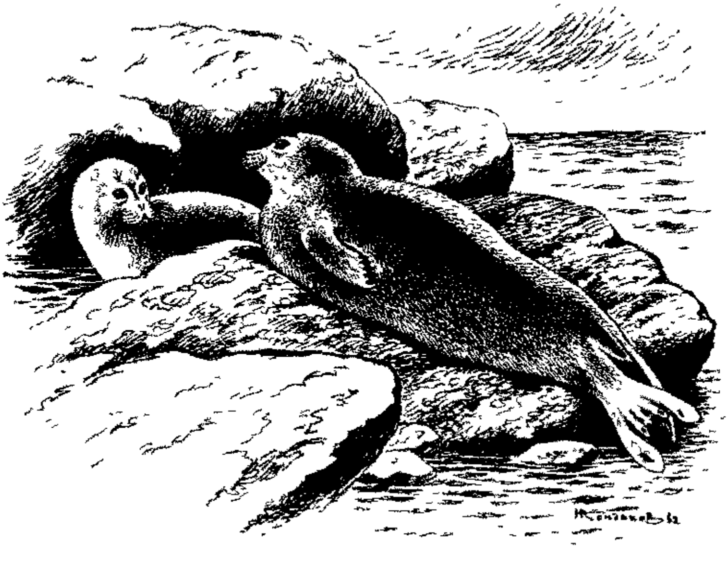
LAKE BAIKAL

Evolution and Biodiversity

edited by

O.M. Kozhova and L.R. Izmest'eva



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evolution and biodiversity

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Preface to the first edition

Baikal is the deepest lake on earth and one of the most ancient. The pronounced endemism and specific wealth of its fauna and flora has attracted the keen interest of biologists and biogeographers all over the world.

A start on the Baikal studies was made at the middle of the 18 century, but they have been carried on with the greatest intensity in the 20 century, and a lot of works devoted to it have appeared in this period. Hence there is an urgent need for a summary of the main results of more than 250 years' study of one of the most remarkable lakes of our planet, and this the author has endeavoured to provide. A zoologist and hydrobiologist himself, he has concentrated on the living world of the lake.

The author has for many years worked at Baikal as head of the Biologo-Geographical Institute and the Baikal Biological Station of Irkutsk State University. In preparing this book for the press the author has received invaluable assistance from cartographer N.V. Tyumentsev, algologists N.L.Antipova and O.M.Kozhova, hydrobiologists G.L.Vasilyeva, G.I.Shnyagina, L.J.Protasova and R.A.Golyshkina, painters B.I. Lebedinsky, N.N.Kondakov and from V.B.Kochetkov, who has been of great help in preparing the English text. Very valuable advice and recomendations have been given to the author by L.A.Zenkevich (Moscow), B.G.Ioganzen (Tomsk), E.I.Lukin (Kharkov), M.Yu.Bekman (Institute of Limnology), G.G.Martinson (Institute of Limnology), N.I.Livanov (Kazan), V.V.Izosimov (Kazan), A.A.Linevich (Irkutsk), G.G.Abrikosov (Moscow), G.I.Galazy (Institute of Limnology), and K.K.Votintsev (Institute of Limnology), to all of whom he expresses profound gratitude.

The author is grateful to the late Prof. Dr. W.W.Weisbach, Den Haag, and to Dr. W Junk, Publishers, Den Haag, for having given him an opportunity of publishing this work in the Monographiae Biologicae series, to Mr. Allan Brindle of the University of Manchester, who read the whole manuscript before it was sent to the printers and to Mr. K.J.Plasterk of Dr. W.Junk, Publishers for the proof-reading and his work in the preparation of the book and the indices.

Irkutsk, USSR. Mikhail Kozhov

Preface to the second edition

Lake Baikal continues to be a focus of interest for scientists in the field of nature conservation. The anthropogenic load on the lake is now becoming so great that we came up with the idea of a new edition of the book *'Lake Baikal and its Life'* by M.M. Kozhov, which has always been highly appreciated by specialists. Many new data on Lake Baikal have since been obtained by members of the scientific school established by M.M. Kozhov, who carried out research on Lake Baikal using his programs and recommendations. This made it possible to preserve the basic structure of the original book, while supplementing it with new data, predominantly published and unpublished, including the book of M.M.Kozhov *'Ocherki po baikalovedeniyu '(Treatise of Baikalogia)*, 1972. In addition, new sections for this edition were written by:

G.P. Chernyaeva (Bacillariophyta in bottom sediments); O.M. Kozhova, B.K.Pavlov and E.A.Silow (Economic use and anthropogenic pressure); L.I. Lut (Climate); V.M. Nikitin, L.P.Spiglasov and V.A. Verkhozina (Bacterioplankton and bacterioneuston); S.M. Popova (Palaeoclimate, palaeontology); P.P. Sherstyankin (Optical properties); M.N. Shimaraev and V.I.Verbolov (Water temperature and circulation); V.V. Smirnov (The omul); K.K. Votintsev (Water chemistry); L.A. Vykhnstyuk (Bottom chemistry); as well as by V.R. Alexeev, E.M.Bolonov, V.V.Cherepanov, E.A.Erbaeva, L.Z. Granina (Leibovich), L.A. Izhboldina, E.Ph. Kornakova, V.D.Mats, E.A. Maximova, B.F. Zhukov.

Major work to improve the section on fauna and benthos was carried out by T.Ya. Sitnikova and M.Yu. Bekman; on flora and plankton by O.M.Kozhova and L.R. Izmest'eva, as well on free-living ciliophora by L.P.Obolkina; on spongia by S.N. Efremova and M.A.Gureeva; on free-living nematoda by S.Ya. Tsalolokhin and A.V.Shoshin ; on mermithidae by M.Yu. Bekman; on parasitofauna by O.T.Rusinek and T.M.Timoshenko; on cyclopoida and ostracoda by G.F.Mazepova, on cladocera and rotifera by N.G. Sheveleva and G.I. Pomazkova; on mollusca by Ya.I. Starobogatov and T.Ya. Sitnikova, on mammalia by B.K.Pavlov.

Consultations on separate systematic groups were acquired from V.R.Alexeev, I.V.Mekhanikova, G.L.Okuneva, V.A.Ostroumov, V.I. Provis, N.A.Rozhkova, V.G.Sideleva, V.V. Takhteev, K.V.Varykhanova.

Lists of species of Baikalian flora and fauna as stated at the beginning of the 90s and their compilers are given in the Appendix according to the scheme developed by O.M. Kozhova. Manuscript was prepared for printing by O.M.Kozhova, T.Ya.Sitnikova and L.RJzmest'eva with the assistance of LK.Bokova, I.Yu.Kuznetsov and S.V.Shimaraeva. The translation was undertaken by R.G.Saifutdinova.

We would like to express our sincere thanks to Prof. H.J. Dumont (Ghent, Belgium) for his valuable assistance during the early phases of the preparation of this volume. Several colleagues have offered valuable suggestions on the taxonomy and nomenclature of the taxa listed in the appendices ; these are : C. Cocquyt (Algae), W. Decraemer (Nematoda), K. Martens (Ostracoda), P. Martin (Ohgochaeta) and H. Segers (Rotatoria).

We appreciate much the efforts of all colleagues who contributed to this book.

Irkutsk, Russia
July 1998

O.M. Kozhova
L.R.Izmest'eva

Evolution and biodiversity in Lake Baikal

Most lakes have a post-glacial origin, which means that they have existed for less than 10-15,000 years About two dozen lakes on Earth, however, are significantly older, up to three orders of magnitude, and can be considered ancient or long-lived lakes (Gorthner 1994) Of these ancient lakes, Lake Baikal is the absolute champion, it is the oldest (the lake has existed continuously, in one form or other, for 30 Myr or more) and the deepest (close to 1,700 m deep, and oxygenated down to the deepest point) of all lakes, and it holds the largest single volume of unfrozen fresh water on the planet (about one fifth of the global supply) (Martin 1994) This combination of factors, together with numerous others, has made that Lake Baikal now holds the largest number of described metazoan species of all known lakes and can be considered a centre of megadiversity

For more than one hundred years, scientists (mostly Russian) have studied the diversity and origin of life in this unique lake, as well as the environment in which this astonishing biological diversity has developed and presently lives physical and chemical limnology, geological history of the lake and its ancestral basins and so on As most reports of these investigations were published in Russian, the lake remained relatively ill-known in the western world until Brooks made ample mention of it in his 1950 milestone paper on 'Speciation in Ancient Lakes' Nevertheless, if anything, this review showed that a wealth of information was at that stage still hidden in the Russian literature, so it was not until Kozhov's famous (1963) book on 'Lake Baikal and its Life' that Baikal became really known and appreciated outside of the (then) Soviet Union Kozho\'s book, an English version of his Russian volume 'Biologija ozera Baikal' (The Biology of Lake Baikal), appeared in the prestigious series Monographiae Biologicae and became at once the bible of biological studies on Lake Baikal The importance of this book (both in the former Sovjet Union and in the western world) cannot be overestimated, as it has stimulated many young researchers to direct their future research projects towards work on this lake, examples from it were cited in several basic text books on evolution and speciation and it has remained the main reference work on the biology of Lake Baikal up to this very moment more than one fourth of all papers in the proceedings of the first workshop on 'Speciation in Ancient Lakes-SIAL' (Martens et al 1994) still refer to this work Kozhov (1963) is, by all standards, a classic book

However, there is a time when even classics become, to some extent, dated Kozhov's standard work was published 35 years ago and written almost 40 years ago Meanwhile, things have changed The lake is still there and much of the objective data published in 1963 remain valid, but a wealth of new information, new theoretical approaches and new methods have become available The time had come to provide a revised edition of 'Lake Baikal and its Life' and it is most fitting that Mikhail Kozhov's daughter, professor Olga M Kozhova, and granddaugher, Dr Lyubov' Izmest'eva, have edited the present book together Several members of the Institute of Biology at Irkutsk State University, as well as people of the Limnological Institute of the Siberian Branch of the Russian Academy of Sciences have summarised the information gathered during the past four decades of dedicated research and integrated it with Kozhov's original compilation The collaboration of scientists from both Institutes is again most fitting, as these two laboratories have been the nuclei and the driving force behind most of the biological research on the lake.

The production of such a massive review takes a long time, and it is therefore understandable that the most recent literature on Lake Baikal and its biota could not be included. For example, the various papers on Lake Baikal presented at (and since) the first SIAL conference in 1993 (see above) and published in Martens et al. (1994) have not been integrated. Nor has it been possible to cite the first volume of a series of faunal treatments on Lake Baikal, edited by O. Timoshkin, and which appeared (in Russian) in 1995. Finally, the application of molecular techniques, using both allozyme divergence with starch gel electrophoresis and DNA-based phytogenies, on Baikalian faunas is a rather recent development, which is also not yet integrated in the present volume. Nevertheless, the present book is still a monumental monograph on the most fascinating lake in the world, much more than just a second edition of the successful 1963 book. It fulfills a need, which has been increasingly felt for more than a decade. Its appearance is timely, as there is a real impetus in research on evolution in ancient lakes in general, and on Baikal in particular (Fryer 1995, Martens 1997). Many of the international research projects during the past years have been initiated under the auspices of the Baikal International Center for Ecological Research (BICER).

The book also comes at a moment when the great lake is, unfortunately, still in peril, as is extensively outlined in chapter 7 of this book. In spite of the fact that measures have been taken by the Russian government to protect one of the most valuable world heritage sites in Asia, we are still ignorant of the vulnerability of such complex, and fine-tuned ecosystems to external influences. We simply don't know the effects of eutrophication, excess sediment input, slight temperature changes caused by global climatic change, etc. on the endemic fauna and flora and the ecosystem functioning of Lake Baikal. More research on the effects of biodiversity on ecosytem resilience is necessary and Lake Baikal is the perfect natural laboratory for such concerted research projects by Russian scientists, in close collaboration with the international scientific community. Continued research at all three main levels of biodiversity (molecular, taxonomic, ecosystem) is an absolute necessity for the future survival of this unique lake. The present book will facilitate these initiatives. It can be read as a basic encyclopedia of extant knowledge, but also as a shopping list of possible (and necessary) research projects.

Koen Martens

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Introduction

The unusual size and depth of Baikal and the originality and wealth of its fauna and flora have long attracted the attention of scientists the world over

The first data on Baikal were published back in the 18th century by G G Gmehn 1751-52, PS Pallas 1776,1811, IG Georgi 1775, and other explorers of Asia But the foundations of the Baikal studies were laid by the remarkable investigation of B Dybowsky, who worked here in 1868, 1870 and 1876, and also by the expeditions of Prof A A Korotnev of Kiev University, who studied Baikal in 1900-1902 The same years witnessed important research in the morphometry, cartography and hydrology of the lake Scientists in many countries took an active part in the studying of material collected by these expeditions and individual researches

After a certain interval the studies of Baikal were restarted and have continued ever since An important part in these studies has been taken by the USSR Academy of science and Irkutsk State University In 1918-20 the Academy of Sciences set up a permanent base for the study of the lake, situated 23 km to the north of the outflow of the River Angara, in the area of the mouth of the River Bolshiye Koty Soon afterwards this base was reorganised into the Biological Station and since 1921 it has been disposal of Irkutsk State University Prof V N Yasnitsky was its first director, since 1931 it has been headed by author of this book MM Kozhov (1890-1968) Continued observations on the Baikal ecosystem state, started on the Baikahan Biological station, have become a basis for ecological monitoring of Baikal, which permitted to make prognoses for its change under pressure of anthropogenic factors

The Biological station, as well as the Biologo-Geographical Institute of the Irkutsk State University (now the Scientific-Research Institute of Biology), at the first stage of their existence in many ways owed their success to the efforts of the professors of the Irkutsk University V Ch Dorogostaisky and B A Svarchevsky

In 1925, the Academy established the permanent Baikal Limnological Station, which till 1942 worked under the guidance of the distinguished limnologist G Yu Vereshchagin, who died in that year Recently it has been reorganised into the Institute of Limnology of the Siberian Branch of the Russian Academy of Sciences Studies of Baikal have also been conducted by many other scientific establishments and workers of the fishing industry, hydro-meteorology service and so on

As a result of these studies, Baikal has emerged before us, not only as a museum of living antiquities, which it was considered to be before, but also as a vast centre of autochthonous speciation continuing at present as well This process is the most remarkable feature of the living world of the great lake Today, science has fathomed deeper than ever before the distinct past of Baikal And we can better visualise the history of its remarkable fauna We know now that over millions of years Baikal and the country around it have lived through many changes They have seen the rise and change of mountain structures, the subsidence of extensive intermountain tectonic depressions connected with Baikal and their filling with deep waters, the transition from warm, almost subtropical climate of the middle of the Tertiary period to the rigorous Quaternary climate and, finally, the moderately cold climate of the modern period, and the reshaping of the hydrographic network linking Baikal with the neighbouring biogeographical regions from which it could receive new immigrants The outlook of the lake itself has also been changing gradually A system of comparatively small lakes, embryos of Baikal, had developed into a single vast and colossal deep body of water whose trough is the deepest continental depression in the crust of the Earth.

All these phenomena were bound to have a decisive influence on the formation of a distinct world of organisms which gradually colonised the lake from the shores to the greatest depths. Life conditions in Baikal proved so favourable for some of the immigrants that they have thrived on an unprecedented scale there, forming a multitude of new species and genera. Elucidation of the time and ways of penetration of the ancient fauna into Baikal basin and the laws governing its further evolution, which has brought about such striking results, is a primary task which will help in understanding the problems of world biogeography and the theory of evolution.

Elaboration of this problem has been greatly facilitated by recent palaeontological studies in the areas of old continental depressions in Central Asia which were once filled with extensive lakes. The problem of the history of Baikal has in itself provided an impetus to a profound study of the geological history and biogeography of the regions neighbouring on Baikal and also of the ancient hydrographycal communications which existed in Central and North Asia. Among the results of recent geomorphological and biogeographical studies of special importance for Baikal problems is the discovery of extensive and deep tectonic depressions of the Baikal system situated in the vicinity of the lake. The large residual lakes still covering the bottom of these depressions have been found to contain living remnants of the Baikalian fauna (Kozhov, 1942,1949).

Considerable additions to the knowledge of the systematic composition of the Baikalian flora and fauna and its congeneric ties with analogous florae and faunae of other countries have been made in the last years. Large-scale studies have been carried out on the distribution of fauna and flora on the bottom and in the mass of water of the lake, as well as of such important factors of the water environment as temperature, chemistry, light intensity and types of sediment peculiar to the separate zones and biotopes of Baikal.

Of great interest are the results of the study of seasonal phenomena in the life of Baikal's pelagic zone, vertical and horizontal movements of pelagic organisms, food relationship between widespread species, diurnal vertical migrations and seasonal and annual fluctuations in the crop of plankton. This results may prove a major contribution to the limnology and ecology of hydrobiota.

In connection with the problem of Baikal, a study has been made of the hydrofauna of the drainage of the Angara and the Yeniseĭ, and the lakes and rivers of the Baikal and trans-Baikal areas. It has been found that only a few Baikalian species live in some of the lakes connected with Baikal. But none of them ever penetrates very far up the affluents of Baikal. It is only down the Angara and the Yenisei that dozens of littoral species of the Baikalian fauna spread for thousands of kilometres, right up to the Arctic coast inclusive. En route they settle in big running-water lakes, including relict lakes (Taimyr, for instance) These facts help towards a deeper understanding of the part played by ecological conditions are responsible for the so-called immiscibility of the Baikalian fauna with ordinary widespread Euro-Siberian fauna inhabiting the lakes and rivers of Siberia.

All these problems have become more urgent in view of the necessity of protecting biodiversity on Earth and making prognoses for natural ecosystem changes under all-growing pressure of anthropogenic factors. As the results of the study on Baikal show, the answer to alarming the mankind questions can be got only if we become aware of the entire processes occurring in natural ecosystems. Baikal as a treasure chest of fresh waters deserves now and in future much attention not only of Russia but of the world community.

We have mentioned here only the main trends of the Baikalian studies. The results of these studies have been printed in many hundreds of works scattered in a numerous publications, and the need has long since been felt for a work summing up the results of these studies. This book is designed to fill, as far as possible, this need and provide a concise review of the results of the many years of Baikal studies and also to outline their further task. We hope that our work will further help to enhance the interest in Baikal, which presents, as it were, a gigantic natural laboratory making possible a fruitful study of the evolution of aquatic organisms, the formation of peculiar endemic complexes, and other important biological and biogeographical problems.

Chapter 1
Natural Conditions

1.1. Geographical position and nature of the region

Lake Baikal is the world's deepest lake and one of the largest, stretching like a giant crescent, 636 km long and up to 80 km wide, amidst mountains on the north-eastern borders of Central Asia, at an altitude of 455.6 m a.s.l. (Fig. 1.1). Covering an area of 31,500 km^2, Baikal ranks seventh in the world after the Caspian and Aral seas, the North-American lakes Huron, Michigan and Superior, and Lake Victoria in Africa.

In depth (1,620 m), Baikal has no rivals in the world.

With its bottom lying at 1,164 m below ocean level, it is the deepest continental depression on our planet.

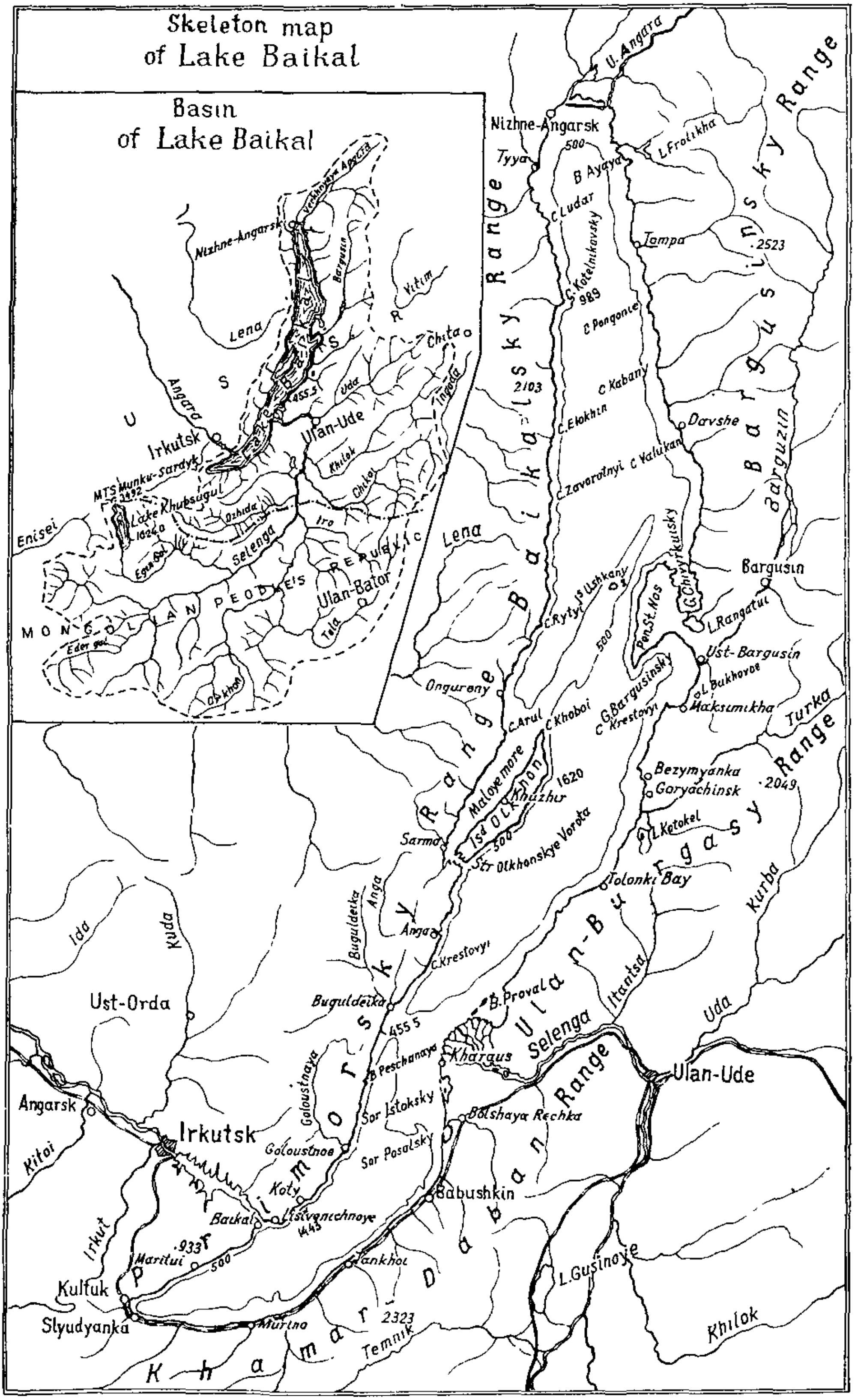
The Baikal rift zone possesses many specific features, although its general evolution has much in common with that of other continental rifts. It is isolated from the World Rift System, presenting an autonomous complex of Cenozoic tectonism and volcanism. Local energy sources played a dominant role in its formation, although the stress field of the Baikalian rift zones has been influenced by movements of large blocks of the Asian lithosphere. The Baikal zone exemplifies directional control of its faults and graben by a structural anisotropy of the pre-existing basement, dependent on the degree of obliquity between the ancient structures and the preferred direction of rift fracturing.

The Baikal rift valleys began with a deep opening of the upper crust at the south-eastern edge of the Siberian platform, in the region of the south Baikal depression, with subsequent prolongation to the west and north-east. Terminal rift valleys in north Mongolia and south Yakutia were initiated not earlier than the Middle Pliocene. The south Baikal depression, the world's deepest intracontinental rift valley, became the node of the entire Baikal system of rift valleys. This rift system is characterized by a high level of seismicity and massive vertical displacements of the basement across the rift valley shoulders (up to 6-8 km). The modest amount of volcanic activity within this rift zone is in contrast with its high tectonic mobility, and the melting sources appear to have evolved independently of the location of rift valleys and their marginal faults (Florensov, 1969; Logachev & Florensov, 1978).

The lake is situated in the centre of a vast mountain region bearing the same name In the south, it is bounded by the Eastern Sayan mountain massif and its spur, the Khamar-Daban Range. The highest point of the Sayan, the Munku-Sardyk (Eternally Snowcapped) mountains, has an absolute altitude of 3,491 m, while that of the Khamar-Daban, reaches 2,400 m. The Munku-Sardyk carries small glaciers. At the foot of its southern slope, extending into Mongolia, lies the large and deep Lake Khubsugul (Kosogol), to the south of which stretch the boundless Mongolian steppes. The linear distance between Baikal and Khubsugul is 200 km. Khubsugul belongs to the Baikal basin and communicates with it through the tributaries of the River Selenga. The Eastern Sayan Range gives rise to the Irkut, Kitoi, Belaya, Oka and other important tributaries of the Angara; many turbulent mountain rivers and streams flow into Baikal from the Khamar-Daban Range.

From the central massif of the Eastern Sayan, the picturesque Tunka and Kitoi Alps branch off (altitude: 3,000 to 3,200 m). The Tunka Alps comprise the northern flange of the tectonic Tunka

Fig 1 1


Skeleton map of Lake Baikal
Basin of Lake Baikal
Verkhnyaya Angara
Nizhne-Angarsk
Barguzin
Vitim
Lena
U S S R
Chita
Angara
Uda
455.5
Ulan-Ude
Irkutsk
Munku-Sardyk
MTS 3492
Lake Khubsugul
1624.0
Khilok
Chikoi
Dzhida
Ingoda
Iro
Enisei
Egin Gol
Selenga
MONGOLIAN PEOPLE'S REPUBLIC
Ulan-Bator
Tola
Eder gol
Orkhon
U. Angara
Nizhne-Angarsk
500
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L.Frolikha
C.Ludar
C.Kotelnikovsky
989
Tompa
.2523
Barguzinsky Range
C Pongonie
Baikalsky Range
2103
C Kabany
C.Elokhin
Davshe
Barguzin
C.Zavorotnyi
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Lena
G.Chivyrkuisky
Bargusin
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Pen.St.Nos
C.Rytyi
500
L.Rangatui
G.Bargusinsky
Ust-Bargusin
L.Bukhovoe
Onguren
C.Arul
C Khoboi
C Krestovyi
Maksimikha
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Sarma
Str Olkhonskye Vorota
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Tolonki Bay
Kurba
Anga
Buguldeika
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Ida
Kuda
Itantsa
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Buguldeika
B.Proval
Uda
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Selenga
Primorsky Range
Goloustnaya
B Peschanaya
Kharaus
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Angarsk
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Bolshaya Rechka
Irkutsk
Goloustnoe
Sar Posalsky
Khamar Daban Range
Kitoi
Koty
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Irkut
.933
Maritui
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Tankhoi
L.Gusinoye
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Slyudyanka
Murino
2323
Temnik
Khilok

depression, which once contained a large, deep lake (Fig. 1.2). Today it carries the meandering Irkut, which flows into the Angara near the city of Irkutsk, and numerous shallow lakes are scattered in its valley. Traces have also been preserved of the old bed of the Irkut, which in ancient times emptied directly into Baikal. The Tertiary lacustrine deposits in the Tunka depression are about 2,500 m thick.

The Khamar-Daban Range, which fringes Baikal to the south, consists of several mountain chains and spurs constituting the divide between the tributaries of the lake and the River Selenga. It slopes steeply towards Baikal, its snow-capped, jagged, bald peaks seeming to hang over the lake. The Khamar-Daban is crossed by the Selenga valley and runs further on along the northeast coast of Baikal as the Ulan-Burgasy Range, which is lower than the Khamar-Daban, and is dissected by the valleys of the tributaries of Baikal and the Selenga.

The Eastern Sayan, the Khamar-Daban, the Ulan-Burgasy and other ranges fringing south Baikal to the south and west are composed of Archean crystalline rocks, gneisses, mica and hornblende slates, amphibolitcs, marbles and widely distributed Proterozoic metamorphic schists In many places they are broken by granites and other plutonic pre-Cambrian. Palaeozoic and younger rocks. Tertiary basalts he on the tops and crests of the mountains; Quarternary basalts occur in the rift valleys. Plutonic rocks rank first in the area occupied by them Mesozoic continental deposits, such as carboniferous sandstones, conglomerates and schistose clays, are found on the bottom of ancient tectonic depressions. The better known Tertiary lacustrine deposits are those of the terraces of the south-east coast of Baikal resting against the Khamar-Daban and lying at its very foot. A colossal mass of Tertiary and Quaternary sands and clays, up to 6,000 m thick, has been found in the area of the Selenga delta (Florensov *et al*, 1978).

In some places, the more gentle slopes of ranges and valley bottoms are covered by glacial deposits in the form of strongly scoured moraines.

The whole of this part of the south Baikal area is characterized by great vulcanicity, especially in the vicinity of the Sayan mountains, the Tunka depression and the Selenga delta. The Eastern Sayan Range still contains remnants of dead volcanoes with well-defined craters.

To the east of the Ulan-Burgasy along the coast of Baikal stretch several ranges, of which the Ikat is the highest. The northern slopes of this range comprise the left (southern) flange of the vast Barguzin tectonic depression. In the Tertiary period this depression, too, contained an extensive lake. Today, its bottom, which is inclined towards Baikal, is cut by the River Barguzin flowing into the middle part of the lake. The right (northern) flange of the Barguzin depression is formed by the Barguzin Range. Its main ridge, reaching 2,724 m above ocean level, stretches at a distance of 10 to 40 km from the north-east coast of Baikal, which is formed by the foothills and scarps of this range. The Barguzin tectonic depression is up to 200 km long and 20 to 30 km wide. In its lower part it develops directly into the depression of the Barguzin Gulf of Baikal. The bottom of this Barguzin depression is filled with a mass of Quaternary and, underneath, Tertiary lacustrine deposits analogous to those of the Selenga delta area. The total thickness of these deposits reaches 1,700 m (Logachev, 1958).

In the Quaternary period the higher sections of the Barguzin Range were covered by glaciers, which crept down the valleys towards Baikal, piling up heaps of debris in front of them. The north-east coasts of Baikal adjoining the slopes of the Barguzin Range are, in many places, composed of moraines forming broad terraces and in some places descending under the level of the lake surface

To the north-east of the Barguzin Range lie the South-Muya and North-Muya ranges, separated by the extensive tectonic Muya-Chara depression (Fig. 1.2) which is analogous to the Barguzin depression and which, in ancient times, also formed the bottom of a large lake or a system of lakes. This depression, like the ranges flanking it, crosses the valley of the Vitim, the biggest right tributary of the Lena, and extends far to the north-east into the drainage of the Chara, a right tributary of the Olekma in the Lena basin. The north-west slopes of the South-Muya Range serve as the left flange of the large tectonic Tsipa depression (Fig. 1 2), which is up to 200 km long and 25-30 km wide. Numerous lakes lie on the bottom of this depression.The biggest of these are still inhabited by some faunal species identical with or close to

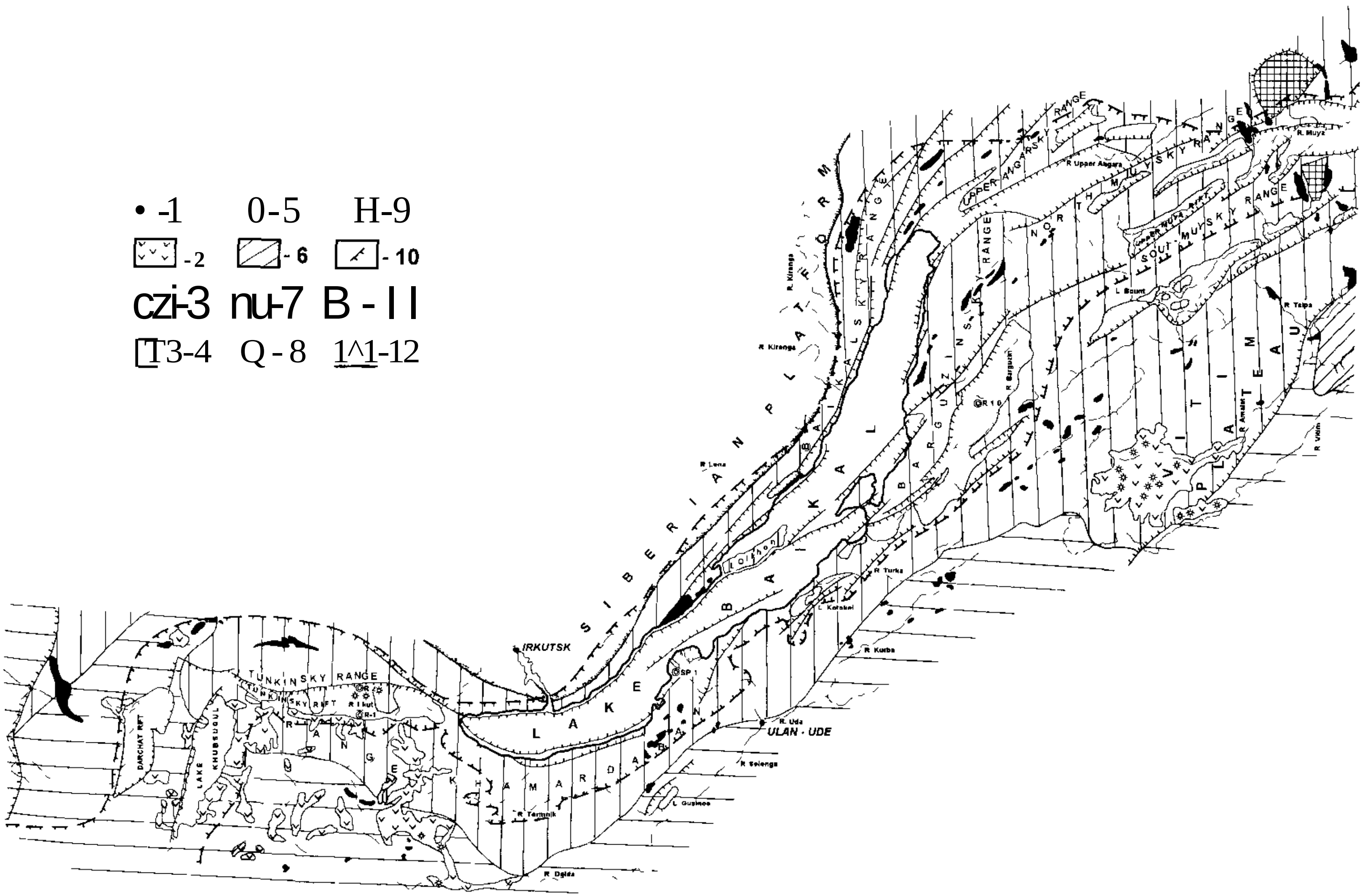


Fig 1 2 Tectonic depressions ot the Baikal system After Florensov, 1969 1 - rift valleys; 2 - Ncogcne-Quatemary plateau-basalts, 3 - extinct volcanoes, 4 ultramafic and basic rocks, 5 - edge of the Siberian Platform, 6 - region of the Preriphean folding; 7 - region of the Baikalian folding, 8 - region of the Caledonian folding, 9 - Aldan Shield and Archean tectonic blocks, 10 - seismic belt, intensity up to M = 6 5; 11 - faults, 12 - some deep bore holes.

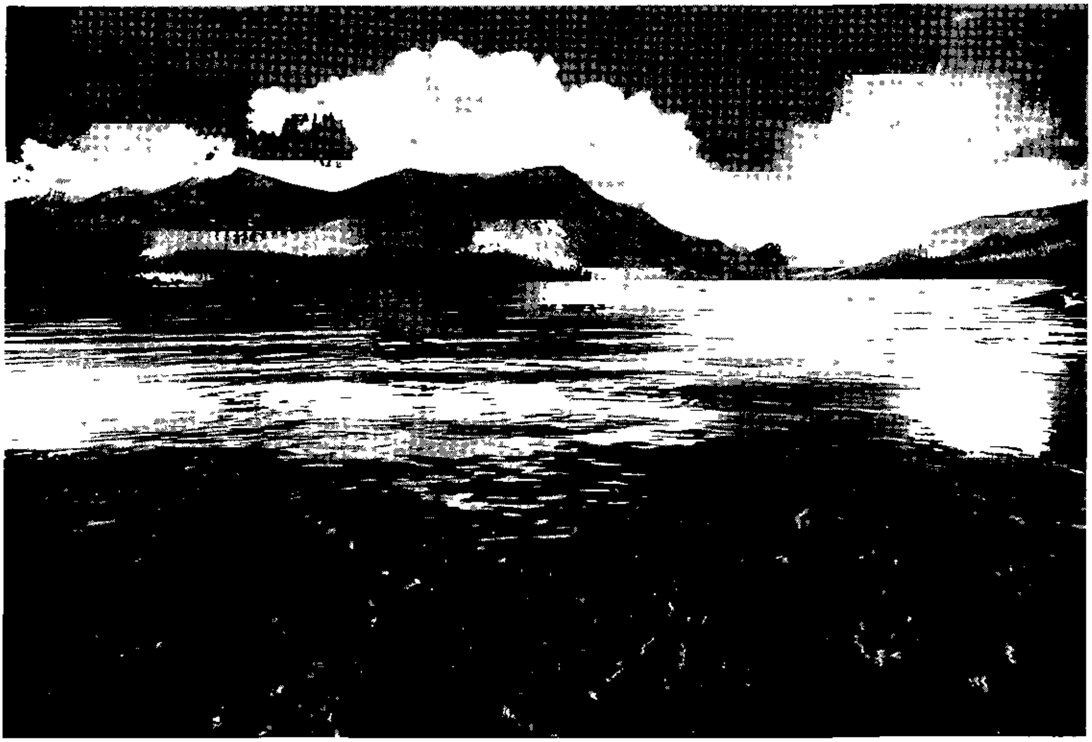


Fig. 1 3 Northern Baikal in summer Photo by O Kostuneii

Baikalian endemics, such as the polychaete *Manayunkia,* one species of the Baikalian fish genus *Asprocottus,* and species of the genus *Paracottus* The polychaete *Manayunkia* has also been found in big running-water lakes of the Muya-Chara depression.

The coasts of the northern extremity of Baikal are formed by the foothills of the Upper Angara Range (absolute altitude up to 2,000 m), which constitutes the divide between the Upper Angara, a big affluent of the lake, and the Vitim, a tributary of the Lena. The Upper Angara Range bounds the right flank of the extensive tectonic Upper Angara depression (Fig. 1.2), along the bottom of which the Upper Angara flows into Baikal. The left flank of this depression is formed by the slopes of the Barguzin and North-Muya ranges. The Upper Angara depression is a natural northern continuation of the northern trough of Baikal.

The north-west coast of Baikal is composed of the steep precipitous slopes of the Baikal Range, rising to 2,673 m above ocean level (Fig 1 6) and the south-west coast, up to the outflow of the Angara, by the foothills of the comparatively low Primorsky Range. The Baikal Range comes very close to the waters of Baikal, forming picturesque rocky cliffs (Fig. 1.3). Its western slopes descend towards the Lena tableland, the drainage of which is towards the Lena. The Lena takes its source on the northern slopes of the Baikal Range, in its central section, 7 km from the lake.

The slopes of the Baikal Range still bear traces of the work of glaciers, such as hanging valleys and cirques with snow at the bottom. In summer the vivid white patches of snow stand out boldly against the background of grey rocks and debris. The slopes are cut by deep gorges with noisy rivers rushing down (Fig. 1.4). These rivers meander in a sea of stones, washing out their own debris and old glacial moraines. Often they disappear under debris and reach Baikal as subterranean streams or drop as waterfalls from cliffs of considerable height.

The geological composition of the mountain structures fringing the northern half of Baikal, as throughout the Baikal area, is characterized by the

Fig 1 4 Taiga at Baikal coast Photo by 0 Kostunen

predomination of Archean and partly Proterozoic crystalline rocks. An outstanding part is played by plutonic rocks everywhere.

The mountain frame of Baikal is broken only in a few places by broad valleys of affluents to the lake, such as the Selenga, Barguzin, Upper Angara, Turka, and others. Low-lying deltas and sand and rocky beaches are formed in the mouths of these rivers.

1.1 1. Climate

The climate of the country around Baikal is distinctly continental. The continental coefficient (according to Zenker) within the Baikal trough decreases to 50-60, the lowest values for the whole Eastern Siberia. Marine tendencies are responsible for a mitigating effect of the Baikal water mass. This allowed Vereshchagin to distinguish the climate of Baikal and areas adjacent to it as a '"peculiar freshwater type of sea climate" (Vereshchagin, 1947).

Table I 1 Mean monthly temperatures of the air (in °C) on the coast of Baikal and m Ulan-Ude (the Trans-Baikal area)

Month	*Coast of southern Baikal, Berg, 1955*	*Coast of central Baikal, Tkachuk* et al *1957*	*Ulan-Ude*
1	-154	-18 7	-25 7
II	-15 7	-18 2	-21 2
III	-10 1	-109	-11 8
IV	1 0	*-2 2*	05
V	50	3.7	85
VI	10 1	9.1	17 0
VII	127	12 9	19 7
VIII	13 Q	13 5	169
IX	87	8.3	88
X	1 5	1.5	-0 6
XI	-5 3	-6 7	-12 5
XII	-]] 9	-12 6	-22 3
Average	-0 6	-1 7	-1 9
Amplitude	29 6	32 2	45 4

Atmospheric circulation dramatically redistributes the solar energy coming down to the Earth surface; it is a strong climate-forming factor. The circulation above Baikal is the result of an interaction between different wind transferences. The most *important of these are wind fluxes, connected* both with a common circulation processes and with local circulation, which is dependent on the character of the pre-terrestrial field of atmospheric pressure above the lake (Lut, 1985).

Radiation regime conditions are indicators of the Baikal climate Annual solar irradiance on Baikal is 2.200 hours. Maximum values for sunshine duration were recorded at the south of the lake and on the Olkhon Island - 2,300-2,400 hours; minimum values, 1,700-1,800 hours - on the eastern coast at the south and north of the lake. These values are considerably lower than 2,000 hours in other areas at the same latitude: on the Riga sea-shore - 1,830 hours, mountain health resorts in the Caucasus 1.838 hours (Teberda), 1,994 hours (Abastumany).

The amount of ultraviolet radiation in the Baikal region is similar to that of Alpine regions. Atmospheric transparency in the Baikal trough is much higher than that of regions at the same latitude but east and west of Baikal. Water currents play a main role all around the year as reducers of radiation under cloudless conditions. Aerosol influence occurs during winter-spring periods Coefficients of transparency range from 0.82 to 0.73 across the

Fig I 5 The Lake Baikal in lale autumn Photo b> V Korolkoiuchko

year. On average, the annual value of atmospheric transparency for the whole lake (0 775) corresponds to "an increased gradation" according to Pivovarova and Krayushkina's classification {1970). The maximum of atmospheric transparency is recorded in autumn-winter; the minimum is in spring-summer, for all parts of the lake. The transparency coefficient for the south Baikal region is 0.76. This value is within the range of "normal transparency". According to this classification, middle and north Baikal regions arc classified as having an increased transparency of the atmosphere (0.78). The transparency coefficient of the atmosphere in spring-summer in the south and north Baikal regions decreases to 0.74, which is taken as "normal". Only within the middle Baikal region does it remain high. Such variability in transparency values is due to changes in the degree of various moist air masses, extent of their aerosohc turbidity, as well as peculiarities in the atmospheric circulation in each of the three zones of Baikal (Panova, 1980).

The thermal regime in any region is formed under the influence of solar radiation, atmospheric circulation and local physical and geographical conditions, such as height above sea-level, relief, distance from waterbodies, and orographical protection.

The winter is long, cold and dry, the summer short and relatively hot, with considerable precipitation. January is the coldest month of the year, with a mean temperature m various parts of the coast of Baikal ranging from -17° to -25°C, the absolute minima being -37° to -40°C, dropping to -50°C in some bays. In regions away from Baikal, the winter is still cold. For instance, in the city of Ulan-Ude, situated 75 km to the south of the lake. the mean January temperature is -25° to -26°C. In the Eastern Sayan Range the winter temperature often falls to -55° and -60°C. Table 1.1 shows the mean monthly temperatures of the air at Baikal and Ulan-Ude.

July is the warmest month in the Baikal area, but August is the warmest on the shores of the lake proper The mean summer temperature in July in the Trans-Baikal area (Ulan-Ude) is 19° to *20°C*, the absolute maximum reaching 38°C (Preobrazhensky *et* a/., 1959; Tkachuk *et a!.*, 1957). At the coast, the temperature of the warmest month, August, varies between 13° and 14°C with a maximum of 20". On exceptionally warm and calm days, it may reach 25° to 30°C.

As can be seen from these data, the waters of Baikal noticeably influence the climate of its shores: January and December are about 10°C warmer and June-July 7°C colder than Ulan-Ude and the city of Irkutsk, 60 km west of the lake, where the air temperatures in June reach 25° to 30°C. while at Baikal they do not exceed 15° to I8°C. In the first half of December, frosts at

Irkutsk reach -20° to -25°C, while on the coasts of Baikal the temperature does not fall more than 12° to 15°C below zero, and above the water, not more than 7° to 8° below zero. But this influence of Baikal on the coastal climate does not spread further than the ridges fringing it. Due to the thermic influence of the water masses of the lake, the duration of the frostless period here increases by 5-20 days. The decrease in the air temperature amplitudes is as follows: diurnal 1-8°C, annual 30-32°C, while above the land surrounding Baikal these values vary from 4 to 16°C and from 35° to 50°C, respectively. A one-month delay in the onset of annual extreme air temperatures takes place, compared to neighbouring land areas. This is a tendency typical of sea-shore areas. The winters in the Baikal trough are the warmest in eastern Siberia. The cooling effect of water masses as well is responsible for lower temperatures in summer in the Baikal trough compared to Predbaikalye and Zabaikalye stations located at the same latitudes. The annual maximum of the air temperature for the majority of the Baikalian stations reaches 12°-14°C. Thus, the Baikal trough constitutes a disturbance of the latitudinal spatial distribution of air temperatures in south-east Siberia during all seasons.

The precipitation regime over the south of Eastern Siberia is primarily controlled by cyclones of western origin. Humid north-western winds bring moisture to the Baikal trough. Maximum precipitation falls on the north-west and west slopes of the coastal ranges (1,000-1,400 mm a year (Obolkin, 1977)). Minimum precipitation falls in winter (January-March), when the region is affected by a strong Siberian anticyclone and the circulation resulting from it. Maximum precipitation is recorded in summer in case of cyclonic activity in the Baikal region. In some regions (Ust-Barguzin, G. Ushkany Island) two annual precipitation peaks are recorded: the main one in July, and a second, less significant one, in November-December. The second peak is connected with an additional influx of moisture due to increased evaporation from the lake surface during autumn.

During cold periods (November-December), when Baikal is still unfrozen, and the air temperature in the trough is higher than that of the surrounding land, favourable conditions occur for evaporation from the open lake surface, which increase the water steam elasticity in the lake trough (Verbolov *et al.*, 1965) (Fig. 1.5). After the freeze-up, humidity differences between the Baikal trough and the surrounding land smooth over, but nevertheless the humidity in the trough is slightly higher. The daily course of relative humidity is the reverse of that of the air temperature; it reaches its maximum in the morning and its minimum in the afternoon.

During the warm half of the year, when there are summer pressure maxima over the lake, winds of flux nature, blowing the water surface towards land, occur above the Baikal trough, in the southern part of the lake these winds have primarily south-western and western directions. In the middle and north parts, together with the south-western wind fluxes, winds with an eastern component blow along the west coast of the lake. In cold weather, seasonal banc minima arise above the lake, and the winds blow from land to water. On the west coast, these are north-western and northern winds; on the east coast, winds with an eastern component occur.

The wind direction in cold seasons is from land to the lake, in warm seasons - from the lake towards land, which is indicative of the presence of a circulation typical of sea coasts. The main cold intrusions over Lake Baikal occur from the west and north. Such intrusions of cold air masses are possible if their vertical power exceeds the height of the ranges. Above the trough, typical Baikalian winds have local names - two lengthwise winds: Verkhovick and Kultuk of north-eastern and south-western direction, respectively, and winds directed from one shore of the lake to the other, Gornaya and Shelonnik, with a north-western and south-eastern direction (Vereshchagin, 1947). For typical Baikalian winds average velocity, recurrence and stability have been calculated. They have been determined across the year, for a navigation period on the lake, (June-December), as well as for warm and cold seasons, within a navigation period (Lut, 1976). In warm seasons, Verkhovick and Gornaya show the highest average velocities (8-9 m sec^{-1}). Average maximum velocities for Kultuk and Shelonnik range from 4 to 6 m sec '. In cold periods, average velocities of the winds from all directions increase. The greatest average velocities of Gornaya, Verkhovik and Kultuk reach 9-10 m sec"[1], and of Shelonnik 6 m sec '. The analysis of the data on wind stability has shown Gornaya to be most stable. Over south Baikal, Kultuk is a stable wind, along with Gornaya, in middle and north Baikal, Verkhovik is stable. In places where the coastline of Baikal is broken by river valleys, two predominant wind fluxes of opposite direction, coinciding with the direction of the valley, are commonly recorded. So, over a year, wind fluxes with a western component are typical of the Baikal region, as well as a west-east transference of air masses. Recurrent values of wind transferences in the above-mentioned directions range from 40-60 msec[1]. The recurrence values of the winds with an eastern component are about 10%.

Total cloudiness above Baikal has two annual maxima (July-August and November-December) and two minima (February and September-October). The highest cloudiness values reach 7-8 and are recorded on the north-east coast of Baikal in December, according to long-term observations (Osmolovskaya, 1964).

Mists on Baikal are similar in their nature to sea types. The maximum number of misty days on the north-east coast of the lake is 23-25 days (Ladeishikov & Mizandrontseva, 1977). The minimum number of days with hail in the trough are: Olkhon Island, 0.1-0.8; and, coasts of Baikal, from 4 to 7 days per year. In the lake trough, descending air fluxes prevail, which result in clouds dispersing above the lake. This is the reason why ascending fluxes do not develop above Baikal, and no convective cloudiness is formed, which could cause hails.

Snow-storm occurrence on the coasts is from 120 to 430 hours; in orographically closed places (Sludyanka, Nizhneangarsk) this value does not exceed 50 hours. The above-discussed meteorological variables and climatic features profoundly influence the animal and plant world living in the lake.

1 1.2. Terrestrial plant communities

We appreciate the efforts of such botanists as Tyulina, Epova, Popov, Bardunov, Reschikov, Malyshev, and others who have helped us become familiar with the flora of the Baikalian mountain region.

The south of Siberia is dominated by the taiga. This coniferous forest contains pine *{Pinus silvestris)*, larch *[Larix sibirica, L. dahunca)*, cedar *(Pinus sibirica)*, spruce *(Picea obovata)*, and fir tree *{Abies sibirica)*, with an admixture of poplar *{Populus suaveolens)* and aspen *{Populus tremula)*, and an undergrowth of shrubs of alder *(Duschekia fruticosa)*, birch *(Betula)*, bird cherry tree *(Padus avium)*, rowan *(Sorbus sibirica)*, *Ledum, Rhododendron dahuricum, Spiraea media, Cotoneaster melanocarpa*, berry bushes *(Vaccinium vitis indaea, Vaccinium myrtillus, Vaccinium uliginosum, Bergenia crassifolia)*, forest grasses, ferns, lycopodiums *(Lycopodiacae)*, mosses *(Bryophyta)*, and other shade- and moisture-loving plants. Dense tracts of various plant communities are a typical landscape of the plains, river valleys and mountain slopes of south Siberia. But in Zabaikalye, at a latitude of 51°-51° 30' N, forest-steppe and steppe vegetation predominate. To the north of Baikal there are vast areas of steppe and forest-steppe, particularly on gentle slopes, on the terraces of wide river valleys, and on flat watersheds where steppes alternate wHh pine and mixed forests.

In south Siberia east of the Yenisei, there are no broad-leaf forests. Only near Krasnoyarsk has a small relict forest of lime trees been preserved. More considerable remnants of broad-leaf forests have been preserved to the east of Baikal. On the boundary of Zabaikalye and Pnamurye, in east Zabaikalye, oak groves and such grass and shrub plants which are connected with previously existing broad-leaf forests occur Several relict plants have been preserved in the south-west areas of the Baikalian mountain region, predominantly near hot springs, or in places where abundant snow prevents freezing of the soil-

Against the general background of the vegetation typical of south Siberia, the flora of the Baikalian mountain region, due to climatic peculiarities and differences in microclimatic conditions, possesses a wide diversity of landscapes. Here, majestic mountain forests growing predominantly on medium-height ranges (along their slopes) are widespread. Above the forest line, stunted shrubs, and here and there meadows, picturesque in spring and summer, are found on the floors of vast depressions. Steppe and forest-steppe, alternating with pine forests at elevations and with marshes in lowlands, abound. This mosaic of landscapes changes, depending on its geographical position, on the exposure of range and plateau slopes, on the height of the region and its latitude position, on precipitation, and *on incident* radiation.

Especially dramatic changes in landscapes occur in the vertical direction from mountain peaks downward. For the Eastern Sayan, Malyshev (1965) offers a scheme of vegetation zones which can be applied, with some limitations, to other areas of the Baikalian mountain region. The highest is the nival zone (snowy or rocky), followed by bald (goltsy), nearly bald, forest (mountain-taiga) and steppe-forest zones. The nival zone occupies considerable areas in high ranges and uplands. In the Eastern Sayan, it occupies an absolute altitude of 2,500 to 2,800-3,000 m Above 3,000 m in the Sayan, all vegetation is absent. The nival zone is a rocky desert which supports only the most enduring plants: *Saxifraga nivalis,* Alpine ferns (Lufbe) and other cold-loving species. The bald zone occupies altitudes from 2,200 to 3,000 m. In its lower half sedge-moss-hchen tundras dominate, with *Kobresia myosuroides, Kobresia sibirica,* in the middle parts *Dryas oxyodonta, Dryas punctata.* In the upper parts, rocky tundra, occupying not only steep slopes, but also coarse-rocky plateaus, occur (Malyshev, 1965). On the southern slopes of the mountains with poor precipitation and higher temperatures, alpine meadows and sub-alpine shrubs appear The vegetation of the near-bald zone at an altitude of 2,000-2,200 m is more diverse. Alongside the meadows forests can be found, which alternate with shrubby tundra and meadows here.

Beside elevation, the vegetation is much affected by moisture, precipitation abundance, the depth of snow cover and the character of the drainage. The height of shrub growth at given elevations corresponds to the depth of snow cover. Above the snow level, shoots are subject to snow corrosion. As a result, Malyshev remarks that shrubs here look as if they have been trimmed, their stems crowned with dead twigs, and the growths of evergreen *Rhododendron aureum* above the snow surface covered with damaged buds and dead leaves.

The upper forest line in the Eastern Sayan fluctuates, depending on exposure and moisture conditions, around an absolute altitude of 1,500 to 2,100 *m.* So does the highest forest line in Khamar-Daban, and on the slopes overlooking Baikal it is situated lower than on the opposite side. Here, above the forest line moss-lichen tundra, willow, *Betula rotundifolia* are dominant (Reschikov, 1958).

In the forest (mountain-taiga) zone of the Eastern Sayan and Khamar-Daban, Siberian larch *(Larix sibirica)* and dark-coniferous taiga, among which cedar *(Pinus sibirica),* cedar-fir *(P. sibirica* and *Abies sibirica)* forests, and also spruce-fir *(Picea obovata-Abies sibirica)* forests prevail. These are particularly well developed on the northern slopes, and often reach the forest line.

On the slopes fringing the north part of the Baikal depression, the forests contain predominantly Daurian larch, *{Larix dahurica),* which is replaced in the south part by Siberian larch *(Larix sibirica),* with the boundary between them lying along the west coast of the lake in the region of the bays Kotelnikovsky-Zavorotny, along the east coast in the region of the River Sosnovka mouth. Alongside larch forests, the slopes of the Baikal range descending towards Baikal are taken up by dark-coniferous taiga of cedar *(Pinus sibirica)* and fir *(Abies sibirica),* with an undergrowth of alder, *Rhododendron dahuricum* and *Ledum palustre,* shrub birch, *Rhododendron aureum* and *Pinus pumila.* There is also on abundance of bergenia (Badan), berry bushes *{Vaccimum vitis indaea, Vaccimum myrtillus, Vaccinium uliginosum),* and here and there birch and aspen groves can be seen, while along the mountain river floodplains fragrant poplars *(Populus suaveolens)* and willows abound. On the south slopes of the ranges considerable areas are covered by pine forests. Along the coasts of the lake, motley grass meadows and steppe patches are not infrequent. Dense impenetrable growths of *Pinus pumila* at the north of Baikal drop towards the water's edge; the dwarf birch *{Betula nana)* is common there. On the slopes of the mountains (towards Baikal), there are steppic patches which also occur along the coasts of the lake, on flat bays deeply indenting the coast. The north-west coast, being more humid, is poor in steppe patches.

The vegetation of the Barguzin Range in the region of the Barguzinsky Reserve (Bannikov & Ustinov, 1966) shows the following succession: on the range peaks there are cliffs and rocky places, covered by lichens. Here and there, near springs bushes of alpine willows and birches occur. On the sodded "yards" there are green meadows of *Kobresia* and sedge with vivid patches of anemones, *Aquilegia, Geranium, Troliius asiaticus.* The alpine plateaus are covered by *Rhododendron aureum* tundras, with rich carpets of *Cladonia* and *Centraphia.* Lower still are growths of *Piius pumila* alternating with reindeer moss and growths of *Betula,* and finally, the taiga Its upper part is dominated by fir-cedar forests with an admixture of stone birch, demarcating the arboreal vegetation. In the middle zone, an admixture of larch and pine is found. Along the river valleys, groves of balsam poplar *(Populus tacamahaca)* and *Chosenia arbuhfoha.* In the floodplains grow pine and birch, aspen and spruce *(Abies sihirica).* The larch within the taiga grows primarily in a narrow coastal zone. In the region of Davsha Bay, Siberian and Dahurian larches co-occur to form hybrids. Pine forests in the taiga are rare due to the severe climate of Podlemorye.

In the mountains of the south part of Baikal there is no or rare *Pinus pumila* spread over the mountains of its north part.

The low mountains of the Primorsky and Onotsky ranges are completely covered with pine and pine-larch forests, although sometimes patches of spruce-cedar taiga can be seen.

The north-cast part of the Baikal mountains is characterized by an extremely severe climate. The ridge peaks and their high slopes are a chaotic conglomeration of talus, precipices, deep gorges with eternal firn snows and groups of small glaciers. Only at an altitude of about 1,500 m do grass and shrub plants appear. The rocky tundras of this region are described by Reschikov (1958), as follows: "Meager bushes of *Pinus pumila,* small canopies *of Ledum* are all that can bring a welcome change from cheerless rocky places covered by lichens". The treeline here does not reach above 1,500 m a.s.l., descending in places to 800-900 m.

In mtermountain depressions, marshes, marshy meadows, sparse growth of *Larix dahurica* with an undergrowth of *Pinus pumila* and dwarf birch are widespread. Pine forests and patches of steppes can also be found, which are more frequent in southern depressions.

Despite these severe climatic conditions, the vegetation of the Baikal mountains is rich in species, due to the variety of habitats present. In the elevated section of the Eastern Sayan, Malyshev identified 540 species of plants, pertaining to 205 genera and 52 families. No less than 2500 species of plants seem to occur in the whole region, including the zones occupied by the taiga, marshes. meadows and steppes. In the Eastern Sayan, according to Malyshev, 62% of all species are Asian and 23% Holarctic. Only 12% are of European and 3% of North-American origin. In the alpine zone, pure Asian species (more than 97%) dominate. Apart from widespread species, more than 20 endemic species have been recorded from the Sayan. Forests dominated by *Larix dahurica* and *L. sibinca* or *Larix* and *Pinus sihirica,* prevail over the western coast of the north part of Baikal, the forests with dominant *Pinus silvestris* - on the west coast of the middle and south parts of Baikal. Forests dominated by *Larix* occupy the lower part of the slopes, and on the upper part of the slope, *Pinus sibinca* and *Abies sibirica* (with *Pinus pumila* in a low layer) are widespread along the east coast of the northern part of Baikal. Forests with dominant *Larix* and subdominant *Pinus silvestris,* and with dominant *P. silvestris* and subdominant *Larix* prevaïl south of the Barguzin River valley (as far as the River Selcnga valley) as high as 1,000-1,100 m a.s.l. Higher up, *Pinus sibirica* with an admixture of *Picea obovata* and *Larix* prevail.

South Baikal fringes the Khamar-Daban Range. Its slopes are covered by fir-tree *(Abies sibirica)* and cedar-fir *(P. sibirica-Abies sibirica)* forests The state of these forests is determined by a combination of natural (diseases, forest pests) and anthropogenic (woodfires, effects of technogenic atmospheric pollutants) factors. Forest felling was prohibited here in the mid 50s of the 20th century

1.1.3. Animal world

Thanks to its location at the junction of Central-Asian, European-Siberian and Eastern-Asian faunas, the terrestrial animal world of the Baikal mountain region comprises representatives of all these complexes. One of the causes of the diversity of this fauna is the extreme variety of landscapes present.

In the south part of Eastern Siberia more than 100 species of Mammalia and 326 species of birds are known, with a dominant share of this fauna occupying the Baikalian mountain region The terrestrial invertebrates have not been sufficiently studied yet, but the material available displays a remarkable variety and abundance of species, particularly of insects and Arachnida.

Typical mammals of the high plateaus and ridges are *Capra sibirica* (Eastern Sayan), *Ovis nivicola, Alticola macrotis, Ochotona alpina,* and, in places, *Marmota camtshatica* and lemming *Myopus schisticolor.* In summer in the bald and near-bald zones, one can come across ungulates, predators, and brown bear. Below the plateaus, in the region of coniferous taiga, *Cervus elaphus, Rangifer tarandus, Alces alces, Moschus moschiferus, Capreolus capreolus pygargus* are common. In the foothills, the Sayan wild boar *(Sus scrofa),* can be found, and along the rivers there are occasional *Lutra lutra* and *Neomys fodiens.* In the taiga, besides brown bears, *Felis lynx* and *Gulo gulo* live, as well as the fur-bearing *Sciurus vulgaris, Mustela sibincus, Vulpes vulpes, Lepus timidus,* and *Eutamias sibiricus.* There, numerous rodents and insectivores find refuge and food. Sable, *Martes zibellina* is the most typical and valuable animal of the mountain taiga of south Siberia. Especially valuable is the Barguzin sable which occurs in mountain, taiga with growths of *Pinus pumila.* In the forrest-steppes *Capreolus capreolus pygargus, Mustela eversmanni, Qtellus undulatus,* Microtinae, Insectivora and *Canis lupus* are common. Birds in the taiga zone include *Tetrastes bonasw, Telrao urogallus, Nucifraga caryocatactes, Dendrocopos major, Sitta europaea, Loxia curvirostra, Parus major, Parus palustris, Phylloscopus trochilus, Garrulus glandarius,* and many others. A considerable number of forest birds from the south of Siberia overwinter here.

The Baikalian mountain region is a boundary for the distribution of numerous animal species. Almost half of all bird species find their critical habitats here, and many birds are represented by endemic species. Even cursory studies reveal significant endemism in many groups of the terrestrial fauna of the region as well, and its significance as a demarcating line between western or eastern species is enormous.

Table 12 Birds of Lake Baikal After Skryabin, 1975

Order	*Number of species*	*Migratory habits*		
		Nesting	*Flying over*	*Flying in*
Gaviiformes	2	2	-	–
Podicipediformes	4	4	-	–
Pelecaniformes	1	-	-	1
Ciconiiformes	4	3	-	1
Ansenfocmes	30	19	*1*	4
Falconiformes	7	7	-	–
Grui formes	7	4	1	2
Charadrnformes	52	27	20	5
Columbiformes	1	1	-	–
Stngiformes	1	1	-	–
Apodiformes	2	2	-	–
Coraciiformes	1	1	-	–
Passcnformes	13		13	

There are only 2-3 species of frogs, a toad *(Bujo bufo),* Siberian newt *Hynobius keyserlingi,* and *Lacerta vivipara.* The snakes *Vipera bents, Agkistrodon halys, Natrix sp.,* and *Elaphe dione* occur near warm or hot springs. In the same places, heat-loving insects occur, including a southern species of Odonata. Commonly those sections of the taiga with hot springs serve as a refuge for animal and plant species which used to live in south Siberia in warmer epochs, but disappeared here due to the cooling of the climate in the Quaternary.

Among insects, mention should be made of a scourge to animals and man of Pribaikalye, *i.e.,* Siberian mosquitoes. These mosquitoes include several aggressively bloodsucking species among the Simuliidae, Ceratopogomdae, Culicidae, Tabanidae, Gasterophilidae. Not infrequently *Dendrolimus sibiricus* is encountered, which destroys coniferous needles and causes the "death" of vast areas of forests. There are other harmful insects and as well as Ixodoidea in the taiga.

The list of Baikalian birds includes species whose life is closely associated with water and marshy habitats. Most of this group are representatives of two orders, the Anseriformes and Charadriiformes (Table 1.2).

By establishing contact between the terrestrial and aquatic components of the lake and its coasts, these birds play a considerable role in the transport of organic matter.

The list of this group of birds is not yet complete, since their role in the functioning of the ecosystem has not been sufficiently studied

An interesting habitat for waterfowl migrating to the south in autumn is formed by the upper reaches of the Angara River, which stays unfrozen for as far as 15-20 km upstream from its mouth Goldeneye *(Bucephala clangula), Mergus merganser* and *Mergus serrator, Avthia fuhgula,* sometimes *Mergus albellus, Clangula hyemahs,* and others (Gagina, 1958, Skryabin, 1975) use this opportunity to feed on the abundance of Gammands and insect larvae populating the bottom of the river At night these birds fly towards Baikal, to hummocks cluttered with snow, to escape the night frosts

The fauna of the waterbodies of south Siberia, except Baikal with its endemics, is a dramatically impoverished European fauna Fish in lakes and rivers include *Rutilus rutilus, Perca fluviatihs, Esox lucius, Leuciscus leuciscus, Phoxinus phoxinus Lota lota, Leuciscus idus, Carassius carassius* and others Common river fish are *Thymallus arcticus, Brachymystax tenok, Hucho taimen, Coregonus lavaretus, Cottus sibiricus* and *Cobitis taenia* Species widespread in Europe such as *Parasilurus asotus, Cyprinus carpio, Coregonus albula,* and *Abramis brama* are absent Some relatives of these occur in waterbodies of West Siberia, but never east of the River Yenisei They can be found in the Amur basin, however Among water mammals, *Ondatra zihethica* became acclimatized here as early as the beginning of this century, as well as *Arvicola terrestris*

The fauna of aquatic invertebrates of south Siberia is rather rich qualitatively, but poor in species compared with the European part of Russia This is, for example, seen in the limited number of mollusc species present There are none of the species widespread in Europe, such as *Viviparus sp Umo sp* , and many others The poor species richness of the aquatic animals of Pnbaikalye not only results from the present severe climatic conditions, but also from its historical past The dramatic cooling of the climate in the Quaternary period indeed caused many previous (Tertiary) residents to leave the waters of Siberia

1.2. Morphology of Baikal

Basic data on the morphology of Baikal (after Vereshchagm, 1949) are

Altitude a s 1	455 6	m
Length	636	km
Maximum width	79 4	km
Minimum width	25	km
Mean width	47 81	km
Area	31,500	km^2
Length of coastline (without islands)	2,000	km
Length of coastline of islands	1392	km
Maximum depth	1,620	m
Mean depth	740	m
Volume of water mass	23,000	km^3

Verbolov (1977) provides the data presented in tables 1 3, 1 4

Water exchange time is to be understood as (1) without taking into account the wind-driven water mass directed offshore or shoreward, and (2) taking into account the wind-driven water mass directed offshore or shoreward

The basin of the lake consists of three troughs separated by submerged sills (Fig 1 6)

The southern trough, situated south of the Selenga delta is cordoned off from the central trough by a submerged elevation with a complicated relief, lying opposite the Selenga delta The maximum depth of this trough, after Vereshchagm, is 1,473 m (1,419 m, according to acoustic sounding in 1961), whereas depth above the sill does not exceed 400 m This zone covers an area of 6,890 km^2

The extensive region formed by the underwater elevation, plus the banks opposite and on both sides of the Selenga delta is called the Selenga Shallows

The central trough is bounded by the Selenga Shallows in the south and by a massive submerged elevation (the Academichesky Range of Vereshchagm) in the north, stretching obliquely across Baikal from Olkhon Island, in the direction of the Ushkany Islands By rope fathoming near Olkhon Island, several kilometers from the Ukhan Promontory, Vereshchagm found a depth of 1,741 m (ac-

Table I 3 Morphometric characteristics of different parts of Baikal After Verbolov 1977

	North	*Middle*	*South*	*Total*
Area (km^2)	13310	11300	6890	31500
Depth (m)				
average	527	814	792	688
maximum	989	1620	1414	1620
Volume {km^1}	7020	9200	5450	23670

cording to acoustic sounding in 1961, the maximum depth here equals 1,620 m), whereas the depth over the Academichesky Range is not more than 300-400 m The area of this central trough is 11,295 km^2

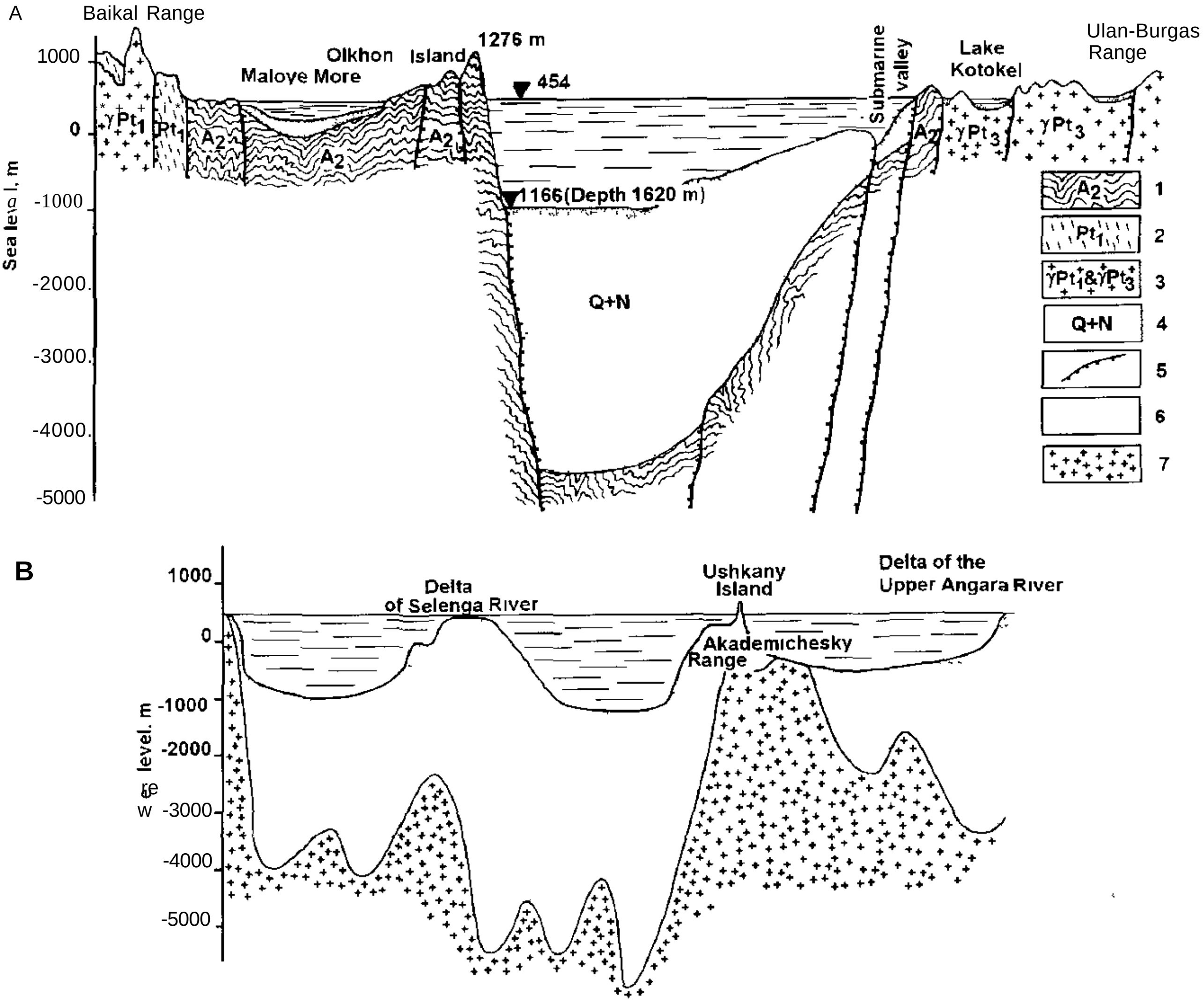
The northern trough embraces the whole north part of Baikal Its maximum depth is 890 m and its area is 13,315 km^2

The morphology of Baikal has been studied by geophysical methods (Fedinsky, 1951) These studies have given reason to suppose that the southern and central troughs present a single morphological unit, and that the elevation separating them (the Selenga Shallows) consists of thick sedimentary deposits of Tertiary and Quaternary age Fedynsky writes in this connection 'The single deep depression of the southern trough of Baikal with maximum depth near the mouth of the Selenga, is in its deepest part filled, as it were, by a colossal underwater sandy-argileous levee This levee, formed as a result of a recent tectonic subsidence accompanied by many centuries of work by the Selenga, has for a long time been regarded as an intermediate intermountain dike dividing south Baikal into two parts[1]'

A characteristic feature of the relief of all three troughs is their asymmetrical structure, the underwater gradient on the east coast being, as a rule,

Table I 4 Water balance of different parts of Baikal After Verbolov 1977

	North	*Middle*	*South*	*Total*
Inflow (surface and underground) (km^1)	13 8	23 7	23 4	
Transient inflow from adjoining part of lake (km^3)	-	13 9	36 2	-
Inflow of wind-driven watermass directed shoreward from adjoining part of lake (km')	10	20 from South 10 from North	20 from North	
Atmospheric precipitation on surface (km)	3 7	2 8	2 8	
Evaporation (km^3)	3 6	3 5	2 3	
Outflow into adjoining part of lake (km^1)	13 9 into Middle	36 2 into South	60 1 into Angara	
Outflow of wind-driven watermass directed off-shore (km^J)	10 into Middle	20 into North 10 into South	20 into Middle	
Conditional water 1)	508	254	90 7	
exchange time (years) 2)	225	132	66	393 8
Total volume of lake after Atanasyev (km^1)				23670
% of total volume	**32 4**	**42 4**	**25 2**	



/w̃g / 6 Altitudinal (A) and longitudinal (B) profiles of Baikal After Florensov, 1969

1 - Marble, gneiss, hornblende schist, 2 - volcanic sedimentary metamorphic formation, 3 - granitoids. 4 - Neogene-Quatemary formations, 5 - faults, 6 - soft soils, 7 - crystalline rocks

much gentler than on the west coast. This asymmetry also holds true for the underwater elevations, the west slopes of which are gentler than those on the opposite side.

The littoral along the west coast of all three troughs (with depths of less than 20 m) is very narrow; it usually ranges from 20 to 200 m (Fig. 1.7), the gradient sharply increasing after 2-3 m or slightly greater depths, often to an angle of 60-80°. On rocky shores, the water directly washes the bases of sheer coastal cliffs. Along the east coast, and especially opposite the mouths of big rivers, the gradient is less steep, but even here, at depths of 10-15 m, the bottom plunges down steeply. Table 1.5 shows the area of the bottom at different depths.

Thus, the zone down to the 250 m isobath occupies about 600,000 hectares, *i.e.*, only about one-fifth, and the zone of 0-20 m not more than one-fourteenth, of the total area of the lake.

The underwater slopes of the Baikal depression have preserved distinct traces *of the* ancient relief of the coastline (Fig. 1.8). Up to depths of 500-600 m submerged mouths of rivers and creeks, ancient

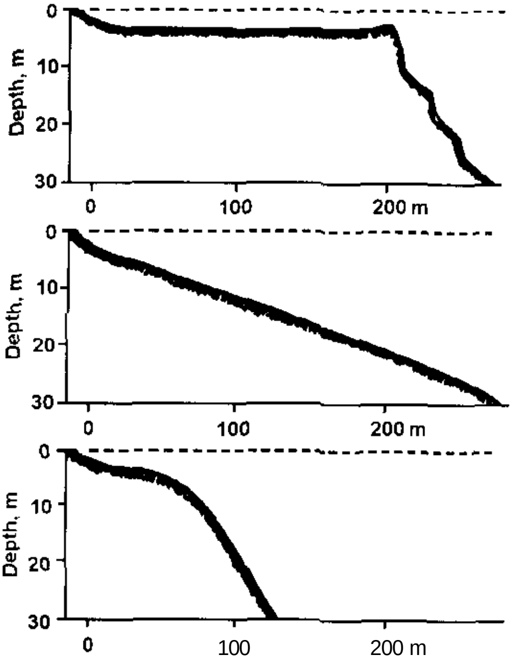


Fig 1 7 Examples of Baikahan coastal zone relief Data of the Research Institute of Biology

valleys and coastal promontories can often be detected, extending deeply into the lake (Fig. 1.9, 1.10). But the shores also bear traces of water levels higher than today's. In some places terraces 2-3, 6, 15-20, 40-50, and 80-100 meters occur at above the present lake level. The Ushkany Islands in the central part of the lake have up to 11 such terraces and step-like rocky scarps with pebbles at their foot. The highest of these even lies more than 200 meters above the modern level of the lake (Fig. 1.11). All this illustrates the complicated history of the Baikal basin, which will be discussed in detail in the chapter on the history of the lake.

The shores of Baikal are comparatively weakly indented. The main gulfs. Barguzin and Chivyrkui, are situated on the east coast in the central part of the lake (Fig. 1.12). They are separated from each other by the Svyatoi Nos Peninsula, a system of two ridges rising 1,315 m above the level of the lake. The peninsula is 50 km long and 20-22 km wide, and a broad and low ridge connects it with the mainland.

Close to the west coast of central Baikal lies its largest island, Olkhon. Its length is 71.7 km, average width 10.5 km, and maximum width close to 14 km. The island has an area of about 730 km^2 It consists of a mountain range, the highest point of which is more than 800 m above the lake level. The island is practically devoid of vegetation, except for its northern part, which is covered by a coniferous forest (Fig. 1.13). Its eastern coast is very steep and precipitous. The west coast is not so steep, yet also has many high abrupt scarps.

Table I 5 Area of depth zones of Baikal After Kozhov & Tyumentscv, I960

Depth (m)	*Area (10" ha)*	*% of total bottom area*
0-5	94	3.00
5-10	56	1.77
10-20	78	2.47
0-20	228	7.24
20-70	*192*	*6. OS*
70-250	180	5.71
0-250	600	19.03
From 250 to the bottom	2,550	80.97

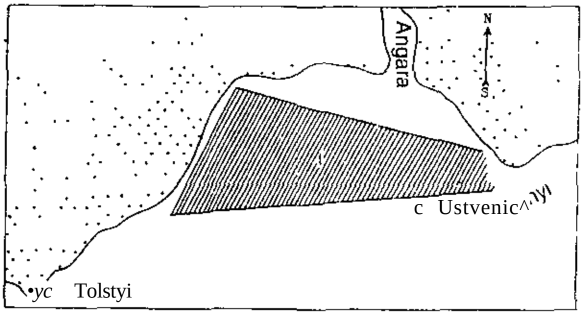
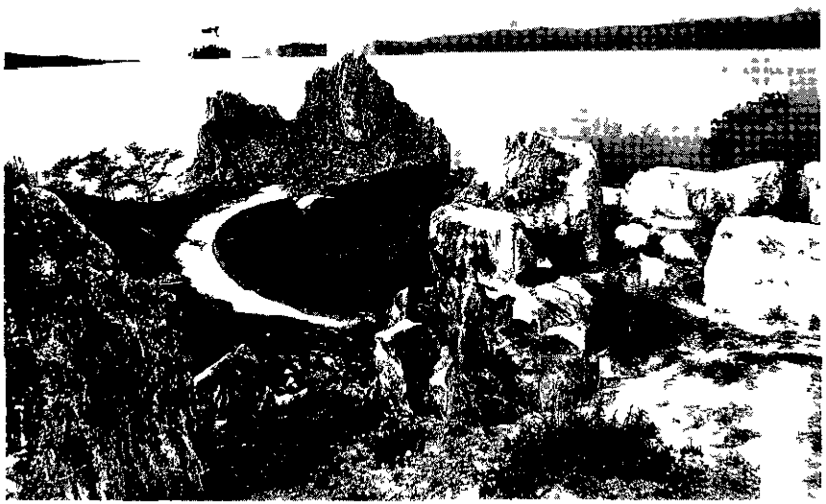


Fig I 8 The scheme of Listvenichnyi Bay 1 the block which tore away from the continent and fell down beneath the Baikal level After Lut, 1964.

The extensive stretch of water lying between Olkhon Island and the west continental shore is called the Maloye More (the Minor Sea). It is 70 km long and 18 km wide at its broadest north part In the south it is connected with the lake by the Olkhonskiye Vorota, a strait about 2 km wide, 7 km long and up to 30-40 m deep. The total area of the Maloye More is about 800 km^2 (Fig. 1.14-1.16).

Among other islands, mention should be made of an archipelago of four islands called Ushkany.



In, 19 Burkhan (. ape Photo by V Korotkoruchko

Ftg I 10 Pcschaundva Bay Photo by V Korotkoruchko

Fig I II Great Ushkany Isldiid Photo by V Korotkoruchko

Fig I 12 Chivyrkui Gult Photo bv V Korotkoruchko

Fig I 13 OIkhon Island Photo bv O Kostuncn

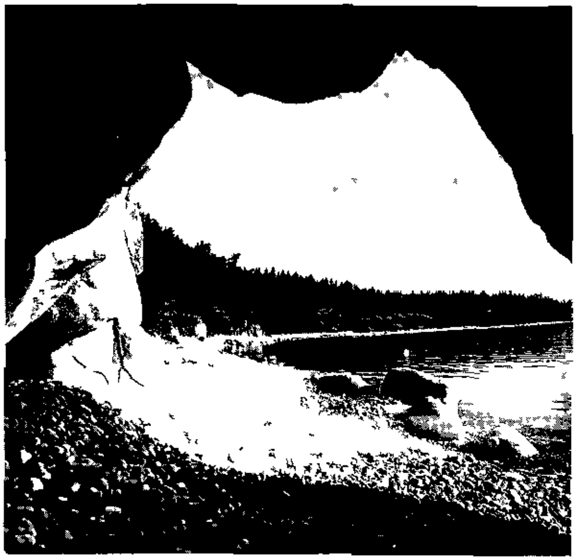


Fig 117 Pcschera Bay Great Ushkany Island Photo by V Korotkoruchko

They he in the central part of Baikal, 7 km from the Svyatoi Nos Peninsula The Great Ushkany Island has an area of 9 4 km^2 and rises to 211 m above the level of Baikal In many places the picturesque abrupt shores of the islands are formed by marble rocks. The rows of large marble blocks rising from the water along the coasts are a favourite spot for the Baikahan seal. The summits and slopes of the islands are covered by forest, chiefly Jarches *(Fig* J J 7)

Apart from big gulfs, there are several dozen bays Some of these are very deep, gently sloping and poorly protected against the prevailing winds, others deeply indent the coast and are shallow and picturesque, such as, for instance, the Aya (Fig 1 18) and Peschanaya bays on the west coast In the area of Peschanaya Bay (Fig 1 10) the thickly wooded slopes of the Primorsky Range descend to the water in steep scarps Their products of weathering have accumulated along the shores, and form sandy beaches In the south and north the bay is bounded by rocky promontories rising majestically over the water and called Bell Towers

The region of the mouths of big affluents contain extensive shallow lagoons, popularly called "sors" The water level in the sors is regulated by the lake They are connected with Baikal by gullets of varying width Sors were formed as a result of the interaction of the surf of the lake with river currents filling the mouths with silt, sand and other material The biggest one, Sor (Gulf) Proval, has an area of about 18,500 ha and a maximum depth of 5-6 m It lies north of the Selenga delta Before January 1861, a bogged lowland with small lakes existed here, but a strong earthquake in early January 1861 drowned this lowland, which *was* inundated by water from the lake (Fitingoff, 1865) All that has remained above water is the long and narrow strip of land which separates Proval from *Baikal today This sandy spit is broken m many* places, and in high water years it is completely flooded

The bottom soils of Baikal vary widely Their properties depend on distance from the shore and from river mouths, or the composition of the shore. and the bottom relief, direction of prevailing currents, etc

According to Knyazeva (1954), the following main types of soil predominate in south Baikal stones, shingle, gravel, sands and silts (coarse- and

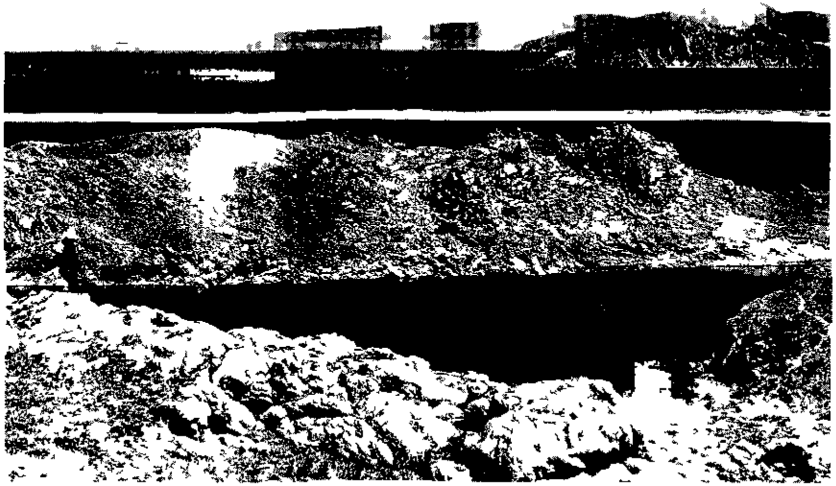


Fig 1 14 Maloye More Photo by V Korotkoruchko

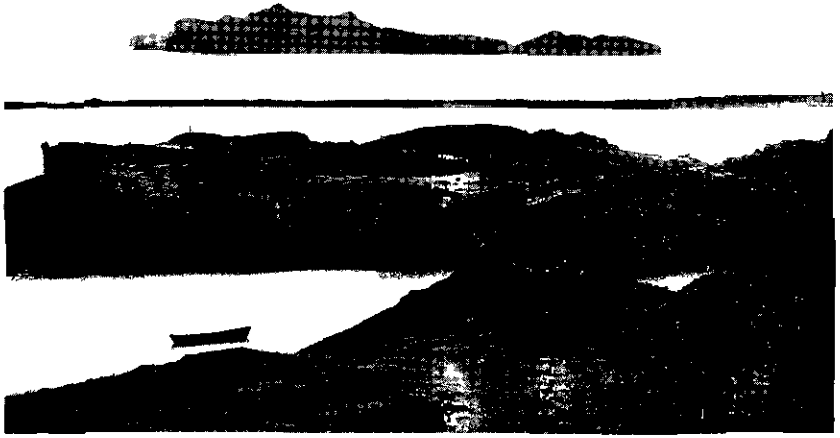


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Fig I 16 Boutgchin Island Maloye More Photo by V Korotkoruchko

tig I IS Aya Bay Photo by V Korotkoruchko

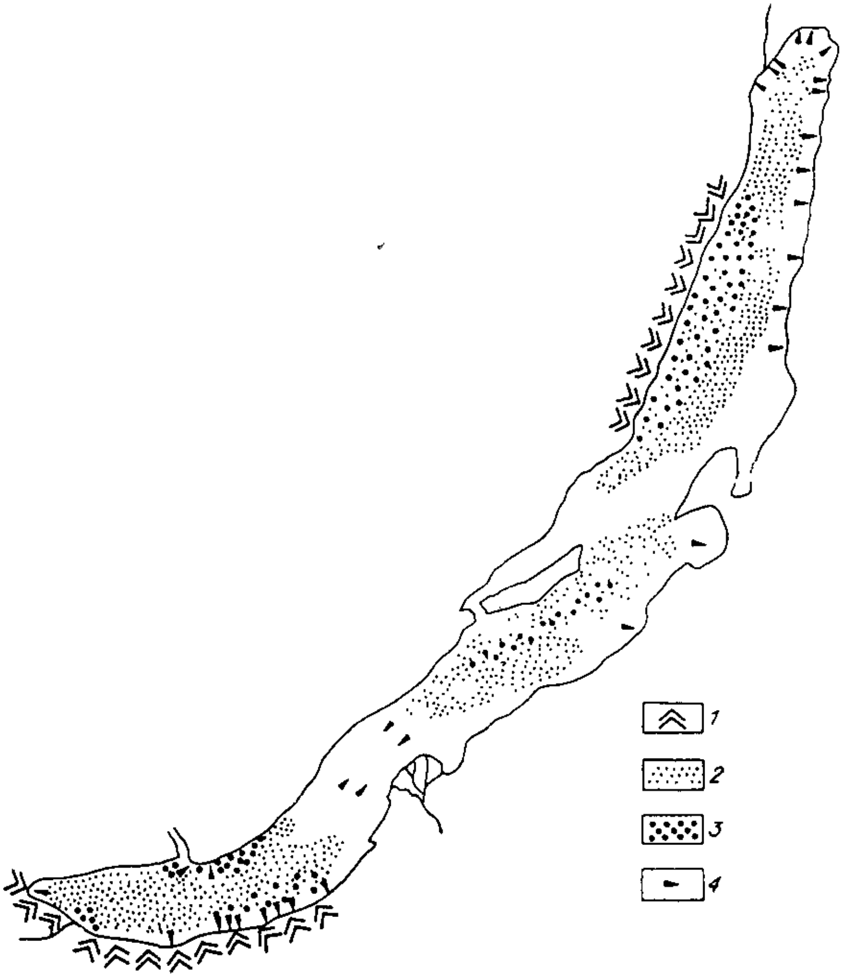


Fig I 19 Distribution of sand and aleurite layers in deep-water sediments in Baikal. 1 regions of the coast with mud Hows dangerous for the inhabitants, 2 regions of distribution of sand and aleurite layers; 3. regions of most numbers and thickness of layers; 4. regions of location of submarine canyons. After Karabanov & Fialkov, 1987

fine-aleuntic, slightly diatomaceous and diatomaceous). Far offshore, beyond 400-600 in depth, silty soils enriched with valves of diatoms, particularly *Melosira* and *Cyclotella* (Patrikeeva, 1959; Kozhova, 1959b) are predominant.

Along the shores, tongues of silty soil extend into submerged valleys. In many places the steep slopes of the basin of the lake are rocky, but are shallowly covered with a layer of silt and sand. Opposite the mouths of the Selenga, Upper Angara, Kichera and Turka, the bottom is sandy-silty; near the shores it is sandy. Pebbles, boulders and roughly rounded stones and fragments of rocks predominate in the shallow along rocky shores. Opposite low sandy shores, the gentle slope of the bottom is covered to a considerable depth with more or less silty sand (Fig. 1.19).

In many places, especially in the Maloye More, central Baikal, and in the regions of underwater sills, sections of the bottom strewn with coarse detritus (gravel, pebbles and even large blocks) occur at considerable depths, often at 100-200 m and deeper. The thickness of the silty deposits in the deep sections of Baikal is not known. Probably this is very great. In the Selenga delta region, as stated above, the deposits of sand and silt washed out by the river are up to 6,000 m thick. This delta protrudes far into Baikal and is close to 40 km wide.

Some details of the distribution of soils in various sections of the lake will be given in the section on the lake's benthos.

Lake Baikal is the only freshwater body in which there are submarine canyons (Fig. 1.20), as in the World Ocean. These submarine canyons are routes for transportation of terrestrial material from a coastal zone to great depths.

The first data on these canyons can be found on the bathymetric charts of Drizhenko (1908); they include the heads of practically all canyons and valleys. Some of the canyons of north Baikal were studied by Lut (1964). He stressed the great depth of incision of these canyons, and the proximity of their heads to the coastline. The canyons of south Baikal were studied by Ladokhin (1957), Kulish & Pinegin (1976), Zolotarev (1958), Tyumentsev (Kozhov, 1972), Mirlin *et al.* (1978); and Karabanov & Fialkov (1979, 1987).

Below we provide brief data on the canyons, based on the monograph by Karabanov & Fialkov (1987).

Lake Baikal harbours more than 100 submarine canyons. Their morphology and size vary greatly. For instance, the Kukuisky canyon (in the north part of the Selenga avandelta) is more than 20 km long and 500 m wide at its lower part; the small canyons-gullies of the Goloustnaya fordelta are about 200 m long and 5-10 m wide.

Most canyons begin at 3-5 m depth, but some of them arise at greater depths (for instance, the Kurlinsky canyon, which begin at a depth of 18-20 m), close to the coast (for instance, the Tyya canyon).

In the upper reaches of the canyons, sediments (silty sands) are finer than in the adjacent shallows (sand, gravel, pebbles). In the canyon beds, on the contrary, coarser sediments occur (sand, gravel), while finer sediment (aleurite silt) is found on the flanks.

The lithodynamic processes, controlling transportation of materials along the canyon beds, are similar for all canyons. These processes include currents of different nature, turbulence, washout of surface layer, slow movement of the whole mass of sediments or their surface part, landslides, and suspension streams. The upper reaches of some canyons (*e.g.*, Zhilishe) (Fig. 1.20) are typically in a dynamic equilibrium between input and drift of sediment along their floor. The input of new material causes the transference of an equal amount of older sediment down the canyon. Suspension streams are capable of transporting terrigenous materials not only from one flank, across the Baikal depression, to the other, but also move them along the depression occupying the whole area of the bottom and form "puff-pastry"-like sediments with interlayers of gravel, sand, aleurite and clay. The mineral composition of these sediments may be alien to the given region, since they were brought in from another region. The interlayers may include pollen of modern and ancient plants from sediments washed out by streams. The interlayers contain remains of Diatoms, Ostracoda, Porifera and other organisms not typical of a deep-water region.

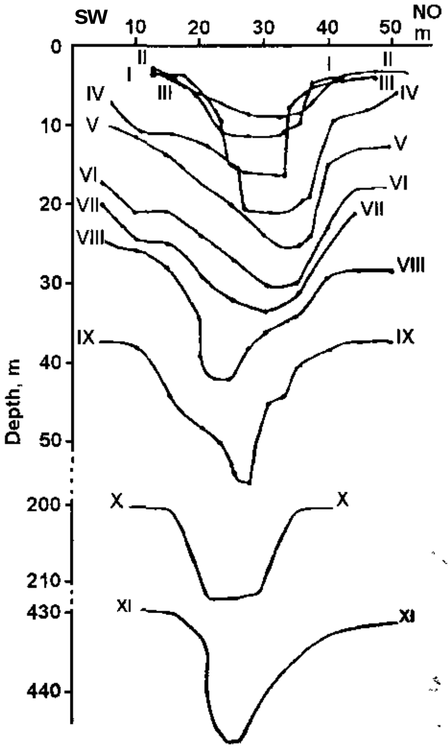


Fig. 1.20. Longitudinal profiles of underwater canyon Zhilishe by rope sounding (I-IX) and observations from on board the submarine "Pisces" (X-Xl). After Karabanov & Fialkov. 1987.

The heads of the canyons are "traps" for plant detritus brought in by rivers. The share of organic matter in the sediments reaches 30%. Later, all this is transported to the Baikal depression where it gets buried.

Fig. 1.21. The Selenga River in the area ot the delta. Photo by P. Malmovsky.

The canyons take up a considerable part of the terrigenous materials from shallows, which results in destruction, Hooding and washing out of the coasts.

Little is still known about the genesis of most submarine canyons of Lake Baikal (or their parts). **The** data available suggest different origins. Some authors (Zolotarev. 1958; Lamakin, 1958; Kozhov, 1972) consider them to be flooded valleys of the rivers, others forms of tectonic relief (Galkin, 1975), while others (Ladokhin, 1957) connect their origin with the formation of transversal fractures and faults, in the development of which erosion activity of drifts (landslides, collapse), gliding along the canyon, was of great importance.

Karabanov & Fialkov (1987) describe the different genesis of some of these submarine canyons. The Tyya and Portovsky canyons are erosive by nature. They have several tributaries and are cut into loose sedimentary material. The Cherny, Zhilishe, Sennoi, and Bolshoy Cheremshany canyons are of tectonic origin. They were weakly changed by erosion processes and cleave original crystalline rocks. The Kurlinsky canyon is of mixed origin, tectonic-erosive. It is cut into both loose sediment and crystalline rocks. The heads of the canyons located opposite the Shinanda and Tompuda rivers, and the Frolikha inlet, finally, were created by glaciers.

1.3. Affluents and drainage

More than 300 rivers and rivulets flow into Baikal from a catchment area of 540,000 km^2. Of these, the rivers Selenga, Upper Angara, Kichera, Barguzin, Turka and Snezhnaya are the largest. All big affluents rise in the east and north parts of the catchment area. The rivers and streams flowing from the mountains on the west coast are very short; before emptying into Baikal, many of them disappear under screes. In winter, they are frozen to the bottom, forming extensive ice bodies. After heavy and prolonged rainfalls in summer, they turn into tempestuous mountain streams carrying all kinds of material into Baikal: boulders, pebbles, clay, whole trees, and sometimes carcasses of dead animals. In such periods, the waters of Baikal turn turbid over large distances.

The Selenga (Fig. 1.21), Baikal's biggest affluent, rises in the spurs of the Khingan Range in Mongolia. Its total length is 1,480 km (1,591 km according to other sources). It drains north Mongolia and the eastern part of the Trans-Baikal area. The Egin-Gol, one of its tributaries, flows out of the large Mongolian Lake Khubsugul (Kosogol), which has been mentioned earlier.

The Upper Angara takes its source in the North-Baikalian Highland. It is 640 km long and flows first in a narrow mountain valley and then along the broad Upper Angara tectonic depression, emptying into the northern extremity of Baikal. The wide pre-delta section of this depression directly adjoins the trough of north Baikal.

The Barguzin, 370 km long, flows into the Barguzin Gulf of Baikal. Its valley is structurally analogous to the valley of the Upper Angara. After emerging from the mountains the river flows towards Baikal along a broad tectonic depression.

The Turka, 171 km long, empties into Baikal in the central part of the east shore.

All affluents combined deliver into Baikal up to 60 km^3 of water annually, with the Selenga accounting for 50%, the Upper Angara for 15%, and the Barguzin for *7%*. Moreover, Baikal receives more than 9 km^3 of direct atmospheric precipitation at its surface (Table 1.6).

The coasts of Baikal and the surrounding mountain slopes abound in hot springs which never freeze. In such springs or in their immediate vicinity, overwintering ducks can sometimes be seen; tertiary relicts of plants and invertebrates whose life is connected with water are also often observed here.

Table 1.6. Water supply and loss in Lake Baikal Mean estimates for the years 1901-1971. After Afanasyev, 1976

	Layer thickness (mm)	*Volume (km^3)*	*%*
Supply			
Precipitation	296	9.29	13.1
Inflou-surface	1.870	58.75	82.7
Inflow-underground	68	2.30	3.0
Total supply	2,261	71.16	100.0
Losses			
Outflow	1.916	60.39	84.8
Evaporation	331	10.33	14.6
Total losses	2,261	71,16	100.0

Fig. 1.22. The outflow of the Angara in the summer. Photo by V. Korotkoruchko

All water brought into Baikal, with the exception of 9 km^3 which evaporates, is carried out by the Angara (Figs. 1.22). Cutting through the granite massif of the Primorsky Range, the Angara is a powerful river more than 1 km wide, leaving south-east Baikal towards the north. After 1.853 km it merges with the River Yenisei which, at the point of confluence, carries half the water of the Angara. The point of confluence lies almost 360 m below the level of Baikal. With the erection of big hydropower stations on the Angara, Baikal has begun to play the part of a giant reservoir feeding the entire system of the Angara hydropower chain.

The level of Baikal varies in the course of the year Its peak level is attained in September-October, sometimes in August, the lowest mark is reached in April-May In years with little precipitation, the difference between the lowest spring and highest autumn levels is only 60-80 cm, but in years with maximum precipitation, 120-140 cm may be reached (Vereshchagm, 1949, Lopatin, 1954)

The usual long-term level of Baikal, as already mentioned, stands at 455 6 m, but there are years with exceptionally high or low levels The highest level in the last century, observed on October 2, 1869, was 457 14 m, the lowest, 454 92 m, was registered in April 1904

According to research carried out by Galazy (1956), the level of Baikal in 1785 was 30 cm higher, and in the period between 1395 and 1405, 50-60 cm higher than in 1869, judging from beach ramparts and trees that have survived since then Galazy points out that in many parts these ramparts are overgrown with arboreal vegetation, with many trees of 450 to 550 years old It can be supposed that the amplitude of secular fluctuations in the level of Baikal in the last 500-600 years was of the order of three meters

Under the impact of winds and of changes in atmospheric pressure, the water level of the lake changes periodically During strong winds, the level falls near the leeward shores and rises at the opposite shores In south Baikal the maximum wind-induced fall of water level at the west coast reaches 17 cm and the maximum rise 14 cm A maximum wind tide of 17 cm has been observed for north Baikal and 20 cm for the south extremity of the lake Oscillations of the water level during strong winds and with sharp changes in atmospheric pressure also occur during the ice period (Pomytkm, 1960)

These oscillations give rise to seiches According to Solovyov (1925), the seiches vary in periodicity and amplitude In the north part of the lake, their amplitude does not exceed 10-12 cm, in the south part, they reach 14-15 cm The period of oscillation of seiches differs widely, but Vereshchagm writes that a seiche with a period of oscillation of 4 hours 51 minutes is common in south Baikal

In 1956 the Irkutsk hydro-power plant dam was built on the Angara River Later, the Bratsk and Ust-Ilim dams followed Due to these dams the lake's level now depends on the working regime of these plants Modern changes of water level and oscillations are shown in Fig 1 23 An elevation in water level after the creation of the Irkutsk dam caused a significant reforming of the coast Thereby, input of large amounts of suspended material became possible For example, in 1984 the input due to coastal erosion was 400,000 t (Lut, 1985), or 10% of the total supply of suspended material Coast structure changes also affected the migration of omul in the River Selenga mouth, and the spawning sites of *Cottocomephorus grewmgh* around the lake

1.4. Water temperature and circulation

1 4 1 Heat budget

Baikal is not thermally uniform (Fig 1 24) Depending on the relief of the bottom, the distance from the mouth of the big rivers, the indentedness of the coastline and the size of the shallows, the following regions can be distinguished

1 coastal shallows cordoned off from open waters (sors, internal sections of bays and gulfi.),
2 extensive open shallows lying opposite the mouths of large atfluents,
3 big gulfs (not very deep) and the Maloye More,
4 open waters far from river mouths and extensive shallows, including not only the deepwater part of the lake, but also the open coastal zone with *d* poorly developed (narrow) littoral, not more than several tens or hundreds of meters wide

The waters of these regions interact in the various seasons of the year, thus making the establishment of any strict boundaries between them impossible

We begin the review of the thermal regime of Baikal with sors and shallow gulfs, which differ little in regime from the ordinary eutrophic lakes of south Siberia As an example, we take Posolsky Sor and Proval Gulf (Figs 1 24, 1 25)

Posolsky Sor lies to the south of the Selenga delta Its area is 3,500 hectares, its maximum depth 3 3 m, and several rivers flow into it Its water is renewed two or three times a year It is connected with Baikal by a short shallow gullet, about 200 m

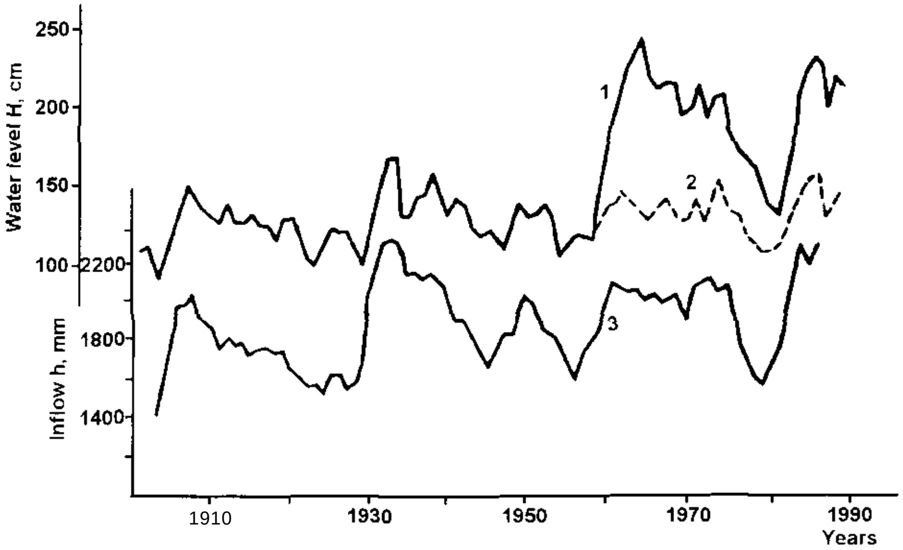


Fig 123 Dynamics of the water level in Baikal After Verbolov *et al* 1992, H 1 observation data, 2 curve calculated according to water inflow, h. 3 average schedule of water inflow

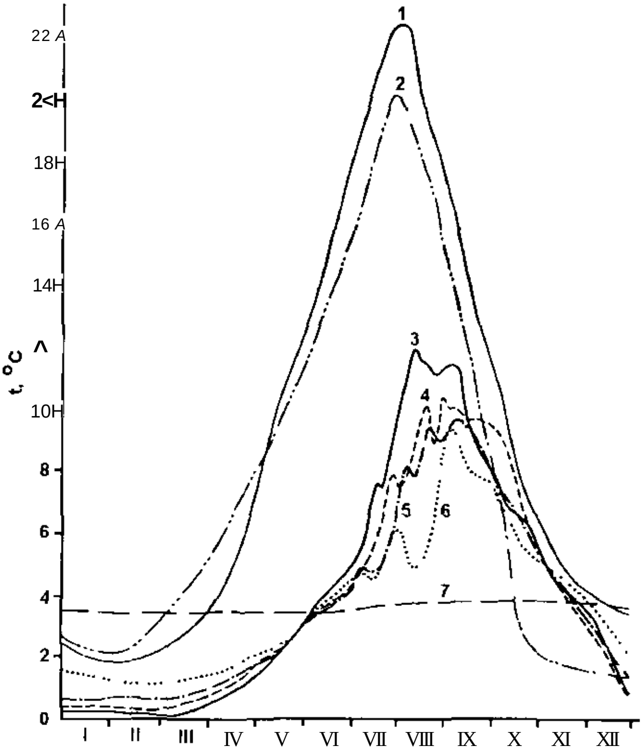


Fig. 1 24 Seasonal changes in the temperature of water in the sors, gulfs and open waters of Baikal. 1 Posolsky Sor, 3-4 m,, 2. Mukhor Gulf (the Maloye More), 5 m; 3-7. open Baikal 3. at a depth of 0 m; 4 10 m, 5 25 m, 6 50 m, 7 250 m. After Kozhov, 1963

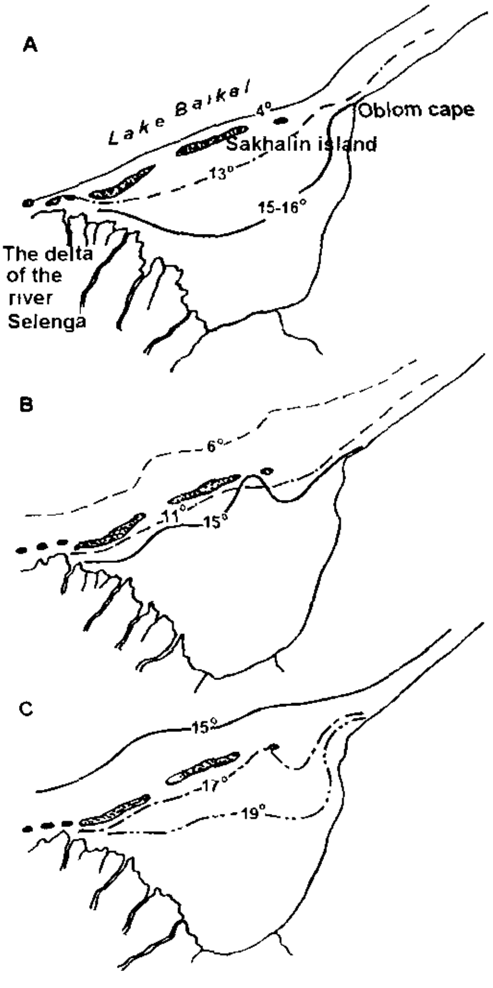


Fig 1 25 Water temperature in the area of the Proval Gulf in June 1955 A beginning of June. B middle of June; C end of June After Popovskaya. 1961 —?

Table I 7 Water temperature in Proval Gulf in 1943 After Kozhov, 1947

Region	*Total depth (m)*	*March 29*		*April 29*		*June 16-24*		*Juh*		*Sept 3-10*		*Sept 15-16*	
		Surface	*Bottorn*	*Surface*	*Bottorn*	*Surface*	*Botlorn*	*Surface*	*Botturn*	*Surface*	*Bottorn*	*Surface*	*Bottorn*
South-western part of the gulf, 1-2 km from the shore	12	-	-	0 2	-	19 6	18 2	22-26	-	14 5	-	–	–
Middle of the gulf	4-4 5	-	-	0.2	2.5	19.2	16 7	22-26	-	14.7	14 0	-	–
Opposite Oblomovskaya Bayou	3-4 5	-	-	-	-	15 0	15 0	-	–	–			
Off Sakhalin Island	2-3	0 3	3 9	-	-	-	-	-	-	14 4	-	12.6	-
Lake Baikal near Cape Oblom	10-15	-	-	-	-	-	-	19 0	-	15 6	—	–	–

Table 18 Temperature in the central part of Proval Gulf in winter 1925-26 After Rossolimo. 1957

November 27		*December 30*		*Febiuan 8*		*March 3*		*\pnl 13*	
Depth. m	*t° C*	*Depth, in*	*t'' C*	*Depth. in*	*t° C*	*Depth. in*	*i° C*	*Depth, m*	*t° C*
0	**0**	**0**	**0.4**	**0**	**0.6**	**0**	**0.4**	**0**	**0 4**
3 (bottom)	1 0	1.3	2.0	1.5	1.8	-	-	-	–
		2 5 (bottom)	3 2	2 9 (bottom)	3 8	3 (bottom)	4.5	2 5	2.9

broad. Ice cover forms at the end of October and lasts until early May, breaking up at the mouths of the affluents in April.

After ice break, the water in the sor rapidly warms to the bottom. Towards the end of May the temperature of the superficial layers already reaches 14-18.5° and that of the bottom layer, 13-15°. In open Baikal, the surface temperature at the same point in time does not exceed 0.5-1.0°.

In July and August the temperature of the entire water mass of the sor reaches an annual maximum of 19-23°. In middle and late August, a gradual cooling sets in. Early in September the temperature stays at a level of 14.5-16°, and then drops sharply. At the end of October the sor covers with ice. The thickness of the ice cover reaches 1.2-1.4 m, and therefore a considerable part of the shallow coastal belt freezes to the bottom. At the outset of the sub-ice period, the bottom temperature remains comparatively high. In 1938-1943, for instance, it was 4.5-4.8° and remained at 3.5-4° even in the first ten days of April. During the sub-ice period, the bottom layer retains this higher temperature thanks to the heat accumulated during summer by the viscous soil rich in organic substances (Kozhov, 1947).

The outflow of water from the sor to Baikal through the gullet is maintained around the year. In spring and summer this water slightly warms up the nearshore surface layers of Baikal.

The extensive shallow Proval Gulf, which has an area of 18,500 ha and is 4.5 to 5 m deep, is situated to the north of the Selenga delta and receives several arms of that river, carrying vast amounts of suspended material, responsible for the exceptional turbidity of the gulf. In summer its transparency does not exceed 10-20 cm, and less after strong winds When winds cause a rise in water level, the waters of Baikal easily penetrate into the gulf through short, broad channels. In quiet weather, a slow permanent current can be observed from the pre-estuannc areas of the Selenga arms, through these channels, to Baikal. As in Posolsky Sor, the waters of Proval Gulf are rapidly warmed up after the break-up of the ice in middle or late May (Table 1.7). In the second half of July, its temperature rises to 18-20° at the surface, and 16-18° at the bottom.

In July the temperature remains at 19-26° throughout the water mass. In summer, the water temperature in the vicinity of the channels is usually 4 to 5° lower than in the middle of the gulf. In mid-August, signs of autumnal cooling appear. In the first half of September, the temperature falls to 14-15°.

At the end of October and the beginning of November, Proval Gulf becomes covered with ice. The water temperature during ice cover is shown in Table t.8.

The regions opposite the mouths of big nvers are characterized by a prevalence of shallows, strongly influenced by fluvial waters This influence is particularly pronounced opposite the delta of the Selenga. In winter, cold fluvial waters penetrating to Baikal cool its open waters, but in April-May they are heated better than the waters of the lake, and warm them up. Between June 10 and 20, when a homothermy of 3-4.3° is established in the deepwater area of the lake, the superficial temperature opposite the Selenga delta reaches 8-11°. With distance from the shore, the temperature usually falls sharply to 4-5°. Later on, towards the end of June and in July, the tem-perature of nearshore waters opposite the delta reaches 15-16° on the surface, whereas 2-3 km from the shore it does not usually exceed 11-12° over considerable depths. In August, the surface water temperature opposite the delta rises to 18-19°, over a depth of about 4 m, and 3 km from the shore, over a depth of more than 50 m, it is 14-15°.

In summer, currents carry the warm waters of the Selenga Shallows to the neighbouring deepwater regions and considerably raise the temperature of their water. A permanent current is known to run from the shallow to the south-west, towards the outflow of the Angara. Spreading over the surface, the waters of the Selenga Shallows gradually mix with Baikal water. The thickness of the layer of mixed waters, in which an admixture of the Selenga waters can still be detected by chemical analysis, does not normally exceed 5-10 m, but in some instances, patches of these waters are observed to extend to a depth of 25-50 m (Votintsev, 1960). When the southwesterlies prevail, the Selenga waters are driven comparatively far away to the north of the delta, but in calm weather and during winds from the north-east, the southward current restarts. The changes in the direction of the Selenga current often result in a rather complicated horizontal distribution of temperatures in central Baikal. Some peculiarities of this distribution will be described in the chapter on life in thewater mass.

The influence of fluvial waters on the thermal regime of the adjacent regions of the lake is also seen in Barguzin Gulf. A diagram of the warming of the waters of that gulf in 1932 is given in Fig \.26 (Kozhov, \934b). The pre-estuarint area of the River Barguzin is shallow, the 20 m isobath being situated at a distance of 4-6 km from the shore.

The Barguzin empties into the gulf in the central part of its eastern shore. The fluvial waters incite a current in the gulf directed from the mouth of the river into the open lake along the Svyatoi Nos Peninsula. In summer winds from the south shift this current towards the coast of the Svyatoi Nos where it flows along in a band of 2 to 3 km wide and 2 to 4 m deep. In accordance with the flow of fluvial waters, the June temperature of the superficial layers of water m the gulf along the Svyatoi Nos coast, where depth reaches 300-500 m and more, is 9 to 10° higher than in open Baikal. For instance, on June 20, 1932, the surface temperature here reached 11-16°, whereas a 3.4-4° homothermy prevailed at that time in the gulf and in open Baikal.

Towards the beginning of July, the water temperature throughout the gulfs shallows more or less evens up, reaching 15-20° at the surface. In the outer part of the gulf it does not exceed 11-12° and in the depths of the gulf, 6-8°. In early August

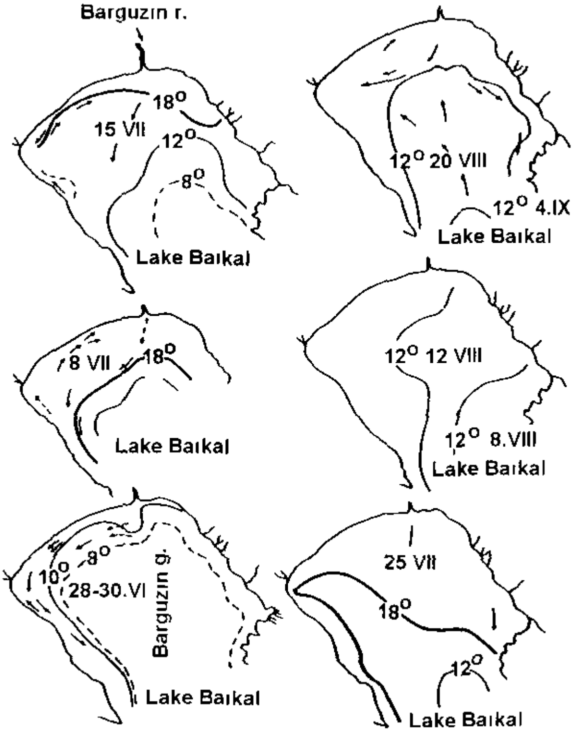


Fig. 1.26. Water temperature in the Barguzin Gulf in the summer of 1932. The arrows show the direction of the current. After Kozhov, 1934

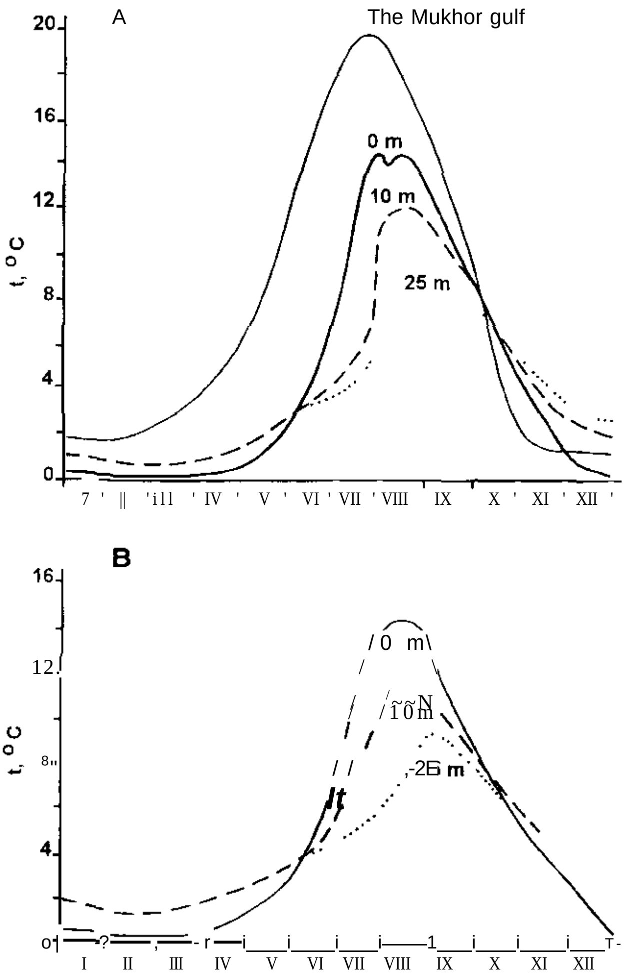


Fig I 27 Seasonal changes in water temperature in the Maloye More A southern part; B central part After Kozhov, 1958 ->

the temperature of the surface layers climbs to 17-22° in the shallows, to 17-18° at a depth of 5 m, and to 12-14° at 10 m. In the open outer part, the surface layers are also warmed up to 15-16° and the bottom layers at 25 m to 5-6°. At the end of August and the beginning of September the water temperature from the surface to a depth of 10 m is, to a considerable degree, homogeneous throughout the gulf, at 12-15°

A permanent current of fluvial water has also been discovered in the north part of Baikal. It flows from the mouths of the Upper Angara and the Kichera southward along the north-west coast. In summer it has a marked wanning effect on the region lying along the north-west coast of the lake.

A brief geographical survey of the Maloye More has already been given. In its open parts, ice cover forms between December 20 and 31, and much earlier in the shallow bays and gulfs. The Mukhor Gulf, for example, freezes in late October. If the autumn is warm, the formation of the ice cover is delayed until the end of December, and in the northern part at times even to January. The ice cover in the southern and central parts of the Maloye More breaks up in the middle of or between the 20th and 31st of May, and in the northern part at the end of May. The ice break-up occurs still later if the spring is cold. For instance, at the end of May 1951, the central and northern parts of the Maloye More were still under ice, and in 1953 its southern part was freed from ice only at the beginning of June. The thermal regime of the Maloye More in its northern part does not differ essentially from that of open Baikal, but the thermal regime of the shallow southern part has its own peculiarities (Fig. 1.27). In the Mukhor Gulf (the southern extremity of the Maloye More), the water temperature reaches 18-20° at the end of June, whereas in the same period, in open Baikal, the surface layers are at 4-5° Towards mid-August, the temperature throughout the Maloye More is more or less even and differs little from that in the open lake By the middle of September the surface temperature falls to 10-12° everywhere The cooling of the waters of the southern and central parts of the Maloye More proceeds faster than in open Baikal

As has been mentioned, in open Baikal the inshore shallows 3 to 10 m deep *are very narrow*, with the exception of shallow regions opposite river mouths Due to this, the open coastal waters are under the constant influence of the neighbouring deepwater areas, while having only a faint influence on the thermal regime of the latter

Open Baikal freezes in the first half of January in its south part and somewhat earlier in the north part (Fig 1 28) The duration of ice-cover varies markedly between years, depending on meteorological conditions Often, just-forming ice is broken by strong winds, then restored, only to be destroyed again Not infrequently this process lasts for many weeks The ice cover becomes definitive at an average temperature of 2-2 9° in the 0-250 m layer, with fluctuations from 1 60 to 2 93° (Rossolimo, 1957)

In February-March the thickness of the ice reaches 80-120 cm (Fig 1 29) The ice break-up in south Baikal occurs at the beginning of May and in the north part at the end of May and early June Thus, Baikal is ice covered for four to five months

The fluctuation in temperature of the ice caused by ice-air heat exchange and heating by direct solar radiation is chiefly responsible for the formation of numerous cracks and breaks in the ice cover Cracks evidently also develop due to strong winds, causing sub-ice turbulence Some cracks stretch for many kilometers and are up to a meter or more in width During strong winds, ice movements and hummock-building are observed along the cracks, which widen and form open-water spaces, especially in spring before the break-up of the ice (Fig 1 30) The cracking of the ice and appearance of hummocks and thrusts is accompanied by weird sounds Now a threatening rumble of distant ice ruptures can be heard, now thunderous strokes are heard quite near by and a wide crack suddenly opens before one's eyes, then there comes a long-drawn groan, produced by small local ruptures, or the noise and crackle of hummocking This "symphony" attains particular force in the morning and evening at the beginning of winter

Thermally, the mass of water of open Baikal forms two vertical zones the upper, or alternating (after Vereshchagin, 1927, 1933), and the lower, or perennial The boundary between them lies approximately at a depth of 250-300 m, but it is not permanent (Figs 1 31-1 33)

In November a reverse thermal stratification is established in the upper layer and is sustained there throughout the ice cover, lasting until the end of June or the beginning of July Under ice cover, the temperature of the surface is close to zero and gradually rises to 3-3 5° with depth At a depth of about 200-300 m, the temperature stops rising and a gradual fall begins, which continues down to the very bottom Thus, in this period the maximum temperature at 200-350 m stands at 3 5-3 6° Vereshchagin called this maximum mesothermic It can, of course, only be observed in the autumn-winter period and partially in spring before the start of the spring warming The position of the mesothermic maximum is usually accepted as the boundary between the upper and lower zones of the mass of Baikal water, but it often lies lower than 300 m and is sometimes found at a depth of less than 200 m

While the reverse thermal stratification in the upper zone in the cold period is explained by autumn-winter cooling of the upper layer, the slow fall in temperature below the mesothermic maximum towards the bottom depends on changes in the temperature of the water of maximum density with increase in depth

Soon after the establishment of the ice cover, a slight increase in temperature is noticed under the ice, caused by penetration of solar radiation through the transparent ice, which is very intense in Baikal in winter This is the start of the spring warming of the water Before the break-up of the ice, the below-ice layer from several centimeters to a meter thick already has a temperature of 0 4-1 7° In this period the temperature rises somewhat in the lower layers as well The general rise in the

Fig 1 28 Baikalian ice Photo by O Kostunen

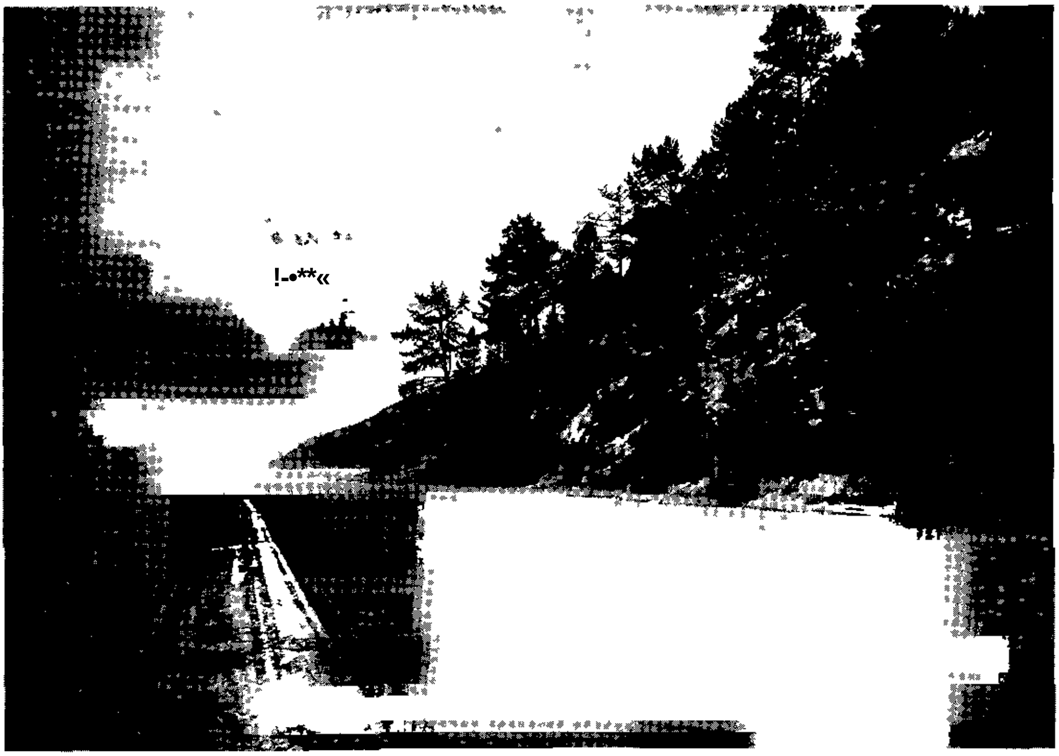


Fig 1 29 Winter way on Baikal Photo by O Kostunen

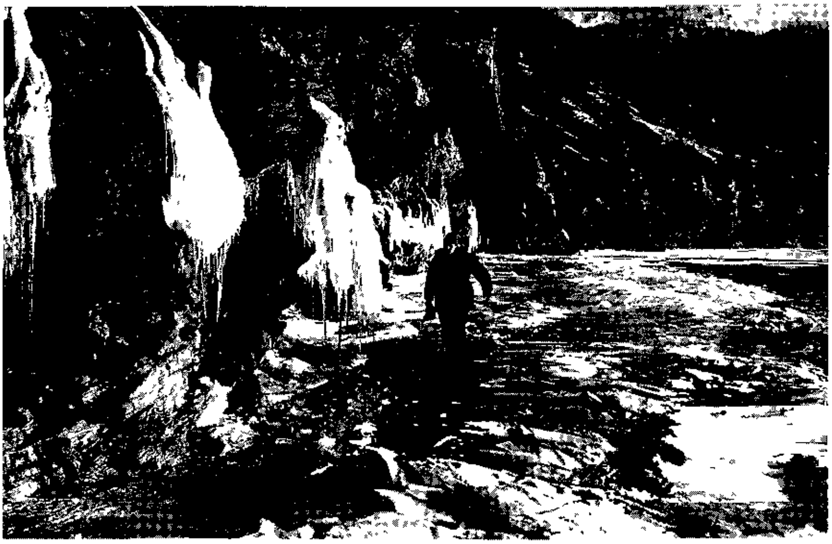


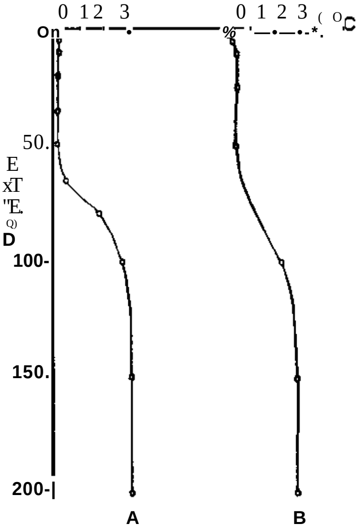
Fig. 1.30. The Lake Baikal in winter. Photo by V. Korotkoruchko

temperature of the upper layer up to 200 m during the ice period may be due not only to the penetration of the heat caused by solar radiation into the depths by means of convection, but also to the mixing of the water of this layer with that of warmer deep layers, the temperature of which is close to that of the mesothermic maximum. In the ice cover period the temperature of the lower layers of the upper zone changes by a very small vertical gradient, while the gradient in the middle layersis somewhat higher. The temperature of layers lying below the mesothermic maximum does not remain constant either. It changes vertically, first within a range of several tenths of a degree, while at a depth of more than 400 m the thermal gradient per 100 meters does not exceed, on average, 0.05°.

The changes in temperatures of the water mass during ice cover show that the movement and mixing of waters continues even under the ice. For this reason the classical state of "winter stagnation", common in shallow lakes, is practically non-existent in Baikal.

The destruction of the ice cover also takes a long time. The complete ice melting of the south part of the lake usually takes place at the beginning of May, and in the north part in the second half of May or in early June. It is followed by a very slow warming up of the entire upper zone of the lake. At the outset of the warming up period, an especially intensive convective water circulation is observed, and wind-induced circulation also increases. As a result, a partial homothermy sets in, first in the uppermost layer, 10-20 m in thickness, and then spreading to the deeper layers. In the 0-50 m layer, it is established around the middle of May at a temperature close to 1-1.5° and, in the 0-100 m layer, at the end of May or beginning of June, at a 2.2-2.5°. Finally, the temperature evens up throughout the water mass of the lake. In south Baikal a relatively complete homothermy usually sets in around June 20 and in the north part, in mid-July. In different years the onset of homothermy may vary within two to three weeks.

The period of summer warming up begins with the appearance of the first signs of direct thermal stratification. Already the beginning of summer warming up witnesses the establishment of an epilimnion with increased temperatures and a small gradient, a metalimnion, with a sharp gradient (thermocline), and a hypolimnion, or layer of low temperature with a small gradient. In sunny, calm weather during summer warming up, the metalimnion can be clearly located. On many occasions, at the end of July and beginning of August, a sharp temperature drop at a depth of only 4-5 m occurs. In such periods, the upper 0-3 m may have a temperature of up to 12-15°, while at 3-4 m the tem-



^g- i 3/ Vertical distribution of temperature m Baikal's deep-water regions at the onset of the ice period A in the area of the Ushkany Islands on January 9, 1915 (average temperature in the 0-200 m layer 1 82°C), B the Bolshiye Koty on January 14, 1932 (average temperature in the 0-200 m layer. 1.97 °C) After Rossohmo, 1957.

perature will be 10-13°, and at 5-6 m only 4-5°. In August, the metalimnion descends to 10-20 m and deeper. But the temperature layering is often broken by strong winds. In summer, after a period of calm days, the temperature of the upper layers often rises to 14-16°, but in the first hours after a strong north-western wind it drops to 4° along the leeward coast, indicative of the emergence of deep, cold water to the surface.

At the end of the summer warming-up, the temperature layering of the upper zone becomes more stable than at the start of this period, which is probably explained by a subsidence of the metalimnion below the zone of intense mixing.

Owing to the frequent disturbance of the layering, the warming up of the upper zone proceeds unevenly. Disturbances are especially manifest near the shores.

As mentioned above, the surface temperature of open deepwater regions is influenced by currents from river mouths and extensive shallows The zone of influence of the waters of the Selenga Shallows occupies a large area, spreading in both directions from the delta of the river. The shallows warm up the superficial waters of the neighbouring deepwater regions in summer and cool them in autumn.

In summer, the surface layers of open Baikal reach a maximum of 14-16° in warm years and not more than 12-13° in colder years (Fig. 1.34). In south Baikal this maximum falls at the end of August or beginning of September, after which the autumn cooling sets in. Stratification can still be observed in the upper zone at the beginning of cooling, but it is often broken. The depth where the metalimnion begins increases in this period to 30-50 m, its lower limit lying at about 100 m. The autumn homothermy develops gradually. Around the middle of October the temperature of the top 50 m in south Baikal evens up at 9-10°. Later, the homothermy spreads deeper and deeper, with a simultaneous decrease in temperature. In south Baikal, full autumn homothermy usually sets in during the course of the last ten days of November or at the beginning of December, at 3.2-3 7°. In north Baikal, this happens a little earlier.

After the onset of autumn homothermy, the temperature of the upper layer does not decrease further for four to six weeks, until the formation of the ice cover, and the reverse stratification characteristic of the entire late-autumn and ice cover periods is established.

The amplitude of annual fluctuations in temperature of the surface waters in south Baikal reaches 12-16° with the maximum in late August and early September, and the minimum in January. In the 10 m layer the lowest temperature (0.2-0.5°) is reached in January and the highest (12-13°) in August and the first half of September. At 20-25 m the periods of the thermal minimum and maximum are about the same, while the amplitude decreases to 9-11°, in some years reaching 12-13°. At a depth of 50 m the maximum temperature is usually attained later, in autumn, and the amplitude dwindles to 6-8° in warm years and 4.5-5° in cold years (Fig. 1.35). At 100 m the lowest temperature (2.2-2.8°) is observed in April and the highest (6.0-6.5°) in autumn, with an amplitude not exceeding 4-4.3°. Finally, at a depth of 200-250 m, as already mentioned, the temperature never goes beyond 3.4-4.5°. Seasonal changes are sometimes observed deeper, to 300 m and more, but their amplitude is extremely small.

Table 1.9 shows the mean monthly temperatures

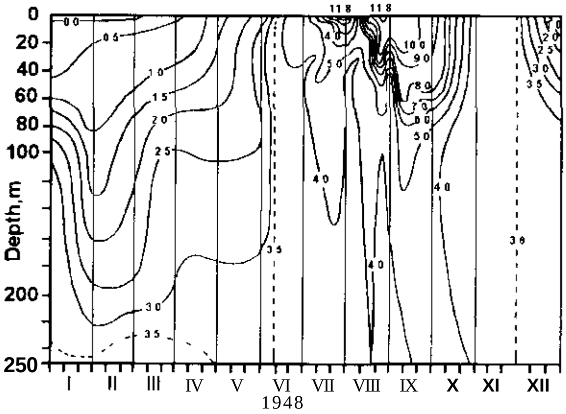


Fig I 32 Isotherms in °C in the southern part of Baikal (the Bolshiyc Koty) in 1948 (a cold year) After Kozho\, 1963

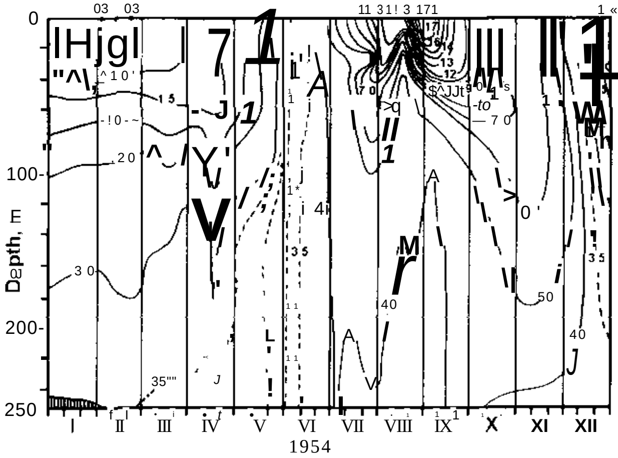


Fig I 33 Isotherms in °C in the southern part of Baikal (the Bolshiye Koty) in 1954 (a warm year) After Kozhov, 1963.

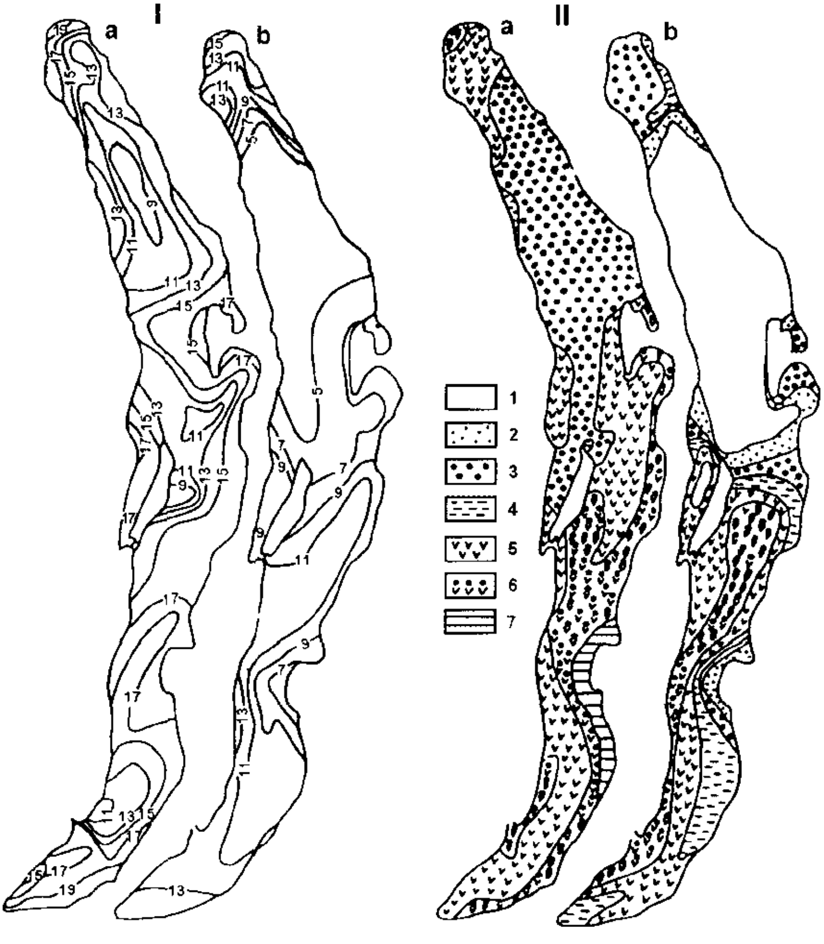


Fig I 34 I Surface layer temperature under abnormally warm (a) and abnormally cold (b) conditions at the beginning of August II. location depth of lower boundary of seasonal thermoclme under abnormally warm (a) and abnormally cold fb) conditions at the beginning of August. 1 depth 0 m, 2 5 m; 3 10 m, 4 15 m, 5 20 m, 6. 30 m, 7. 50 m, bottom. After "Prediction ..", 1986.

Table I 9 Mean monthly temperatures of the surface water layers in the Maritui area. After Vereshchagm, 1949

Months	*I*	*II*	*III*	*I*	*V*	*VI*	*VII*	*VIII*	*IX*	*X*	*XI*	*XII*	*Yeai*
Temperature. °C	0 17	0 01	Oil	041	1 95	429	932	1275	10 18	7 98	464	2 41	4 15

Table I 10 Annual turnover of heat (kcal cm^2) After Shimaraev *et al*, 1994

Parts of Baikal	*3 km from western coast*	*7 km from western coast*	*Centre of the lake*	*7 km from eastern coast*	*3 km from eastern coast*
South	60 5	54 2	35.0	42.6	57 0
Middle	63 0	57 0	*50.0*	*49.0*	54 0
North	*46 0*	*44 0*	*39.0*	37.0	41 0
Average	56 0	52 0	**43.0**	**43.0**	51 0

Table III Values of vertical gradients of water temperature (°C nr^1 10^4) After Shimaraev *et a!.*, 1994

Layer, m	*South Baikal*	*Middle Baikal*	*North Baikal*
300-500	5 0	5.5	4.0
500-800	2 7	38	2.0
800-1000	1 2	2.6	-
1000-1300	07	1.9	-
1300-1500	-	1.4	-

of the surface layers in south Baikal. January and February are the coldest months and August is the warmest month there.

Vereshchagm (1949) stated, on the basis of isolated measurements, that at the very bottom of the abyssal region the water temperature rises again within a few hundredths of a degree, which supposedly testified to geothermic warming of the bottom layers owing to the deep position of the bottom of Baikal. This supposition is yet to be confirmed by highly sensitive instruments.

The amount of warmth in various sections and at various depths is essential to its life. A computation of the average annual amount of warmth in day degrees by using material on south Baikal, is shown in Fig. 1 36. It is a striking fact that the nearshore waters of the open lake (0-20 m depths) differ little from the deeper zones in annual accumulated heat. This means that the waters of open Baikal are a thermal whole from the shores down to the greatest depths. At the same time, they differ sharply from the sors and sheltered gulfs, in which the annual accumulated temperature is two to three times higher than in the open littoral of the lake. There are also sharp differences between shallow gulfs and open waters in seasonal distribution of heat This has certainly been a factor in the evolution of the Baikalian fauna, and its immiscibility with the fauna of sors and adjacent lakes.

The heat balance of the lake and main parameters influencing it are represented in Fig. 1.37. The distribution of the heat balance in different parts of the lake is given in Table 1.10.

The seasonal changes of the vertical heat currents are shown in Fig. 1.38.

The vertical temperature distribution for different parts of the lake is pictured in Fig. 1.39 Seasonal changes of vertical gradients in water temperature are insignificant; average values are given in Table 1.11. Some local rises of temperature gradients are determined with the use of a thermoprobe across a year (Fig. 1.40).

Seasonal changes in temperature in different parts of the lake are represented in Fig. 1.41. The spatial and temporal distribution of the temperature in the lake is shown in Fig. 1.42. Finally, Figs. 1.43-1.45 present long-term changes in water temperature.

1.4.2. Currents

Baikal is a turbulent lake, especially in autumn, when the number of stormy days exceeds that of calm days. The winds induce powerful horizontal

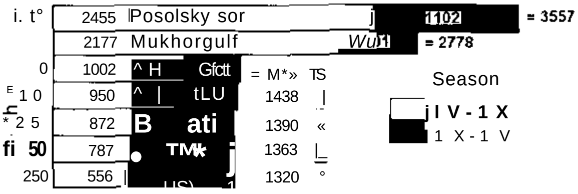


Fig 1 36 Accumulated temperature in Baikal's sors, gulfs and open waters (in day degrees) After Kozhov, 1963

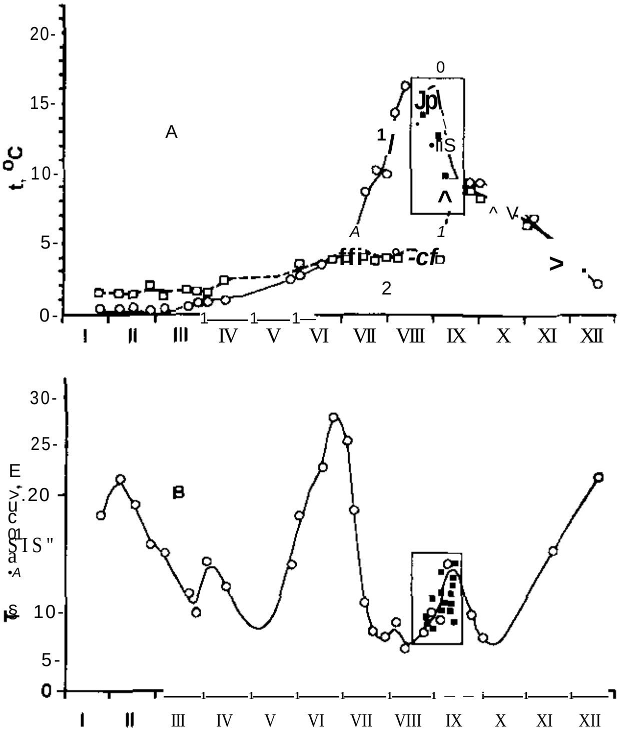


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Fig 1 35 Temperature (A) and water transparency (B) South Baikal, Bolshiyc Koty 1992 Framed the date of the temperature at the water surface and water transparency all over Baikal Temperature 1 at water surface, 2 depth 50 m Data of the Research Institute of Biology

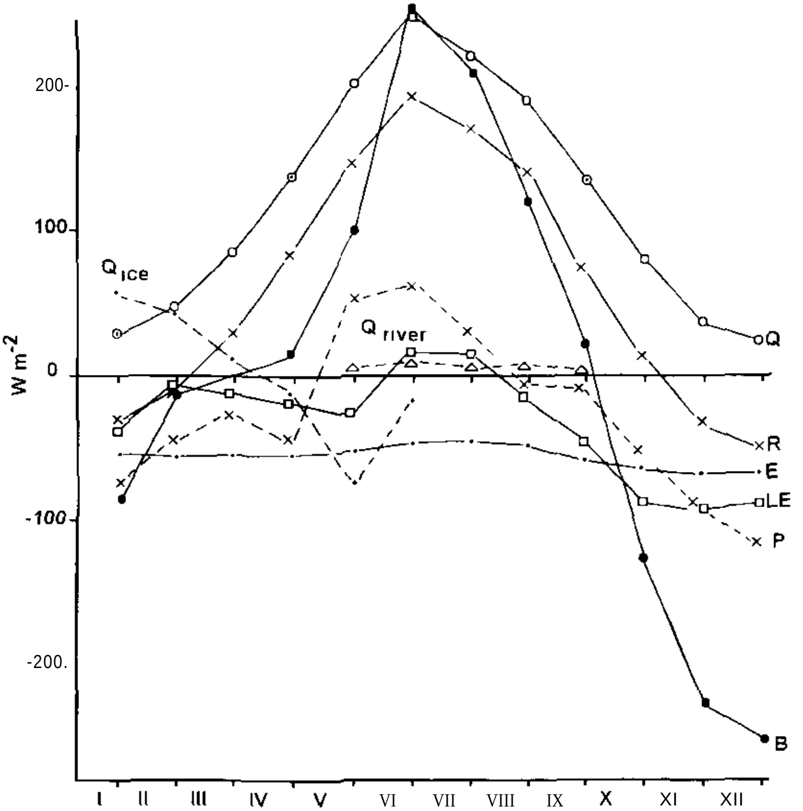


Fig 1 37 Mean values of the thermal regime of Baikal 1971-1984 Q accumulated absorbed radiation R - radiation balance. E - balance of infrared radiation, LE - latent heat flux, B - accumulated energy flow (heat budget of surface), Qice - heat of crystallization and melting, Qriver - heat influx of the rivers, P - sensible heat tlux After Shimaraev *el a!,* 1994

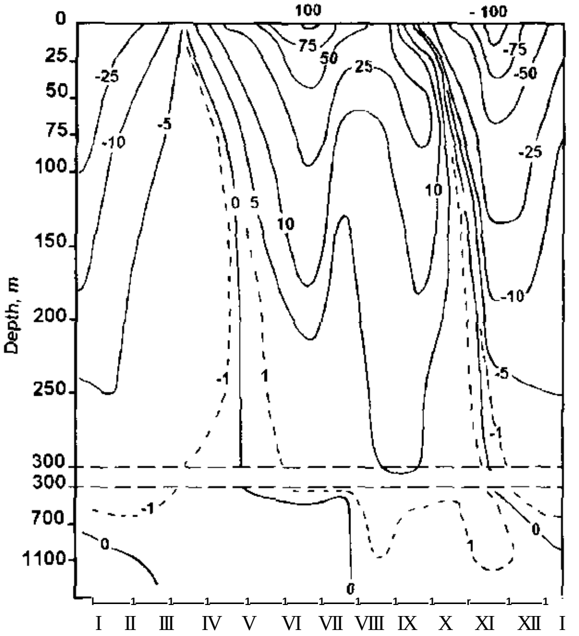


Fig I 38 Seasonal changes of vertical heat flows through separate horizons (in % from maximum through the surface in June) South Baikal, section Listvemchnoye-Tankhoi settlements \fter Shimdraev *el al,* 1994

currents and a vertical circulation embracing the entire water mass, down to the bottom, is established. Northeasterlies and southwesterlies prevail. The northeasterly begins in the morning and calms down at night, but in late summer and in autumn it is usually sustained for several days During the north-east wind, known as Barguzm, Baikal is especially beautiful. This wind blows as a rule on bright sunny days, making the foamy crests of high waves gleam and the sprays and foam opalescent in the sun. The rumble of the surf can be heard far on the slopes of the mountains and in deep gorges. The south-west winds, also blowing along Baikal but in the opposite direction, are locally called Kultuk. They, too, can be very strong and prolonged, especially in inclement weather in the autumn.

The differences between the temperature of the air and the atmospheric pressure over Baikal and in the coastal regions give rise to constant winds, blowing alternately from the shores or from the lake. Of particular constancy are cold breezes blowing in summer and winter in the evening and sometimes also at night from deep creek valleys and gorges. In summer they drive the heated surface water from nearshore shallows to open regions and cool them.

The greatest power is packed by the hurricane winds blowing across Baikal from the mountains of the north-west coast at a velocity of up to 30-40 m sec '. They have an especially strong influence on the rise and fall of the water level and vertical movements of masses of water.

Research by Sokolnikov (1960) and Krotova (1967) has revealed a rather complicated system of currents and vertical circulation both in the ice-free and ice cover periods. There are cyclonic currents with a horizontal and vertical axis, and currents directed offshore in the surface layers and shoreward in the lower layers, with emergence to the surface. Often currents change direction in different periods of the day. Several independent closed systems of horizontal counter-clockwise circulation have been established. These horizontal circulations are overlapped by vertical *currents* of different velocity and direction.

Verbolov reviewed current conceptions of the currents in Baikal, based on direct measurements of currents (Fig. 1.46).

Velocities and directions of currents change depending on the time of the season, depth of a site, distance from the coast and underwater coastal slope, temperature (density) stratification, and have a complex temporal and spatial structure.

The greatest vertical velocities are recorded at the surface of the lake, and decrease with depth. Maximal values of vertical velocities decline with depth logarithmically, having different parameters for the coastal and offshore parts of the lake. Mean monthly and seasonal velocities vary by one order of magnitude across the water column.

In coastal shallows and bays, the regime and scales of currents are determined by local winds.

In coastal regions currents are more intensive over the underwater coastal slope than 7-10 km away from it. In spring and autumn they usually embrace the water column down to the bottom, but in the central part of the lake, at depths of 300 or more meters, a motionless "kernel" can be preserved. Below, a more active prebottom layer, where velocities of currents increase again, although not always or everywhere, occurs. This is

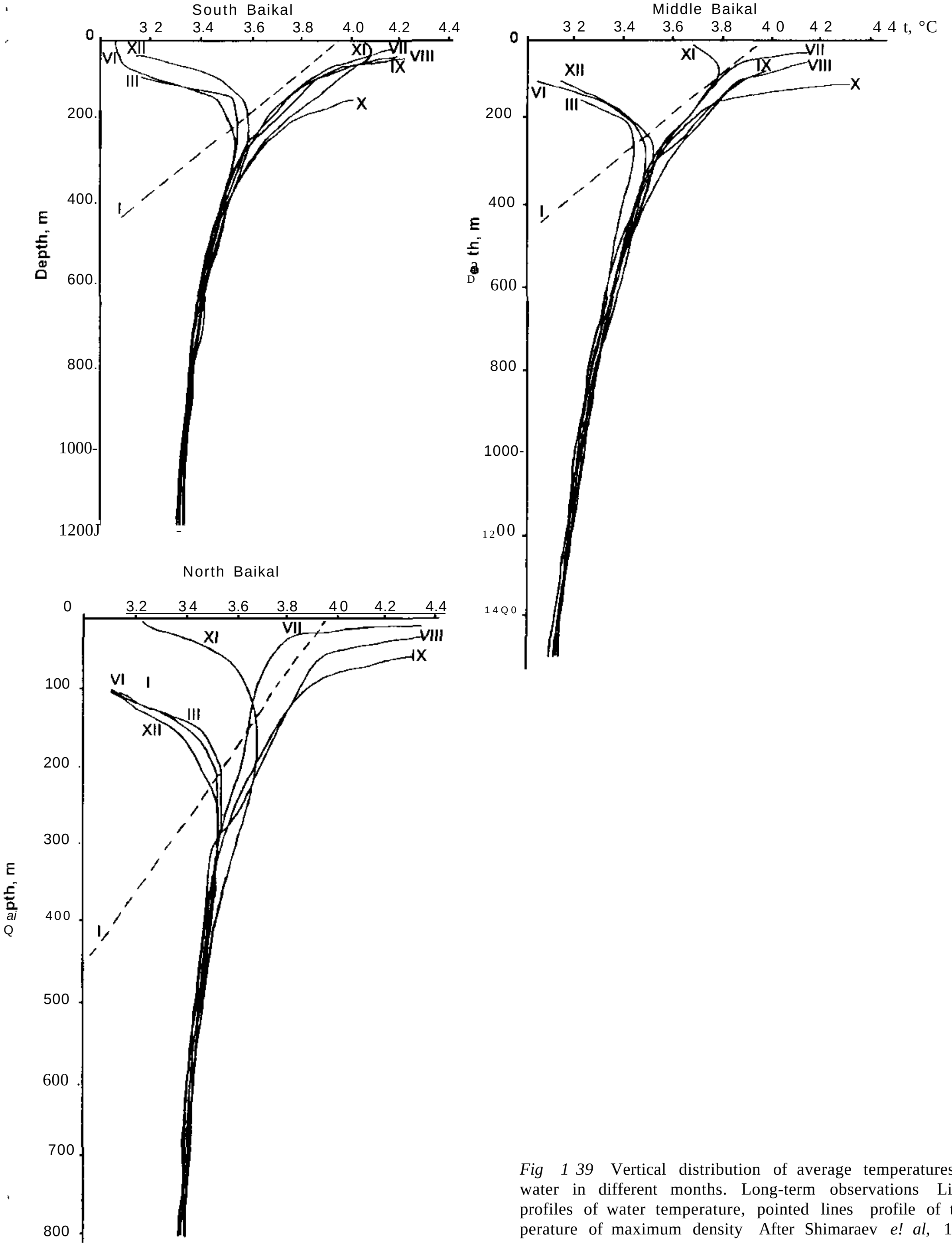


Fig 1 39 Vertical distribution of average temperatures of water in different months. Long-term observations Lines- profiles of water temperature, pointed lines profile of temperature of maximum density After Shimaraev *e! al*, 1994.

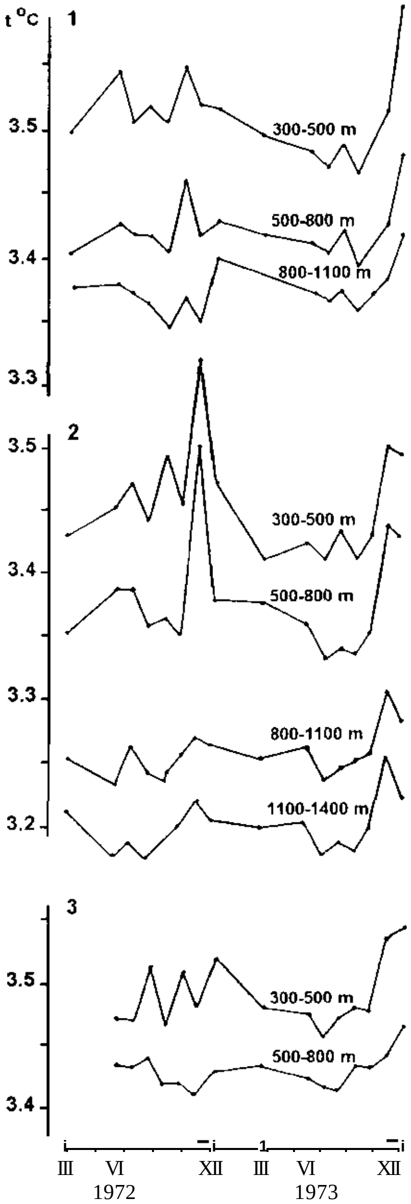


Fig. 1 40 Seasonal changes in temperature of deepwater layers Temperature values were obtained by averaged measurements at 4-6 stations along the lake in each part of the lake After Shimaracv *et al*, 1994
1 south Baikal
2 middle Baikal
3 north Baikal

distinctly displayed near the transition of the underwater coastal slope into an underwater valley or near great rises of bottom relief (near the Selenga elevation and the Academichesky Range). A "Decpstream" of the pre-bottom flow is located at approximately 40-70 m above the bottom, and its direction is close to the direction of the currents in adjacent deep waters.

During ice cover and in times of weak summer winds (July), currents are minimal, but they are maximal in spring (the period of freeing the lake from ice to homothermy) and autumn.

The vertical distribution of the mean velocities of water transfer vector is greatly affected by temperature stratification. As a rule, high velocities are recorded at the water surface. They decrease linearly to a minimum towards the thermocline layer, after which they increase again and then slowly decrease with depth.

The temporal structure of the currents is complicated. Spectra of currents are of a continuous character. Their greatest energy corresponds to oscillations of their velocities with periods of tens of hours (synoptic oscillations of wind velocities - from 2-3 to 5-7 days), after which it diminishes with a decrease in oscillation periods, retaining a series of distinctly expressed maxima at the periods: 24 hours (diurnal oscillations of wind velocities), 14-15 hours (typical of the latitude inertia oscillations), 12 hours (tidal component), 278 and about 120, 93, 53 minutes (the dominant seiche and its overtones). In the inertia frequency interval, the energy with frequency growth diminishes according to powers close to "minus five thirds'[1] and "minus three". This testifies to the existence of both three-dimensional and two-dimensional macroturbulence in the current structure, and a great influence of wind regime and wave processes upon it.

The horizontal structure of the currents is complicated There are meso- and macroturbulent vortices, the source of their origin being inertia oscillations (clipsoid in coastal areas and almost rotary far from it, with a diameter in the upper layer of 1 - 6 km). Moreover, in southern and northern parts of the lake large circulation structures are observed, the dimensions of which reach 70-90 km Likewise, momentary formations, connected with wave phenomena of Kelvin-wave type, Poincare-wave type and others occur. The coastal zone of friction in the upper layers is 2 km in size. On its lake border, transfer velocities are the greatest, then they slowly diminish towards the middle of the lake where the circulation changes its direction for the opposite one.

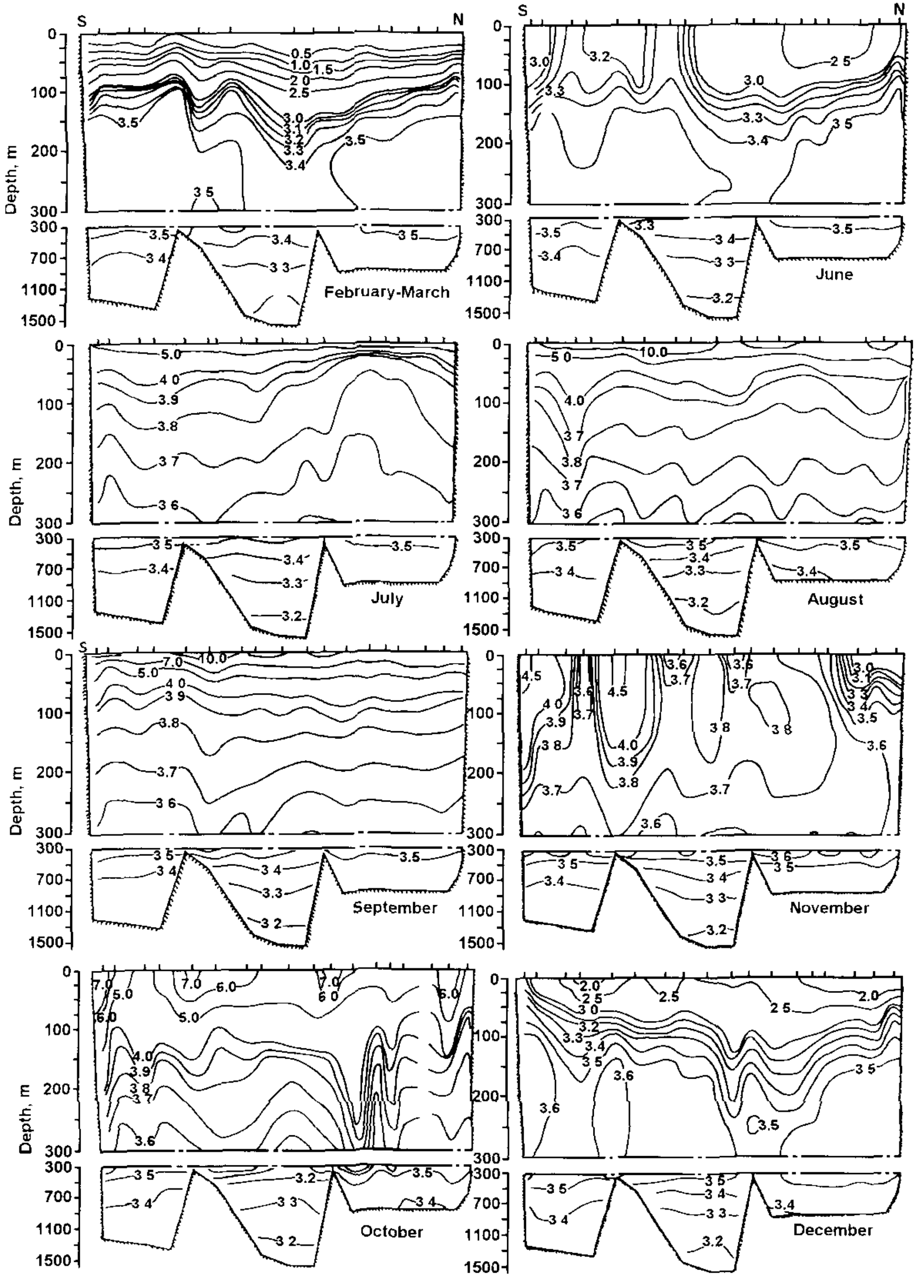


Fig 1 41 Distribution of temperature in the water mass on a longitudinal section in the central part of Baikal Long-term observations Mean for 1972 through 1985 After Shimaraev *et at,* 1994.

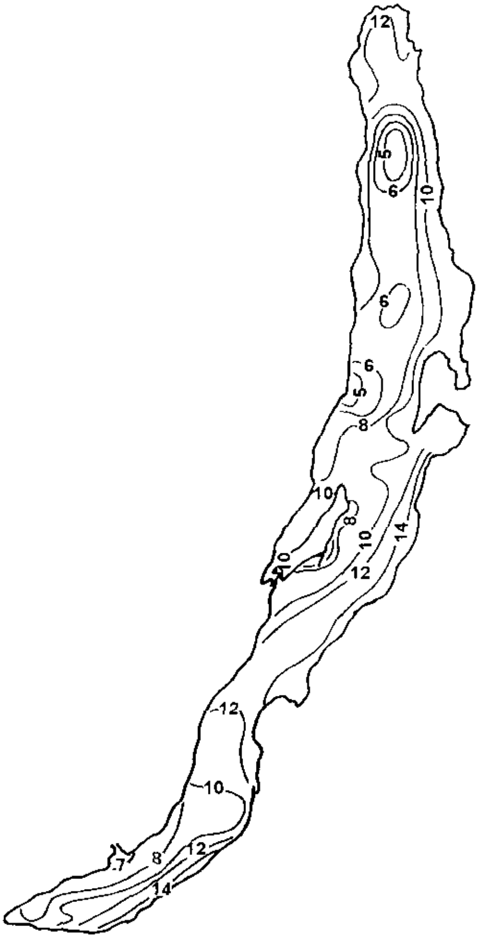


Fig 1 42 Distribution of temperature in the superficial layer of Baikal End of July-early August, 1988 After Shimaraev *et al,* 1994

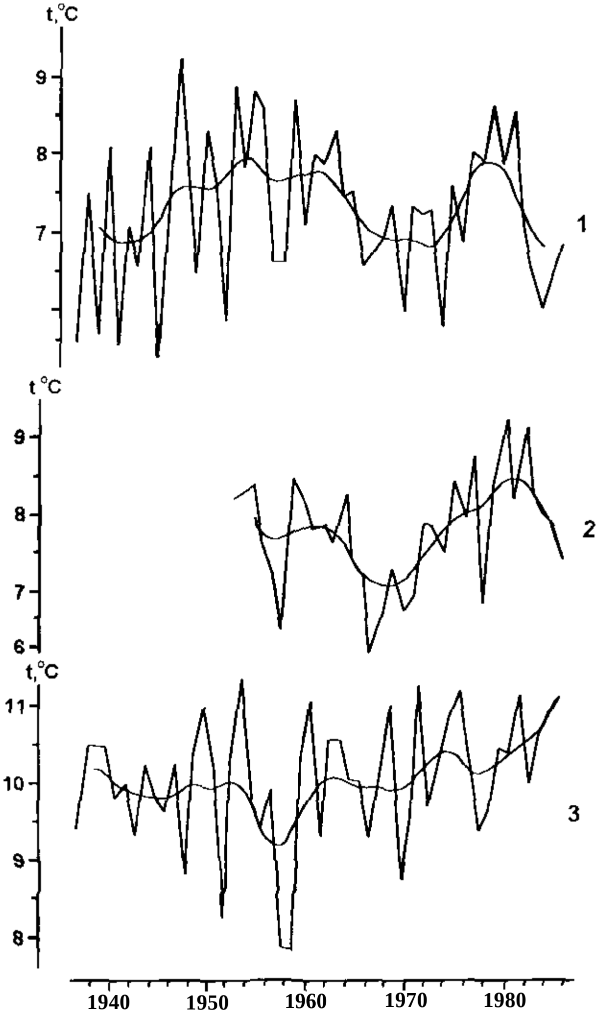


Fig 1 43 Long-term changes during May-October of mean temperature *of the* superficial water layer *near* the coast 1 south Baikal, 2 middle Baikal, 3 north Baikal After Shimaraev *et al.* 1994

The whole lake is subject to a coastline cyclonic circulation which from time to time undergoes breaks. Fig. 1.47 shows the results of continuous observations of the currents (including long-term observations), showing the overall picture of water movements in the 15-100 m layer.

Between large circulation structures there are zones of turbulence connected with divergence zones and large elevations on the bottom. Calculations of convection-gradient circulations by dynamic methods averaged for a long-term period have shown that temperature and current fields are deeply related.

Major sources of energy of the currents are wind friction against water surface, atmospheric pressure gradients, unevenness of warm upper layers of water, river inflow, and solar and lunar tides.

The water movement is primarily affected by friction against shores, the thermocline, internal bottom friction, the Earth's revolution, density (temperature) stratification, and wave phenomena. Wind plays the most significant role in the formation of the currents. It apparently creates up to 80% of their energy, while 10-15% is created by changes in atmospheric pressure. Under ice, the current velocities are ten times lower, and currents have been recorded down to great depths, with a prebottom maximum over the coastal slope. In the central part of the pelagial a maximum occurs in

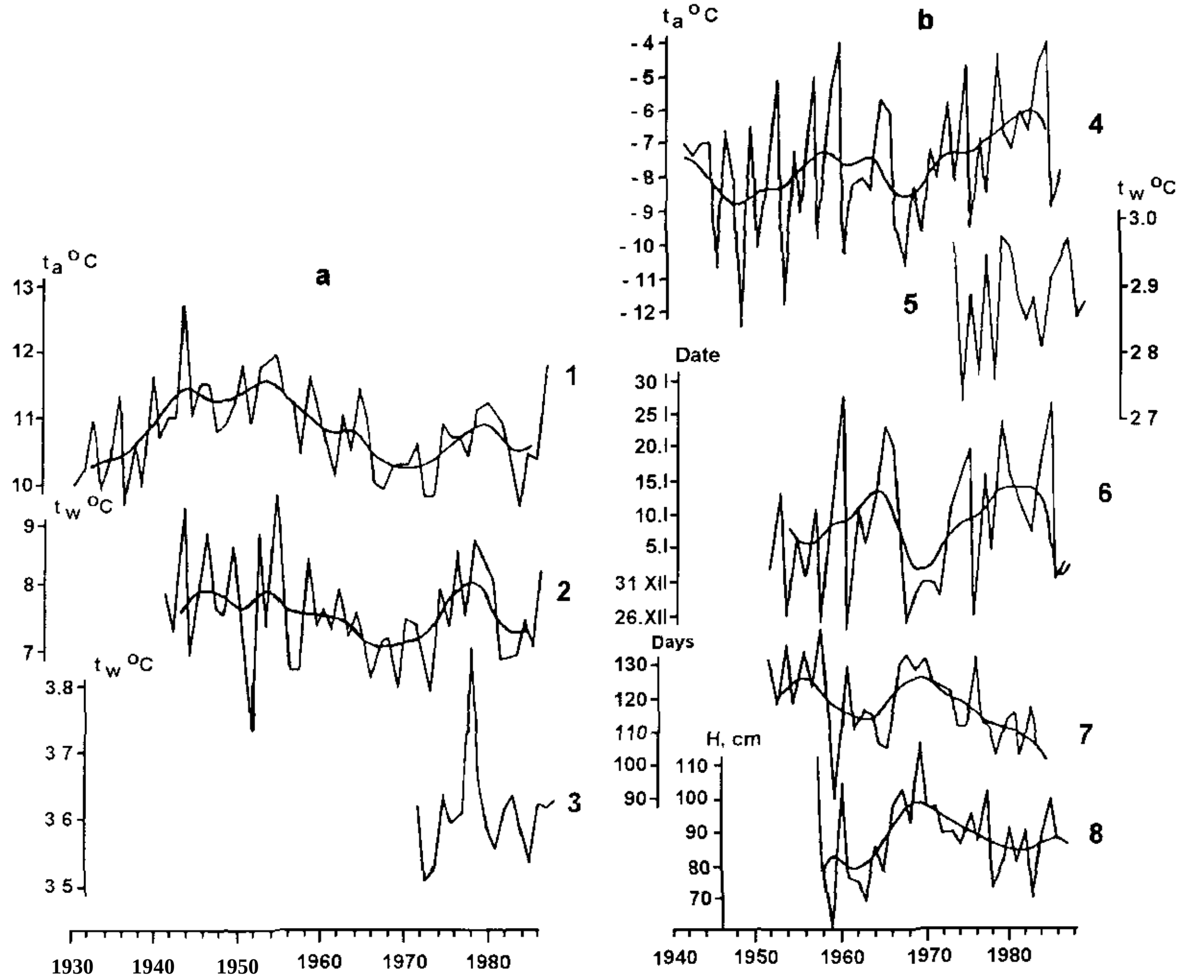


Fig 1 44 Long-Term changes in hydrometcorlogical characteristics in the sub-ice (a) and ice (b) periods South Baikal 1, 4 mean air temperature abo\e the lake 1 May-October, 4 November-December, 2 mean surface water temperature, May-October, 3, 5. mean water temperature in the 0-300 m layer 3 September, 5 February-March, 6 time of freezing, 7 duration of freezing; 8 maximum thickness of ice. After Shimaraev *et al,* 1994.

the upper 100 m layer (with a distinctly expressed sub-ice layer of friction, 10-20 m thick). Generally, under ice cover, current velocities do not exceed 4-6 cm sec^{1}, maximum 9 cm sec '.

Near mouths of large rivers, streams of river water cause local vortices. The modal stream of the major Selenga River channel is traceable to one kilometer from the shore. Under flood conditions, this becomes 3 km or more, deviating to the right. Away from the mouth, river water get mixed with lake water and is included in the currents of the lake. A similar picture is observed at the Upper Angara and Barguzin rivers.

Coastline circulation and a coastal layer of friction leads to the formation of a vertical circulation over the underwater coastal slope. In the epilimnion and hypolimnion such circulations are formed separately, and the thermocline serves as a boundary. The general structure of the water masses is preserved, with the exception of some cases of upwellings, when wind from the shore drives the epilimnion and thermocline far away from the shore.

Cyclonic circulation is twice as frequent in Baikal as anticyclomc circulation. Under cyclonic circulation in the coastal zone, the upper part of the hypolimnion sinks.

The zone of descent is formed by lateral friction

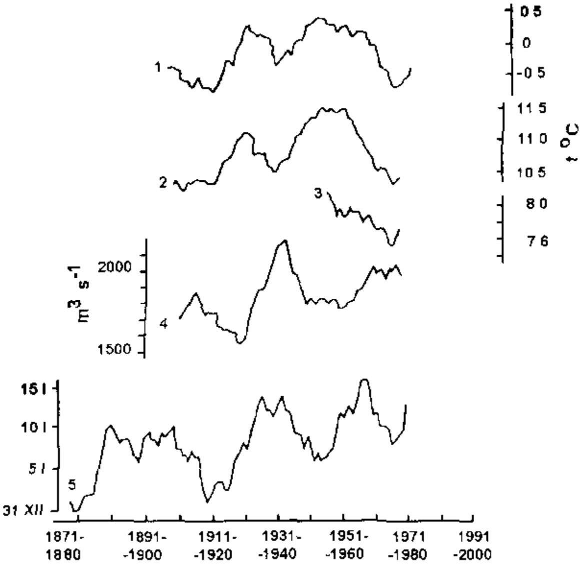


Fig I 45 Intra-dge changes in yearly mean (I) and warm period (2) of air temperature, mean temperature during May-October on the water surface (3), time of freezing (5) in south Baikal and yearly mean ot influx into the lake (4). Sliding len-year averaged values After Shimaraev *el a/.*, 1994

of a current against the underwater coastal slope. It stretches to 2 km from this slope into the lake, then a compensatory ascent of water occurs, the size of which is three times larger. Under anticyclonic circulation, a reverse situation occurs: rise of deep water towards the thermocline is observed at the underwater coastal slope and, outside the zone of currents, a compensatory descent of waters.

The velocities of vertical circulation are low and do not exceed 7% of the velocity of horizontal circulation. During a single storm the particle transfer trajectory rarely exceeds 100 m day"^{1} The processes of vertical and horizontal diffusion take place simultaneously. Penetration of waters from the upper part of the hypolimnion into deepwater layers at the shore occurs about twice as fast as in the central part of the pelagial. Sunken waters get mixed with waters from adjacent parts of the central zone. Horizontal gradients in concentrations of compounds in the deepwater zone can be preserved for a long time.

Fig I 46 Map-scheme of Baikahan surface convective-gradient currents After Verbolov, in. Atlas of Baikal, 1993

1.5. Optical properties

A light regime depends on several external and internal factors. External factors, such as solar radiation on the water surface, depend on geographical and physical conditions: latitude of the area, altitude above sea level, the Sun's altitude above the horizon, atmospheric conditions (transparency, cloudiness, moisture), and the air-water interface of the lake (turbulence, presence of ice and snow). Internal factors define the distribution of light in the water column and depend primarily on optical properties of the water and their spatial-temporal variation. In water, most radiation is distributed in the spectral range of 400-700 nm (photosynthetically active radiation - PAR). On Lake Baikal, located between latitudes 51.29' and 55.46' N, maximum (noon) solar altitudes vary from 62° to 11°, and day length is from 17.00 hours in June to 7.00 hours in December. The duration of sunshine, taken as a ratio of the maximum possible,

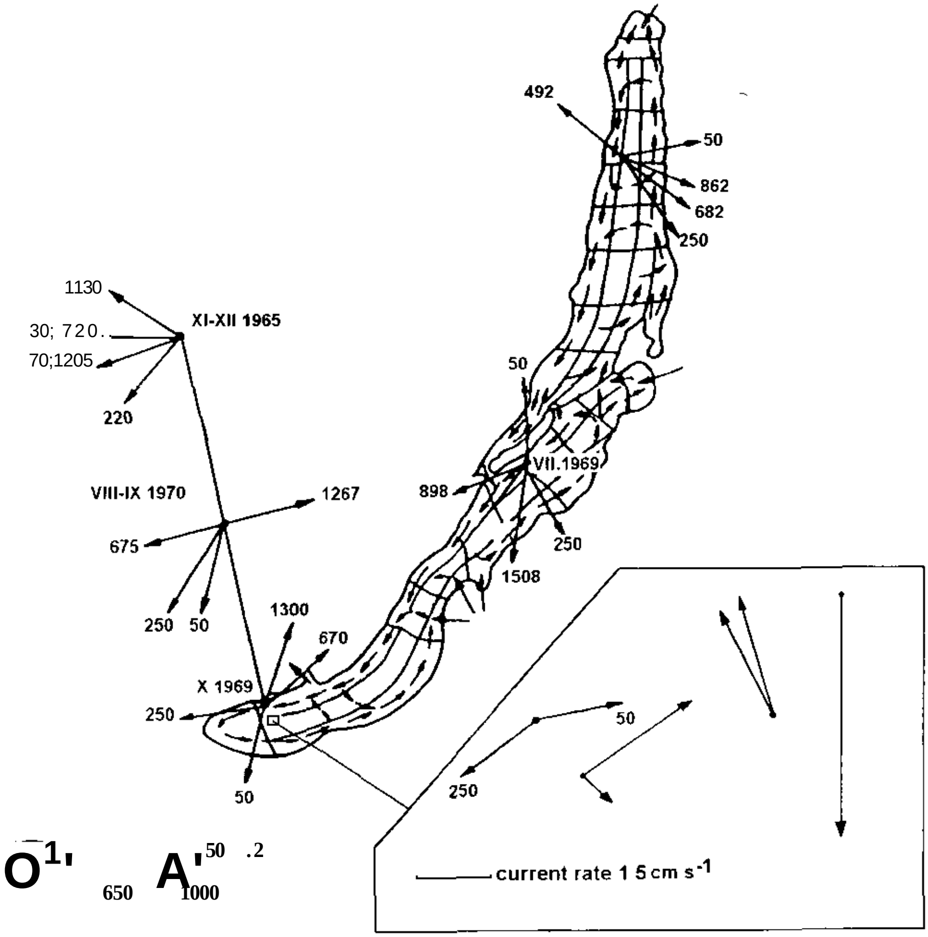


Fig I 47 Direction of water transmission in Baikal 1 geostrophic circulation of the surface, 2 average current directions on some horizons (Figures at the end of vectors arc depths) In-cut average current directions and average rate in horizons 50 and 250 m on the area (9 x 4 5 km) **X111-1X** 1970 After "Prediction ...", 1986

fluctuates from 63% in February and March, to 22% in December; the total, direct and penetrated PAR is 440, 360 and 380 W m"^{2} in June, and 110, 60 and 70 in December, respectively (Fig. 1.48).

The spectral distribution of PAR on the lake surface, calculated by intervals of 20 nm, shows that total and incident radiation at 450 nm or less declines quickly with decreasing wavelength, and remains practically constant in the rest of the spectrum (Fig. 1.49). Readings obtained by gamma-spectroradiometer with a resolution of the order of 2 nm, confirm these calculations and display a more sophisticated spectral structure of incident radiation (Fig. 1.50).

Albedo in the area of PAR on a clear, cloudless day in calm weather is minimal during midday and reaches maxima in the morning and evening hours due to a great reflectivity at small solar altitudes (mirror component); low values for scattered irradiance at sunset, from the solar disk from behind the mountains, occur (Fig. 1.50). Spectral albedo in the area of PAR in the range of solar altitudes greater than 20° depends only slightly on wavelength (Fig. 1.49). During winter, the flux of solar energy into the water reaches a greater extent, defined by the state of ice-snow cover, its impact on albedo and transmittance. Spectral albedo of newly fallen snow is weakly selective and has high values, of the order 97-80%. For snowless ice, the

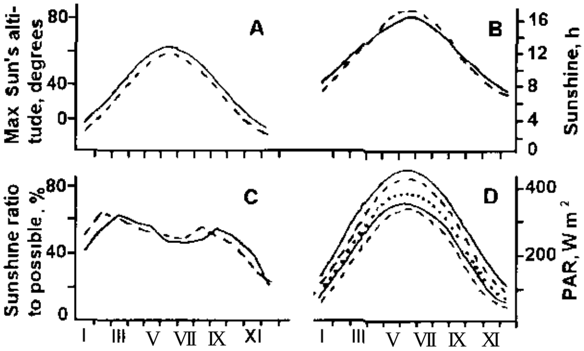


Fig I 48. Annual course of elements of the light regime, calculated on the 15th day of each month, for south (solid) and north (broken lines) Baikal A maximum midday Sun altitudes, *B* duration of sunshine, *C* ratio of observed duration of sunshine to maximum. D total (curves at the top) and direct (curves at the bottom) PAR The dashed line (D) shows maximum entering the water PAR for south Baikal, calculated by the Baumert formula (1987) After Stcpanova & Sherstyankin, 1984

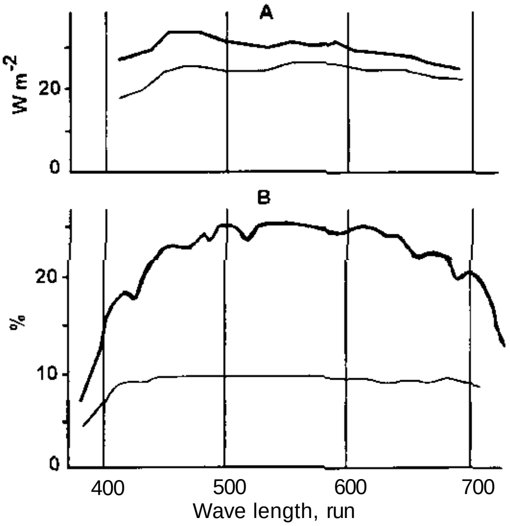


Fig I 49. Spectral onset of total and incident (thick and thin lines, respectively) in the range of PAR. calculated by spectral intervals of 20 nm (A) Recording of total PAR with scanning spectroradiomctcr with a resolution of about 2 nm (thick line) *and* spectra] dlbedo, measured at the same place (thin line). South Baikal (B) After Stepanova & Sherstyankin, 1984.

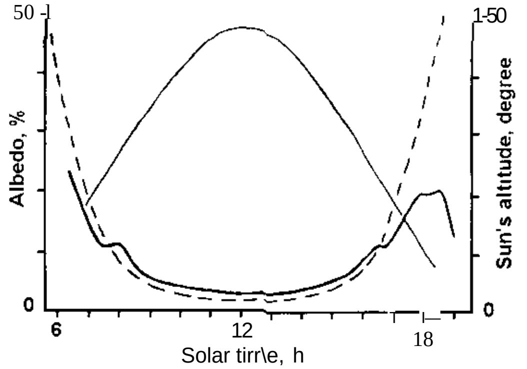


Fig I 50. Albedo on a clear, cloudless day in calm weather (thick line) and albedo according to Frcnel (dashed line) The sun's altitude (thin line) is given from the sun rises from behind the mountains and to the moment it sets behind the mountains North Baikal After Sherstyankin, 1975

albedo decreases to 35-20% (Fig. 1.51). The spectral transmittance of snowless ice about 1 m thick at midday hours is maximal (about 80%) in the range of 500 nm and decreases towards the visible part of the spectrum. The presence of newly fallen snow of the order of 2.5 cm in thickness lessens PAR transmittance approximately ten times (Fig. 1.51). The measurement of spectral irradiation in the water from above, expressed as a ratio of irradiation from above, shows that at great depths light radiation is usually in the range of 480-500 nm, with 2 10"^{5} of light radiation reaching the 100-m level in this part of the spectrum, and approximately 2 10"^{6} in the presence of 2.5 cm of snow (Fig. 1.52). The values of spectral irradiation on separate horizons, taken as a ratio to subsurface irradiation, change little in the course of the day (Fig. 1.52). In the period of open water, irradiance reaches great depths, in the range of 480-500 nm, the "transparency window" of the Baikal waters (Fig. 1.52). In June, approximately (1-10) 10"^{4} of irradiance reaches the lQO-m mark in the "transparency window"; in winter this value is reduced to (2-100) 10 ^{6} from downwelling irradiance (Sherstyankin, 1975). Measurement of light fluxes by highly sensitive photometers has shown that solar radiation during winter reaches depths of the order of 400 m, and moon radiation - 200 m. In the absence of an atmospheric background (light from the Sun, Moon, stars, *sky), fluorescence of Baikalian* waters has been observed, apparently of chemical-luminescent nature. Its intensity decreases from the surface to the bottom (Bezrukov *et al,* 1984)

Transparency by Secchi disk. One of the easily determined optical characteristics of natural waters is transparency measured by a standard (30 cm diameter) Secchi disk. Systematic measurements of

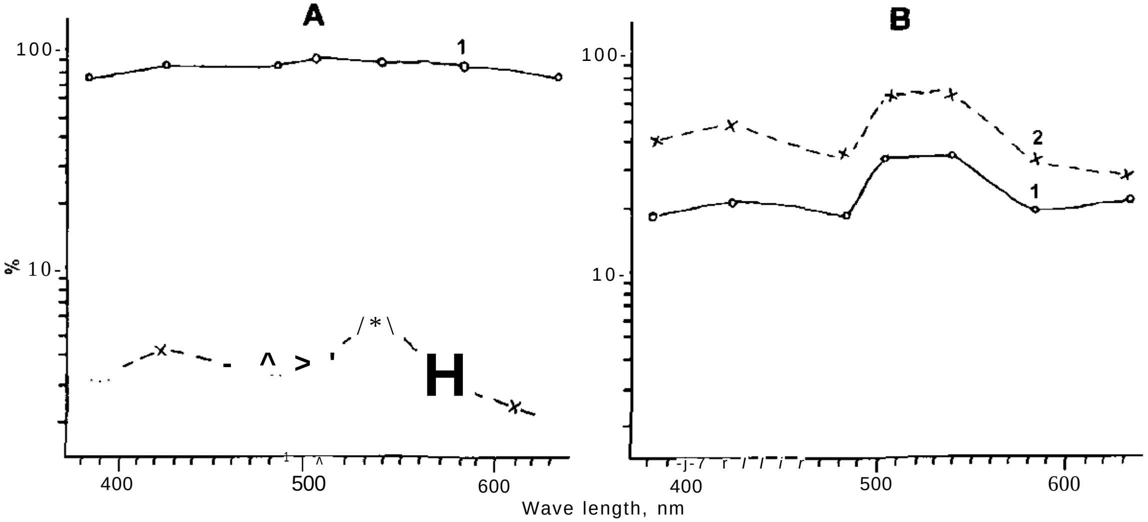


Fig 1 51 Spectral course of albedo (1) and trans-mittance coefficient (2) of ice cover 80 cm thick on clear, cloudless days at about noon A. newly fallen snow 2 5 cm deep, B pure ice. After Sherstyankin, 1975

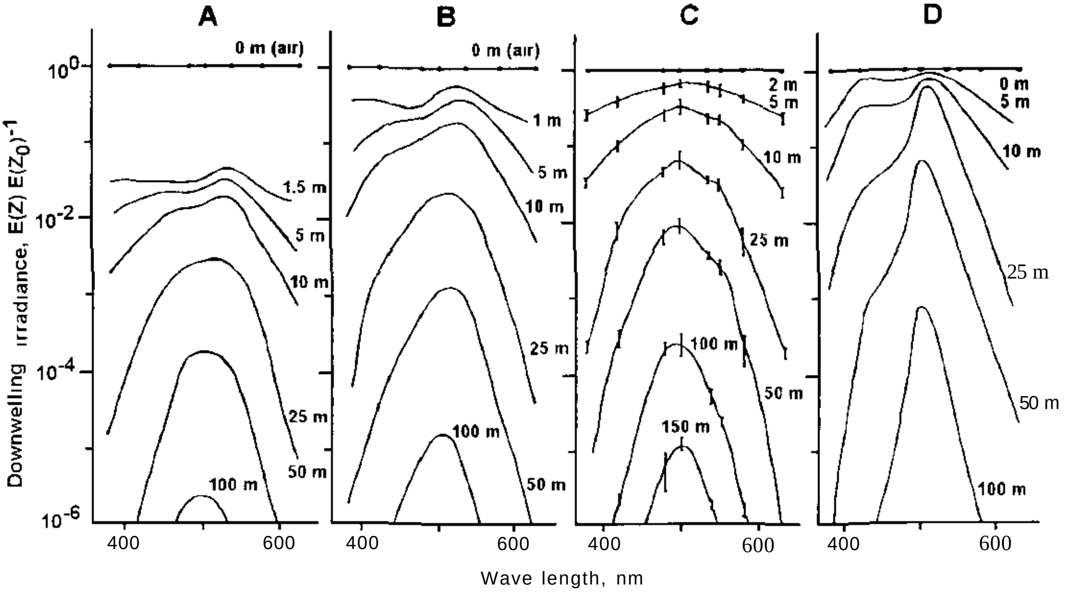


Fig I 52 Spectral irradiation from above at different depths normalized to irradiation from above in the air or in the water A. under ice-snowy cover with newly fallen snow 2 5 cm deep, B under pure ice 80 cm thick; C under pure ice during daytime (vertical lines show variability range), D in open water After Sherstyankin, 1975

transparency were conducted in 1909-1918 near Maritui, where remarkably high transparency values, up to 40.2 m, were obtained (Shostakovich, 1924). A series of long-term ob-servations of transparency at Bolshiye Koty is available at the Research Institute of Biology of Irkutsk State University (Fig. 1.53).

The transparency of the open waters and its seasonal changes are shown in Figs. 1.54, 1.55. In open deepwater regions, the highest transparency is observed from the end of November (the period of autumn homothermy) until January to mid-Feb-ruary. At that time the white disk can be seen up to a depth of 25-30 m and in regions

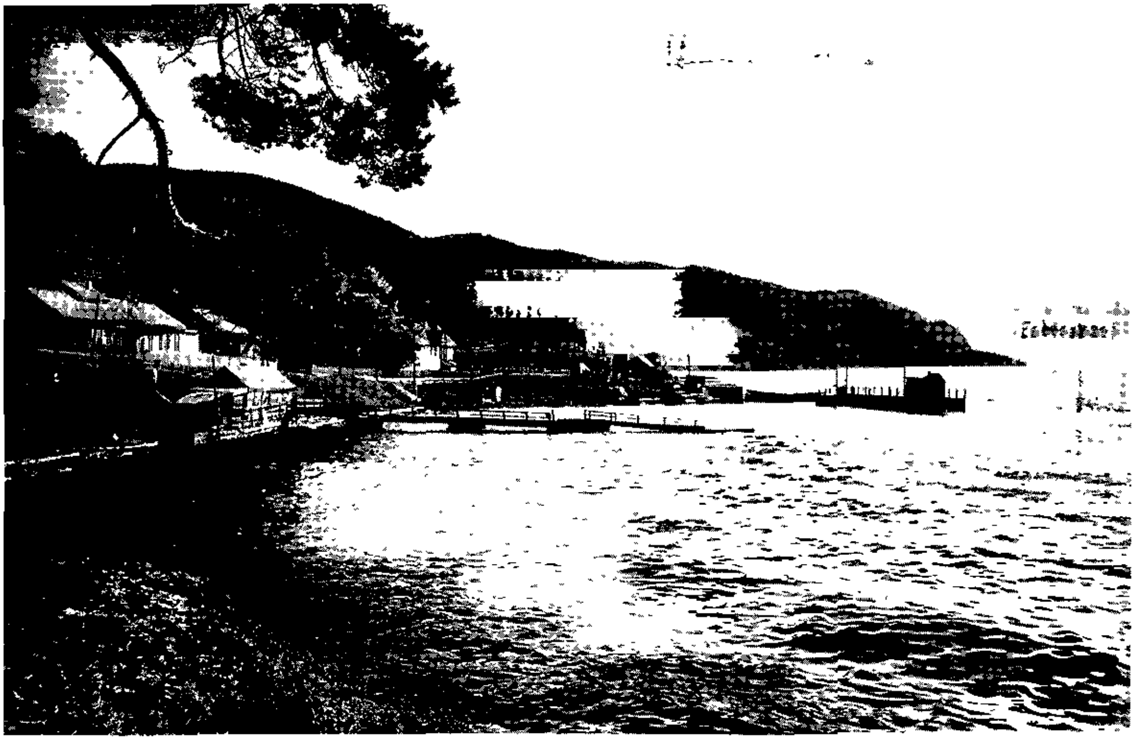


Fig. I 53. Biological Station in BoUhiyc ICoty settlement. Photo by V. Ostroumov.

removed from the shores and river mouths, up to 40-41 m. In shallows and opposite river mouths, transparency is much lower than in deepwater regions. During the spring bloom of algae, the transparency grad-ually diminishes, and in March-May the white disk cannot be seen at 8-10 m even in deepwater regions. In years with particularly high crops of algae, water transparency can fall to 6-8 m in April-May (still under ice cover!) and to 2-3 m in shallows. As the vernal algae die and homotherm y sets in, transparency increases again, reaching 20-25 m or more towards the end of June. In summer, with the onset of thermal stratification, trans-parency decreases once again, the summer mini-mum of about 6-8 in (and in some years, 4-5 m) being reached in August. The relationship between water transparency and phytoplankton biomass is shown in Fig. 1.56.

In shallows, especially opposite the Selenga delta, transparency can drop to 1-2 m or less after strong winds. The water then turns muddy-yellow, because of large amounts of suspended material stirred from the bottom. September sees the beginning of the autumn increase in transparency, which reaches a maximum towards December, during autumn homothermy.

Transparency coefficients are distributed unevenly in different seasons of the year. In June-July and October-November, when there is no mass development of phytoplankton, the range of transparency changes is wide, from 20-30 m to some meters. In August-September, it narrows to 5-10 m (Fig. 1.57).

Light attenuation coefficient. Optical properties of Baikalian waters were studied, using photometers, by Lcc, (1969) and Granin *et al.* (1977). They measured light attenuation coefficients (A.C.), a, or transparency 0. For a water column 1 m long, a = -In 8 (1 m''^{1}). We shall apply also oc$_{10}$ = -lg B = 0.4343 a 0 rn), where a$_{1()}$ is the optical density of a water layer of 1 m thickness. Attenuation coefficients equal the sum of absorbtion coefficients, ae, and scattering, a. and their value depends both on the content of suspended compounds in the water, responsible for scattering, and on dissolved and suspended absorbing compounds

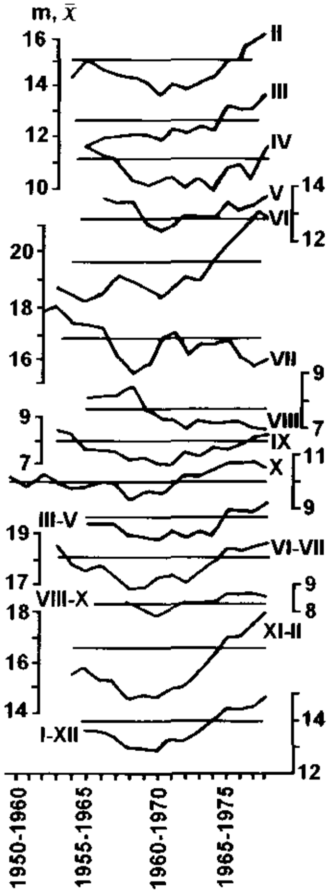


Fig 1 54 Dynamics of water transparency (Secchi disk) Sliding 11-year average values of water transparency (x_M) by months (I-XII). South Baikal, Bolshiye Koty, 1950-1975 After Kozhova, Krotova, Mezentseva, 1982.

(dissolved organic matter, DOM, phytoplankton pigments, etc.). Seasonal and " jump" A.C. profile areas are distinguished where vertical A.C. gradients are maximal - the so-called layers of A.C. "jump". In the upper layers there are two zones with A.C. "jumps", which, by analogy with temperature, are called seasonal and deep. The change in vertical A.C. profiles in the course of a year for the deepwater region of open Baikal is shown in Fig. 1.58. A deepwater layer with an A.C. "jump" is formed at 200-600 m in south Baikal; in relative depths this is approximately at 0.150-0.45 (the ratio of the depth of the layer to the maximum depth). The existence of a deepwater layer of A.C. "jump" is attributed to dynamic processes, whose intensity is changing in time, re-sulting in a change of depth. A seasonal layer of A.C."jump" is formed after homothermy First, it occurs in the uppermost layers (Fig. 1.58. 7,8), then with summer and spring warming up under the ice, it is lowered (Fig. 1.58. 1,3,4). In the same layers phytoplankton develops intensively, which leads to a significant, up to 1 (In m^{-1}) or more, increase of A.C, and promotes a better warming-up of the water. The values of vertical A.C gradient in the seasonal "jump" layer during this period exceed by two-three orders those in the deep "jump" layer. As summer and spring warming continues, the depth of the seasonal "jump" layer increases, while A.C. values and its gradient diminish (Fig. 1.58. 2,5). In the period of homothermy, the seasonal

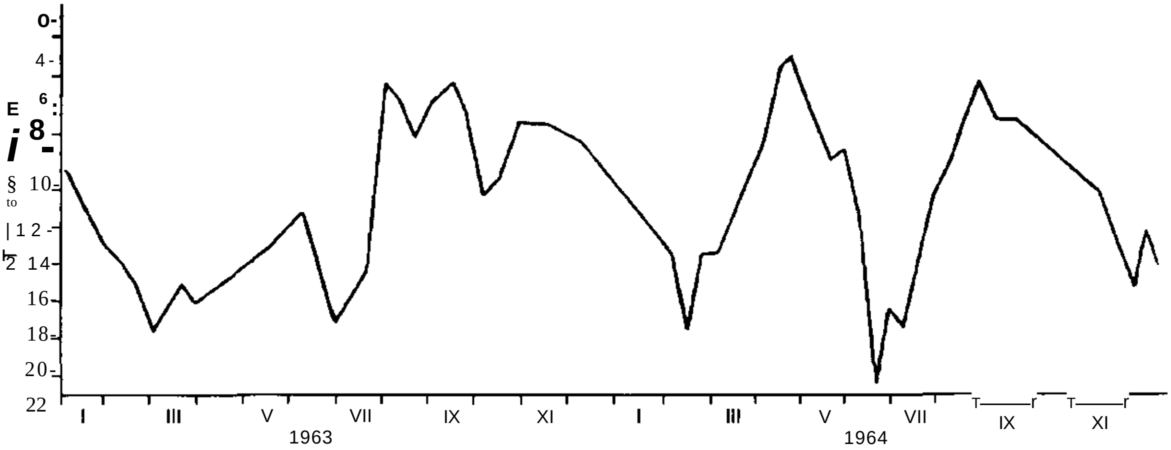


Fig I 55 Seasonal changes in Secchi disk transparency in the open waters of south Baikal, Bolshiye Koty, I 5 km offshore. After Kozhov, 1972.

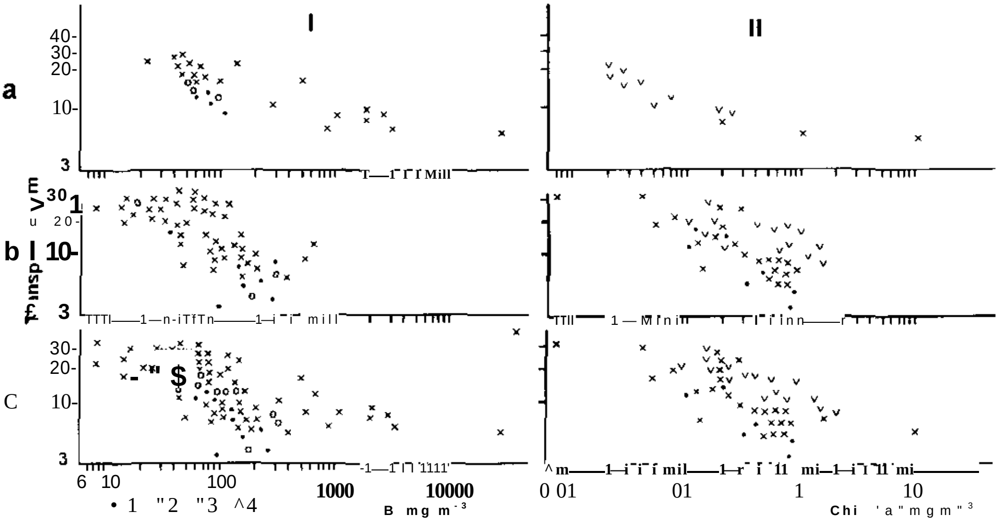


Fig 1 56 Dependence of water transparency upon the algae biomass (J) and chlorophyll "a" concentration (]I) 1979] predominantly ultranannoplankton algae 2 larger than 25 fim 3 number of ultranannoplankton and larger than 25 (.im' algae is approximately equal, 4 composition of algae is unknown, a - under ice, b - ice-free period, c - all seasons After "Prediction ", 1986

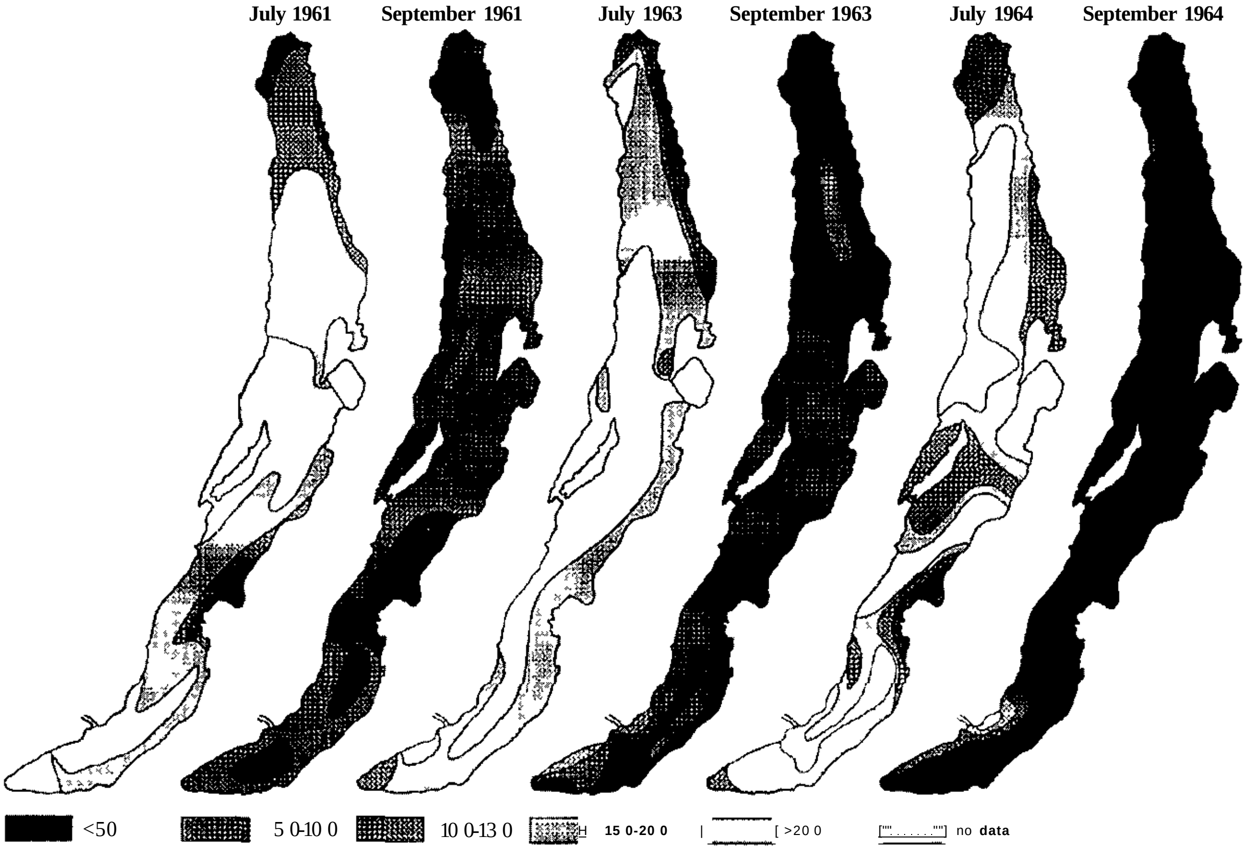

July 1961 **September 1961** **July 1963** **September 1963** **July 1964** **September 1964**

Fig 1 57 Distribution of transparency throughout Baikal After Sherstvankin in Atlas of Baikal, 1993

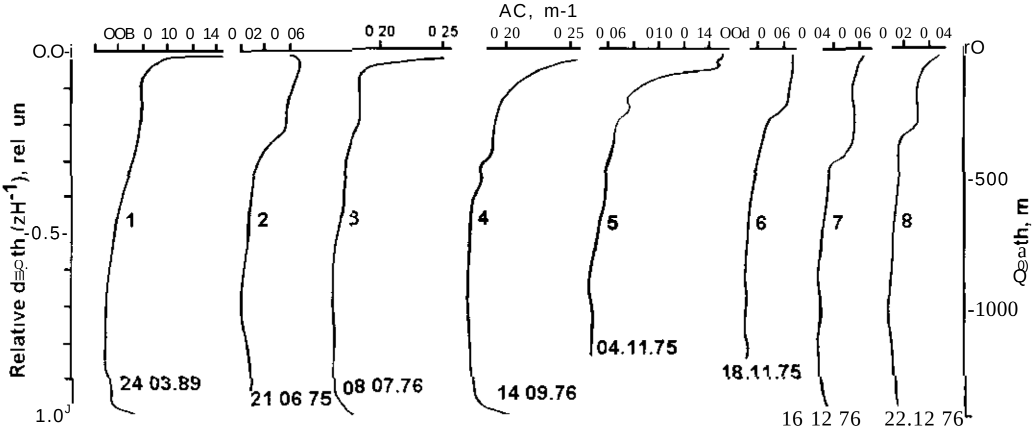


Fig I 58 Vertical profiles of attenuation coefficient (here and further - AC) typical of deepwater zones of the lake South Baikal. Dates are given at the bottom of each profile After Sherstyankin, 1979a

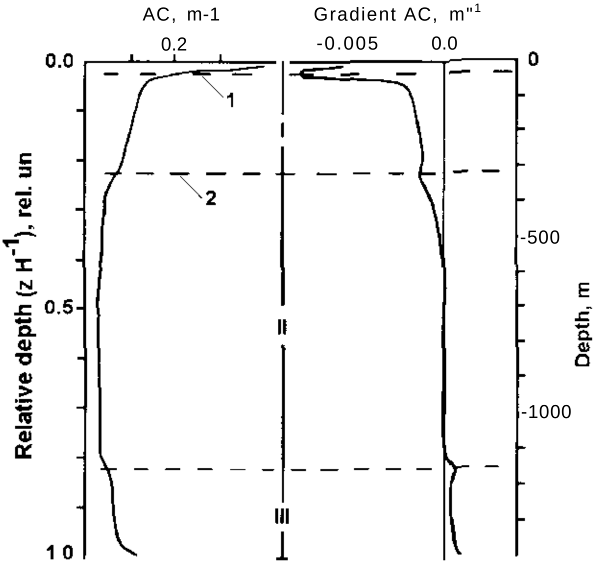


Fig I 59 Scheme of vertical structure of Baikalian waters for deepwater zones of the lake Seasonal (l) and deep-water (2) layers of attenuation coefficient "jump" (AC) I surface (upper) zone with maximum AC and gradient values, II deepwater zone with minimum values of AC and near to zero gradients of AC, 111. prebottom zone with increasing values of AC and positive gradients. After Sherstyankin, 1979a

"jump" layer coincides with the deepwater layer (Fig. 1.58. 2,6), to finally reappear in the uppermost layers (Fig. 1.58. 7,8). In the period close to homothermy, values of vertical A.C. gradients in seasonal and deep "jump" layers are of the same order of magnitude.

Vertical structure of Baikal waters. The analysis of numerous A.C. profiles, carried out throughout the lake from aboard ship, and for south Baikal in winter, makes it possible to distinguish three zones in vertical structure of Baikal waters: surface, deepwater and prebottom (Fig. 1.59). The surface zone has maximum values in A.C. and vertical gradients. It starts at the surface and ends at the deepwater "jump" layer, *i.e.,* at relative depths of 0 15-0.45. The deepwater zone has maximum A.C. values and near-zero vertical gradients. This is the zone of the most transparent waters. The approximate range of their relative depth is 0.45-0.85. The prebottom range is again distinguished by higher A C. values and positive vertical A.C. gradients. At a distance of 20-30 m from the bottom, A.C. increases quickly while approaching the bottom. The prebottom zone is not always present at one and the same stations, which suggests a dynamic mechanism of its appearance, apparently due to exchange of slopes. The vertical structure of Baikal water by its optical characteristics supports the idea of disting-uishing three water mass zones, suggested for the first time by Tolmachev (1957), based on an analysis of vertical distribution of hydrochemical indices.

Spatial distribution of attenuation coefficient (A.C). To characterize the spatial distribution of A.C. in the lake, we shall draw on general features of optical structures, obtained from longitudinal and transverse sections.

1. The character of optical structures depends on

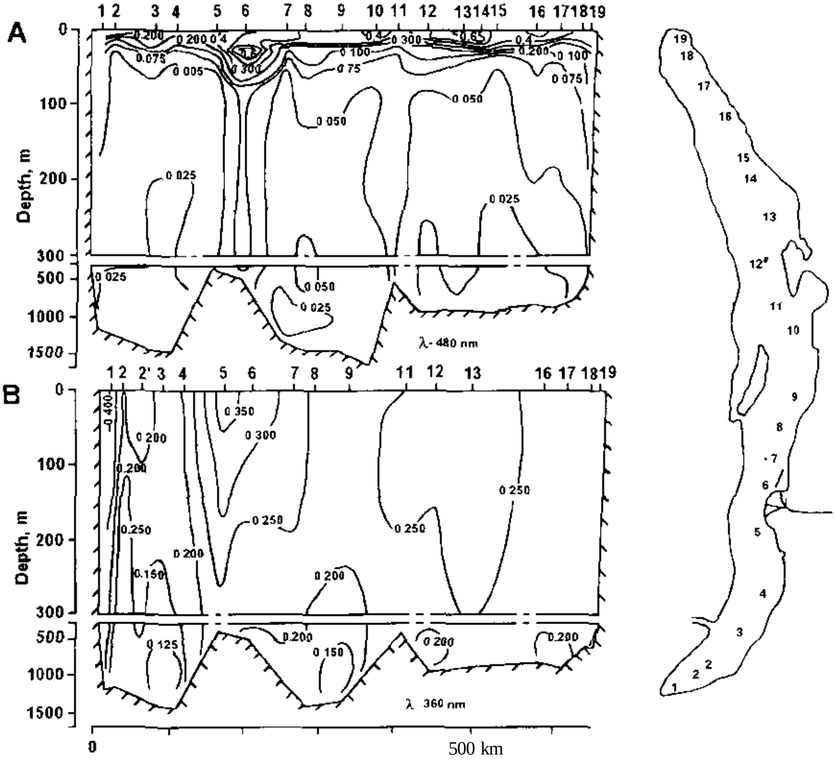


Fig I 60 Spatial distribution of AC (m^{-1}) on the longitudinal section of the lake A at the end of summer warming, 4-1009 1975, B in the period of autumnal homotermia, 16-30 11.1975 After Sherstyankin, 1979a

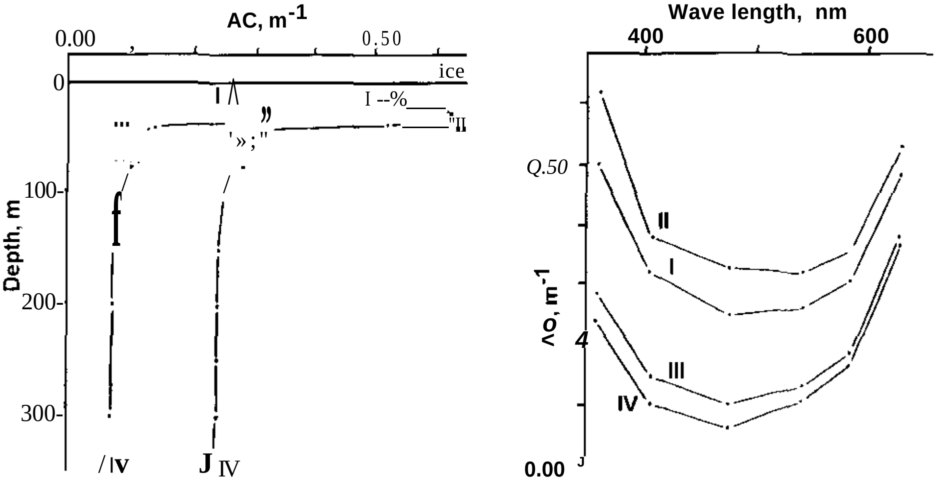


Fig I 61 Spectral course of AC in different parts of -vertical profile To the left, profiles of attenuation coefficients are shown A - for the range of 480 nm, B - for 360 nm South Baikal, Bolshiye Koty, ice station March 6, 1971 After Sherstyankin, 1978

the seasonal course of the A.C.: (a) during summer warming up (July-September) the optical structure of the water in deepwater zones of the lake is characterized by vertical rather than horizontal heterogeneity. In the upper layers (10-30 m) there is a sharp (with a spread in A.C. values of up to 0.4 Ig m ') A.C. "jump" layer (Fig. 1.60); (b) during spring (June) and autumn (November) homothermy, the heterogeneity in vertical A C distribution decreases, and increases horizontal The A C "jump" \ayer occurs at depths of 100-300 m and lower, with a spread in A C values of less than 0 2 lg m ' (Figs 1 60, 1 61)

2 In pre slope zones and also above under water elevations, a destruction of "jump" layers is observed The A C isolines are strongly inclined (Figs 1 60, 1 62), indicative of an increase in vertical exchange in these zones

3 Each trough of the lake in decpwater zones contains an individual water mass(Figs 1 60, 1 63)

4 Waters with the lowest values of A C occur in deepwater zones and, as a rule, in regions of maximum depth (Figs 1 61, 1 63)

5 In the area of the Selenga Shallows, the frontal structure is continuous, which indicates that mixing of river waters occurs from surface to bottom, and only during summer warming can part of the mixed water in the surface layers cross the whole lake Temporary variations in attenuation coefficient caused by non-stationary abiotic and biotic processes give rise to temporal AC variations Momn *et al* (1974) distinguished phenomena with different time scales In Baikal, small scale, mesoscale synoptic, seasonal and interannual phenomena can be distinguished Small scale A C variations with periods ranging from seconds to tens of minutes were identified in 1968, using the difference of depth location of the "jump" layer under a lowering and lifting of the transparency-measure (Belosertsev *et al* 1975) Mesoscale AC variations with periods from several hours to days were detected by vertical movements of the A C isopleths at fixed stations during 4-5 days of observation., u.smg corcelaUoc. *Z.VAVJ%\%* of diurnal observations of A C Variations recorded ranged from 05 03 to 04 04 1971 at the ice station in Bolshiye Koty (Stepano\a *et al*, 1984) Seasonal A C changes have been given above They cover the whole water column The character of their changes m surface and deepwater zones varies, and may come close to a phase opposition, (e , when A C values in the upper zone decrease, they increase in deepwater and vice versa A C changes m the prebottom area have a seasonal character Interannual A C changes are brought about by fluctuations in phytoplankton stocks ("rich-crop" years), and are indicative ot great long-term variabihty For example, at Listvyanka and Tankhoi, average values of A C in 1976 (high algal stock) were twice as high as in 1975 An analysis of yearly variability in transparency at Bolshiye Koty from 1950 to 1978 showed that both short-period (from 2 to 6 years) fluctuations and fluctuations with periods close to the 11-year solar cycle, with periods of 10-12 and 20-24 years, can be distinguished

Spectral distribution of attenuation coefficient Spectral variations of A C in natural waters are caused by different contributions of absorption and scattering processes to total attenuation In the long wavelength part of the spectrum, absorption by the water molecule predominates In the middle of the visible part of the spectrum, absorption by phytoplankton pigments and scattering by suspensions prevail In the short wavelength part, effects of light scattering by water, suspension and absorption by dissolved organic and "yellow substance" occur In Baikal waters, A C minima tend to fall in the visible part of the spectrum For greater A C values, typical of surface waters, they are displaced towards long wavelengths (550 nm and above), and for more transparent deep waters an A C minimum or "transparency window" occurs in the range of 480-500 nm (Fig 161) (Sherstyankin, 1978) Extremely low AC values of Baikal waters in the "transparency window" are approximately twice as high as A C for the most transparent waters of the World Ocean, the Sargasso Sea (Matlak, 1972, Kuleshov *et al*, 1987) and 8-10 times as high as the A C of pure water (Kopelevich, 1974) In the blue and ultraviolet pans, of the spectrum, the atteauaUoa coefficients. of Baikal waters increase rapidly with a decrease in wavelength This is due to their higher content of dissolved organic matter (DOM) and "yellow substance", compared with the ocean (Sherstyankm, 1979a, b. Fig 1 64)

Relationship between light attenuation coefficient and water transparent On the basis of hydro-optical studies, relationships between transparency by Secchi disk (S), photic zone thickness (Z_E), and attenuation coefficients can be established

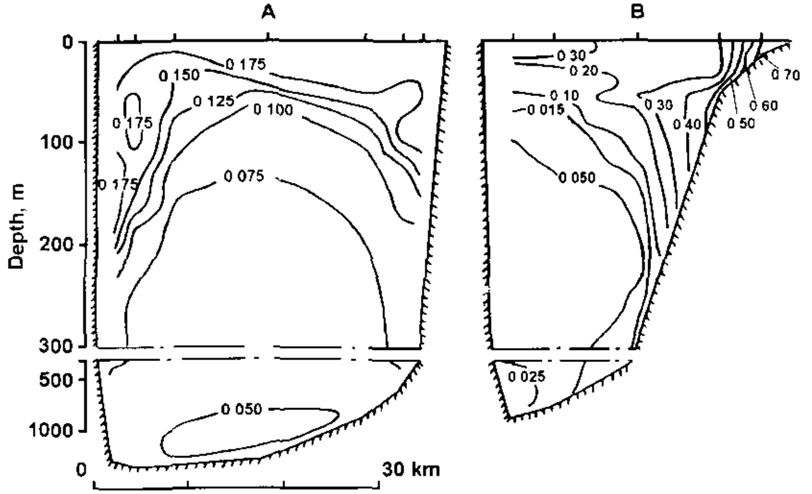


Fig 1 62 Spatial distribution of AC (nr') on transverse section of the lake A - in the south Baikal 03 11 75, B - in the middle Baikal 24.09 75 After Sherstyankin, 1979a.

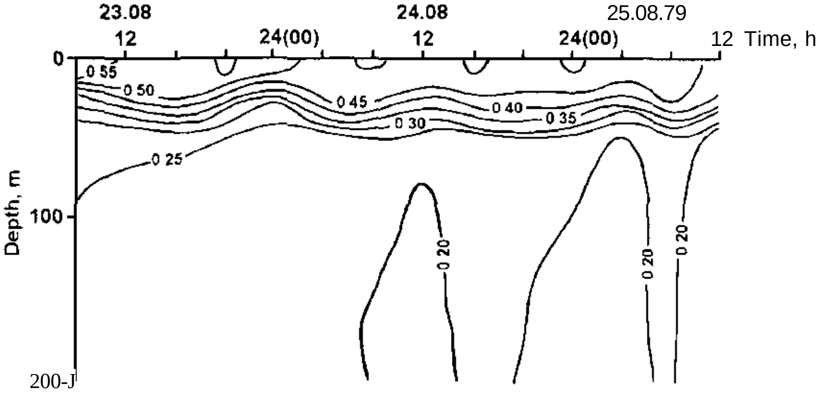


Fig 163 Isopieths of AC (m^{-1}) at diurna! station. North Baikal, Khoboi Cape. 23-25 August, 1979 After Sherstyankin, 1979a

$$Z_E(m) = 2.8\ S \qquad (1)$$

and

$$a\ (In\text{-}rrr^1) = 7.28\ /\ S\ (m) + 0.004 \qquad (2)$$

From (2), water transparency can be calculated:

$$6\ -\ e''^a \qquad (3)$$

On the basis of monthly mean transparency values, calculated from long-term observations (1955-1985) at Bolshiye Koty and expressions (l)-(3), the annual course of photic zone thickness, attenuation coefficient, transparency, corresponding to mean, maximum and minimum values of transparency (Fig. 1.65) were obtained. The data in Fig. 1.65 are applicable only to the characteristics of surface water. If equation (2) were true without any restrictions, such as for the exceedingly transparent Baikal deepwaters (a $\approx$ 0.041 In m''^1), we would get a transparency value equal to 197 m.

Comprehensive hydro optical surveys (Sherstyankin, 1975) made it possible to find a relationship between the probability of photon survival in a single scattering and the attenuation coefficient:

$$A\ -\ -0.048\ /\ a\ (In\ m'^!)\ +0.969 \qquad \textbf{(4)}$$

Its seasonal course in surface waters, calculated by (4), is shown in Fig. 1.65, leading to an evaluation of the seasonal course of all major optical characteristics: as = a (1-A) and a = Aa. Joint

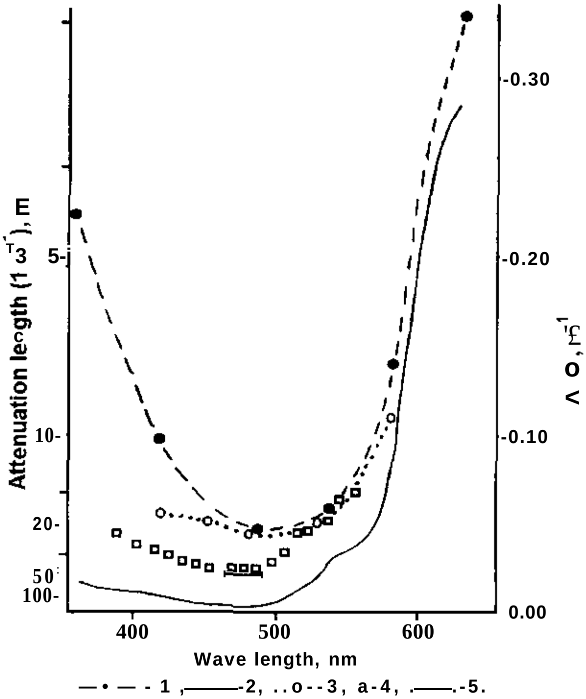


Fig 164. Spectral course of attenuation coefficient. 1. for exceedingly transparent deep waters of Baikal; 2 for pure water, after Kopclevich, 1976, IvanofF, 1978, 3-5 for different regions of the Sargasso Sea 3 after Lee, Neuimm, 1969, 4 after Matlack. 1972; 5 after Kuleshov, Karabashev, Khanaev. 1987 After Sherstyankin m Shimaraev *et a!,* 1994

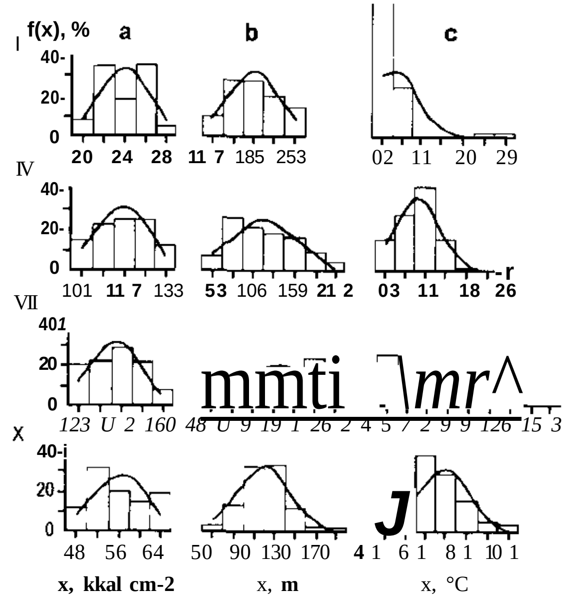


Fig I 66 Empirical distribution of sum radiation (a), water transparency (b), surface layer temperature (c), approximating their normal curves in central months of the seasons (I, IV, **VII,** X). After "'Prediction . ", 1986

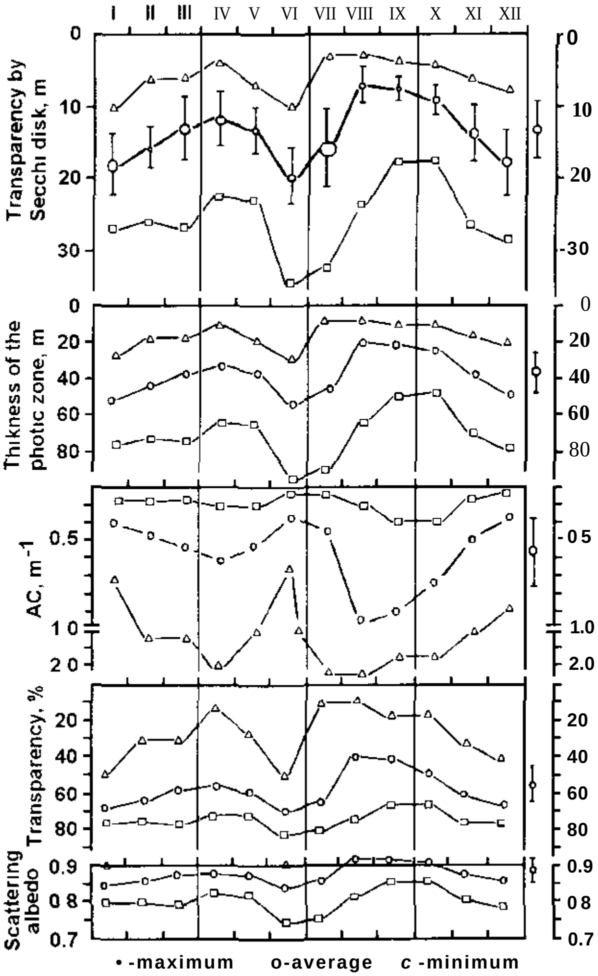


Fig I 65 Mean monthly values of transparency for deep water open regions of the lake and mean annual values (to the right), calculated from observations in 1955-1988 in the Bolshiye Koty, and also calculated thickness of photic zone, attenuation coefficient for the range of 480 nm, transparency and the probability of survival of photon in a single scattering After Sherstyankin, unpublished data observations with biologists and chemists have shown that there are significant correlations between the attenuation coefficient in the visible part of the spectrum and suspension concentration (r = 0 80-0 87), chlorophyll concentration (r - 0 77-0 73) (with a maximum near 420 nm, / *e* , near the short wavelength maximum chlorophyll maximum) (Sherstyankin *et al,* 1988) Vertical profiles of attenuation coefficient, zoo-, phyto- and microbial plankton have common features (Sherstyankin *et al* 1972), which allows a selection of samples to be carried out and their volume to be optimized It has been found that accumulations of some hydrobionts *(eg, Maciohectopm)* produce specific disturbances of attenuation coefficient, providing a method to define sizes of spatial assemblages (of the order of 50 m) of *Macrohectopus,* to trace its vertical migrations, to determine its maximum vertical rate of rise (about 4 m mm '), and its mean daytime depth (180-270 m) (Sherstyankin & Kaplin, 1973) The distribution of the attenuation coefficient and temperature in the upper (to 400 m) layers of water has shown that in periods of distinctly expressed temperature stratification (and density stratification), correlation coefficient are close to +0 9 in the period of direct, and -0 9 in the period of inverse stratification In periods close to homothermy, relationships between attenuation coefficient and temperature become weaker, and correlation coefficient decrease to 0 5-0 6 (Stepanovaef *al,* 1984)

In conclusion, we can demonstrate a close relationship between total radiation, water transparency and surface temperature distribution across an annual cycle (Fig 1 66)

1.6. Chemical environment

1 6 1 Water chemistry

The waters of Baikal are poorly mineralized soft waters of the hydrocarbonate class, Calcium group The sum of major ions is from 95 7 mg 1 ' (Vereshchagin, 1947) 96 6 mg 1 ' (Votintsev, 1961) The content of biogenic elements and organic matter is insignificant (Table 1 12)

Vereshchagin (1947) divides all compounds dissolved in water into three groups The first group comprises compounds with an even distribution at all depths throughout the year These are major ions (hydrocarbonates, sulphates chlorides, calcium, magnesium, potassium), and gaseous nitrogen and rare gases The second group consists of compounds, the concentration of which increases with depth These are carbon dioxide (Fig 1 67), phosphates (Fig 1 68), nitrates (Fig 1 69) and silica (Fig 1 70) The concentration of these compounds increases in the upper layers of water (to a depth of 50-100 m) in winter, and decreases in summer-autumn due to their utilization by phytoplankton The third group are compounds the concentration of which decreases with depth and increases in autumn-winter month (prior freezing of the lake) These compounds are oxygen (Fig 1 71) and organic matter

Table 1 13 shows average long-term concentrations of the chemical constituents of open Baikal Inter-annual changes are given in brackets For comparison, data on the chemical composition of the water of the major affluents of Baikal are also given (Table 1 14)

The average chemical composition of the water of most affluents is rather similar to that of the lake itself, but the composition of the water of some of these rivers is quite variable

The water of most affluents belongs to the hydrocarbonate-calcium-silica or even to hydrocarbonate-silica-calcium hydrochemical facies which, according to Maximovich (1948), are typical of rivers of mountainous regions in temperate climates Changes in the water of the affluents are brought about by diatoms, consuming silica In the course of a year, diatoms consume on average 240 10^3 tonnes of silicon After dying off, they carry this silica to the bottom sediments Research into the silica balance shows that mass development of diatoms, *Melosira* in particular, cannot occur in Lake Baikal every year the silica balance would be disturbed Moreover, mass development of *Melosira* does not occur throughout the lake, probably because of silica limitation (Votintsev, 1961)

Nutrients, organic matter and gasses (0_2, $C0_2$) are distributed unevenly not only across the water column, but throughout the water mass (Table 1 15, Fig 1 72) The concentrations of mineral and organic compounds of nitrogen and phosphorus are characterized by two maxima in the course of

Table 1.12 Average chemical composition of water in open Baikal and its affluents (mg l^{-1})

	Open water		*Affluents*	
	*After Vereshthagm 1949 (South Baikal)**	*After Votintsev, 1961*	*After Votintsev, 1961*	*After Bochkarev, 1959*
HCO_3	63.5	63.5	79.3	72.8
SO_4^{2-}	4.8	5.2	6.7	7.0
Cl^-	0.7	0.6-1.4	1.8	1.3
Ca^{2+}	15.2	15.2	20.0	18.0
Mg^{2+}	4.1	3.1	4.3	3.6
Na^+	3.9	3.8	$Na^+ + K^+$ 5.1	$Na^+ + K^+$ 4.6
K^+	2.3	2.0		
SiO_2	1.5-5.5	Si 1.1	4.4	–
Al	traces	traces	–	–
Mn	–	0.0015	–	–
Fe, total	–	0.028	0.28	–
NO_3	0.19-0.62	N 0.045	–	–
PO_4	0.01-0.06	P 0.024	–	–
Oxidizability, mg O_2 l^{-1}	–	1.62	4.3	–
CO_2 free	0.44-5.28	1.49	–	–
O_2	14.4-9.6	11.64	–	–
N_2	22.4-16.8	–	–	–
Sum of ions	–	93.4	117.2	–

* The first figure stands for the surface layers, the second for deep waters

a year. The annual maximum of nitrate-N is observed in January-February. Nitrite and ammonical nitrogen are almost absent from the upper zone, approximately to a depth of 500 m, and appear in very small quantities only in the period when plankton is dying-off. At great depths, especially near the bottom, ammonia nitrogen is present in somewhat greater quantities. In spring (May-June), the first vernal minimum of nitrogen and phosphorus compounds in the upper layer of water coincides with a maximum *content* of organic *forms* of nitrogen, and the vernal plankton dying-off.

The summer maximum of inorganic nitrogen and phosphorus, coinciding with a summer depression in the phytoplankton development and, likewise, with minimum concentrations of organic forms of nitrogen and phosphorus, is observed in July. It is followed by an August minimum of these nutrients, accompanied by a maximum of their organic forms during the summer phytoplankton bloom. The summer maximum of inorganic nitrogen and phosphorus is short-lived and rather weak.

The summer minimum, on the contrary, is long and results in a complete consumption of nitrate-N in the upper 10-25 m water, and in a decrease of phosphate-P down to 1-3 mg m^{-3}. This can be explained by the somewhat isolated trophogenic water layer by the thermocline. The concentration of mineral forms of nitrogen and phosphorus increases with depth, while that of organic forms decreases. Seasonal changes in the content of mineral and organic forms of nitrogen and phosphorus extend down the upper 100 m layer In that layer, maximum gradients of change in these biogenic compounds are noted. The horizontal distribution of nitrogen and phosphorus compounds across Baikal waters is rather variable. Of great importance is the shift of phenopauses in a latitudinal direction. This is exemplified by long-term data of seasonal changes of nitrogen, phosphorus and silica in south Baikal (Table 1.15), and throughout Baikal as well (Fig. 1.73).

The concentration of silica, as stated earlier, is small: in the upper water layers it averages 1.07 mg l^{-1}. At great depths, and near the bottom, it

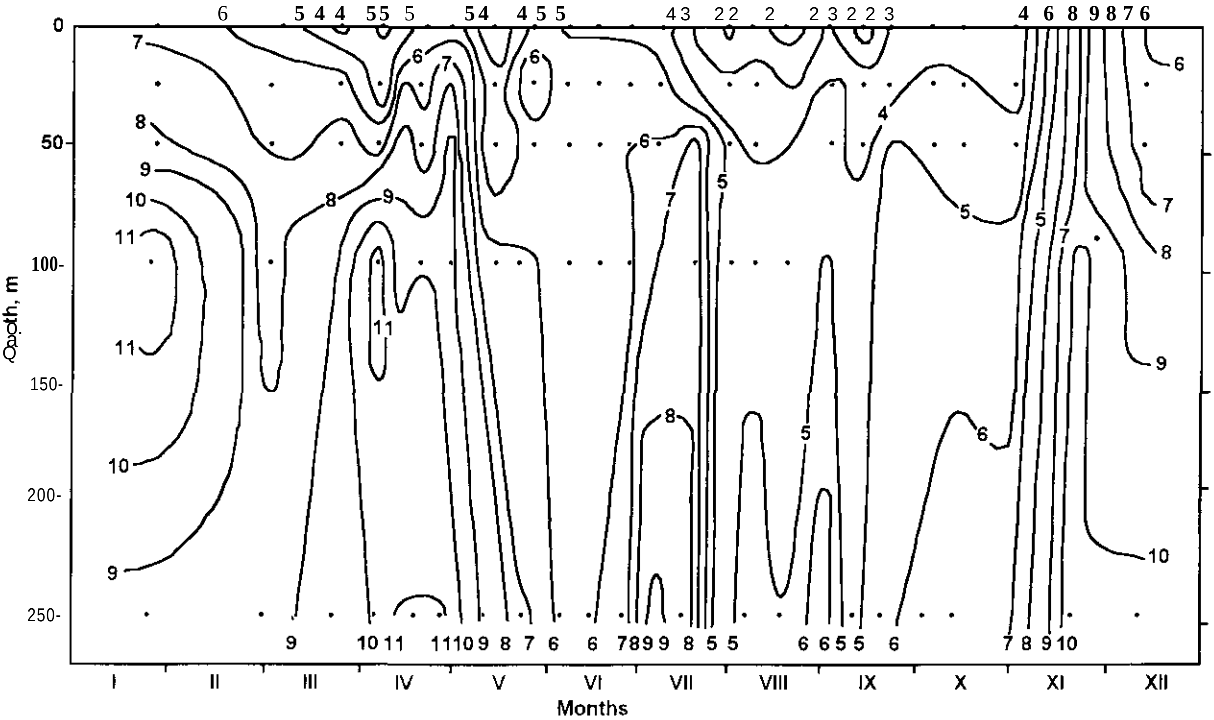


Fig 167 Seasonal dynamics of partial pressure, 10^4 atm, dissolved free CO_2 After Mizandrontsev & Mizandrontseva, 1994

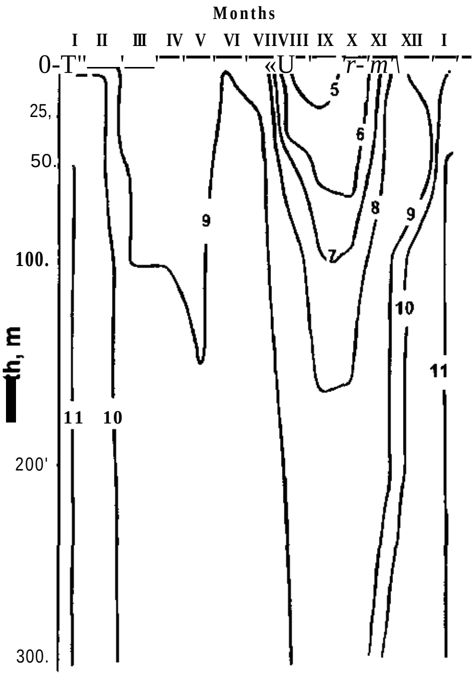


Fig 1 68 Seasonal change of phosphate-phosphorus content (mg m^{3}) in the Baikal waters Listvenichnyi settlement Average values 1950-1960 After Votintsev & Glazunov, 1963

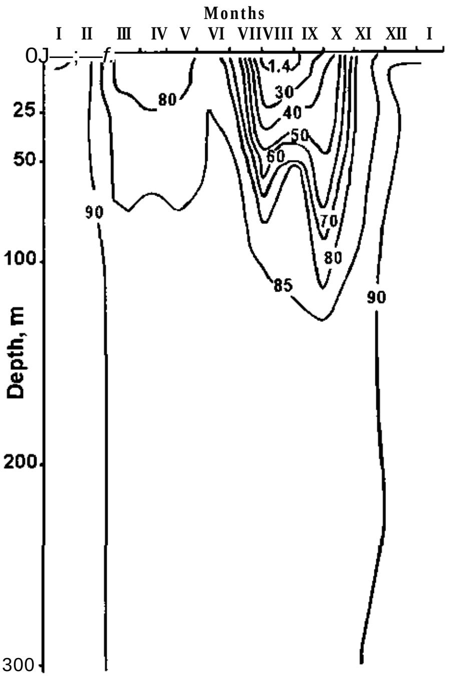


Fig 1 69 Seasonal change of nitrate-nitrogen content (mg m') in the Baikal waters Listvenichnyi settlement Average values 1950 1960 After Votintsev & Glazunov, 1963

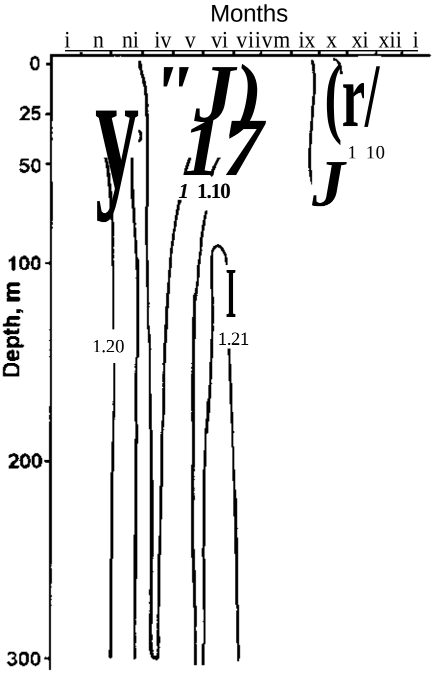


Fig 1 70 Seasonal change of silicon content (mg l^{-1}) in the Baikal waters Listvemcfmyi settlement Average values 1950-1960 After Votintse\ & Glazunov, 1963

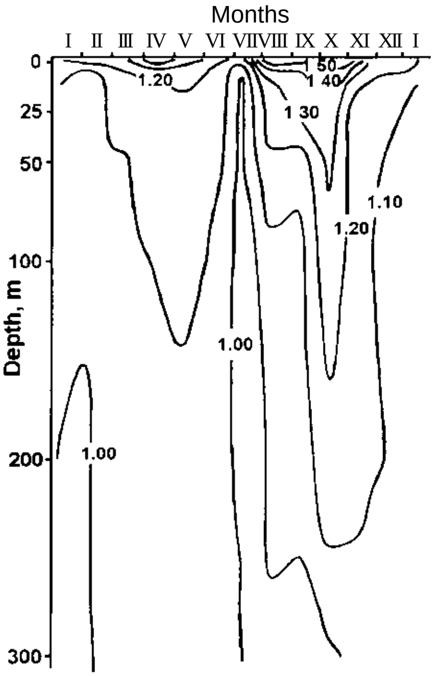


Fig I 71. Seasonal change of permanganate oxidizability values (|ig O l^{-1}) in the Baikal waters Listvemchnyi settlement Average values 1950-1960 After Votintsev & Glazunov, 1963.

reaches up to 2.5 mg l^{-1}. Its seasonal changes in the upper layers are directly dependent on the quantity of diatoms. Maximum silica is observed in winter, when diatoms are depressed. The minimum, in spring, coincides with the diatom maximum. In some years a second maximum of silica concentration is observed in September-October. This is generally less significant, sometimes absent.

The iron concentration is not higher than 0.06 mg l^{-1} (usually less), of manganese - 0.0012-0.0023 mg l^{-1}.

Iron compounds chiefly occur as colloids and suspension-oxides. Iron content is conditioned by input by affluents, which is why it is higher in autumn. In winter, it decreases to a minimum. Probably, the particulate oxides are sedimented. Seasonal changes in manganese in the upper layers are considerable. In autumn-winter it is at its maximum, after the ice break-up it decreases to 0.0014-0.0013 mg l^{-1}. In deep-waters, manganese content increases somewhat.

The concentration of organic matter near the surface is 1.0-1.6 mgC l^{1} (Fig. 1.74). There are two maxima and two minima during the year. The first minimum is observed in spring (April-May), the second, and strongest, in August.

Minima are observed in February and July. All peaks coincide with the seasonal development of phytoplankton. With increasing depth, organic matter content decreases (Table 1.16), but this decrease is small, which testifies to a rather intensive destruction of organic matter in the upper layers. Throughout the water mass of the lake, the content of organic matter differs very little (20-25%). Interannual changes, likewise, are small. The ratio of permanganate oxidizability to bichromatic is 40% on average, indicating a predominance of oxidation-resistant organic compounds. The organic matter entering into Baikal during the year is subject to a 70-75% destruction.

The remaining fraction is decomposed in the following five to six years. Hence, accumulation of organic matter in the water column does not occur, and its content remains stable (Votintsev, 1983).

Calculations have shown that in the weakly-mineralized Baikal water only K^+, Na^+ and Cl^- do not combine into complexes, whereas all other elements form combinations of the ion-pair type

Table 1 13 Changes in the chemical composition of the water of south Baikal with increase in depth (mg 1 '), midsummer After Vercshchagin, 1949

Depth m	0 ,	*Free* CO_2	*Oxidizability*	SIOJ^2	NO,	POf	*Free* N_2	HCOj	**so/**	***a***
0	12 44	2 6	1 11	1 60	0 30	0 031	17 27	63 9	5 18	0 78
100	11 35	2 9	1 03	2 42	0 31	0 025	20 05	63 9	5 27	0 78
200	11 32	3 0	0 87	2 73	0 43	0 034	20 08	63 9	5 46	0 71
300	11 24	3 0	0 89	3 64	0 44	0 037	-	64 1	5 37	0 71
400	11 01	3 3	0 91	3 11	0 40	0 039	20 27	63 7	5 27	0 71
500	10 71	3 9	0 96	3 64	0 38	0 042	20 30	63 3	5 66	0 75
600	10 55	3 7	0 77	4 10	0 46	0 047	-	63 7	5 46	0 68
700	10 44	3 8	0 79	4 95	0 46	0 049	20 30	63 5	5 18	0 64
800	10 31	3 9	0 78	5 09	0 46	0 049	20 30	63 7	4 90	0 78
900	10 27	4 2	0 79	5 00	0 47	0 049	20 30	63 5	5 09	0 82
1,000	10 20	4 1	0 90	5 09	0 47	0 049		63 5	5 27	0 75
1,100	10 18	4 2	0 87	5 61	0 49	0 062	-	63 1	5 46	0 71
1,200	10 16	4 2	1 00	5 40	0 52	0 06!	20 30	63 8	S 56	0 75
1,300	10 12	4 2	0 68	4 78	0 53	0 062	20 30	63 7	5 56	0 75
1,400	10 10	4 3	0 75	5 40	0 54	0 063	20 24	63 4	5 27	0 71

Table 1 14 Average (weighted by drainage) chemical composition of the waters of the major affluents of Baikal (mg l^{-1}) After Votintsev *et al*, 1965

Affluent	HCO_3	SO_4^{2-}	Cl	NO_3	PO_4^{3-}	Ca^{2+}	Mg^{2+}	$Na^+ + K^+$	*OM*	*Fe*	SiO_2	*Total sum*
Selenga	88 67	6 50	[illegible] 23	0 43	0 040	20 69	4 55	5 17	10 62	0 89	11 58	127
Upper Angara	[illegible]	[illegible]	[illegible] 27	[illegible] 20	[illegible]	14 90	[illegible]	[illegible] 65	[illegible] 04	[illegible] 15	[illegible] 41	81
Barguzin	[illegible]	[illegible]	[illegible] 06	[illegible] 39	[illegible]	24 05	[illegible]	[illegible] 52	[illegible] 14	[illegible] 30	[illegible] 13	131
Turka	[illegible]	[illegible]	[illegible] 62	[illegible] 54	[illegible]	8 55	[illegible]	[illegible] 27	[illegible] 48	[illegible] 23	[illegible] 96	54
Snezhnaya	[illegible]	[illegible]	[illegible] 10	[illegible] 63	[illegible]	8 89	[illegible]	[illegible] 12	[illegible] 11	[illegible] 34	[illegible] 86	48
Tyya	[illegible]	[illegible]	[illegible] 42	[illegible] 32	[illegible]	11 09	[illegible]	[illegible] 30	[illegible] 92	[illegible] 02	[illegible] 89	67
Tompuda	[illegible]	[illegible]	[illegible] 49	0 68	[illegible]	20 82	[illegible]	[illegible] 67	[illegible] 41	[illegible] 09	[illegible] 41	107
Khara-Murin	[illegible]	[illegible]	0 18	[illegible]	[illegible]	4 72	[illegible]	[illegible]	7 70	0 04	8 37	31
Utulik	[illegible]	[illegible]	0 13	[illegible]	[illegible]	11 45	[illegible]	[illegible]	5 92	0 03	9 22	66
Rel	[illegible]	[illegible]	0 14	[illegible]	[illegible]	2 50	[illegible]	[illegible]	5 02	0 13	5 49	20
Goloustnaya	8[illegible] 28	[illegible]	0 66	0 25	[illegible]	19 69	[illegible]	[illegible]	13 73	[illegible]	9 87	126
Manturikha	4[illegible] 68	[illegible]	0 29	0 11	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0 18	13 30	[illegible]
Sarma	5[illegible] 04	[illegible]	0 58	0 55	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0 18	8 98	[illegible]
Bol Buguldeika	199 35	[illegible] 73	[illegible]	0 72	0 050	[illegible]	[illegible]	[illegible]	10 83	0 35	10 24	[illegible]
Bol Sukhaya	38 98	[illegible]	[illegible]	0 35	0 044	[illegible]	[illegible]	[illegible]	4 32	0 04	[illegible]	[illegible]
Mysovaya	36 61	[illegible]	[illegible]	0 27	0 020	[illegible]	[illegible]	[illegible]	5 63	[illegible]	[illegible]	[illegible]
Pe[illegible]naya	34 15	3 41	[illegible]	0 53	0 106	[illegible]	[illegible]	[illegible]	14 96	[illegible]	13 22	[illegible]
O[illegible]ivsha	61 58	4 37	[illegible]	0 29	0 035	[illegible]	[illegible]	[illegible]	9 10	0 10	12 86	[illegible]
Average of 18 affluents	75 78	5 93	0 90	0 41	0 036	18 39	3 53	4 37	8 82	0 59	9 98	109
Average of all affluents	74 60	5 98	0 78	0 37	0 05	18 18	3 23	4 66	9 59	0 48	10 30	107 9

Note OM - organic matter

Table 1 15 Average long term content (mg m"^{3}) of nitrate-N, phosphate-P and silica in the waters of south Baikal (1950-1960) Middle *of* the lake opposite Berezovsky Cape After Votintsev & Glazunov, 1963

Months	*Depth, m*	*Nitrate-N*	*Phosphate-P*	*Silicon*
I	0	88	106	1130
	50	95	11 3	1140
	100	95	11 3	1140
	300	97	1! 4	1150
II	0	95	106	1190
	50	97	11 3	1210
	100	**102**	11 0	1300
	300	**104**	11 3	1300
III	0	63	8 3	1120
	50	77	96	1180
	100	81	99	1000
	300	*86*	10.2	1000
IV	0	66	94	1120
	50	77	94	940
	100	81	97	980
	300	*$6*	99	1020
V	0	61	85	980
	50	61	8.5	980
	100	*84*	96	980
	300	88	100	1020
VI	0	72	9.5	990
	50	79	108	1120
	100	79	10 9	1230
	300	90	12 1	1060
VII	0	63	89	1160
	50	79	10 0	1130
	100	81	10 1	1080
	300	84	11.5	1190
VIII	0	14	45	1140
	50	52	7.0	1180
	100	77	8 8	1180
	300	81	99	1190
IX	0	27	5 6	1140
	50	52	7 0	1140
	100	77	8 8	1180
	300	81	94	1200
X	0	34	5 2	1150
	50	50	72	1060
	100	**34**	72	1150
	300	86	84	1190
XI	0	68	7 6	1110
	50	66	8 2	1120
	100	79	95	1130
	300	88	94	1150
XII	0	86	103	1190
	50	88	106	1190
	100	93	11 1	1160
	300	93	10 8	1160

(Tables 1.17,1.18). Al, Fe and Mn are completely bound; Ca^{2}~ and Mg^{2}* are bound to 85.8 and 99.5%, respectively.

An equilibrium model of Baikalian water does change conceptions about the state of solution of one of the major anions, SO_4^{2}", which occurs primarily not as a negatively-changed radical, but reacts with the calcium cation to form the neutral molecule $CaSO_4^0$, in which more than 96% of all dissolved sulphur is bound. Dissolved carbon - 92% - is represented by HCO_3'; about 5% of its total concentration is CO_2°, 1% is HCO_3 and only 0.4% is free anion CO_3^{2}\

The degree of complexity increases somewhat with temperature, but relationships between dissolved components do not change much (Table 1.18). Attention is drawn to over-saturation of Baikalian water with Fe and Mn, which are precipitated as goethite and pyrolusite. Moreover, part of Fe together with Al, Si and a small quantity of alkaline and earth-alkali elements form autogenic smectites, whose composition depends on temperature conditions.

At the low temperature (4°C) typical of the major mass of Baikalian water, different ferriferous montmonllonites are formed, with a stoichiometric formula K_{024g} $Na_{00\%}$ $Ca_{0\,009}$ $Mg_{0\,009}$ Al_{Jm} Si_{3g44} $Fe_{024||}$ $O_{10}(OH)_2$. When warming up to 20°C, secondary layerlatice-silicates of a hydromica type are formed, K_{0437} Na_{Q066} Ca_{0009} Mg_{0OO9} Al_{2163} Si_{3727} $Fe_{002|}$ $O_{|0}(OH)_2$ with a small content of Fe, precipitated primarily in the form of a hydroxide.

Apatite is another solid phase, crystallizing directly from solution; in the mineral skeleton of apatite more than 97% of the chemically precipitated calcium is *bound. In* a *closed* system *of* Baikal water without contact with the atmosphere, the existing chemical equilibrium is disrupted and there is additional precipitation of smectites which do not contain ferrum, of the composition: $K_{0\,3()7}$ Na 0 103 Ca 0 0 1 *U%0(>1* Al 2 105 *Si 3S08* $O_{,0}(OH)_2$. Thus, the annual total excess of elements is precipitated in the form of autogenic layer lattice silicates, apatite, hydroxides of Fe and Mn. Thus, a stationary chemical composition of Baikal water is ensured. An imbalance between the annual residue and the quantity of newly-formed minerals is due to the existence of additional sources of input of dissolved matter into the lake, which might be underground inflow and bottom discharge.

Underground inflow into Baikal is estimated at *3.15-3.78 km^{3} year*' (Afanasyev & *Didenko,* 1976), and its average mineralization is about 0.2

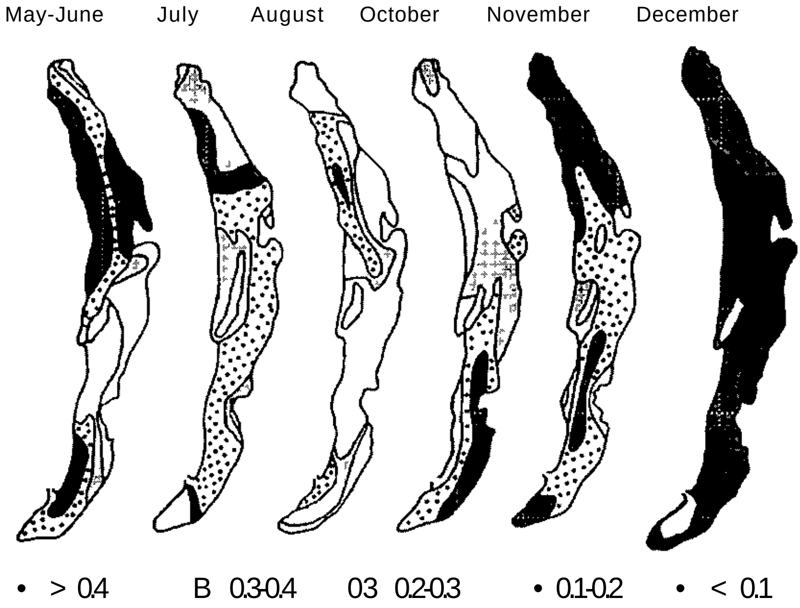


Fig I 72 Distribution of nitrates (mg l ') in the surface layer of Baikal After Votintsev *et a!*, 1975

Fig 1 73 Seasonal changes in the content of N P, Si in the open waters South Baikal, Bolshiye Koty 1948-1950 After Votintsev, 1952a

Table 1 16 Mean annual values of permanganate oxidizability (PO), bichromatic oxidizability (BO), biochemical oxvgen demand in 5 days (BOD) (mg 1 ') in the Bolshiye Koty area After Votintsev, 1961

Depth m	*1948*		*BOD*	*1955*		*average 1948 1955*	
	PO	*BO*		*PO*	*BO*	*PO*	*BO*
0	1 99	4 65	1 73	1 77	461	1 88	4 63
5	1 90	4 75	-	-	461	1 86	4 68
10	1 74	4 83	-	-	4 02	1 74	4 42
25	1 74	5 12	1 56	1 38	4 02	1 56	4 12
50	1 53	4 59	1 41	1 32	3 78	1 43	4 18
100	1 56	4 06	1 40	1 24	3 68	1 40	3 86
250	1 46	4 36	1 32	1 18	3 57	1 32	3 96
500	1 09	4 47	1 06	1 03	3 62	1 06	-
750	1 03	3 98	-	-	-	1 03	-
1000	1 03	3 41	-	0 74	-	0 88	-
1200	0 80	3 52	_	_	_	0 75	_

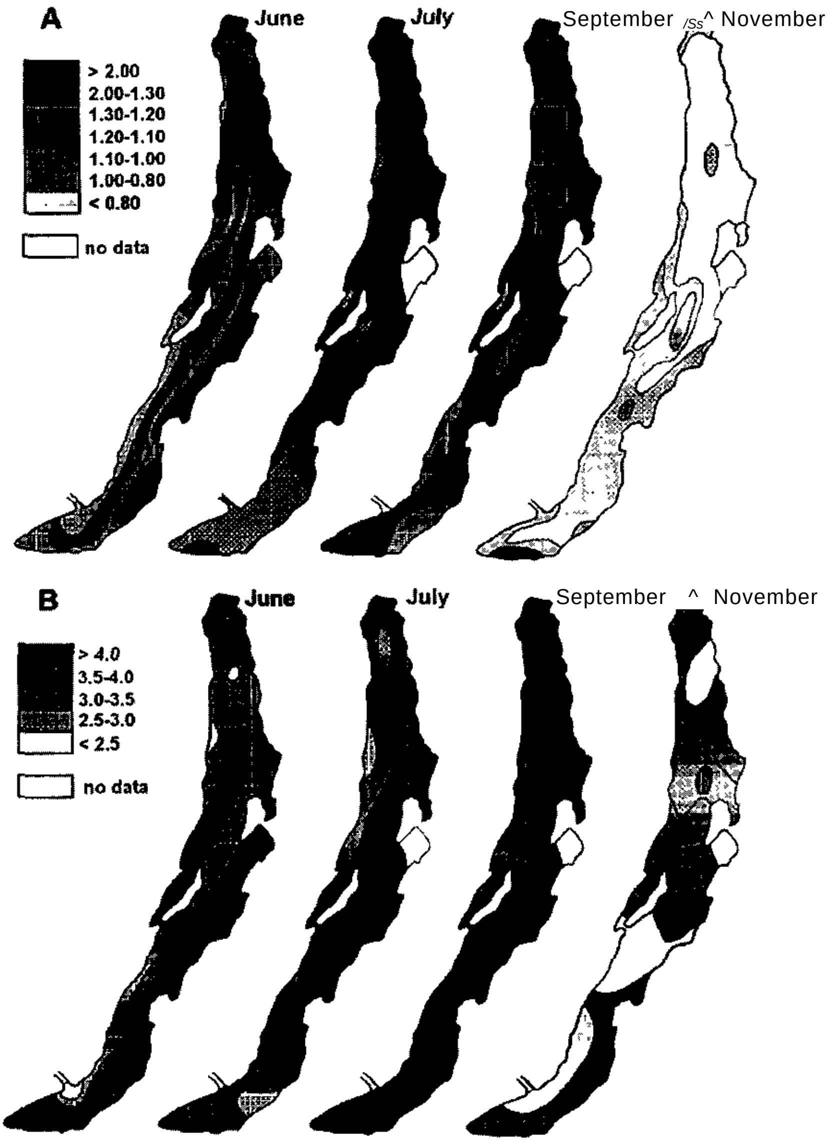


Fig. 1.74. Horizontal distribution of the values of permanganate (A) and bichromate (B) oxidizability in the surface layer of Baikal, 1978, mgO 1 '. After Votintsev in: Atlas of Baikal, 1993.

g $1''^{J}$ (Pisarsky, 1987). Hence, this means an annual entry of 6.3 10^{M} to 7.56 10'' of dissolved matter. Submarine inflow adds approximately another 3.15 10^{9} g year^{1}, and the remainder of the imbalance is made up for by chemical interactions between river suspension input to the lake and weakly-mineralized Baikalian water.

Kashik & Mazilov (1991) point out that the above hydrochemical analysis gives only an approximate idea of the content of its major elements. They developed an extended balance model of Baikal waters using relationships of ion pairs, formation of complexes and chemical precipitation of a part of the elements (Table 1.19).

1.6.2. Oxygen regime

The gaseous regime of Baikal is stable and favourable for life at all depths. The oxygen content, like the organic matter content, decreases slowly with

Table I 17 Chemical balance of elements in Lake Baikal After Kashik & Mazilov, 1991

Component	*Annual reiddue in Baikal After Votintsev et al, 1965 W"g*	*Precipitates chemically in Baikal 10" g*
K	0 0711	6.070
Na	0 229	1.376
Ca	1 570	9 468
Mg	0 600	0 151
Al	0 059	31.0
Si	7 92	67 36
Mn	0 0021	0.576
Fe	0 553	9 084
P	0 024	4 28
Total	11 0282	129.365

depth. In the upper layers its content averages 11.7-11.9 mg 1'", at 1400 m it is still 9.9-10.6 mg l"^{1}, and at a depth of 1600 m, it decreases to 9.5 mg I"^{1}.

It is of interest to note that maximum concentration of oxygen in the upper 50-70 m layer is observed in winter, increasing from January to March. This can be explained by the early bloom of phytoplankton in February (Figs. 1.75, 1.76).

Yearly mixing of water embraces all depths, down to the very bottom. It is especially intense in spring and during late autumn-winter homothermy, when the mesothermic maximum, located at 250-300 m tends to be destroyed, and free water exchange takes place throughout the water column (Votintsev, 1983).

There are distinct zones in the vertical distribution of oxygen in Baikal.

The first or photosynthetic zone, stretches from the lake surface to 5-10 m in winter (ice period), and to 70-80 m in summer It includes two upper sub-zones (Vereshchagin, 1936), the sub-zone of wave mixing, and the sub-zone of diurnal convection. The characteristic feature of this zone is a regular diurnal fluctuation in dissolved oxygen content due to phytoplankton photosynthesis, and sharp seasonal fluctuations in absolute values of its content (Fig. 1.77, A). The amount of dissolved oxygen in this zone is usually near saturation (87-98% of saturation). At maximum development of phytoplankton in spring and summer, a weak oversaturation is observed - up to 107-115%. In winter (ice period) and in *Melosira-poor* years, the oxygen content diminishes with depth. This decrease is small, though, and does not exceed 0.5 mg l"^{1} within the 25-50 m limits. In *Melosira-rich* years,

Table 1 IS Chemical balance of Baikal, 10^{3,} Tonnes year^1 After Votintsev, 1978

Source	*Supph*				*Loss*	*Remains in Baikal*	*Ren tains in Bai kal (in % of the input)*
	18 major rivers	*Rest of affluents*	*Precipitation over Baikal*	*Total*	*Outflow of the Angara*		
$HC0_3$-	3539	1004	53	4596	4051	545	12
$s0_4^{2}$-	277	87	9	373	255	118	32
Cl	42.2	5.4	0.9	48.5	25.8	22.7	47
N03-	19 2	3 6	5.5	28 3	18 3	100	35
p<V	1 68	1 86	0.40	3 94	1 57	2 37	60
cJ^+	859	248	18	1125	1007	118	10
Mg^{2+}	165	32	1	198	138	60	30
Na^++K^+	204	80	4	288	258	30	10
Organic matter	412	172	24	608	148	460	76
Fe total	27 7	1 8	—	29 5	0 6	28.9	98
$Si0_2$	466	161	4	631	136	495	78
ions sum	5107	1462	92	6661	5755	906	14
Total mineralization	6013	1796	120	7929	6039	1890	24

Table 1 19 Physico-chemical models of Baikalian water. After Kashik & Mazilov, 1991

Compo- nent	*Average composition according to Votintsev (1961), mol /-'*	*Equilibrium composition*				
		Open system				*Closed system*
		t=3 8° C	*t=10° C*	*t=15° C*	*1=20° C*	*1=4° C*
K$^+$	5.115·10 ^{s}	5.045-10'^{5}	5 032 lO"^{5}	5 021 10 ^{5}	5 Oil 10'^{5}	5 029-10 ^{5}
Na$^+$	1 652 10-^{4}	1.649 10^{4}	1.649 10-^{4}	1 649 lO"^{4}	1 648 lO'^{4}	1 648 lO"^{4}
Ca^{2t}	3 792 ID"^{4}	3 236 lO"^{4}	3 226 10^{4}	3.215-10"^{4}	3201 10^{4}	3 236 10"^{4}
CaHCOf		1 148 10'^{6}	1 184-10"^{6}	2 404 JO"	3 104 10^{6}	1 184-10^{6}
CaC0$_3$°		1 155 10^{6}	1 155 10^{6}	2 428 10-6	3.295 10'^{6}	1 150 10 ^{6}
Mg^{2+}	1 275 10'^{4}	1.268 10"^{4}	1 268 10^{4}	1 265 lO"^{4}	1 262 10 ^{4}	1 268 lO'^{4}
MgHC0$_3$~		3,953-10 ^{7}	3 953 10"^{7}	5 692 10 ^{7}	6 490 JO"^{7}	3 954 10 ^{7}
MgC0$_3$°		2 066 lO'^{7}	2 066 10 ^{7}	3 957-10"^{7}	5 154 10^{7}	2 058 lO"^{7}
Al(OH),^{0}	5 189 10^{6}	6 72 lO"^{9}	6 72 10 ^{9}	1 342-10-^{9}	1.862-10^{9}	8 218-10'^{q}
Al(OH)$_4$"		4 145 10°	4 145 10"^{9}	1 458 10 ^{9}	2 580-10'^{9}	5 053 10 ^{9}
H$_4$Si0$_4$°	3 795 10'^{5}	2 695 10 ^{5}	2 695 10 ^{5}	2 829 lO'^{5}	2 843-10'	2 695-10-'
H,Si0$_4$		1 773 lO"^{7}	1 773 10^{7}	4 552-10'^{7}	6581 10^{7}	1 781-10"^{7}
MnOH$^+$	4 732 10 ^{s}	1 699 10 "	1 699 10"^{11}	2 426 10 ^{n}	2,790 lO'^{11}	1 762-10"
Fe(OH),^{0}	7.341 tO"^{7}	5.688 lO"^{12}	5 688 10 ^{12}	1 210 10"^{12}	1 740 10 ^{12}	4 430 lO"^{12}
CaS0$_4$°'		5.212-10°	5 212-10-'	5 175 10'	5 158 10^{s}	5 212·10 ^{5}
S0$_4$^{2}-	5 413·10 ^{5}	1 995 10 ^{6}	1 995- lO'^{6}	2 366-10^{6}	2.529- lO"^{6}	1 995 10'^{6}
H$_2$C0$_3$°		1 430 10"^{5}	1 430 10'	1 239 10'^{5}	1 152 10^{5}	1 435-10"^{5}
HC0$_3$"	1 17 10^{J}	1.085-10^{1}	1.085 10'^{3}	1 071 10 *	1 063 10'	1 084 10 ^{1}
C0$_3$^{2}-		4623-10^{6}	4 623 10"^{6}	7 987 10"	9 891 10'^{6}	4 606 10 ^{6}
Cr	1 692-10"^{5}	1 692 10"^{s}	1 692 10 $^{;}$	1 692-10°"	1 692-10-	1 692-10'^{5}
N0$_3$"	6.451-10 ^{6}	2 787 10^{6}	2 787 10'^{6}	4 028 10 ^{6}	4.691-10"^{6}	2 740-10-^{6}
O$_2$°	3.75-10"^{4}	4 246 lO"^{4}	4 246 10 ^{4}	3 198 10'^{4}	2.865-10^{4}	4 220-10"^{4}
N$_2$°	1 4-10-^{3}	6 254-10-^{4}	6 254 lO"^{4}	6 005 10 ^{4}	5 524 10 ^{4}	6 183 lO'^{4}
C0$_2$°	6.4-10"^{4}	6.259 lO"^{5}	6 259 10 ^{5}	1 665 10°	1.267-10 ^{5}	6 280 10"^{5}
Eh			0 800	0 762	0 744	0.800
pH	7 4-8 1		8 17	8 25	8 29	8.17

such as 1950, the numerical density of *Melosira* remained low in January-March, and its biomass in the 0-25 m layer did not exceed 0.26 g m"^{3}. Changes in oxygen content within the upper 25 m remained low, 0.2-0.3 mg l"^{1}, oxygen as well. But at the beginning of April, *Melosira* developed heavily in the upper 25-m zone, and a sharp rise in dissolved oxygen, up to 0.9-1.0 mg l"^{1}, occurred, with some decrease at the 25-50 m depths. By the middle of April, the *Melosira* biomass reached 2.5 g m"^{3}, which resulted in an increase in oxygen content in the 25-m zone of from 12.2 mg I"^{1} (3 April) to 13.6 mg l^{1} (20 April).

Diurnal fluctuations in oxygen content in January-February are only measurable in the upper 5-m layer and are weakly expressed (Fig. 1.77, B). During spring, phytoplankton blooms, and the amplitude of diurnal fluctuations in oxygen content rises from March onwards. In *Melosira-rich* years the diurnal changes of oxygen in April to early June become significant and extend down to 25-50 m (Fig. 1.78, A,B)- In July, diurnal changes are manifest down to 10-15 m. In August, in the period of summer algae, they are felt down to 50 and even 60-70 m. From the beginning of September, diurnal changes become weak and restricted to the 10-15 m zone.

The second zone, that of seasonal fluctuations in dissolved oxygen content, embraces depths to 250-300 m. It corresponds to the sub-zone of seasonal convection according to Vereshchagin (1936). The characteristic feature of this zone is the presence of only seasonal fluctuations in dissolved oxygen content. Diurnal changes are absent since photosynthesis does not occur here.

On the vertical, there is some decrease in dissolved oxygen, usually not more than 0.5 mg l"^{1} oxygen per 100 m depth. In spring and during

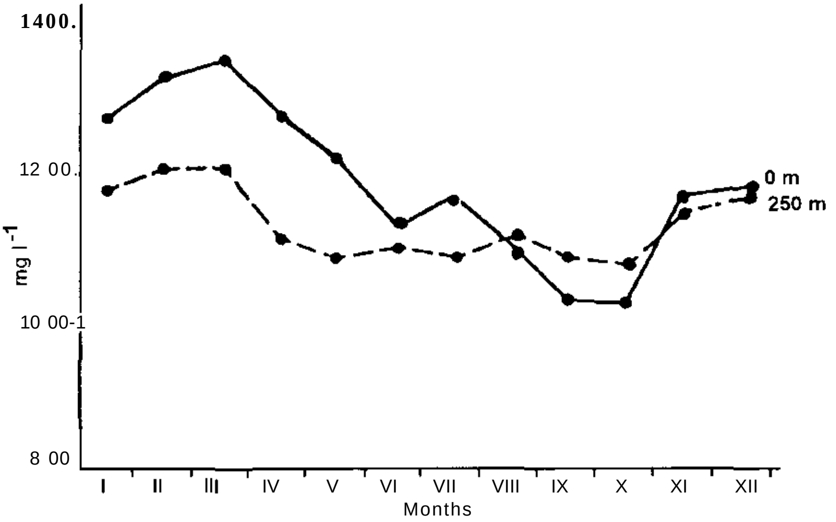


Fig I 75 Seasonal changes in the oxygen content in the waters of Baikal Bolshiye Koty 1948-1951 After Votintsev, 1961

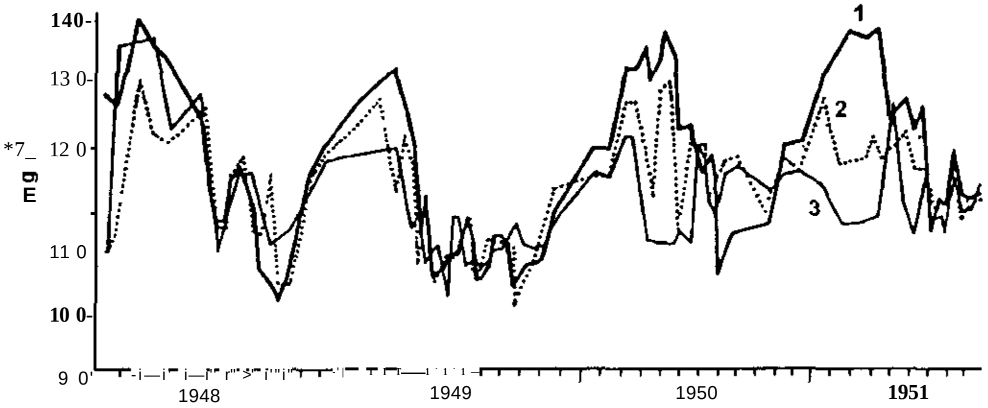


Fig 1 76 Annual and seasonal changes in oxygen content in the open waters of Baikal Bolshiye Koty 1948-1951 1 on the surface, 2 at 50 m 3 at 250 m After Votintsev 1961

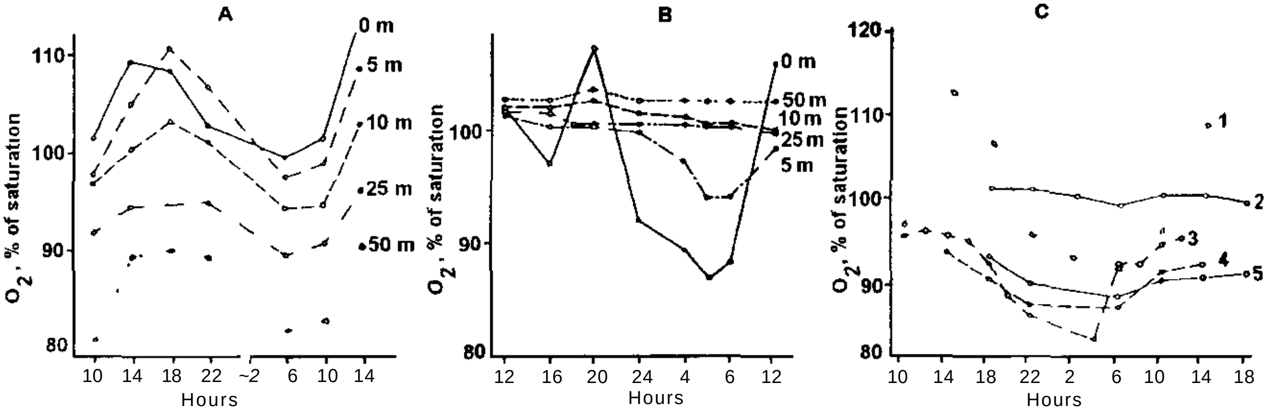


Fig 1 77 Diurnal changes in the oxygen content {% of saturation) in the waters of Baikal Bolshiye Koty A pelagial, 19-20 VIII 1948, B pelagial 22-23 IV 1953, C littoral, 1948 1 July, 2 February, 3 March, 4 December, 5 April After Votintsev, 1961

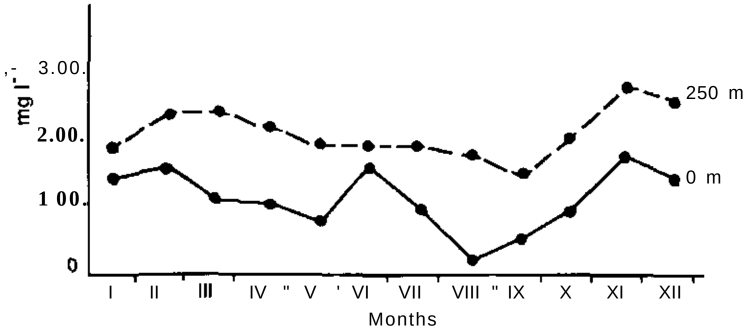


Fig I 78 Seasonal changes in free C0$_2$ content in the waters of Baikal Bolshiye Koty. 1948-1950 After Votintse\, 1961

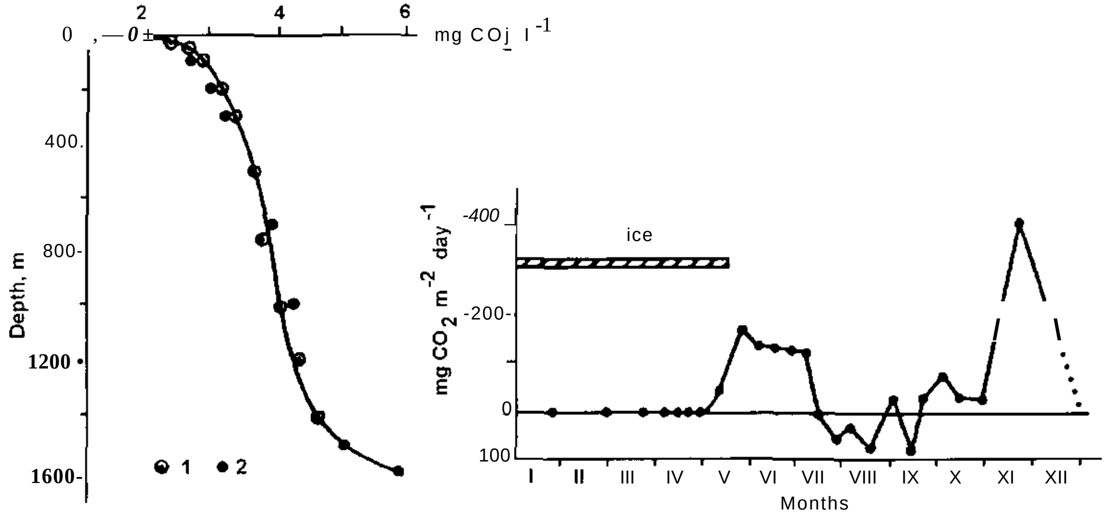


Fig I 79 Yearly average distribution of free CO-$_2$ in the water thickness in open Baikal (I Berezovy-Tankhoi. south Baikal, 2. Ukhan-Turka. middle Baikal) and seasonal changes of the CO$_2$ free flux through the surface of Baikal After Mizandrontsev & Mizandrontseva, 1994

autumn homothermy, the oxygen content is evened up across the whole zone.

Finally, the third or deepwater zone extends from lower surface of the zone of mesothermic maximum down to the bottom. Regular fluctuations in oxygen content, both diurnal and seasonal, are absent. The changes observed here are due to the presence of the zone of mesothermic maximum and its destruction during homothermy.

The free C0$_2$ content in the waters of Baikal is not high. In surface water, it is 1.5-1.7 mg l"^{1} (Figs. 1.78,1.79), at maximum depths it increases to 4.3-4.6 mg 1 '. Despite, this low content of C0$_2$, and thanks to its low general mineralization and a low content of hydrocarbonates, the waters of Baikal contain small amounts of aggressive CO.$_2$ (1.0-1.5 mg l"^{1}) during the greater part of the year. Only in August, and sometimes in September, do the waters lose this aggressive property. Because of their low mineralization the waters of Baikal also possess leaching aggression. As a result of this, the bottom sediments do not contain carbonates, and shells of dead invertebrates quickly decalcify, retaining only chitin. It should be added that the waters of Baikal have a corrosive action on iron and steel constructions. In view of its low free C0$_2$ content and low mineralization, the hydrogen ion concentration in the waters of Baikal lies in the neutral-alkaline zone, within the range of 7.0-8 5 pH units. pH decreases with depth. Maximum values in the surface layers of the water are observed in September, and sometimes in spring (May).

The oxygen regime of the littoral zone of Baikal is characterized by sharp fluctuations During daytime it reaches 13-14 mg 1 ' Under wave disturbance it decreases quickly, becoming equal with that of neighbouring open Baikal At night, oxygen here decreases to 10 or even 9 0 mg 1 ' (Fig 1 78, C)

The free CO_2 of the littoral and even in the surface layers of open Baikal during daytime is completely consumed by phytoplankton and bottom macrophytes In the water monocarbonates appear (up to 5-7 mg 1 '), and in the littoral these amount to 10 mg I '

pH in the littoral during daytime may increases to 9 0-10 5 in calm weather At night, it decreases and it $C0_2$ is completely depleted, it again increases The waters of most affluents are poor in minerals (Table 1 14) and have been divided into five groups (Votmtsev, 1978) The River Buguldeika is heavily mineralized - above 300 mg 1 ' The largest affluent of Baikal, the River Selenga, is less mineralized, (150 mg 1 ' on average) In winter, an increase to 180-200 mg 1 ' occurs Only the River Rel has a mineralization below 30 mg I^{l}

Most affluents of south Baikal rising on the slopes of the Khamar-Daban Range, and the affluents of the north-western coast flowing from the north Baikal highland have a mineralization of 50 to 120 mg 1 ' The waters of the sors and shallow parts of sheltered gulfs and bays show increased contents of silica, calcium, bicarbonates, and other components, particularly in winter (ice period) (Table 1 20) Thus, the waters of Proval Gulf, into which the Severnaya River flows, has an increased content of hydrocarbonates, calcium, silica and other components in its internal part The water of Mukhor Gulf (the southern extremity of the Maloye More) is high in chlorides, calcium, bicarbonates The water of its internal part has an increased content of silica but, compared to the Maloye More, a lower calcium content This is because this part of the gulf is influenced by the River Kuchelga, which has a different chemical composition

The North-Baikahan Sor, affected by the waters of the Upper Angara and Kichera, is characterized by a lesser content of bicarbonates and calcium

The large gulfs of Baikal - Barguzin and Chivyrkui - in the regions adjacent to the inflow of the rivers, likewise show some differences due to the impact of these rivers The waters of the external parts of the gulfs, under the impact of the waters of open Baikal, are close to the waters of Baikal in chemical composition

The chemical composition of the waters of the Selenga Shallows is greatly affected by the waters of the Selenga River Depending on wind direction currents and water drainage the influence of Selenga water may be traced up to the west coast of the lake (Fig 1 80)

The zone located directly over the bottom, *i e*, a layer of water approximately I m from the bottom, has an ionic composition practically identical to that of the deep-water zone An insignificant increase in bicarbonate content by I 5-2 0 mg 1 ', and in calcium - by 0 5 mg 1 ', is possible The oxygen content decreases markedly, the CO_2 content rises There is a marked increase in phosphate-P and mtrate-N (by 2-4 times) as well as of silica, iron and oxidizability Ammoma-N is detected here more often than in the zone above

Finally, in regions with silty sediments, there is a zone of pore waters, heavily enriched in iron, silica and organic matter Their oxygen content drops sharply to analytical zero after the first cm of silt Free $C0_2$, however, rises sharply The appearance of hydrogen-sulphide is possible The content of nitrate-N, phosphate-P, silica, iron, manganese and organic matter increases by 2-8 times or more In pore waters of sandy bottoms and in coarse-aleunte silts, no such great increases occur These are typical of regions with a high content of organic detritus Having analyzed the dynamics of the major components of Baikal water, the next step is to consider its chemical balance Baikal filled up with the waters of its affluents in a short (in terms of geology) period of time, estimated at about four hundred years Intense horizontal and vertical water exchange prevents relict waters from being preserved even at the greatest depths of the lake

Mixing accounts for the homogeneous distribution of most chemical compounds in space and time, and the stability of their concentration This is facilitated by the similarity in mean chemical composition of the lake waters and the waters of its feeding rivers Only the pre-estuary regions of some big affluents such as the Selenga, Barguzin,

Table 1 20 Chemical composition of the waters of bays and sors of Baikal, mg 1"\ July 1955 After Votintsev, 1961

Sites of sampling	*pH*	*Fiee CO,*	*0_2*	*HCO_i*	**SO/-**	**Or**	*Ca-²'*	*Si*
Olkhonskye Vorota Strait	8 3	no	8 50	67 3	5 5	1 2	165	1.27
Maloye More, middle of the lake at Ugungoi Island	8.3	no	8 11	67 3	5.6	09	165	0 90
Mukhor Gulf, external part	8 1	no	9 37	68 4	5 8	2 5	27 8	0 84
The same, internal part	7 6	no	7 36	61.8	68	40	12 8	1 20
Barguzin Gulf, region of Kultuk	78	0 34	9.91	63 7	5 8	1 3	19.1	1 80
The same, at Maximikha	7 7	0 56	11 06	68 1	5 5	1 0	15 9	1 48
Chivyrkui Gulf. internal part	8 2	no	8 94	68 2	5.6	1 2	16 8	1.10
The same, external part of Svyatoi Nos	7 7	0 76	7 70	67 1	5 7	1.1	17 0	1 10
Proval Gulf, internal part	8 8	0 36	8 28	1168	-	10 8	22.1	4.16
The same, at Oblomovskaya inrush	8.1	0 40	10 40	107 3	-	5.4	19 1	2 10
Posolsky Sor. near Bolshaya River estuary	7 6	3 08	9 04	36 1	-	1.5	11.8	5.60
The same, opposite to inrush into Baikal	76	I 80	6 90	29 0	-	1 5	9.3	4 30
Anga Bay, internal part	84	-	11 53	106 8	-	07	162	7 23
The same. external part	82	1 36	10 60	72 2	-	06	164	1 77
Severobaikalsky Sor	74	2 70	9 14	33 0	—	—	78	2 30

and Upper Angara, are under the impact of their waters and have shown a spatial distribution of some chemicals (Votintsev, 1960).

The intensity of the destruction of organic matter is responsible for the stability of the concentration of organic matter across long-term observations under distinct seasonal variations, connected with the biological activities of aquatic organisms. Considerable latitudinal differences, resulting in a shift of phenopauses of biological processes throughout the lake also play a role (Votintsev *et al.* 1975).

These data should be kept in mind when considering the chemical balance of Baikal, its changes in time and prognosis for the future. The balance of the major components of the chemical composition of Baikal waters has been well studied (Votintsev, 1961; Votintsev *et al.*, 1965; Votintsev, 1978, 1982). The "supply" part is surface inflow with rivers, and the "loss" part is outflow through the River Angara, Baikal's single outflow river, and sedimentation (Table 1.18, Fig. 1.81). Other balance constituents are of secondary importance. Thus, in the "supply" part, the input of compounds with atmospheric precipitation on the lake amounted to 1.5% in 1951-1955, and increased to 3.0% in 1976-1979. Aeolian transfer is even less significant: 0.03-0.04% (Votintsev & Mescheryakova, 1961). Abrasion of the coasts contributes no more than some tenths of a percent.

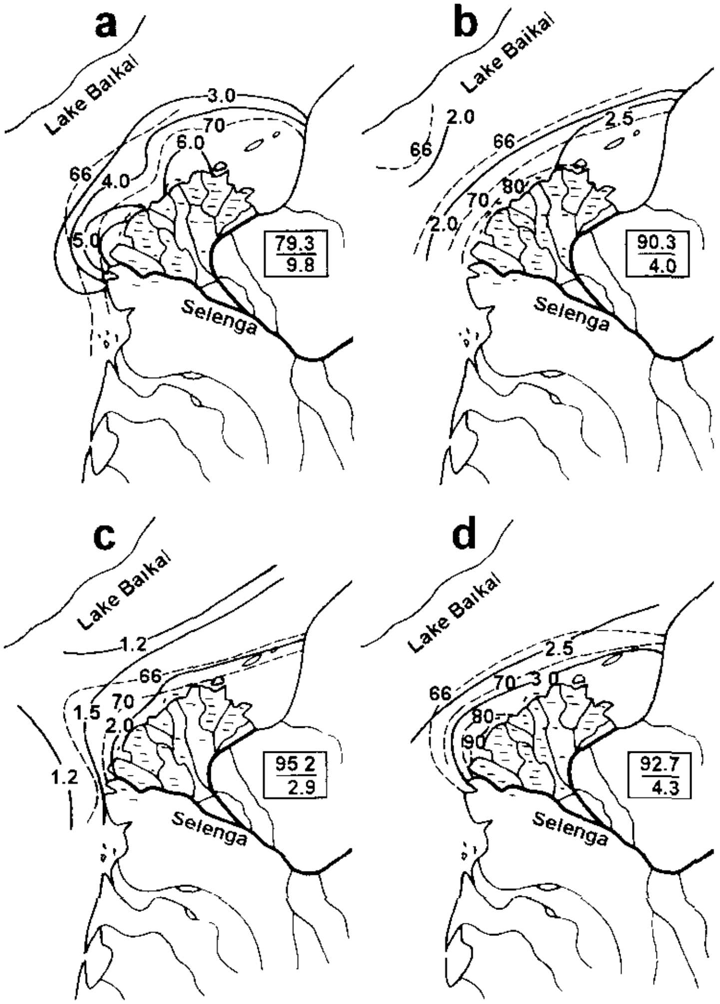


Fig 1 SO Distribution of mixed waters in Baikal under winds from various directions a 16-18,V|I, weak (2-3 m sec^{-1}) south-western wind, b **7-9,VIII;** north-eastern wind of variable strength (to 4-5 m sec^{-1}), c. 16-21 ,VIII; calm after strong north-eastern wind, d 9-11, IX, weak north-western wind (1-3 m sec^{-1}) Solid lines isoconcentrates of silicon, broken lines^{-} the same of hydrocarbonates In frame hydrocarbonate content (numerator) and silicon (denominator) in the waters of the predelta stream of the Selenga River. All concentrations are given in mg l^{-1} After Votintsev in Atlas of Baikal, 1993

In the "loss" part, except for outflow the Angara, sedimentation prevails. In the course of a year, an average of 560 10^3 tonnes of silica (in the form of diatom valves, and spicules of sponges), 28.5 10^3 tonnes of iron (in the form of oxides and phosphorus-containing minerals), up to 3.2 10^1 tonnes of phosphorus, and 126 10^3 tonnes of C_{org} are added to the bottom sediments (Votintsev *et al,* 1965).

At present, the chemical balance of Baikal is disturbed. Several ions enter Baikal in greater quantities than are carried away with the Angara. Despite this seemingly insignificant increase in mineralization, this process is irreversible and therefore of primary importance. A comparison of accumulation rates in Baikal of components with whole-lake exchange rates over 460 years, shows that, at the present level of economic activity, the concentration of these compounds in the **lake will** rise continuously, and in the course of the next 100 years the sum of ions will increase by 4%. As to the organic matter balance in Baikal, a predominance of autotrophic productivity by phytoplankton characterizes its supply part (Table 1.22).

Table I 21 Chemical composition of pore waters of some types of sediment in the area of Bolshiye Kotv Lpper 0 10 cm layer (mg I ') After Votintsev, 1961

Dates	*\atiual kumiditi*	*pi!*	*HCO_3*	*\-\H,*	*\-\H,*	*PPO_4^3*	*Si*	*ft*	*Oxidizability*
1948	Coarse-grained pretoastal sands from 2-3 m depths								
11 VII		7 48	73 20	0 155	0 061	0 196	2 09		10 91
17 IX	19 14	7 60	73 20	0 155		0 046	3 18	0 000	8 90
1949									
29 III		7 09	77 80	0 074	0 093	0 072	4 99	0 800	4 00
26 V	-	7 88	65 85	0 000	0 016	0 032	0 897	0 040	2 14
4 X	19 74	7 60	67 32	0 058	0 023	0 029	I 95		9 38
1948	Coarse-grained preioastal sands with detritus from 4 m depth								
6 VIII	42 0	7 36	73 92	0 310	0 070	0 653	4 37	-	17 64
22 VIII	18 20	7 60	73 20	0 349	0 068	0 392	4 35	-	15 71
1948	Fine sands from 50 m depth								
22 VIII	2108	7 60	73 80	0 116		0 039	1 49	0 03	6 07
1948	The same, with detritus, 6 m depth								
22 VIII	26 23	7 60	74 46	0 034	0 086	0 222	4 39	-	18 17
1948	Coarse-aleunte silts from 300 m depth								
10 VII	42 43	7 36	73 20	-	0 084	0 300	2 353	0 094	16 90
22 VIII	46 87	7 86	73 08	0 178	0 061	0 137	4 39	0 097	17 86
1949									
29 III	44 91	7 00	72 68	0 098	-	0 098	6 16	1 800	10 40
4 X	43 12	7 36	73 17	1 552	0 081	0 327	4 36	-	14 58
1948	Deepwater diatom silts from 700-800 m depth								
25 VIII	62 78	7 36	73 20	0217	0 090	0271	12 90	0012	14 46
1949									
29 III	61 80	7 00	72 68	0 466	0 059	0 168	2 70	2 200	100
26 V	62 74	7 00	71 73	0 466	0 059	0 140	2 62	-	10 03
19 VII	62 46	7 09	71 10	0 008	0 106	0 294	6 63	-	6 40
4 X	61 81	7 30	73 17	2 760	0 095	0 245	2 33	0 140	26 68

Table ! 22 Balance of organic matter (C_{ort} 10^3 tonnes vear ') in Baikal After Votintsc\ *et al* 1975

Supph	*C_{org}*	*low*	*C_{org}*
Production of phytoplankton	3925	Outflow of the River Angara	74
Production of phytobenthos	26	Burial in bottom sediments	26
Inflow of allochthonous organic matter with effluent waters	292	Use by man (fish, seals and others)	I
Input due to human activities	100		
Input with atmospheric precipitation	12		
Total	4380	Total	4380

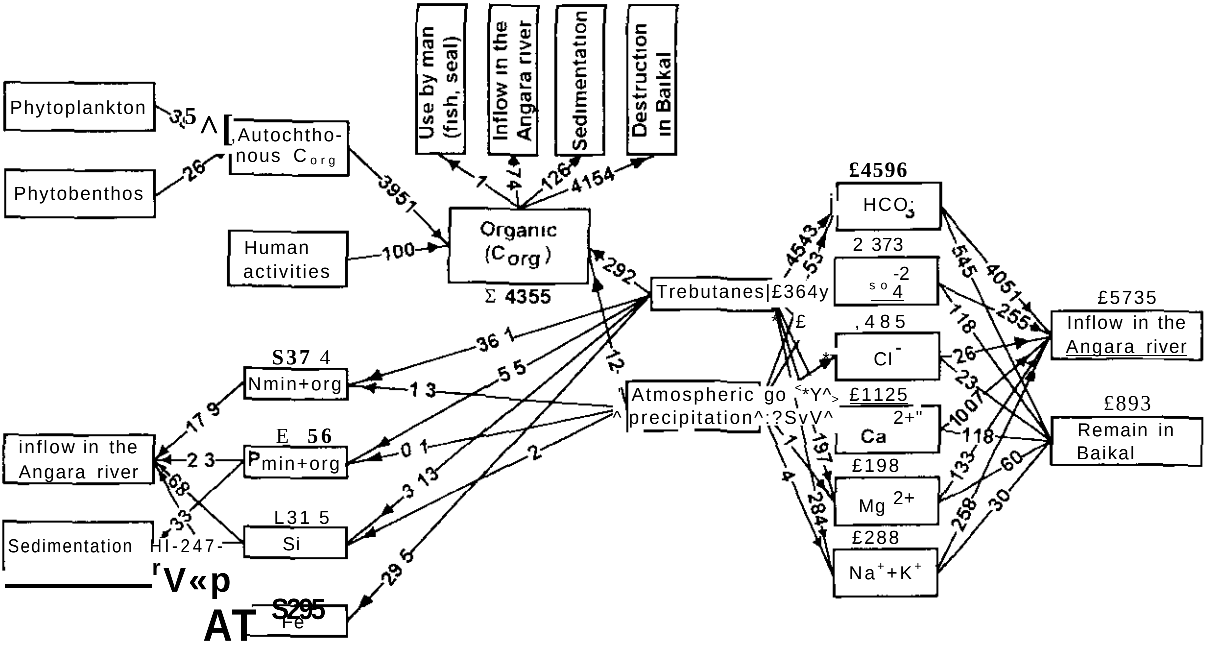
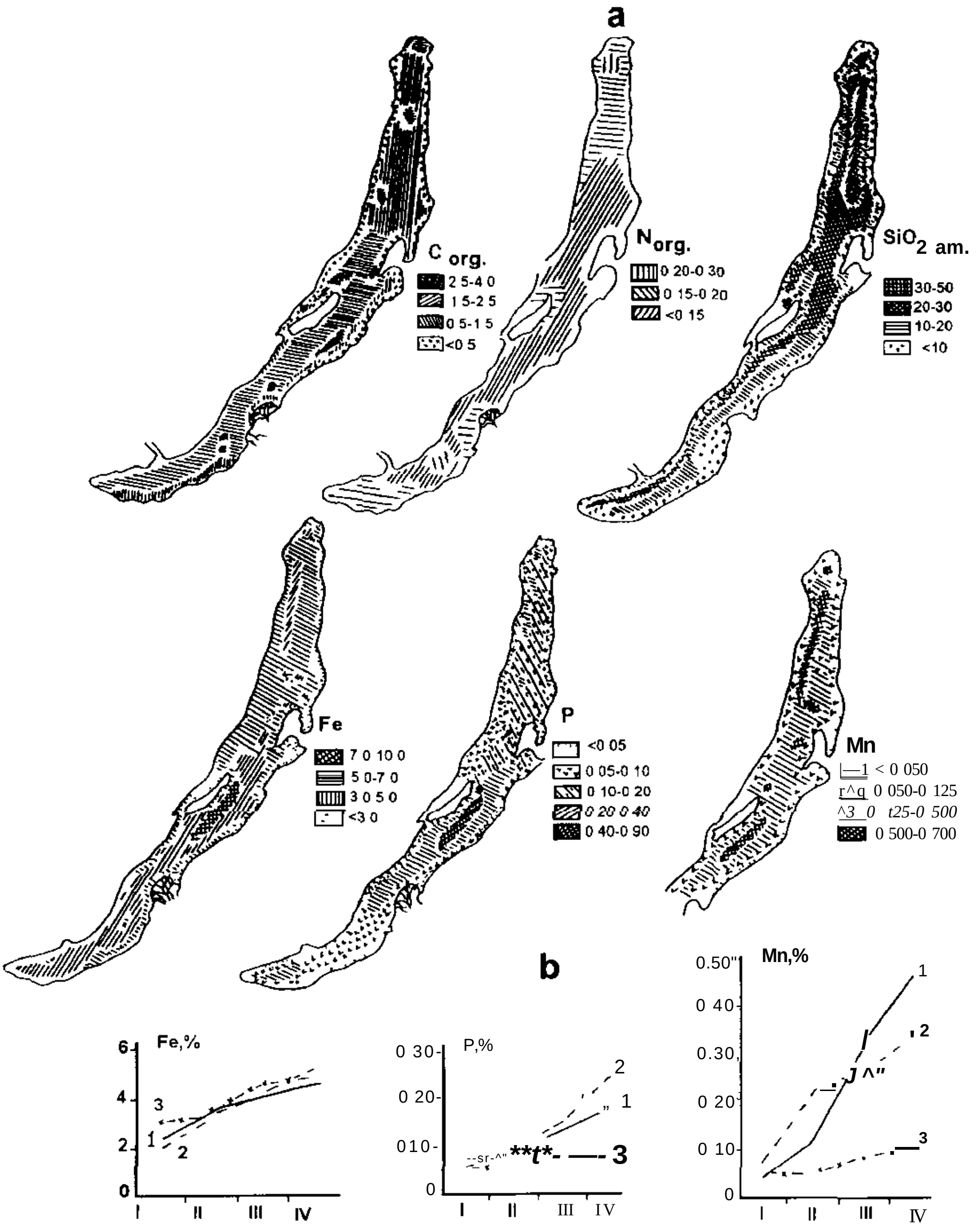


Fig 181 Scheme of chemical balance of Baikal 10 tonnes year[1] After Votintsev, 1982

Table I 23 Chemical composition of surface layer of sediments of Baikal (% m air-dry soil) After Vykhnstyuk 1980 1981

Region	*P*	*Mn*	*Fe*	*SiO-₂ amoiph*	*C org*
Throughout Baikal (open part) including	Oil ±0 01 0 01 - 0 93	0 180 ± 0 035 0 001 - 0 748	4_!_L^L_0_23 0 56 -10 64	20 34 ± 0 2 ß 0 12 - 46 90	1 9 ± 0 1 0 55 - 3 70
North Baikal	0 12 ± 0 01 0 10 - 0 49	0 232 az 0 030 0 004 - 0 748	3 84 ± 0 23 0 56 - 8 12	?S3? ± 3n 2 22 - 46 90	1 7 * 0 3 0 55 - 5 13
Middle Baikal	0 12 ± 001 0 03 - 0 93	0 231 ±0 039 0 001 - 0 704	3 90 ± 0 23 0 56 - 10 64	20 84 ± 2 1 351 - 46 72	20 ± 03 0 68 - 3 98
South Baikal (K.nya?e\a, 1954)	0 9 0 040- 0 14	0 070 0 037 - 0 125	4 60 1 84 - 6 04	14 87 1 00 - 38 39	19 0 0 - 3 50
Maloye More (Patnkeeva, 1959)	0 07 0 02 - Oil	0 050 0013 - 0 069	2 05 0 60 - 3 97	11 90 0 16 - 56 25	0 79 0 00 2 86
Selenga Shallows	0 09 ± 0 01 0 05 - 0 18	0 065 ± 0 002 0 030 - 0 128	3 25 ± 0 10 0 70 - 5 76	7 11 ± 10 0 14 - 28 82	1 4 ± 0 1 0 19 - 3 82

Numerator a\erage values and confidence intervals, denominator fluctuation limits Methods C_{org} wet combustion by chromic acid mixture after Knopp, SiC^ amorph two-times soda extract with further treatment with hydrogen fluoride acid calcination and weighing P treatment of the weight with HCI and $HN0_3$ mixture, colorimetry with molybdenum blue Fe and Mn from dhquotic solution under silicate analysis Mn pcrsultate method colorimetry Fe reduction bv lead titration by potassium bichromate in the presence of diphenylamine



F(g / 52 Concentrations of chemical elements in surface layer of bottom sediments in % content in absolute dry soils of open Baikal (a) and their dependence upon the type of sediment (b) *I* sands, II coarse-aieuntic silt, III fine aleuntic silt, IV pelitic silt, l north Baikal, 2 middle Baikal, 3 south Baikal After Vykhmtyuk & Lazo, 1980

Allochthonous organic matter (OM) coming into Baikal, is only about 10% of the total annual input.' But it is through this "slot" that a considerable amount of nitrogen (up to 24 10^3 tonnes) and phosphorus (up to 4 10^3 tonnes) enters Baikal annually.

The nutrient balance shows that, in the course of a year, up to 18.2 10^3 tonnes of nitrate-N, and up to 3 2 10^1 tonnes of phosphorus accumulate in Baikal At an average content of nitrate-N of 80 mg m^3, organic nitrogen of 53 mg m \ / *e* , a total of 153 mg m^3, and phosphorus of 14 0 and 4 5, respectively, *i e* , a total of 18 5 mg m^3, the supply to the water column is estimated at 3060 10^3 tonnes of nitrogen, and 425 10^3 tonnes of phosphorus

In the process of primary productivity in the course of a year, the biotic turnover is as follows nitrogen and mineral compounds 286 10^3 tonnes (9 1 g m^2), phosphorus 62 10^J tonnes (2 0 g m^2), silica 280 10^3 tonnes (8 8 g m^2), iron 1 0 10^3 tonnes (0 03 g m^2), carbon dioxide 14400 10^3 tonnes (10 6 g m^2) The degree of utilization relative to their total supply in the water column of the lake is 5% for nitrogen, 6% for phosphorus, 8-9% for silica, and 0 13% for iron Up to 11-12% of carbon dioxide is depleted

The present state of investigation does not permit a more complete overview of the turnover of matter in terms of cycles to be given

Eutrophication can be expected under an increase in content of these elements However, a doubling in concentrations of nitrogen will take 170 years, of phosphorus, 130 years

In the present situation, the increase of these components by the year 2000 will be 12% for nitrogen and 15% for phosphorus To double their supplies, it is necessary to deliver 150 10^3 tonnes of nitrogen and 50 10^3 tonnes of phosphorus to the lake, *i e*, the in supply must increase by eight and 16 times, respectively

Phytoplankton photosynthesis releases on average 340 g m^2 of oxygen per annum into the water, while 467 g m^2 of carbon dioxide are consumed Taking into account that destruction of OM is in equilibrium with its synthesis, and correcting for oxygen consumption under destruction of allochthonous OM (delivered to the lake) and anthropogenic OM, the total consumption of oxygen exceeds its input by photosynthesis by 20 g m^2 Replenishment of this amount must occur at the expense of atmospheric oxygen There is no doubt that in summer some oxygen is lost to the atmosphere, since surface layers of water are over-saturated (up to 110-115% of saturation) Similar losses are possible for carbon dioxide, although invasion and evasion of gases in Baikal have time variations depending on season As a whole, the system is in equilibrium, ensuring a high content of oxygen and a low content of carbon dioxide at all depths This results from the insignificant consumption of oxygen for OM destruction per unit volume of water Diurnal consumption of oxygen in the water column averages only about 0 02 mg $1^{!}$ day ' Sedimentation rate in the lake largely depends on chemical, and biological processes and on the balance of matter The sedimentation rate in Baikal is made up of talusogenic, fluvigemc and partially aeolian matter The talusogenic factor contributes to the bottom sediments of Baikal some silicon dioxide, phosphorus (in the form of phosphorus-containing minerals, *eg*, complexes with Fe- vivanite) and oxides of iron, all in all constituting on average 5^0 10\ tonnes or 7 2% of the total chemical input of mineral compounds into Baikal (Votintsev, 1970)

The amount of OM settled during the year and buried over a long period of time equals 49 8 10^3 tonnes C_{org} ', or 8 2% of the total amount of allochthonous OM Due to phyto- and zooplankton and partially to other organisms, various quantities, depending on the level of development of these organisms, come into bottom sediments In phytoplankton-nch years, in particular *Melosira* years, up to 8-11 g C_{org} m^2 of the bottom surface, and in poor years 2-3 g C_{org}, enter the lake (Votintsev, 1961)

Taking into consideration the fact that *Melosira*-nch and poor years occur on average every two to four years, this amounts to 3-4 g C_{org} m^2 annually, or 73-104 10^3 tonnes for the whole lake It should be remembered that by the end of its bloom, large quantities of still active *Melosira* sink to a depth of 500 m, possibly to the bottom (Votintsev & Popovskaya, 1964) Undoubtedly, in such years *Melosira* carries enormous amounts of OM and mineral compounds to the bottom Its biomass by the end of the bloom is estimated at 240 g m^2 (Votintsev, 1952b)

Fluviogenic flow of suspended sediments from the drainage equals 4314 10^3 tonnes per year or 137 g m^2 annually Aeolian shift is rather small (Votintsev & Mescheryakova, 1961), not more than 300 mg m^2 of solids, or 9 0-9 5 10^3 tonnes per year for the whole lake On average, according to data by Knyazeva (1954), under a SiO_2 content of 20 1%, the talusogenic constituent equals 4 17 cm in 1000 years, and together with the fluvio-

Table 1 24 Average: chemical composition of various types of bottom sediments of Baikal (% in air-tdry soil) After Vykhristyuk, 1980, 1981

Region	*Saudi*			*Coarse alevrites*			*Fine alevrites*			*Cia\ ,Silts*		
	Fe	*P*	*Mn*	*Fe*	*P*	*Mn*	*Fe*	*P*	*Mn*	*Fe*	*P*	*Mn*
Open part												
North Baikal	2 44	0.07	0 045	3 68	0 09	0 119	*All*	0 14	0 328	4 82	0 18	0 450
Middle Baikal	1 98	0.06	0.071	3 65	0.09	2 232	4 18	0 15	0 258	5 18	0 25	0 338
South Baikal	3 09	0 06	0 051	3 33	0.07	0 052	4 66	0 08	0 086	4 88	0 09	-
Maloye More	1 58	0 05	0.032	2.62	0.07	0.056	-	-	-	-	-	-
Selenga Shallows	1 78	0 07	0 049	3 29	0.09	0.051	4 16	0 12	0 080	4 96	0 17	0 121
Barguzmsky Gulf	*2.22*	0.11	0.046	-	-	-	3 30	0 17	0 085	3 98	0 15	0 121
Chivyrkuisky GuJf	*2* 13	0 07	0.049	] 92	0 08	0 040	3 43	0 12	0 100	-	-	-
Proval Gulf	1 68	0 07	0015	1 81	0 08	-	3 50	0 10	0 056	-	-	-

Region	*Sands*		*Coarse alevrites*		*Fine alevrites*		*Clay silts*		*Diatom silts*	
	SiO,	*C<"S*	SiO,	C«*	*Si0$_2$*	**C,we**	*SiO,*	C<Λ	StO,	C»*
Throughout Baikal (open part)	0.96	0 65	1 90	1 85	25 9	2 03	6 60	2 50	-	-
Maloye More	2.84	051	9 16	0 87	12 1	-	14 18	–	33 4]	1.47
Seienga Shallows	2 66	0 73	3 29	1 47	4 S6	1 96	(180	2 41	22 14	2 *19*

genie one (in terms of porosity and natural humidity of precipitations of the upper 10 cm-layer of silt), it is 7.7 cm per 1000 years (0.077 mm year^{1}) (Votmtsev, 1970). Chemical denudation in the Baikal basin is 5.2 m in 1000 years on average, the total denudation (including the mechanical one) equals 20-25 mm for 1000 years (Votintsev, 1970).

1.6.3. Bottom chemistry

Jn Baikal, terrigenous sediment accumulation predominates. The share of chemical components in silt formation is about 20% of the total material input. The highest of these (12%) is the percentage of amorphous silica minerals which has resulted in the formation of a diatom *silt typica) of oceanic* water-bodies. Up to 80-90% of the bottom is occupied by sediments containing more than 10% of amorphic Si0$_2$, with an absolute maximum of 56.3% (Maloye More) (Fig. 1.82,a). The share of other chemogenic elements in bottom sediments is small (Tables 1.23, 1.24), and their concentration correlates with the pelite fraction content (Fig. 1.82,b). In the sediments, most chemical parameters are subject to considerable fluctuation due to changes in sediment accumulation and diagenetic processes (Fig 1.83, a).

At present, the annual input into the sediments by river inflows and by the activity of organisms is: Si0$_2$ amorph : 405; C_{org}: 126, Fe: 28.9; Mn' 3.3; and P: 2.4 10$^{?}$ tonnes. Their spatial distribution is determined by several factors: hydrodynamics of water masses, bottom relief, and rates of sedimentation (Figs. 1.82,a, 1.84).

Reduction processes

In bottom sediments of deep open water regions of Baikal with a sufficiently developed oxidized top Jayer (5-27 *cm), reduction processes resemb)e, m* many respects, oceanic sediments, containing 1 - 2 % ι c «,

The reduction of reactive Fe forestalls a sulphate-reducing process.

The regeneration of pyrite routinely starts in the oxidized zone. The sulphate-reducing process is intense below the oxidized sediments. Maximum

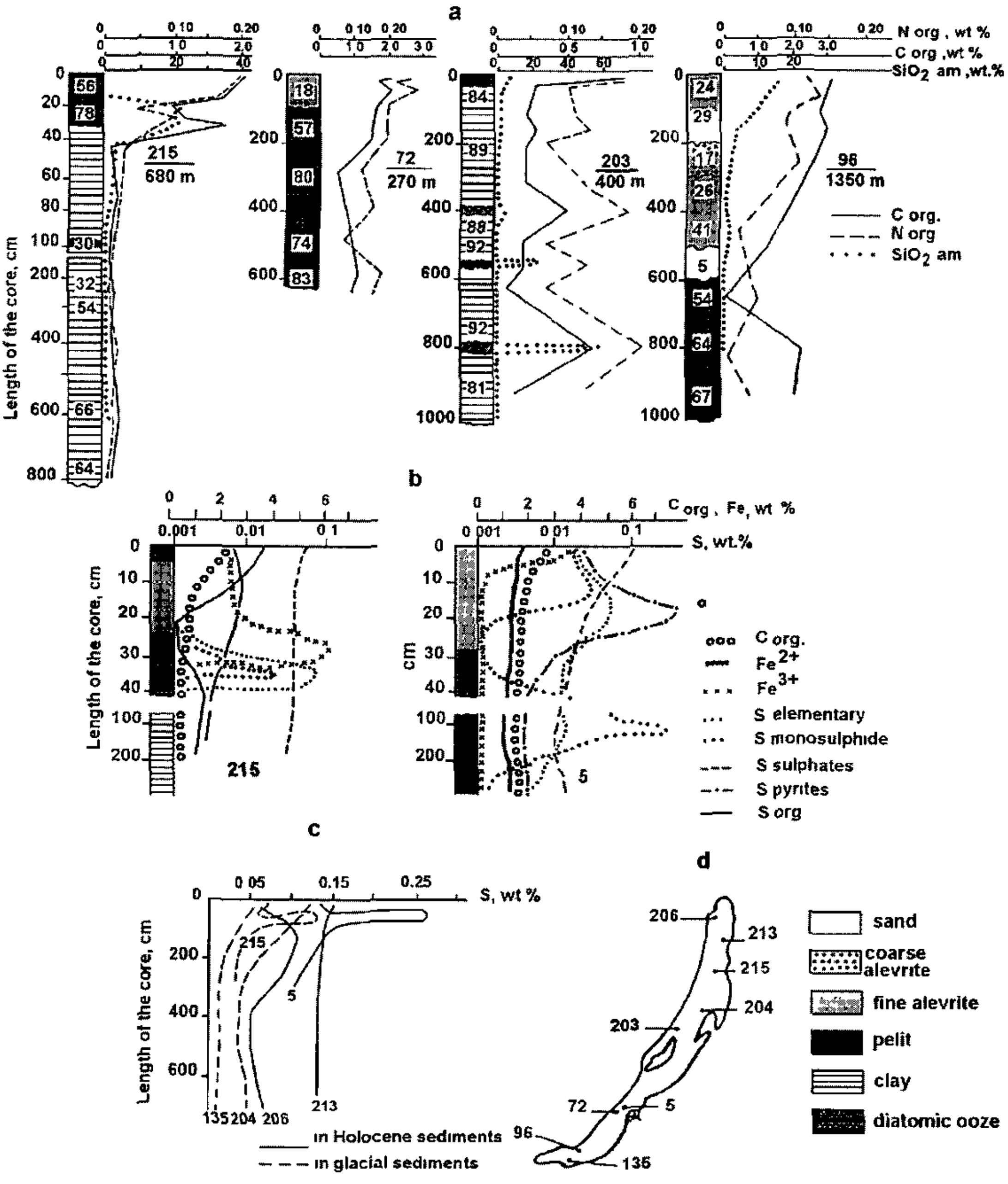


Fig 1 83 (a) Distribution ot amorphous silica, organic carbon and nitrogen in the sediments numerator - number of a station, denominator - depth, m Numbers shoun within the core's scheme indicate percentage of pehtic (particles size < 0 01 mm) fraction After Vykhnstyuk, Lazo, unpublished data

(b) Distribution of organic carbon, different forms of sulphur and reactive iron (Fe$_{reactive}$ = Fe^{2}~ + Fe^{3-}) in the sediments Fe$_{reactive}$ was extracted from fresh wet sediment by 2N H_2SO_4 in CO, atmosphere, Fe^{2+} and Fe^{3}* were determined titramctncally with potassium bichromate

Sulphur forms were isolated from one sample of fresh wet sediment, reduced to H,S then trapped by cadmium acetate with further lodimetry

(c) Total sulphur in the sediments, solid line - the Holocene sediments, dotted line - lacustrine-glacial clays After Lazo, 1989

(d) Scheme of sampling sites

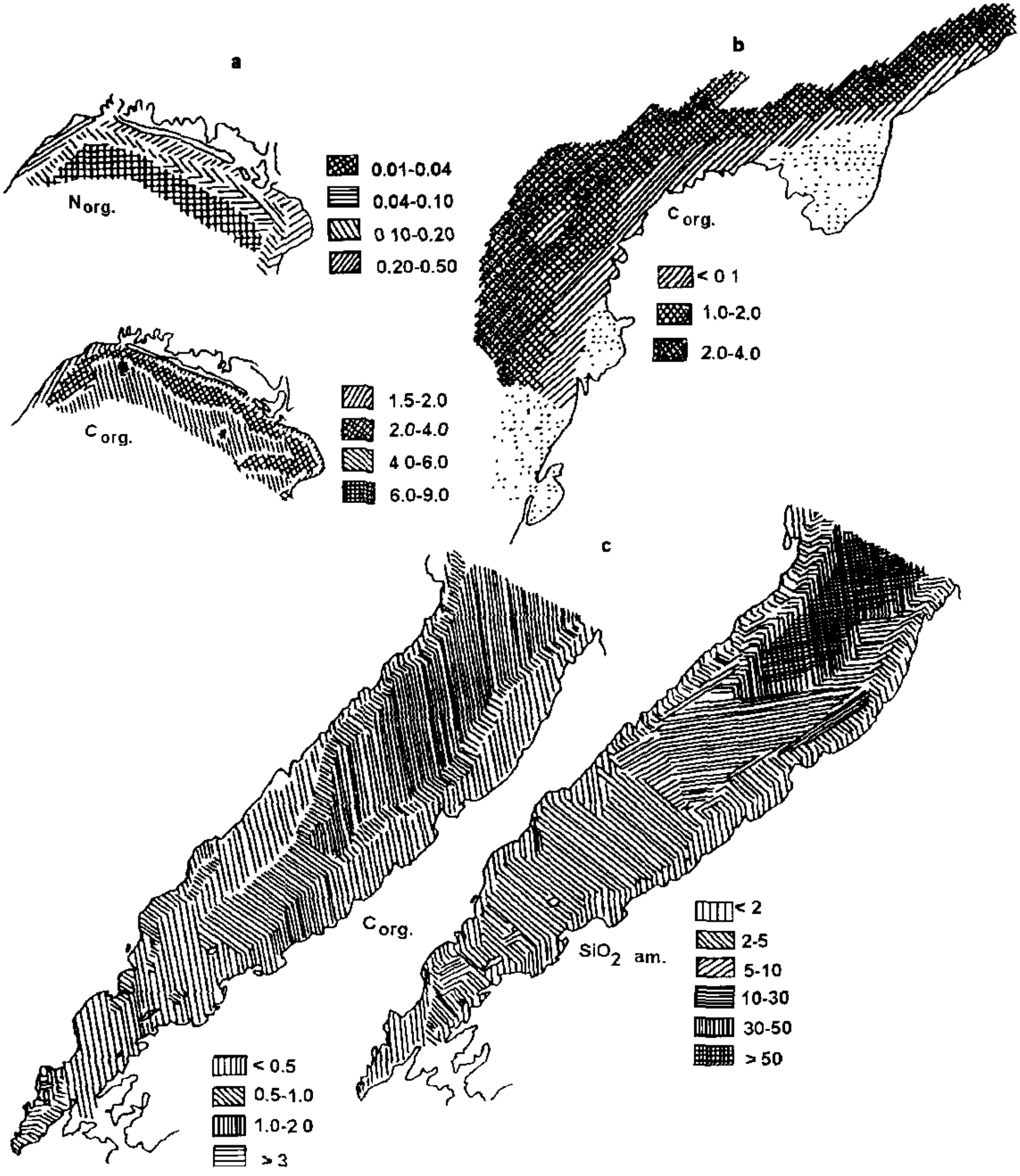


Fig I 84 Concentrations of organogenic elements in surface layer of bottom sediments in % content in absolute dry soils[1] a northern extremity, b Selenga Shallows After Vykhnstyuk & Lazo, 1980, c Maloye More After Patrikecva, 1959

concentrations of hydrogen-sulphide derivatives (0.021-0.280%) are formed most often in the 20-50 cm layer. Free hydrogen-sulphide in sediments is absent, since it reacts with reactive Fe in the process of its formation (Fig. 1.84,b,c,d)- Sulfate reduction and sulphur accumulation in Baikal sediments (Table 1.25) at a low content (5.2 mg l^{-1}) of the sulphate ion in the water are determined by the sedimentation rate and content of organic matter in the sedimentary material.

Accumulation of trace elements occurs in the oxidized layer of Baikalian silts (Table 1.25) and by this fact Baikal differs from lacustrine waterbodies, making it similar to marine ones.

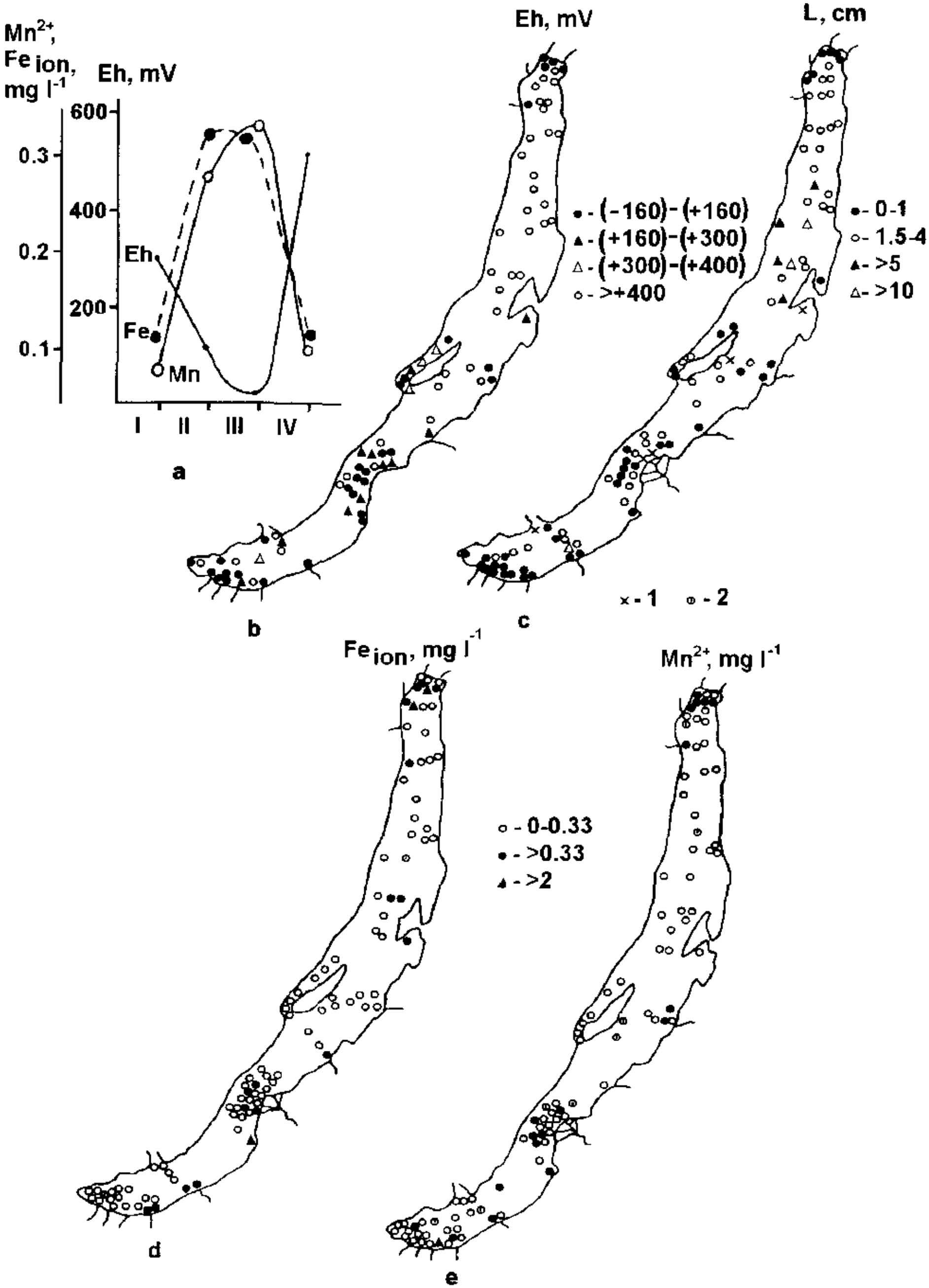


Fig 1 85. Relationship between Eh and Fe and Mn concentrations in pore waters

(a) Mean values˙ I "pure" (not affected by riverine waters) sands; II sands from pre-estuary parts of the bottom; III silts from pre-estuary parts of the bottom, IV deep-water silts (pelogen)

Changes of redox potential of surface sediments (b). depth of oxydized layer (c), Fe$_{]on}$ (d) and Mn$^{2"1-}$ concentration in pore waters in upper layer of sediments throughout the bottom area of Baikal

1. yellowish oxidized sand without a distinct redox boundary,
2 increase of concentrations (more than 0 33 mg l$^{'1}$) is due to the presence of Fe-Mn crusts After Leibovich, 1981

Table 1 25 Concentration of some metals in oxidized (I) and reduced (II) deepwater silts of Baikal {mg g ') coefficients of their accumulation in the oxidized zone (K), concentrations in pore waters (III) squeezed from surface sediments (uu 1') After Granina, 1985 Leibovich-Gramna, 1986

	Mn	*Fe*	*Ni*	*Cu*	*Co*	*Pb*
(	75 3	102 6	0 12	0 10	0 05	0 07
n	17	17	16	17	13	16
II	43	33 2	0 05	0 05	0 03	0 04
n	11	11	II	11	10	11
K= I II	175	3 1	2 4	2 0	1 7	1 7
III	no	40	113	50	31	-
n	23	26	14	14	13	-

Note Trace elements were determined by atomic absorption spectrophotometry Fc, Mn m pore waters by photocolorimetry n - number of measurements

Table 126 Conditions in surface deepwater sediments of Baikal After Leibovich,1983

Specific horizon	*Eh ml*	*n*	*pll*	*n*
Pelogen (the surface semi-hquid layer)	+495	28	**7 00**	**24**
Manganese layer of chocolate colour	+610	7	**7 02**	8
Manganese microzone of black colour	+615	4	**7 09**	3
Ferruginous microzone of yellow-orange colour	+365	10	**7 06**	10
Reduced grey silt	- 90	47	7 22	49
Relict manganese microzone	+495	6	7 24	5
Relict ferruginous microzone	*+85*	8	7 19	9

Table I 27 Redox potential of sediments (mV) and maximum concentrations (mg 1 ') of C_{org}, $Fe_{1()n}$, and Mn m pore waters of bottom sediments rich in detritus After Granina, 1985 Leibovich-Gramna, 1987

Sampling site (single measurements at depths from 1 5 to 40 m)	*Eh*	C_{org}	Fe_{ion}	Mn^{2+}
Opposite mouths of rivers				
Khara-Munn	-145	55	0 29	4 03
Snezhnaya	-140	53	2 68	1 18
Upper Angara	-20	27	**1 72**	1 31
Solzan	+45	50	0 11	0 05
Kielieia	*+20*	*30*	**1 20**	1 *39*
Tyya	+30	19	2 10	0 97
Opposite estuaries of Selenga Ri\er				
Shamanka	+ 140	**42**	0 67	0 42
Srednyaya	+20	**47**	1 05	0 92
Knvaya	-	**23**	0 81	0 63
Severnaya	+5	**27**	0 33	2 40
Middle of North-Baikahan Sor	+40	**44**	*1* 80	0 54
A\erage values for dccp-watei surface sediments	+495 n~28	11 n=20	0 13 n=26	Oil n=23

Note Eh was measured by platinum electrode, Fe_{lon} (Fe^{2+}+Fe^{3+}) dipyndii, $Mn^{2''1''}$ fbrmadoxime method *on* filtered samples (filters with 0 5 *xm* pore size), C_{org} was calcu lated from COD using an empirical coefficient

Concentrations of Fe and Mn in pore waters of reduced sediments are higher than those in oxidized ones (Fig. 1.85a) The same tendencies can be seen for several trace elements

In the process of diagenesis in the deepwater Baikal sediments (with participation of specific microflora), chemical differentiation of Fe and Mn takes place This is well confirmed by the stratification of the sediment redox potentials, since redox potential is closely related to the content of oxdidized Mn in sediments In some places oxidized layers of insignificant (mm and cm) thickness are buried within reduced sediments (Table I 26)

As a result of the destruction of a considerable amount of fresh organic detritus, coming to the bottom sediments in the pre-estuary zones of rivers (and sors), pore waters are enriched in intermediate products of detritus decomposition, which are fixed as C_{org} content in the pore waters Dissolved organic matter behaves as a reducer, and thus promotes a decrease in redox potential sediments are poorly oxidized or reduced Metals are preserved in pore waters in great amounts due to the formation of complexes with organic matter (Table 1.27)

Chapter 2
The Flora

2.1. Fungi

Specific investigations on the aquatic fungi of Baikal have never been conducted, although infections of *Saprolegnia* on *Epischura baicalensis* have been known for a long time.

Parasitic fungi of the class Phycomycetes *(Saprolegnia* spp.) affect the roe, skin, and fins of the omul; mortality of infected omul roe at the Bolsherechensk fishery plant can reach 20-40% (Pronin, 1982). Cherepanov (1966) observed fungal growths on the fins of yearlings in the basins of the biological station of Irkutsk State University, and recorded mortality losses of young-of-the-year from saprolegniosis. Hyphens of *Saprolegnia* also invade the damaged skin and fins of the Selenga omul during its spawning migration into the Selenga river.

2.2. Algae

The algae of Baikal have been studied by Gutwinsky (1890, 1891), Dorogostaisky (1904), Visloukh (1924), Meyer (1930), Yasnitsky (1931, 1936, 1956), Skvortsov (1937; Skvortsov & Meyer, 1928), Skabichevsky (1929, 1936, 1952, 1954), Antipova (1955, 1956a,b), and later by Kozhova, Popovskaya, Izhboldina. According to these studies *(i.e.,* up until 1960) Baikal and its gulfs, sors, pre-estuarine regions, etc., harbour 569 species and 162 varieties of algae. About half these occur in open Baikal, while the other half lives in sors and sheltered gulfs and bays. Among these algae, 35% inhabit Baikal only.

Cyanophyta are represented by more than 70 species, but only 30 of these occur in open regions, and even these live mostly near river mouths and shallow gulfs and bays. Among the planktonic Cyanophyta occurring in open Baikal, mention should be made of *Anabaena flos-aquae* (Lyngb.) Breb., *A. lemmermannii* P. Richt., *A. spiroides* Kleb., *Aphanizomenon flos-aquae* (L.) Ralfs, and *Gloeotrichia echinulata* (J.S. Smith.) P. Richt. These algae are often responsible for summer water "blooms" in coastal areas, pre-estuarine regions, bays and gulfs, and, after long periods of warm, calm days, also in more open regions near shallows.

A microscopic coccus-like alga identified first by Kozhova as a green bacterium, then described by Popovskya as *Synechocystis hmnetica* (cell diameter 1.5-2 mm) is typical of open Baikal. This species reaches 100 10^6 cells per liter, and its biomass 200 mg in"^{3}. Some less well studied microscopic Procanotes dwell in the pelagial, including *Synechococcus elongata,* and *Cyanarcus hamiformis*

Several species of Cyanophyta are typical inhabitants of the benthos, some of which are dominant. *Stratonostoc verrucosum, Tolypothrix distorta, Calothrix* sp., *Schizothrix* sp., *Oscillatoria amoena* dominate the first plant belt to a depth to 1.5 m in some regions of the lake. The phytomass of *S. verrucosum* in bays can reach 3 kg m"^{2}. *Tolypothrix distorta* dominates at depths of 1-1.5-3.5-4 m, and is especially frequent along the coast of north Baikal. In the Olkhonskiye Vorota Strait, Maloye More, Chivirkuisky Gulf, Posolsky Sor, and in some large bays along the open shorelines of the lake, *Sphaeronostoc pruniforme* is prominent.

Only two Rhodophyta species are known, and even those only in sors and river mouths.

Several species of Chrysophyta have been found in Baikal, in the genera *Chrysococcus, Kephyrion,*

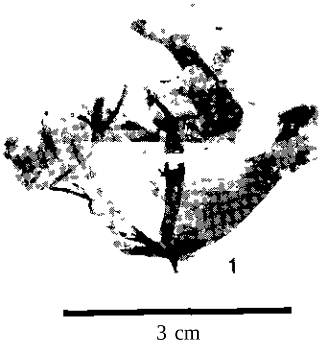


Fig. 2.1. Bottom Chrysophyta *Tetrasporopsis reticulata* C. Meyer: in May-June grows at depths of 2-10 m wherever stones are available. Collection of the Research Institute of Biology.

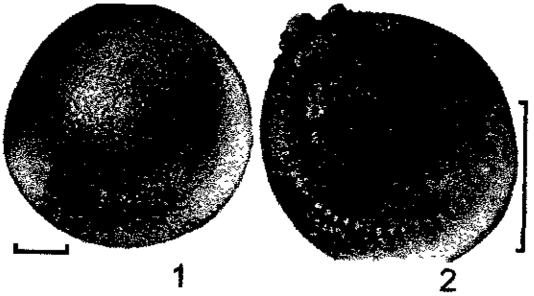


Fig. 2.2. Scanning electron micrographs of the typical planktonic Bacillariophyta. 1 - *CycloteUa baicalensis* Skv., 2 - *CycloteUa minuta* (Skv.) Antip, Scale bar = 10 um. Collection of the Research Institute of Biology,

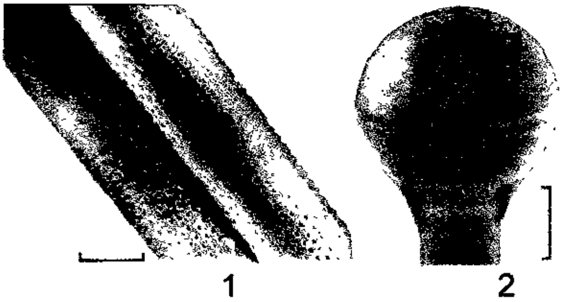


Fig. 2.3. Scanning micrographs *of* the typical planktonic Bacillariophyta *Aulacoseira baicalensis* (K. Meyer) Wislouch. 1 - 'vegetative cells, 2 - formation of the auxospore. Scale bar = 10 um. Collection of the Research Institute of Biology.

Mallomonas, Dinobryon, Chrysosphaerella, Chrysosphaera (= Epichrysis), Uroglena (Uroglenopsis), Synura, Chrysidalis, Tetrasporopsis (Fig. 2.1), and *Chrysothallus.* The latter three genera were formerly considered endemic to Baikal, but in recent years representatives have been found in several European waterbodies.

A species common in open Baikal is *Dinobryon cylindricum* var. *alpinum* (Imh.) Bachm., large amounts of which appear in spring-summer during some years. In summer, *Dinobryon sociale* var. *stipitatum* and *D. divergent* Imh. also *occur* in open regions, but more commonly in shallows. *Mallomonas vannigera* is often observed in the littoral.

Chrysosphaera (Epichrysis) melosirae (Meyer) Bourelly is common in the pelagic zone, where it appears in large numbers on the filaments of the widespread planktonic diatom after which it is named.

Chrysothallus baicalensis Meyer lives on the stems of the algae *Didymosphenia geminata, Cladophora glomerata, C. meyeri,* and *Chaetocladiella pumila.*

Bacillariophyta (Diatomeae) rank first among the other groups in abundance of species. It has been established that in Baikal this group has 334 species, or 60% of the entire number of species of algae. About 33% of these are endemic (Kozhov, 1963). Chernyaeva lists 700 species and varieties for bottom sediments (see chapter 4).

Diatoms play an exceptionally important part in Baikal's productivity. In the waters of open regions they form the main part of the phytoplankton. In the littoral they settle on bottom algae, on stones and other kinds of soil, constituting the main diet of many benthic animals.

Of exceptional importance among the planktonic diatoms of open Baikal are *CycloteUa baicalensis* (Fig. 2.2), *C. minuta, Aulacoseira baicalensis, A. islandica helvetica* (O.Miill.) Sim, (Fig. 2.3), *Stephanodiscus binderanus* (Kiitz.) Krieger, 5. *skabitschevskyi, S. dubius, S. invisitatus, S. makarovae, Synedra ulna* var. *danica* (Kiitz.) Grun., *S. acus* var. *radians* Kiitz., and *Nitzschia acicularis* W.Sm. Moreover, in summer, the open-water plankton contains *Asterionella formosa* Hass., but this is more abundant in pre-estuarine areas, gulfs and other shallow regions.

In summer several species of *Fragilaria* are observed in shallow regions. Among them, *F. cro-*

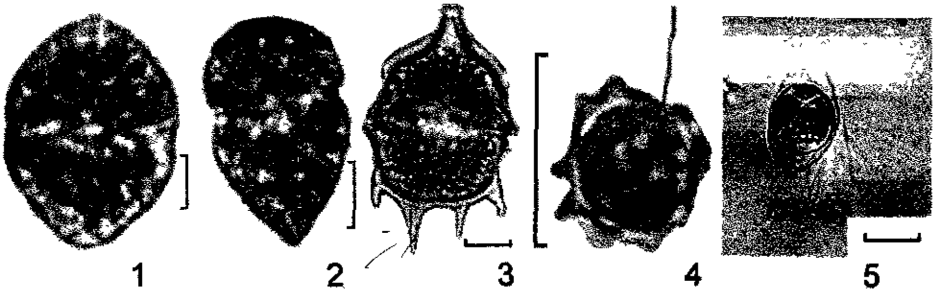


Fig. 2.4. Light micrographs of the typical planktonic algae. Dmophyta: 1 - *Gymnodinium baicalense* Antip., 2 - *Gymnodinium coeruleum* Antip., 3 - *Pendinium baicalense* t.Kissel, et Zwctk., Chrysophyta: 4 - *Chrysococcus sp* (species nova'?), 5 - *Mallomonas vanmġera* Asmund. Scale bar = 10 pm. Collection of the Research Institute of Biology.

tonensis Kitt. and *F. capucina* Desm. sometimes appear in adjacent open regions, brought there by currents. Species of *Tabellaria,* such as *T. fenestrate;* (Lyngb.) Kiitz. and *T. flocculosa* (Roth.) Kiitz. can also be observed in shallow regions in summer.

These are practically all the forms of planktonic diatoms living in open Baikal. All the others only occur in sors, sheltered bays, and pre-estuarine areas.

The vast majority of diatom species are epiphytes living on algae, stones, sand grains, etc. Breaking off from their substrate, they often appear in numbers in water of the littoral and even in neighbouring deep-water regions. Especially frequent in the plankton are *Ceratoneis arcus* (Ehr.) Kiitz., species of *Gomphonema, Navicula, Cocconeis, Achnanthes, Diploneis, Cymbella,* and others.

Epiphytes populate the bottom not only in the littoral, but also spread, gradually growing sparser, far beyond its limits to a depth of 60-70 m or deeper. Of special importance are species of *Gomphonema* and *Didymosphenia,* which occur throughout Baikal, covering stones of the coastal belt in a continuous, yellowish-white layer.

About two-thirds of the epiphytic and bottom diatoms living in Baikal are widely distributed in Europe and Asia. But there are also species with a discontinuous distribution. Some species even live in brackish basins.

It should be noted that the most numerous species of open Baikal are, as a rule, endemic *(Aulacoseira baicalensis, Cyclotella baicalensis, C. minuta).* These represent the main biogenous part of the lake's bottom sediments.

Five species of Xanthophyta have been found in Baikal, living in sors and river mouths (species of *Ophiocytum* and *Tribonema).*

Dinophyta are represented by peridineans. Seven species of peridineans have been discovered so far. Most arc endemic and live in open waters, playing a major role in the formation of the early spring phytoplankton. Of great importance among them are several distinctive species of *Gymnodinium (G. baicalense* Antipova, *G. coeruleum* Antipova) (Fig. 2.4), large numbers of which appear in open waters during ice cover (March-April). In spring and *autumn, Perīdinium baicalense* Kissel. & Zwetk. in open waters can also be observed. *Ceratium hirundinella* O.F. Müll., a widespread species, occurs in open waters only in summer, being more common in shallow gulfs, bays, and pre-estuarine areas.

Gayevskaya (1933) noted the presence of a species of *Glenodinium* in coastal Baikal.

Only three Euglenophyta have been found in Baikal, living in sors.

Chlorophyta are represented by approximately 130 species.

Owing to their abundance, they comprise the main part of the phytobenthos of open regions, which are inhabited by more than 43 species and varieties from this group; about 30 of these are endemic. Five species of Volvocineae are known, one of them belonging to the endemic Baikalian genus *Swartschewskiella: S. hemisphaerica* (Meyer) Jasn. This microscopic alga settles on various bottom diatoms of the open littoral. The other four species occur in well-sheltered gulfs, bays and pre-estuarine areas.

Representatives of Chlorococcales are common components of the plankton of the littoral-sor zone, but are rare in open Baikal. Mention should also be made of *Botryococcus braunii,* which usually appears in the plankton of open waters in summer-autumn. In some years, considerable amounts of it are observed in spring and winter. It is possible that the open Baikal species is not identical to *B braunii* Kiitz., which can be seen in summer in shallows and gulfs. Fairly often, open Baikal also contains *Monoraphydium psendomirabile* (Korsch.) Hindak et Zagorenko, which reaches its highest numerical density in summer, in addition to *Coenochloris polycocca* (Korschik.) Hindak, 1984 and representatives of *Scenedesmus* and other genera, which are brought in from shallow regions by currents.

The benthic Chlorococcales include *Sykidion gomphonematis* Meyer, an interesting endemic species which lives in vast amounts on the diatom *Gomphonema.* It should be noted that elsewhere the genus *Sykidion* is only represented *in* the marine environment

A common algae in open Baikal is *Chtorella vulgaris* Beyer (Zoochlorella), which lives symbiotically in the tissues of sponges and is responsible for their bright-green colour. *Chlorella minutissima* Fott et Novakova occurs also in free water.

The Tetrasporales also deserve attention. In open waters they are represented by species of *Tetraspora: T. cyhndrica* var. *bullosa* Meyer (Fig. 2.5.1) and *T. lubrica* Ag. The latter, a bottom alga, is the more important. It has the form of a long, cylindrical, light-green tube which swells strongly with age and turns into an irregularly-shaped sack with wavy, swollen, corrugated walls. The height of this tube reaches 100 cm, with the diameter equalling a third of the height, but specimens higher than 1.5 m and more than 50 cm in diameter have been found (Yasnitsky, 1952). This alga grows densely on stones in the open littoral at a depth of from 1 to 3 m (Fig. 2.6).

Of great importance in open Baikal are Ulothrichales, represented mostly by endemic species. *Vlothrix zonata* Kiitz., a widespread species, abounds at the edge of the water on rocky shores (Fig. 2.7). This species is also common in large lakes and rivers outside Baikal.

One species of the Ulothrichineae, *Binuclearia tatrana* Wittr., is planktonic, and is fairly widely distributed in large gulfs and in open Baikal.

An exceptionally important part in the phytobenthos of Baikal is played by species of the endemic genus *Draparnaldioides* (family Chaetophoraceae) (Fig. 2.5. 4-8). Thirteen endemic species have been described. The Baikalian species of *Draparnaldia* were originally included in the section *Baicaha.* Later, Baikalian *Draparnaldia* were assigned to a new endemic genus, *Draparnaldiella* Meyer & Skabitsch., which was renamed *Draparnaldioides* Meyer & Skabitsch. (Skabichevsky, 1976). The species most widely distributed is *D baicalensis* Meyer, which forms small dark-green shrubs, 15 to 35 cm high, attaching themselves to stones. Its branches reach *3-4* cm in length and are covered by a layer of transparent slime. The shrubs of other species are smaller. Settling on stones, *D. baicalensis* and other species form thick, dark-green growths, whole meadows of which often cover the bottom along open shores. In sors and sheltered bays, species of *Draparnaldioides* do not occur (Figs. 2.6, 2.8).

The same family includes the endemic genus *Ireksokonia,* represented by the species /. *formosa* Meyer (Fig. 2.5.2), which forms thin threads, 10 to 12 cm long, growing in tufts on stones in the open littoral.

Myxonemopsis crassimembranacea Meyer (Fig. 2.5.3) is also the only representative of an endemic genus, but occurs much more rarely than *Ireksonia.*

Siphonocladineae are represented in Baikal by five genera and 15 species, of which only five species can be found in other bodies of water. The rest are endemic, and one species has caused the establishment of the genus *Gemmiphora.*

The genus *Cladophora* is represented by five endemic species (Fig. 2.5. 9-12), of which *C. compacta* and *C. floccosa* have the widest distribution. *C compacta* forms minute, compact hemispheric cushions, 2 to 5 mm high, and 2 to 10 mm in diameter, which densely overgrow littoral stones. *Cladophora floccosa* forms short (up to 1 cm), dense bushes or sphaeric flackes (to 1-1.5 cm in diameter), formed by numerous filiform branches. In the sublittoral, *Cladophora meyeri* is widespread.

An important part in the phytobenthos of the littoral is played by *Chaetocladiella pumila* Meyer

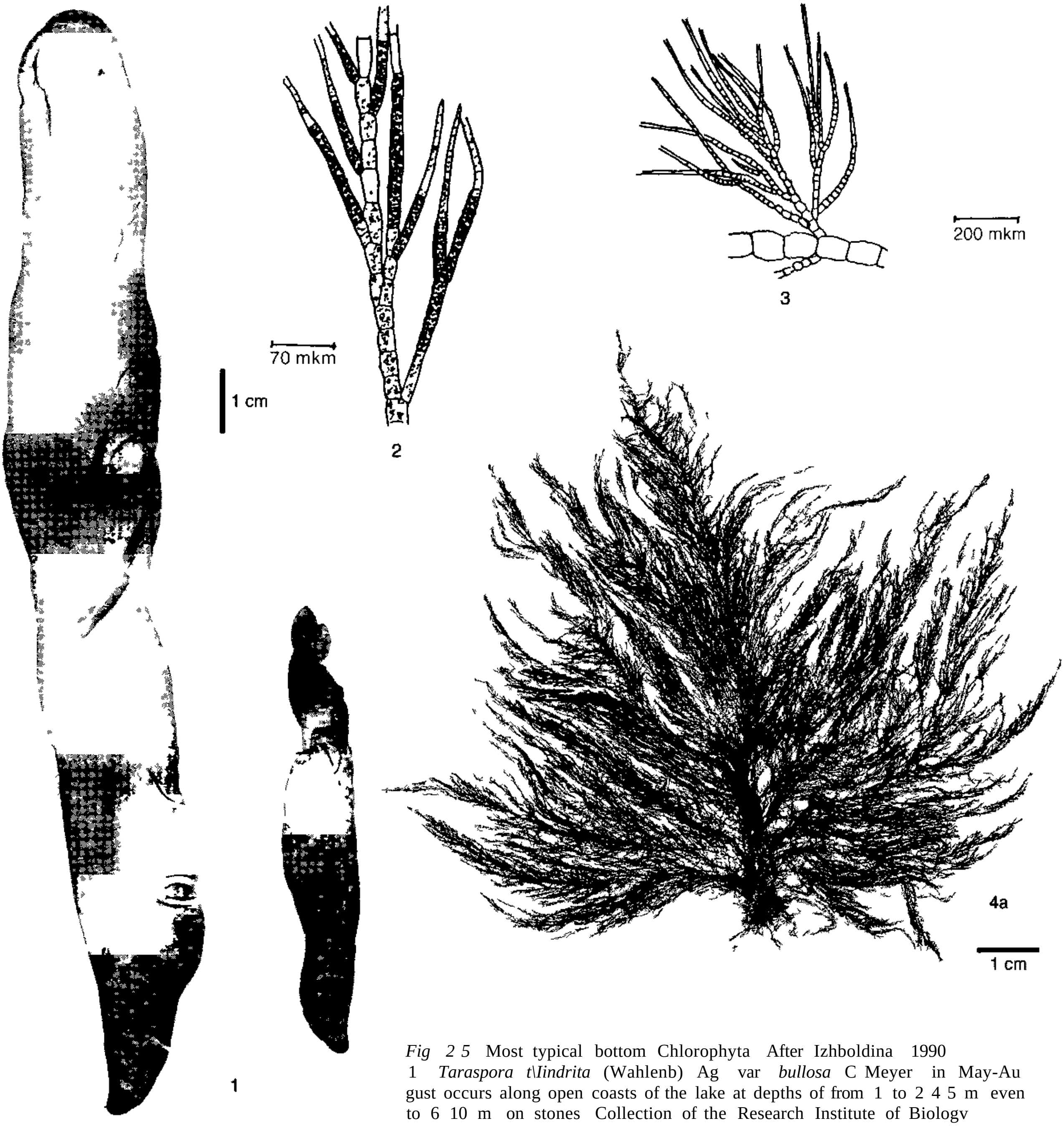


Fig 2 5 Most typical bottom Chlorophyta After Izhboldina 1990
1 *Taraspora t\Iindrita* (Wahlenb) Ag var *bullosa* C Meyer in May-Au gust occurs along open coasts of the lake at depths of from 1 to 2 4 5 m even to 6 10 m on stones Collection of the Research Institute of Biologv
2 *Ireksokoma formo^a* Meyer part of tallome the only species of endemic Baikahan genus widespread m Baikal Grows at depths of from 2-5 m on stones and rocks After Meyer 1930
3 *Wixonemopsii, crassimembranacia* Mever structure of lateral branch the only species of endemic baikalian genus Occurs occasionalh along western coast at depths ot from 2-3 m on stones After Meyer 1930
4 *Drapamaldiotde% simplex* (Meyer) Mever et Skabitsch in May July is widespread along the coasts of Baikal where it grows at depths of from 2 5 to 15 m on stones 4a common view of tallom Collection ol the Research Institute of Biology 4b lateral branches 4c cells ot the stalk After Meyer 1930, 4d areals of spread

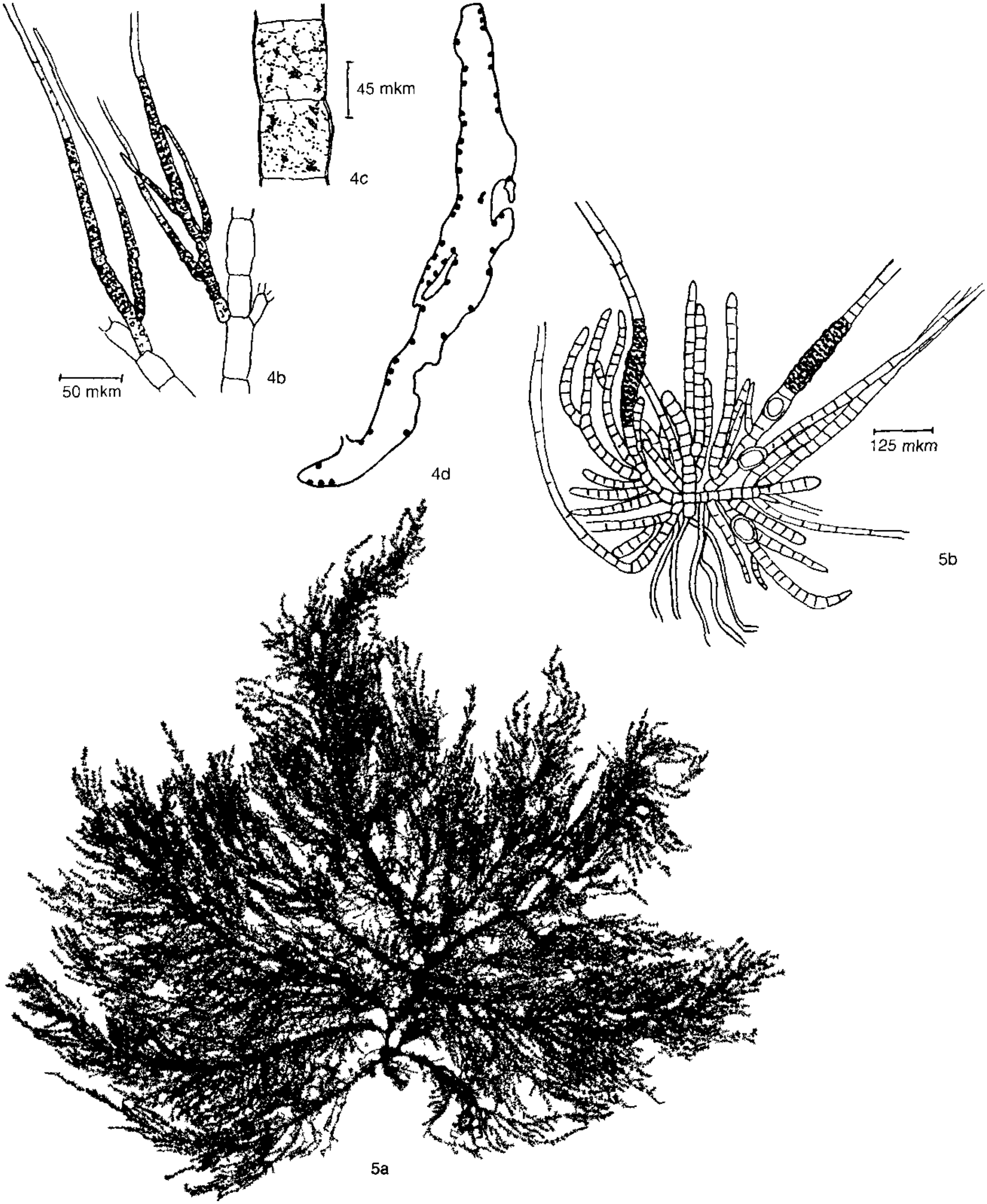
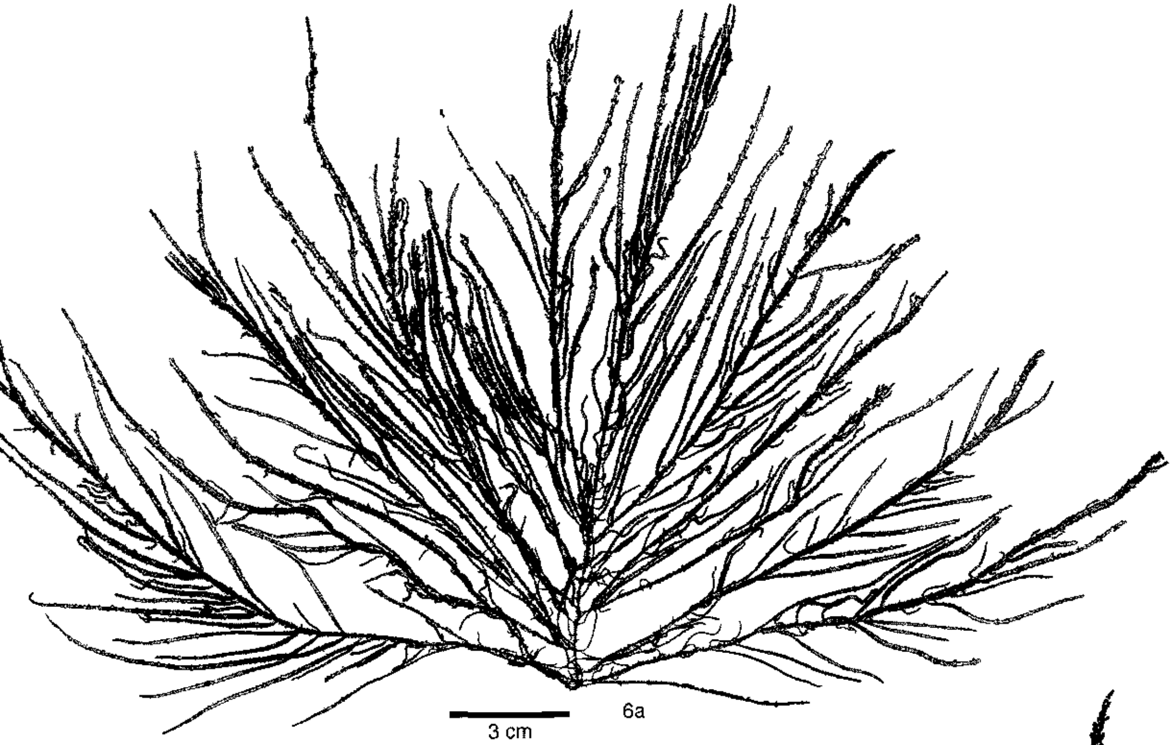


Fig 2 5. Most typical bottom Chlorophyta After Izhboldma. 1990

5 *Draparnaldioides arnoldu* (Meyer) Meyer & Skdbitsch in June-October grows along open coasts at depths of from 1 5-2 to 5-10 m 5a common \ie\\ of tallom, 5b lateral branch Collection of the Research Institute of Biology



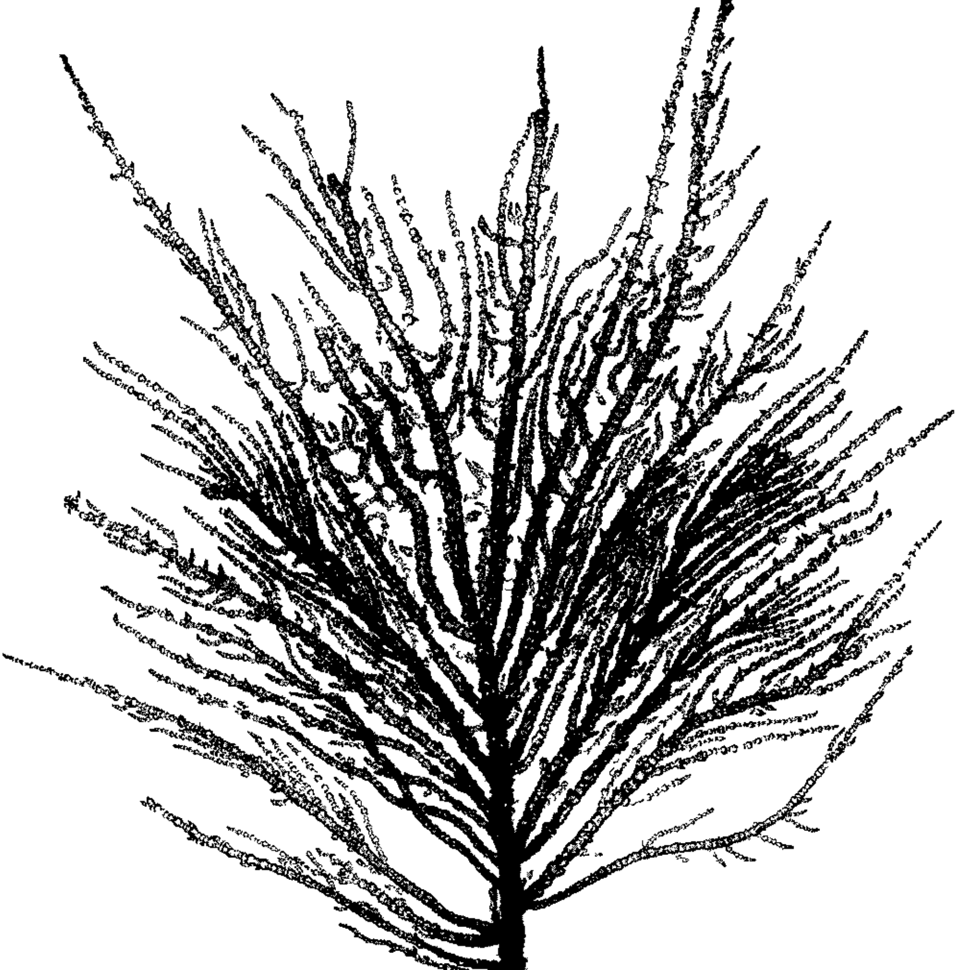
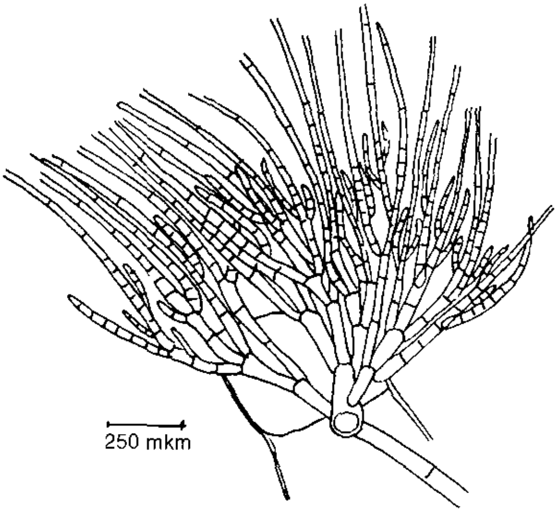


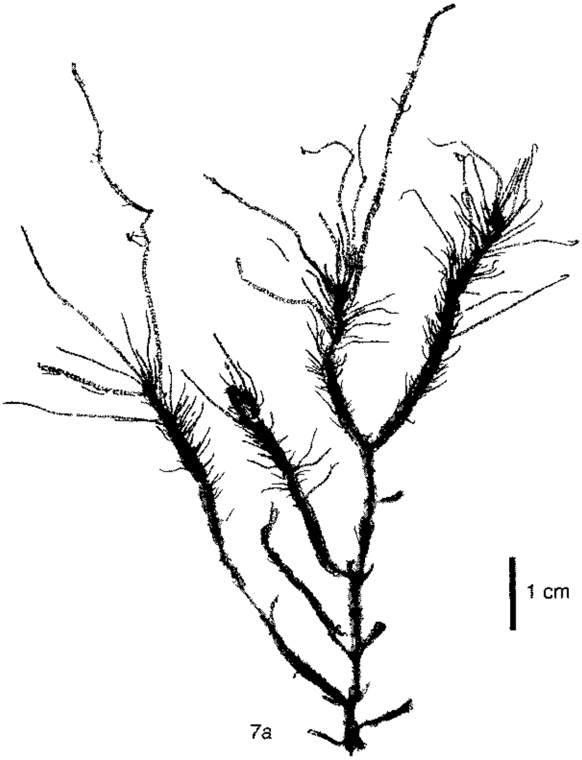
Fig 2 5 Most typical bottom Chlorophyta After Izhboldina 1990

6 *Drapainaldioides batcalenvis* (Meyer) Meyer & Skdbitsch in June-October vegetates at depths of from 2 5-3 to 10-15 m **This** species has the largest, among the representatives of the genus, talloms being 25 cm high, and is most abundant along the western coast 6a b common view of tallom Collection of the Research Institute of Biology, 6c lateral branch After Meyer 1930 6d areals of spread



6c

6d



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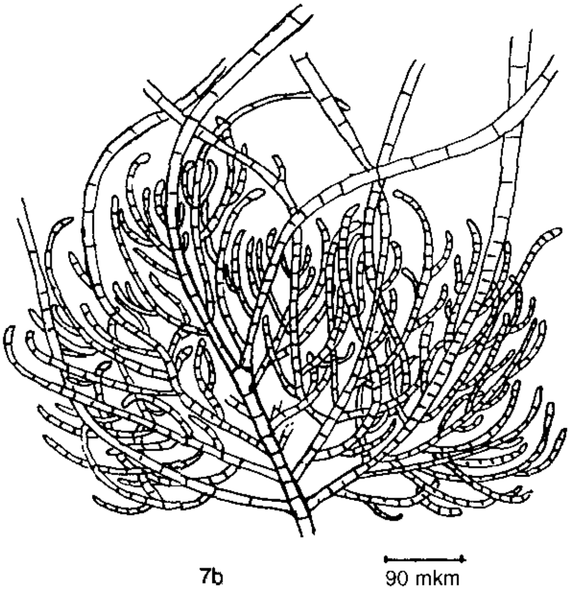
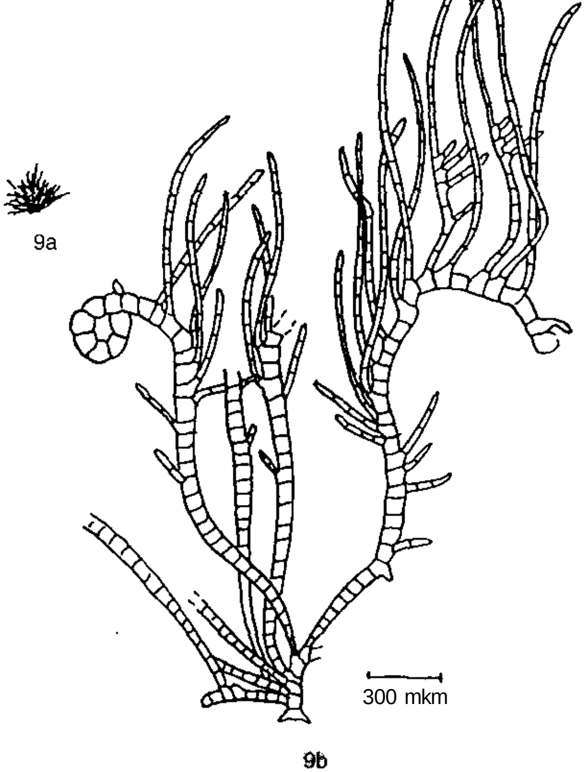


7b

Fig. 2 5. Most typical bottom Chlorophyta. After Izhboldina, 1990.

7. *Draparnaldioides pumila* (Meyer) Meyer & Skabitsch.; in July-November is widely spread in Baikal at a depth of from 1 to 3 m, occasionally 6 m: 7a. common view of tallom; 7b. lateral branch. Collection of the Research Institute of Biology-

Fig. 2 5. Mosi typical bottom Chlorophyta. After Izhboldma, 1990. 8. *Draparnaldwides arenaria* (Meyer) Meyer & Skabitsch.: in June-October grows along open coasts at depths of from I 5-2 to 5-10 m. Col-Jection *of* the Research Institute of Biology. Meyer (1930) noted that the baikahan *Drapamaldia {Draparnaldioides)* should be derived from *Ireksokonia* through *Drapamaldioides simplex. Mixonemopsts crassimemhranacea* should be considered to be a lateral branching from *Ireklokonia formom*



9. *Cladophora floccow* C.Meyer: during the year grows at depths of from 0.5-35 m on stones and silted sand. Occurs along almost the whole coastline: 9a. common \ieu of tailom in true size: Collection of the Research Institute of Biology. 9b. character of branching in different parts of tailom. After Izhboldina, 1990,

(Fig. 2.5. 15), of the genus *Chaetodadiella.* It grows on littoral stones in dense tufts of thick rigid threads. 2 to 4 cm high and about 0.5 mm in diameter, standing more or less erect. In the sublittoral one more representative of this genus, *Ch. microscopica,* is widespread (Figs. 2.5. 14, 2.8).

Conjugatae occur only in sors, isolated gulfs, bays, and other such littoral-sor areas.

Charophyta are represented in open Baikal by three species of *Nitella,* which often form thick growths in bays, gulfs and sors. and by two species of *Chara.*

Modern systematics of algae arc characterized by systems differing from one another even at the highest taxonomic level. Moreover, the application of electron microscopy, biochemical, physiological, genetic and other features have permitted the singling out of many new taxonomic characteristics. This has resulted in deep changes in previous taxonomic combinations, and in distinguishing new species.

In drawing up the list of the planktonic algae of Lake Baikal, we took into consideration these modern approaches *in* their classification. As a base, we accepted the system of the Ukrainian

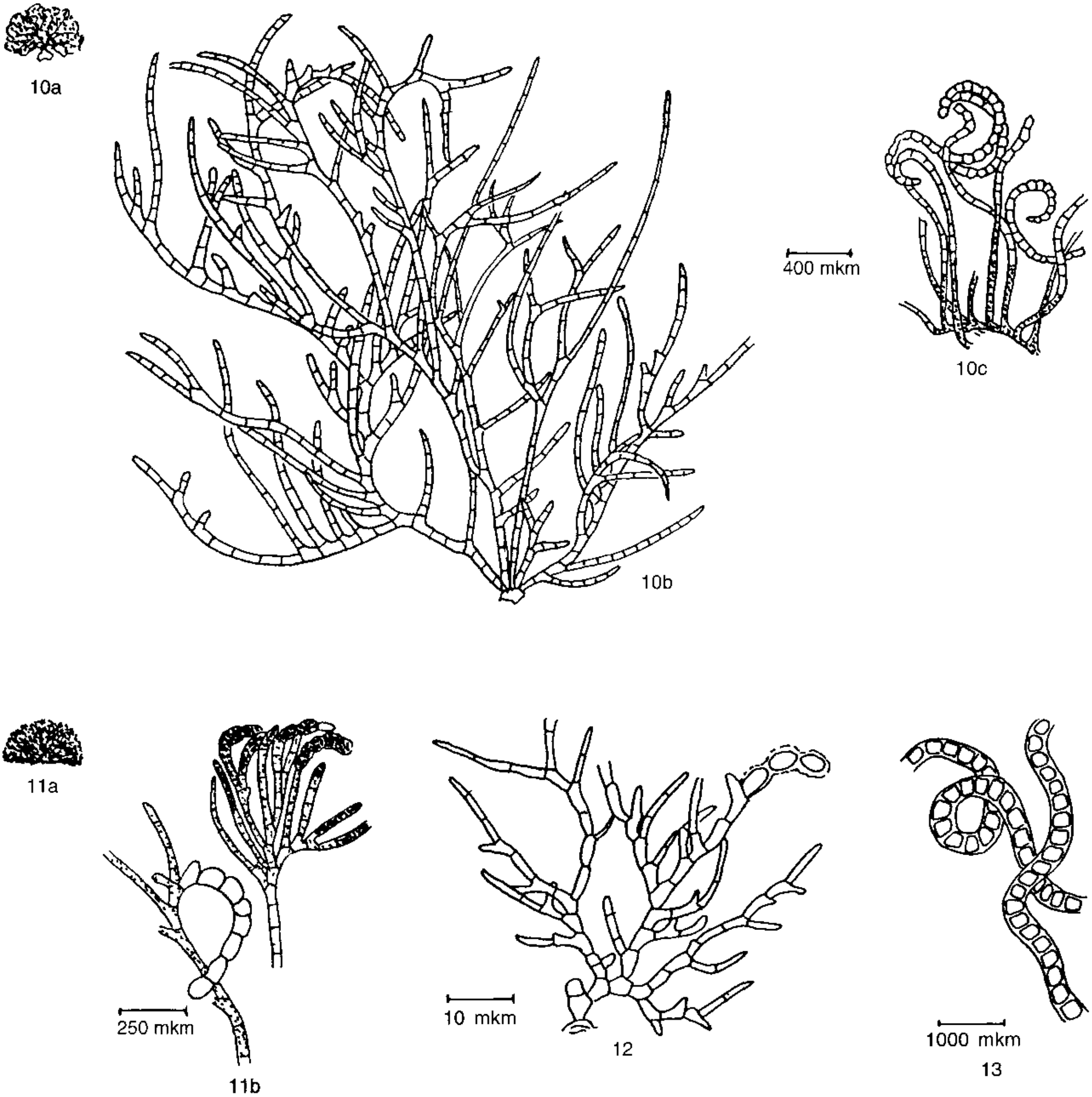


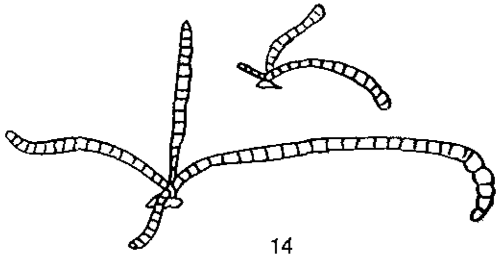
Fig 2 5 Most typical bottom Chlorophyta After Izhboldina 1990

10 *Ciadophora puhinata* (C Meyer) Meyer forms tufts in the shape of small friable cushions of a grey-green colour Occurs at depths of from 5 to 15 m, occasionally at 50 m on coarse-grained sands, pebbles, small stones, which are in sand 10a common view of tallom in true size 10b character of branching in different parts of tallom 10c branches with zoosporangia After Meyer, 1930

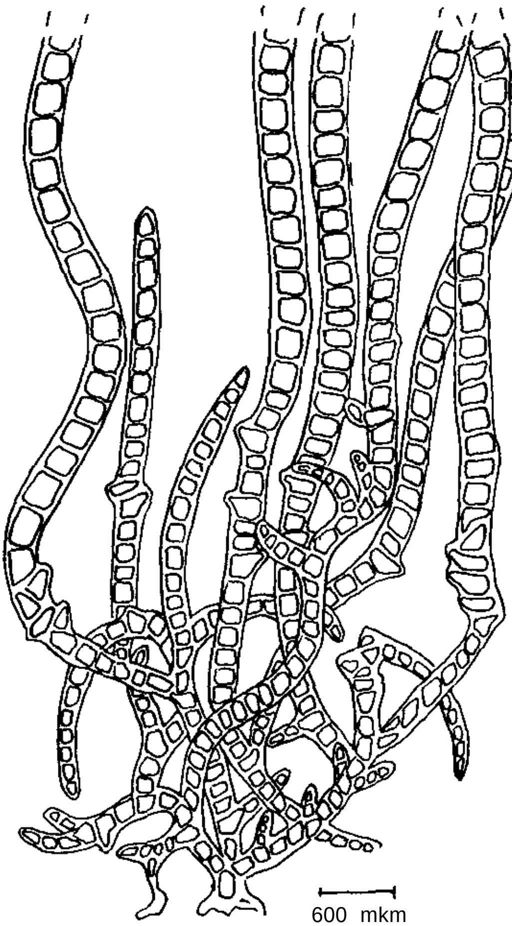
11 *Cladophota compacta* (C Meyer) Meyer grows in compact cushions of green colour Occurs at depths of from 2-8 m, occasionally deeper on stones and rocks I la common view ot tallom in true size 1 lb branches with zoosporangia After Mcvcr, 1930

12 *Ciadophora meyen* Skabitsch var *giacihor* (C Meyer) Hollerb is found at the depths of from 3 to 50 m on silted sands After Meyer 1930

13 *Chaetomorpha baicalensii*, C Meyer treely-lving on silted sand threads from 3-4 to 16 cm long, growing at depths of from 1-2 to 10 m Most abundant in the regions of the straits of Maloye More and Olkhonskiyc Vorota After Meyer. 1930



14



15

Fig 2 5 Most typical bottom Chlorophyta After Izhboldma, 1990

14 *Chaetocladietla microscopica* (C Meyer) C Meyer & Skabitsch is a constant species of the bottom phytocoenoses of the sub littoral zone of Baikal

15 *Chaetociadiella pumila* (Meyer) Meyer & Skabitsch during the year populates depths of from 1-2 to 10-14 m, living on hard soils, occurs predominantly along the western coast On the eastern coast, near the Svyatoi Nos Peninsula and Ushkany Islands

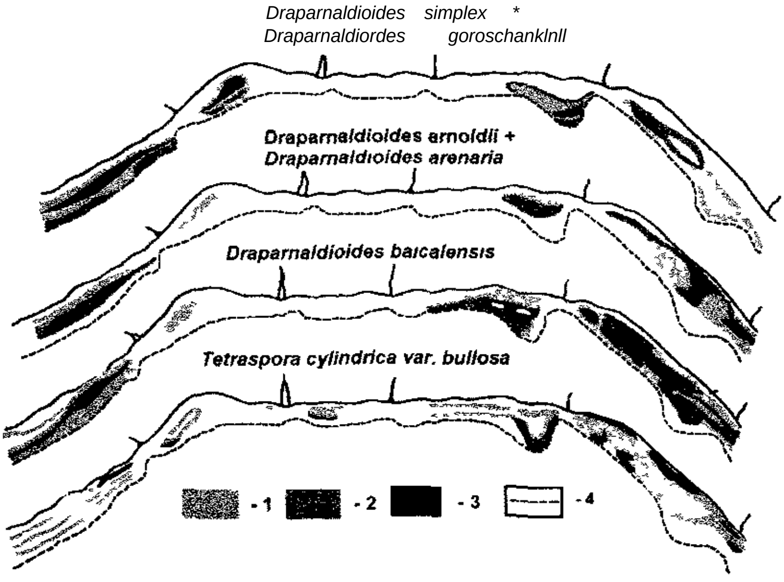


Fig 2 6 Distribution ot biomass (air raw weight, g m"^{2}) of *Draparnaldioides* and *Tetraspora* in the period of maximum development South Baikal, Bolshiye Koty 1 - <- 100, 2 - 100-500, 3 - > 500 g m ^{2} 4 - line of the cliff (depth 20 *m)*

big 2 7 Botrom algae growths Collection of the Research Institute of Biology

school, with the exception of Chrysophyta and Bacillanopyta. The Chrysophyta system, which retains a division status, was characterized according to Hindak *et al.* (1975), and the Bacillariophyta according to the "Diatom algae of the USSR" (1992).

2.3. **Lichens and** Mosses

In the open littoral of Baikal *Collema ramenskh* occurs, forming "curly" bushes consisting of branching, deeply dissected lacimates on stones.

Seven species *of* mosses occur predominantly in

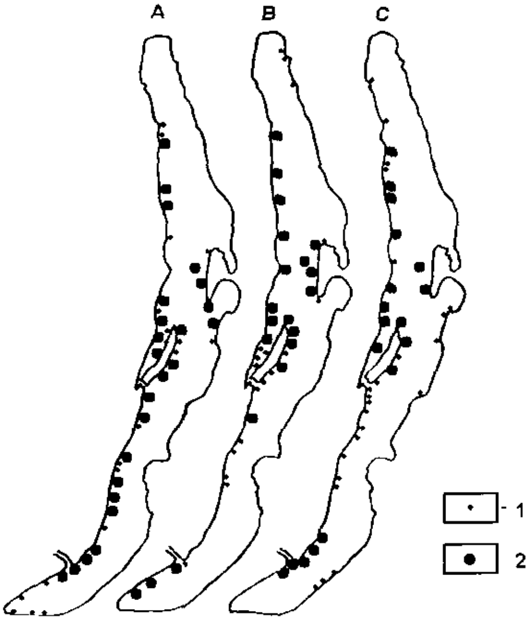


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Fig 2 8 Distribution of *Dtaparnaldioic/es baicatensa,* (Meyer) & Skabitsch (A), *Chaetomorpha batcalenus* C Meyer (B), and *Chaeiodadiella pumifa* (Meyer) Meyer *&* Skabitsch (C) in Baikal

I areals *of* spread. 2 areals of dominating in plant community After bhboldma. 1990 pre-estuarine regions of rivers, and also in interior areas of shallow bays and firths. Along the open coasts of Baikal one species of moss, *Fontinalis nitida* (Azovsky *et al*, 1983), is established.

2.4. Higher water plants

At present the flora of Baikal is comprised of 46 species of higher water plants (Azovsky *et al*, 1983, Gagarin, 1977; Ivanova, 1978; Pautova, 1974). Ferns and flowering plants account for *45* species. Higher water plants occur in the coastal-sor zone, and only a few inhabit regions subject to perturbations. In the 1970s, *Elodea canadensis* appeared and rapidly spread to open Baikal (Fig. 2.9). The majority of plant species in the lake occur at shallow depths (to 2 m), but some *(Fontinahs nitida^ Potamogeton pectinatus, Elodea canadensis, Lemna insulca, Myriophyllum spicatum, Batrachium trichophyllam)* can grow much deeper. The majority of higher water plant species found in the lake are widespread throughout the world. Endemic higher water plants have not been found.

Fig *2 9* A Along the open shallows of Lake Baikal *Elodea canadensis* inhabits silled sands devoid of higher plants. After Ko7ho\d & Izhboldma. 1993

Chapter 3
The fauna

This review presents all taxa, arranged in systematic groups, provides quantitative and qualitative characteristics of each group and of the history of its study, distribution in Baikal, comparative significance, connection with related groups from other waters, and, if possible, its origin.

3.1. Protozoa

3.1.1. Rhizopoda

No bottom rhizopods have been found in open Baikal, but gulf and sors contain species common in Holarctic waters, among which *Diffugia pynformis* Perty, *D. acuminata* Ehrb, *D lemam* Blanc, as well as *Arcella vulgaris* Ehrb. and *Centropyxis aculeata* Ehrb. (Rossolimo, 1923).

A foraminiferan test from the family Rotaliidae or Anomaliidae has been discovered in Tertiary deposits on the coast of the lake, in the area of the River Polovinka

Adjacent waters are inhabited by the heliozoan *Actinosphaerium* sp., but these have not been found in Baikal proper.

3.1.2. Flagellata

For a long time colorless flagellates were unknown in the open waters of Baikal. Thanks to the works of Zhukov (1975), Tanichev & Karpov (1992), 14 planktonic species of flagellates have been found (Fig. 3.1). They are common in freshwater, but two species *(Bodo satmas* and *Paraphysomonas vestida)* also occur in brackish waters. Tanichev (1993) has studied the morphological variability of *Spumella (Monas) termo* and 5 *(M) gregaria*. The latter species are attached or free-swimming cells of oral or round form (3.5-5.5 mkm) with two heterodynamic flagella, bearing mastigonemes. One contractile vacuole is located at the anterior or posterior ends of the cell during digestion.

Three species which are parasitic on fish are known. Two of them *(Trypanosoma carassii* and *T. percae)* parasitize the blood of *Carassius* and *Perca;* one *(Hexamita truttae)* parasitizes the intestine of *Lota lota* and *Coregonus autumnalis migrator IUS.*

3.1.3. Sporozoa

Jn 1910, Svarchevsky found the gregarine *Lankerstheria* sp., an intestinal parasite of the turbellarian *Sorocelis sp., and* gave a detailed description of its life cycle (Svarchevsky, 1910).

Tsvetkov (1928) described two Baikalian species of gregannes, *Gregarina (=Hehospora) acanthogammari* and *Gregarina (=Rotundula) baicalensis* (Fig. 3.2), found in the intestinal tract of Baikalian gammarids.

According to Lipa (1967b, 1968). six species of gregannes are parasitic on nine species of Baikalian gammarides. Four of these were identified as new, *i.e., Rotundula godlewsku, R. dybowskii, Cephaloidophora poltewi* and *C. gerashensoni.* Of 142 examined specimens belonging to nine gammarid species, 26 were infected with gregarines. All gregarines studied showed a rather wide range of hosts, *eg., Rotundula dybowskii* parasitizes six species of gammarids. It is thought that the hosts of these gregarines inhabit the same biotopes and that parasites can easily be transmitted from one host to another (Lipa, 1968).

One species of gregarines, *Nileocephalus astaurovi* Lipa, was found in the larvae of *Baicalina spinosa.* Gamonts of this gregarine are solitary and up to 774 .urn long. Four out of eight larvae were infected with the parasite (Lipa, 1967b).

3.1.4. Other parasitic protozoa

Four species of the Eimeridae (see list of species) are parasitic on the intestine epithelium, gill and urinary bladder of Cottoidei and "sor" fish. Of Microsporidia, two species of the family Glugeidae parasitizing *Lota lota* and *Asprocellus megalops* are known. Protozoa form large oval cysts in the hypodermic and interjoined muscle tissue and on gill covers.

One of the Microsporidia, *Nosema kozhovi,* parasitic on *Brantia lata lata,* a Baikalian gammarid, was described by Lipa (1967a). This species infects gut epithelium, fat body and muscles.

Thirty-eight species of Cnidosponda (six families) are found in Baikalian fish. The Myxidiidae comprises seven species (two or three of which are endemic), Myxobilatidae, two species (one endemic), Myxobolidae, 16 species (two endemic). The families Ceratomyxidae (one species), Sphaerosporidae (nine species), and Myxosomatidae (three species) have no Baikalian endemics.

The endemic Cnidosporidia are found primarily in the endemic Cottoidei. The species *Myxidium omuli* is known to parasitize only *Coregonus autumnahus migratonus.* Parasites affect the skin, gills, oral cavity walls, gullet and intestine, kidneys, liver, heart, muscles, and the walls of the swimming and gall bladders. Some parasites (for instance, *Myxobolus pseudodispar)* are found in the brain of fish, others *(M. ellipsoides)* in gonads, cartilaginous capsules and eye cornea.

Myxidium perniciosus and *Mixobiatus baicalensis* are considered by Doge) to be palaeoendemic, brought to Baikal from the sea by Cottidae. Sporozoans related to these species are parasitic on Cottoidei inhabiting the Arctic Ocean.

3.1.5. Ciliophora

Ciliophora have been studied more thoroughly than other classes of Baikalian protozoans. Thanks to Gayevskaya, Svarchevsky, Rossolimo, Kheisin, Yankowsky and Obolkina, more than 400 species of Ciliophora and Suctoria are known. Gayevskaya (1929, 1933) found 192 species from which 42 species, ten genera and three families were new to science (Fig. 3.3, 3.4). Svarchevsky (1928, 1928-1930) described 86 species living on Amphipoda. Kheisin (1930a, b, 1931, 1932) and Rossolimo (1926) described more than 20 species of Ciliophora, parasitic on various animals. According to Yankovsky (1973), more than 400 species of Ciliophora, about half of which are symbiontic or parasitic, inhabit Baikal.

Recently Obolkina (1989, 1991, 1995a) enriched the list of free living Ciliophora with additional species and genera. Free-living Ciliophora inhabit both the watercolumn and the benthos, and their abundance rarely decreases with depth. Particularly rich and diverse are the communities of shallow regions (bays, gulfs, sors), of the upper layer of the pelagial, water plants and sandy bottoms of the littoral. Most of these free-living Ciliophora are ordinary widespread forms. According to Obolkina, about one-third is endemic to Baikal These are planktonic Ciliophora, described by Gayevskaya (1929, 1933) and the recently discovered psammophilic species. In the psammon, Baikalian Ciliophora have formed a complex of endemic species and genera, adapted to live among minute particles of sand. In fresh waters Ciliophora do not often form a ciliopsammon (sand dwelling Ciliophora-complex), but this is quite common in seas (Obolkina, 1989, 1991, 1995a,b). Endemic planktonic Ciliophora develop in the pelagial of open Baikal during high-crop years of *Aulacoseira (=Melosira)* during the vernal ice maximum. In different years, diverse species of Ciliophora dominate (Kaplin, 1970; Eggert, 1967, 1971): *Cyclotrichium brunneuni, Ophryoglena jlava, Prorodon morula, Lihimorpha viridis, Mucophria pelagica, Marituja pelagica,* and others (Fig. 3.3., 3.4).

The second maximum of the planktonic Ciliophora coincides with the aestival-vernal algal maximum (in August-September). They are represented, as a rule, by ordinary widespread species: *Stokesia vernalis, Amphileptus tracheloides, Didiniidae, Vorticella,* developing massively on planktonic algae, and *Zootamnion, Carchesium,* and others.

Throughout the years the cosmopolitans *Urotricha* sp., *Strombidium* (three species), *Strobidium* (two species), *Mesoclinium pulex, Askenasia* sp., and *Tintinniidae* dominate the plankton (Obolkina, 1995b).

A great contribution to the study of commensal Ciliophora was made by Yankovsky (1973, 1982a, b, 1986). According to him, Ciliophora of the orders Sessihda and Suctoria, dominant in the symbiofauna of Baikal, settle on pelagic algae and all groups of benthic animals and pelagic fish. The majority of the endemic species of the Suctoria are commensals of Amphipodes; these Ciliophora are close to ordinary Palaearctic species. Some orders arc represented in Baikal by single species, for example, Amphileptida, parasitic on Amphipoda and fish; only one species of Heterotrichida *(Stentor)* lives on Amphipoda. Many Ciliophora parasitize a certain group of animals: Folliculinidae live in the base of bark-like sponges *(Swarchewskaja);* Hymenostomata-Tetrachymenida are parasitic on Turbellaria and fish; Thigmotricha of the group Hemispelirina are found in the mantle cavity of Gastropoda and Bivalvia. Yankovsky described the symbiosis of the zoochlorella *Thigmotricha* and molluscs of the genus *Choanomphalus* Endemic Hysterocinetida are found in the intestines of Oligochaeta and Gastropoda. Endemic Hysterocinetida are absent in Sphaeriidae and Unionidae. Apostomatida live in the exuvium of Amphipoda *(Gymrtodimoides)* and parasitize the blood system of some species of Amphipoda *(Collmia).* Mobile Peritricha *(Trichodinidae)* are common in fish (Yankovsky, 1986). Peritricha are found on the skin, fins and gills, in the mouth, gullet, eye cornea. Parasitizing fish (omul, grayling) *Ichtiophtioius multifilhs* can reach gigantic sizes (0.3-1 mm). According to Cherepanov (1966), /. *multifilhs* was brought to Baikal during acclimatizatiom of the Amur sazan. Endemic Peritricha are few and live in Amphipoda, Gastropoda and larvae of Trichoptera. With regard to the testaceous forms, except for *Cothurnia,* the colonial *Nidula* occurs. The formation of cofomaf testaceous forms took place independently in *Cothurnia* and *Lagenophryna. Baikalaster pelagicus* is found on planktonic algae of Baikal, attached to the substratum by a myonema. Yankovsky considered the endemic symbiotic Ciliophora of Baikal to have evolved parallel to the animals in which they live

Gayevskaya (1929) considered about 10% of all Ciliophora, and above all, Tintinmdae, to be species of marine origin. According to previous conceptions, the majority of Baikalian Ciliophora has no close relatives among fresh-water or marine species. From the modern point of view (Yankovsky, 1982a; Obolkina, 1995b), marine elements in the fauna of the Ciliophora in Baikal are absent, although practically all endemic species are close to widespread fresh-water forms.

Protozoa of uncertain position

The systematic position of the genus *Dermocystidium,* including two species of parasites, of Baikal fish, *D. percae* (on perch) and *D. lenoki* (on lenok) is unknown. Before the revision made by Sprague (1966) and Weiser (1979), they were considered to be Haplospondia, but other authors refer to them as fungi (Handbook of the Parasites of Fresh-Water Fishes of the USSR, 1984). Haplosporidia form small spherical or elongated milky-whitish cysts and parasitize the fins and skin of fish.

3.2. Spongia

The sponges of Baikal have been studied by Dybowsky (1882), Sukachov (1895), Svarchevsky (1901, 1923a, 1925), Annandale (1913), Resvoi (1936), Kozhov (1930) and Martinson (1947). They are represented by species belonging to three genera (Fig. 3.6, 3.9, 3.11). Although differing markedly from each other, they all constitute one group singled out in one family, Lubomirskndae. belonging to the order Cornacuspongia. The Lubomirskndae differ from the Spongilhdae by their skeleton, which is stronger and forms a more regular lattice, and by the ends of their spicules, which are more deeply embedded in spongin.

These sponges do not develop gemmules for asexual reproduction. It has long been recognized that the sponges of Baïkal multiply by means of so-called sorites. Sorites were regarded as a form of sexual reproduction, differing from gemmules by some peculiarities of formation, absence of coating with spicules, and development into a free-swimming larva, whereas, from gemmules, a juvenile sponge develops (Svarchevsky, 1923a, 1925; Resvoi, 1936).

In Kozhov's opinion (1963) sorites are parthe-

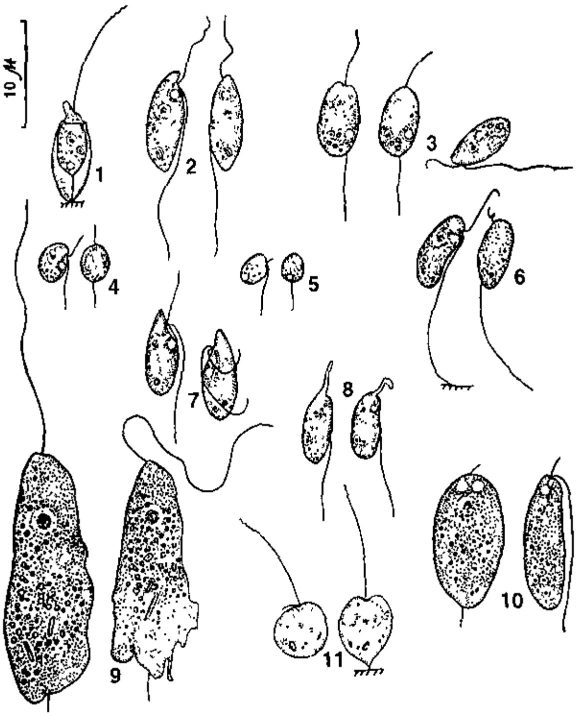


Fig 3 1 Colorless Flagellate of Baikal- After Zhukov, 1975. 1 - *Bicoeca lacustns* Clark, 2 - *Bodo salmons* Ehrenb., 3 - *B. repens* Klebs. 4 - *B minimus* Klebs, 5 - *Bodo* sp,, 6 - *Pleuromonas jaculans* Pcrty, 7 - *Phyllomitus apiculaius* Skuja, 8 - *Rhynchomonas nosuta* (Stores) Klebs. 9 - *Cercobodo sp..* 10 - *Thaumotomonas laulerborni* De Saed, 11 - *Moitas sp.*

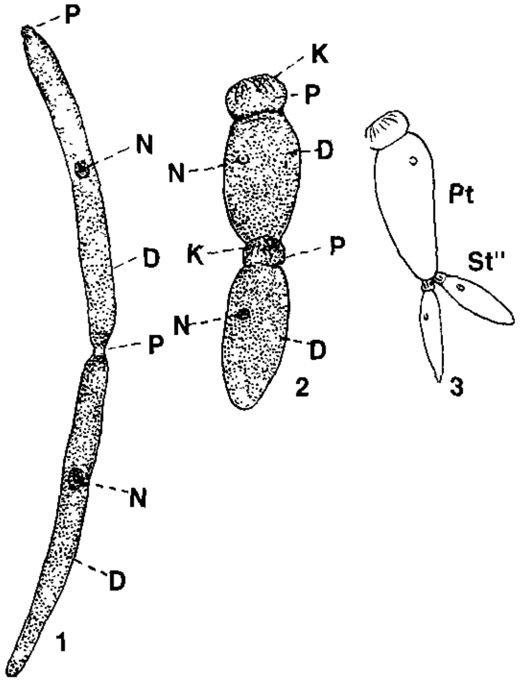


Fig. 3.2. Gregannes. (- two Specimens of *Heliospora acanthogammari* Zwetk., body length 0.5-0.6 mm; 2 - two specimens of *Rotundula baicahmsis* Zwetk., body length 035-0.40 mm; 3 - a colony of three specimens of the same species. P - protomente; D - deutomerite; K - radial furrows; N - nucleus; St. - satellites. After Tsvetkov. 1928.

nogenetic eggs. At present it is well established that sorites are mature oocytes, rich in yolk, which are generated in large quantities by female colonies of sponges by oogenesis. To develop further, they need to be fertilized (Gureeva, 1972; Efremova, 1981). Male sex cells are formed in male colonies (Gureeva, 1968a; Efremova & Papkovskaya, 1980). Fertilization is internal, whereas embryogenesis and formation of larvae occurs in the body of the maternal sponge. The stages of embryonic development and formation of free-swimming larvae in Lubomirskiidae, and the larvae themselves, are similar in various species of Baikalian sponges and shared with the Spongillidae (Brien & Meewis, 1938; Gureeva, 1968b, 1982; Efremova, 1981, 1982).

The sperm of Baikalian sponges and Spongillidae (Efremova & Papkovskaya, 1980; Sukhodolskaya *et al.*, 1986) display a striking similarity with regard to ultrastructural organization. Larvae of Baikalian sponges (Fig. 3.5) are ootype and swim by means of flagellated cells formed by the superficial one-layer epithelium. The anterior half of the larval body U occupied by a large cavity and the posterior half is a dense mass of cells in which spicules are located. Lubomirskiidae and Spongillidae larvae are similar in structure and cell composition. Early differentiation of some embryonic cells is characteristic for the larvae of both families, so that free-swimming larvae already have a considerable quantity of specialized cells typical *of* adult sponges: collencytes, bubble-like and granular eosinophil cells and others (Brien & Meewis, 1938; Gureeva, 1968b, 1976, 1982; Efremova & Efremov, 1979; Alekseeva, 1980). Similar features can also be traced in the metamorphosis of the larvae of Baikalian sponges and Spongillidae. A flagellated epithelium is a provisory, purely larval formation: at the initial stages of the metamorphosis its cells are phagocytized by other cells of the

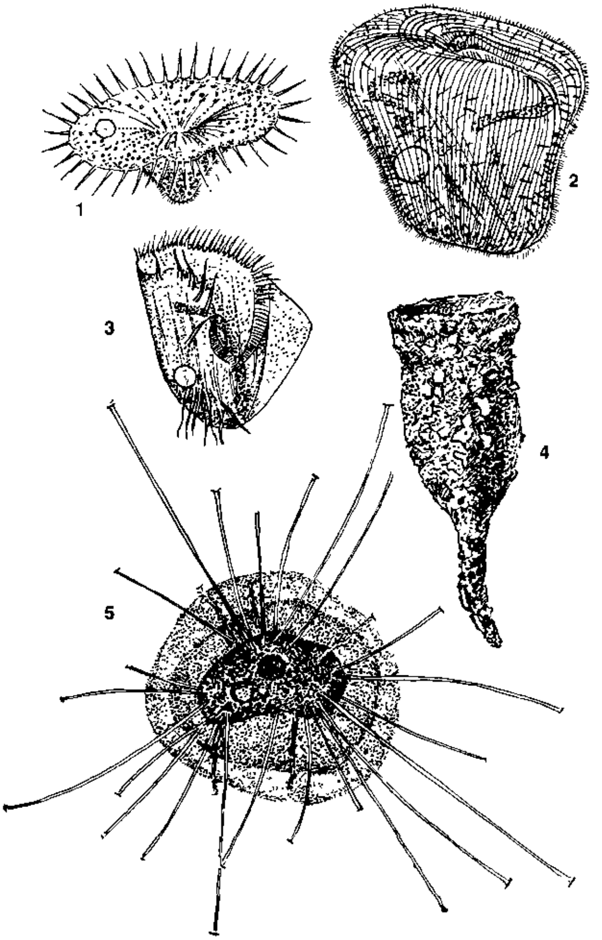


Fig. 3.3. Ciliates of Baikal's open waters. 1 - *LUiimorpha viridis* Gajew.. body length 0.11 mm; 2 - *Mantuja pelagica* Gajew., body length 0.14 mm; 3 *Euplotes. baicailensis* Gajew. (?); 4 - a test of *Coxhella sp.* (?); 5 - *Mucophrya pelagica* Gajew. (?), body length 0.11 mm. After Gayevskaya, 1933.

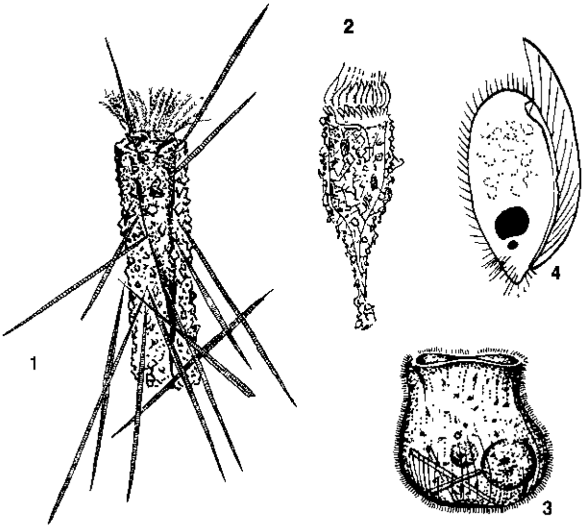


Fig. 3.4 Ciliates of Baikal's open waters: 1 - *Tmtinmdium fluviatile f. cvlindnca* Gajew. (?), body length 0 125 mm; 2 - *Tintinnopsis davidoffi var. cvlindnca f. minima* Gajew. (?); 3 - *Spathidiosus bursa* Gajew. (?>, body length 0.095-0.110 mm; 4 - *Tiarella baicalensis* Chejs. (?), body length 0.05-0.07 mm. 1-3 after Gayevskaya, 1933, 4 after Kheisin, 1931.

larva and are not involved in the formation of the juvenile sponge. Its flagellated chambers are formed from internal archeocytes, and the definitive epithelium from collencytes located directly under the flagellated epithelium (Gureeva, 1968b, 1976; Efremova & Papkovskaya, 1976).

The genus *Swartschewskia* resembles minute, graceful whitish papillae, incrustations or caps 1 to 3 cm in diameter (Fig. 3.6), often with a single osculum at the apex. The genus is represented by the sole species *S. papyracea* (Dyb.), which lives on stones in the littoral and sublittoral. There are two layers in the body of a colony: external, bark-like, and an internal loose mass of cells. The external layer contains a bark-like lattice skeleton from tangentially-located spicules, embedded in spongin. The spicules are thick, short, straight or slightly curved, with blunt ends (Fig. 3.7-1; 3.8-A). The cells of the external skeleton arc of polygonal shape, and line the canals of the water system of the sponge. These canals communicate with numerous flagellated chambers located deep into parts of the colony. There are also drainage canals leaving the flagellated chambers which combine, become larger and flow together into a vast cavity opening to the outside via the osculum. Spongin strands in some cavities of the water-bearing system can be seen. These spongin strands are structural elements strengthening the soft tissues of the sponge, as the spicule skeleton strengthens only the external, bark-like layer of the colony (Alekseeva, 1976).

The genus *Lubomirskia* is characterized by well-defined longitudinal and transversal tufts of spinulated spicules sharpened at both ends (Fig. 3.7, 3.5. 3.8c). The genus comprises three species: the Baikalian branch-like bright-green sponge *L.*

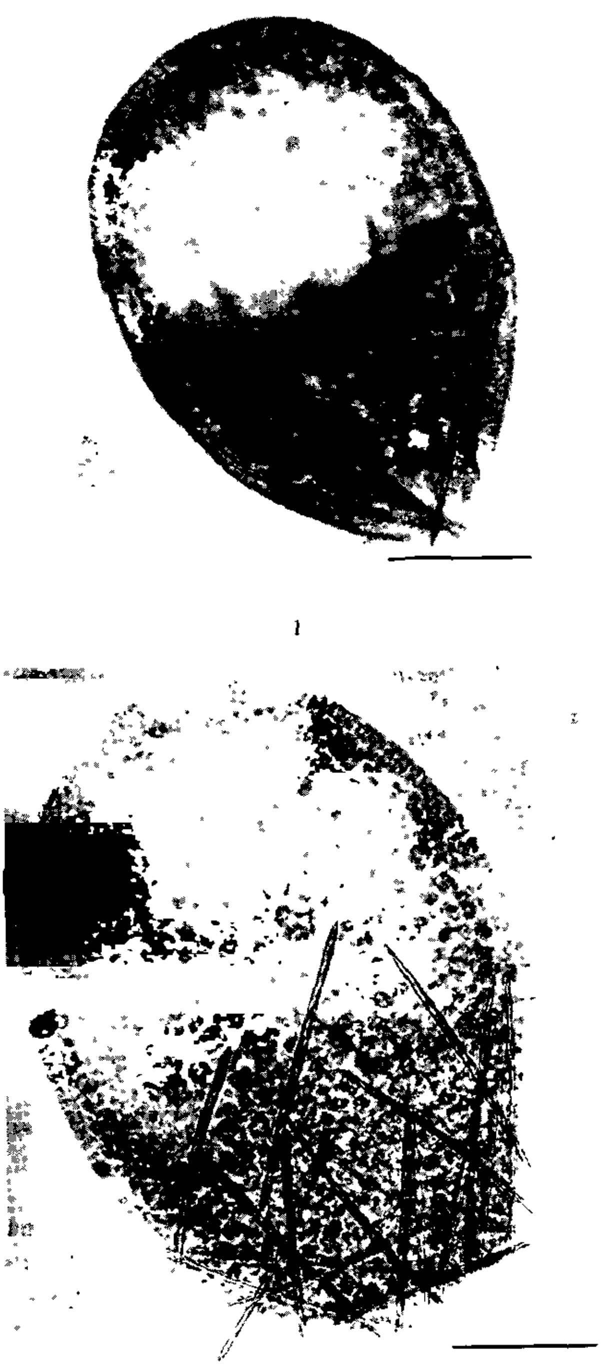


Fig 3 5 Lar\a *Bmcalospongia bacilhfera* (Dyb) (1) and *Lubominkia baicaiensn,* (Pallas) (2) Scale 100 mkm Atter Efrcmova & Gurceva, unpublished data

baicalensis Pallas (Fig. 3,7). the bark-like *L. fusifera* Souk, with loose soft tissue, and *L. abietina* Swartsch. (Fig. 3.7-2), also a bark-like sponge with a weak skeleton.

L. hatcalensis is particularly numerous. It lives on stones and rocks beginning at 1-1.5 m depth, where it is represented by a bark-like form which does not develop branches and covers bottom stones as a bright-green carpet (Fig. 3 9c). It begins to form branches at 3-4 m depth and particularly at 5-12 meters, with thick, cylindrical bright-green branches 60 to 70 cm long (Fig. 3.9a,b), often connected by bridges or fully intergrown, extending from a broad bark-like base attached to a hard substratum. Whole "forests" of these bright-green colonies can be seen in the littoral of Baikal (Fig. 3.10). The sponge owes its color to a symbiotic *Zoochlorella* which lives in its tissues. As Efremova (1981) discovered, the bright-green color is restricted to the external layer, in which these symbionts live. The thickness of this layer reaches 3 mm. and does not contain sex products, embryos, or larvae, which develop in great quantity in deep tissues of the colony, devoid of symbionts. In each branch of the colony apical, middle and basal zones can be distinguished. The apical zone can reach 4 cm in length. It does not carry embryos, although the rest of the branch is filled with developing sex products, embryos and larvae. In the apical zone, active formation of young flagellated chambers and intensive secretion of spongin fibers occur Thus, the apical zone is the zone of growth, the youngest part of the branch.

A well-developed water-bearing system, composed of flagellated chambers, driving and drainage canals and cavities, is characteristic of the middle zone. The intensity of spongin synthesis decreases markedly here. It is in this zone that developing sex products and embryos are abundant. Vast water-bearing cavities are typical of the basal zone, here less sex products and embryos occur, and the spongin secreting cells disappear completely. *L. baicalensis,* like Spongillidae, has a dermal membrane and sub-dermal cavities, although less well developed.

The branches and bark-like base provide shelter to the emerald-green gammarid *Brandtia {Spina-*

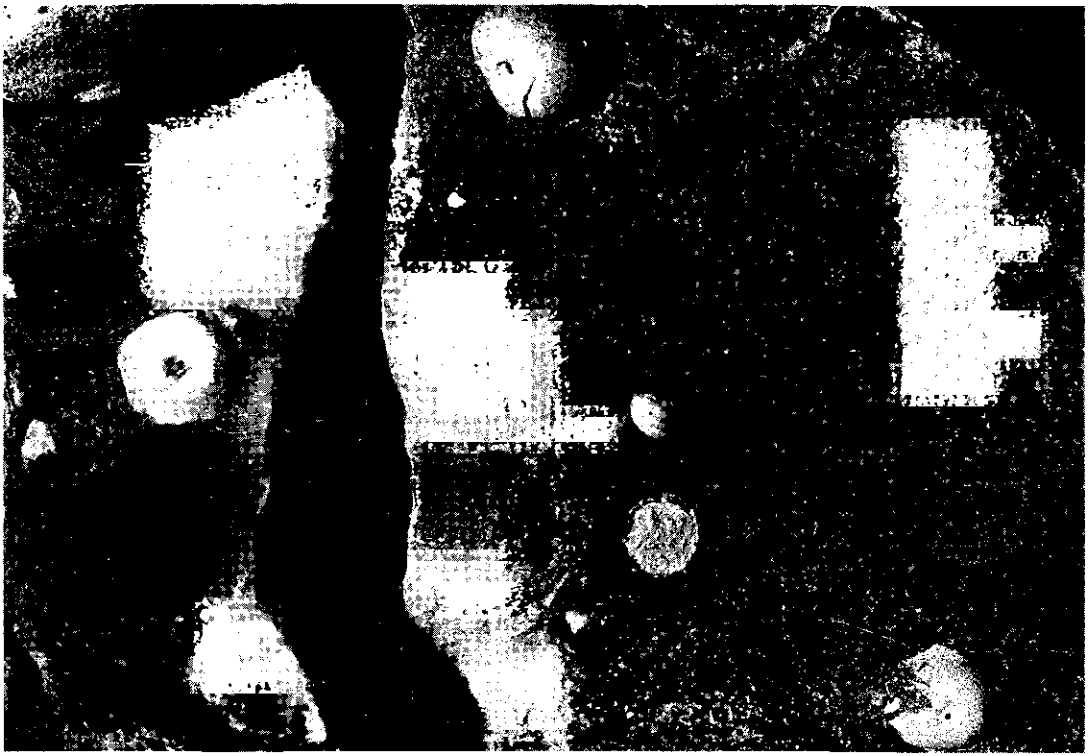


Fig. 3.6. Baikalian sponge. *Swartschewskia papyracea* (Dyb.). with the osculum in the centre. Diameter of sponge 4—6 cm. Collection of the Research Institute of Biology.

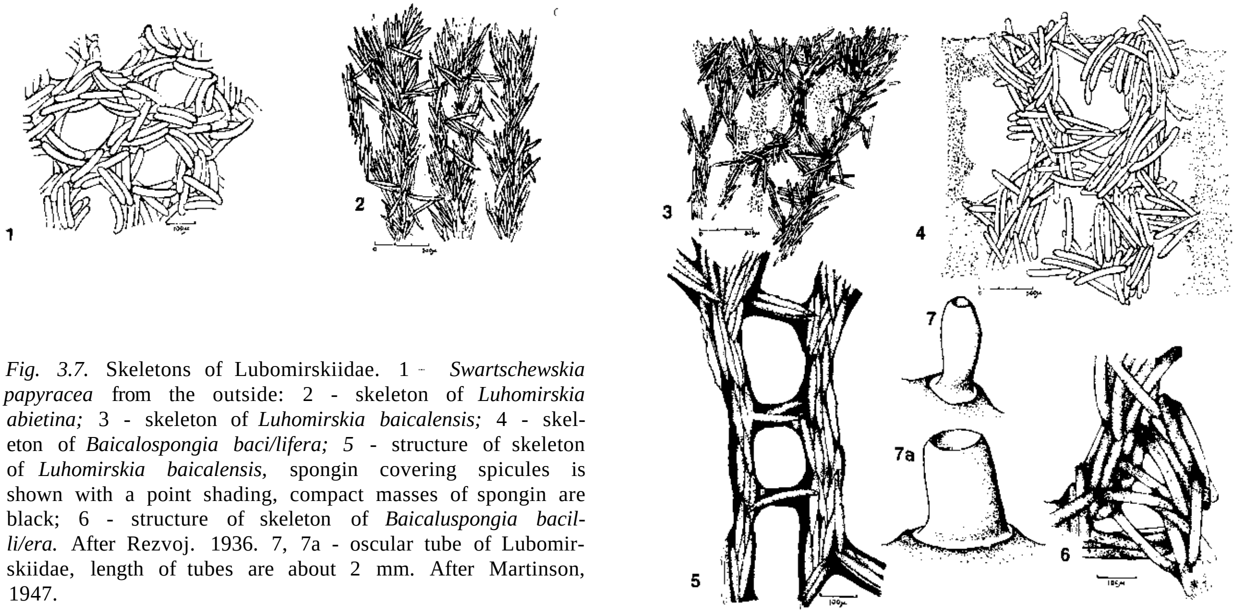


Fig. 3.7. Skeletons of Lubomirskiidae. 1 - *Swartschewskia papyracea* from the outside: 2 - skeleton of *Luhomirskia abietina;* 3 - skeleton of *Luhomirskia baicalensis;* 4 - skeleton of *Baicalospongia baci/lifera; 5* - structure of skeleton of *Luhomirskia baicalensis,* spongin covering spicules is shown with a point shading, compact masses of spongin are black; 6 - structure of skeleton of *Baicaluspongia bacilli/era.* After Rezvoj. 1936. 7, 7a - oscular tube of Lubomirskiidae, length of tubes are about 2 mm. After Martinson, 1947.

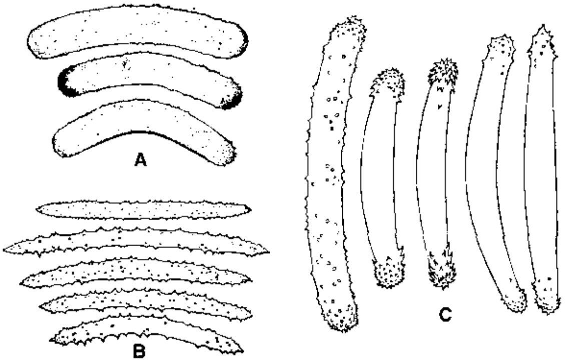


Fig. 3.8. Skeletal spicules (macroscleres) Lubomirskiidae. A - *Swartschewskia papyracea,* length of spicules 112-150; B - *Baicalospongia hacillifera,* length of spicules 170-363; C - *Luhomirskia baicalensis,* length of spicules 145-233. After Resvoi, 1936.

Fig. 3.9a. Luhomirskia baicalensis (Pallas). Collection of the Research Institute of Biology.

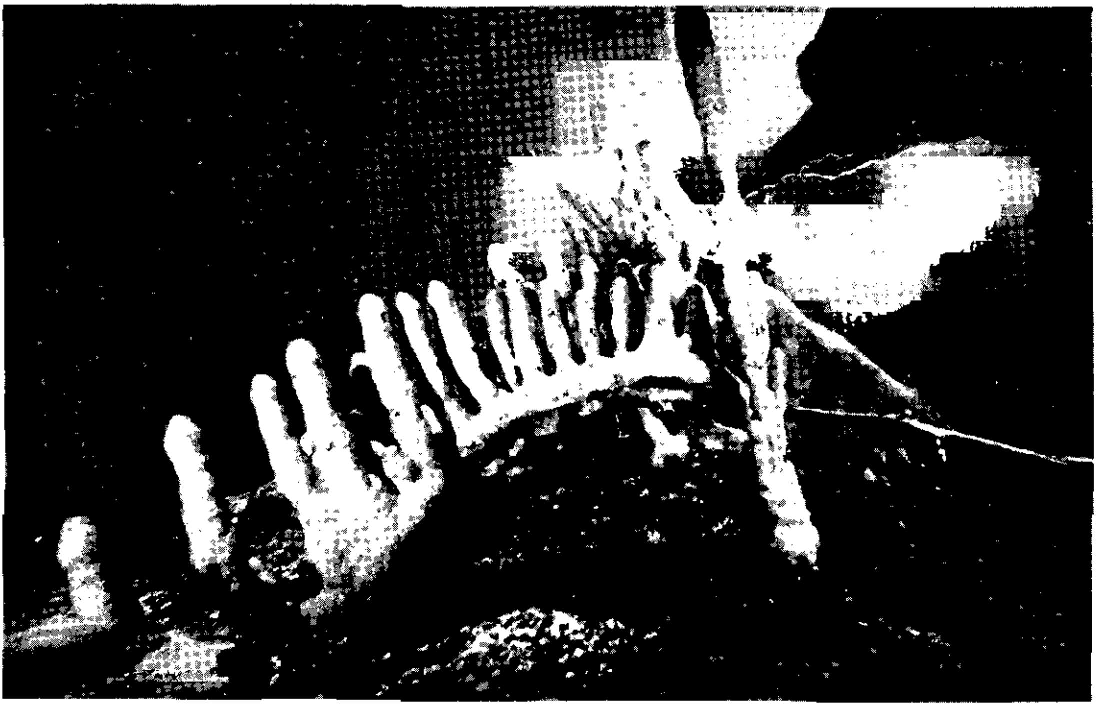


Fig. 3.9b. Luhomirskia baicalensis (Pallas), branchy <comb-shaped| form. Depth 8-10 m. Photo by S. Glushenko.

Fig 3.9c Lubomirskia haicalcnsis (Pallas), overgrown bark-like form. Depth 3 m Photo by S Glushenko.

canthus) parasiticus Dyb. and many other *minute* animals, as well as oligochaetes, turbellarians, etc. Branching specimens of the Baikalian sponge often reach depths of 25-30 m. It is found throughout Baikal and extends, as a trailing bark-like form, to the upper section of the Angara.

The sponges of the genus *Baicahspongia* do not develop branches. They form massive crusts, columns and other growths, of a pale-green color and solid, hard consistency, attached to stones and other underwater objects (Fig. 3.11). The skeletal spicules are pointed at both ends, spiny and rather irregularly spaced in the main tufts. This genus comprises two species: *B. baciilifera* (Dyb). (Fig. 3.7,4,6, 3.8b) and *B. intermedia* (Dyb.), which occur along the coastal belt at depths of from 4 to over 500 m.

The Baikalian sponges prefer rock bottoms in open Baikal and are not observed in gulfs and bays, where they are replaced by widespread species of the genera *Spongilla* and *Ephydatia*. Life in the unusual conditions of these waters causes these species to differ markedly from their relatives in the character of the coating of gemmules. This and. in particular, the deformity and incomplete development of the siliceous needles covering the gemmules (or their entire absence), prompted Svarchevsky (1901) to describe them as independent species while, in fact, they are only varieties (Kozhov, 1947).

Baikalian sponges are highly important consumers of microplankton, especially bacteria, and of silica, from which their skeletons are constructed (Votintsev, 1948a).

Consumption of sponges by animals is insignificant, although there have been reports that Baikal sponges are used as food by sturgeons.

Prior to 1927, representatives of the Lubomirskiidae *were* only known from Baikal; the statement by Dybowsky (1886a), and repeated by many authors, that some Lubomirskiidae occur in the Bering Sea (the Komandorskiye Islands), is a misunderstanding. Resvoi (1927) described a new species *of Baicahspongia* in the large but shallow Lake Dzhegetai-Kul in the Western Sayan region, but this turned out to belong to the widespread Palaearctic family Spongillidae (Kozhov, 1972).

Some authors point out that Lubomirskiidae sponges arc remotely reminiscent of the Caspian *Metschmkowia* and the Ohrid *Ochridaspongia rotunda* Arndt (Arndt, 1937). The latter, in Arndt's opinion, resembles in some respects the Baikahan *Baicalospongia* and also *Corticospongilla barroisi* Tops, from Lake Tiberias in Palestine. *Pachydktym* from Lake Posso in Celebes and, partly, the genus *Nudospongia* from Lake Tiberias and Lake Tali-fu in South China. All these resemblances, however, are due to convergence.

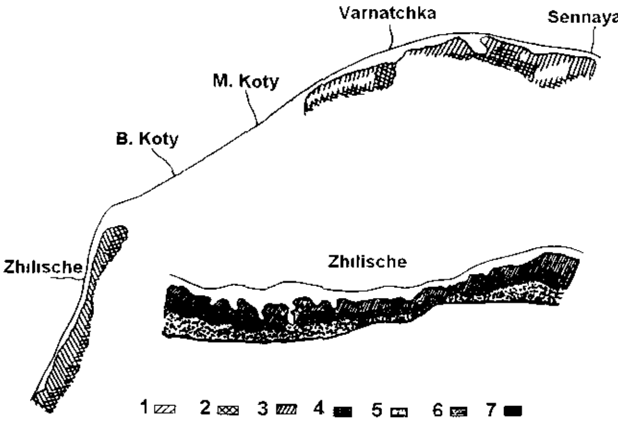


Fig 3 10 Distribution of *Lubomuskia baicalensn* (Pallas) South Baikal. Bolshiye K-oty Data of the Research Institute of Biology

I - projective cover of the bottom by sponges 1 - <50%, 2 - >50%;

II - distribution of colonies of various size on one of the sites of Bolshiye Koty 3 - bark-likc morpha. 4 - height of sponge 0-5 cm, 5 - the same, 5-15 cm, 6 - the same, 15-50 cm, 7 - the same, >50 cm

Arndt (1937) regards all of the above-mentioned sponges as Tertiary relicts. In skeleton structure, *Ochridaspongia* resembles the Lubomirskndae, but the latter are devoid of the subdermal spaces which occur in *Ochridaspongia.* Like the Lubomirskndae, *Ochridaspongia* does not develop gemmules and their embryos, formed sexually, are found throughout the year.

Stankovič (i960) considers *Ochridaspongia* to be a Tertiary relict without close relationship to modern sponges. In the opinion of Resvoi (1936), the Lubomirskndae can be regarded as marine immigrants, independent of the Spongilhdae but evidently dating from a later period Some authors (Makushok, 1925) assume that the Lubomirskndae may have evolved from the Spongilhdae in Baikal itself. Relying on the results of serological analysis, Tah'ev (1940) considers that the Lubomirskndae are closer to the Caspian genus *Metschnikowia* than to freshwater Spongilhdae.

Spicules of Lubomirskndae have been found in Oligocene deposits along the south-east coast of Baikal and in the Tunka trough, close to south Baikal (Martinson, 1936. 1938, 1948b). Spicules resembling those of Baikahan sponges have also been found in Oligocene-Miocene deposits of the Amur-Sungary depression in the Far East (Kozhov, 1972) The investigations of Martinson (1948b, 1958, 1959a, 1967) in Zabaikahe, in Central and South-East Asia, show that in the Palaeogene, and at least in the Oligocene-Miocene, Lubomirskndae were widespread in the waterbodies of these regions. Together with the endemic family of Baikahan molluscs, the Baicalhdae, they belong to the so-called mesohmnetic fauna complex which originated in large waterbodies of Central Asia at the end of the Lower and the beginning of the Upper Cretaceous. Martinson (1967) admits that from the centre of their formation representatives of the mesohmnetic fauna could have penetrated lacustrinc-nver systems and spread to the North, Nortb-East and South-West. It is this wide distribution that can account for the genetic likeness between Caspian and Baikalian sponges, since no direct connection between Baikal and the Caspian Sea ever existed. Pioneer investigators believed endemic Baikalian sponges to be independent and late immigrants from the sea, not related to the cosmopohtic Spongilhdae (Annandale, 1913, 1914; Resvoi, 1936). A well-developed skeleton with a regular lattice of longitudinal and transversal tufts of spicules, a large amount of spongin, periodicity of growth of colonies with formation of "growth rings", absence of gemmules and, particularly, the concept of the propagation of Baikalian sponges by means of "sorites" which proved to be wrong, do not support the hypothesis of their kinship with the Spongilhdae. Investigations during the last decades have now elucidated the origin of the endemic Baikalian sponges. First, it has been found that sponges of the family Lubomirskndae lived in Palaeogene water-bodies of Central Asia (Martinson, 1967). Second, the similarity of embryonic and larval development of the Lubomirskiidae and Spongilhdae is so striking that it can hardly be explained by convergence, but rather

A

B

Fig 3 11 A Baicalospongia bacilhfeui (Dvb *)* diametre 8-12 cm collection ot the Research Institute of Biolog\ B – *BuiLalospongia inteimidia* (Dvb) Depth 6 m Photo b\ S Olushenko

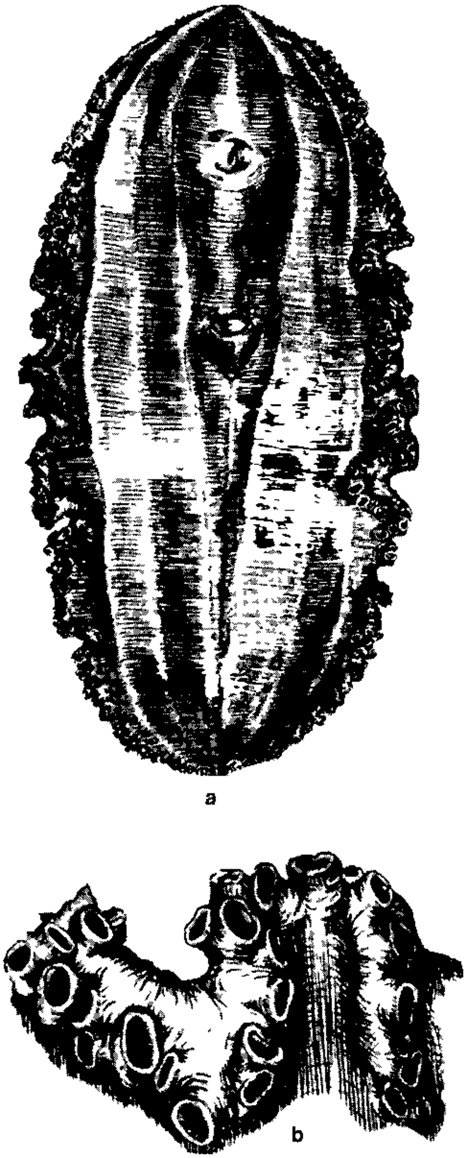


Fig 3 12 Baicaloplana \alula, a fixed specimen from the ventral side, body length when straightened out alive up to 30 cm, width up to 3 cm, b - magnified part of the lateral wall with suckers After Kozhov, 1947

underlines the kinship between these families (Gureeva, 1968b. 1982; Efremova, 1981, 1982).

The family Spongilhdae is more ancient and probably originated in water-bodies in the Trias and Jura. Spongillidae of the Cretaceous period already multiplied by means of gemmules, as seen in the Mesozoic sponge *Palaeospongia chubutensis* of Cretaceous deposits of Patagonia (Racek & Harrison, 1975). Efremova (1981, 1982) therefore concluded that the family Lubomirskiidae has spongillate roots, and the formation of Lubomirskiidae is connected with the colonization by Spongillidae of the Cretaceous-Palaeogene water-bodies of North Asia. A long existence in these hydrologically stable water-bodies contributed to a loss of propagation by means of gemmules in the process of speciation

3.3. Coelenterata

Coelenterates in Baikal are only represented by the widespread fresh-water genus *Hydra,* inhabiting gulfs and bays deeply indenting the coast. Svarchevsky (1923b) described a new species, *Hydra (Pelmatohydral) baicalensis* Svartsch., which was found in *Potamogeton* growths in the shallow southern part of Chivyrkui Gulf.

This species has a slender body reaching 1-15 cm in length (without tentacles) when fully extended. It has six or seven tentacles which are, as a rule, longer than the body.

Among algae in the littoral of open Baikal one can often come across a large hydra resembling the above-mentioned *H. baicalensis;* the specific position of which has not yet been ascertained. Gayevskaya (1933) recorded the presence in Baikal of *Hydra grisea* L. *(=N vulgaris* Pall.).

The sole representative of *Polypodium, P. hydriforme,* is a parasite of the *Acipenser* roe. The detailed systematic position of this *P. hydri/orme* has not yet been ascertained.

3.4. Plathelmintes

3.4.1. Turbellana

The Baikalian turbellarians display an unusual abundance of forms. The first data were published by Gerstfeldt (1859a) and Grube (1871-72, 1872, 1872-73), who described about a dozen species from coastal Baikal and from the upper part of Angara.

A wealth of turbellarians was collected by the expeditions of Korotnev in 1900 and 1901. They

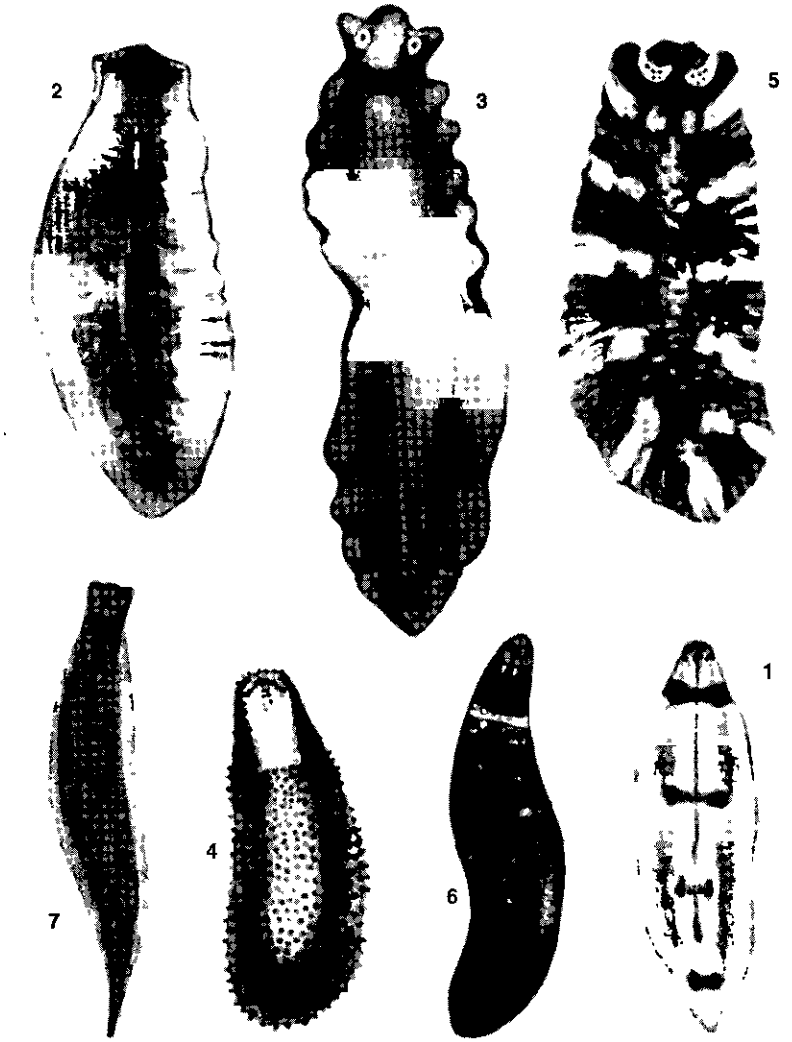


Fig 3 13. Turbellarians: I - *Sorocelis nigrofasctaia* Grube. body length 1 cm; 2 - *Sorocelis hepalizon* Grub.', lergth up to 6 cm; 3 - *Bdeltocephala angaremis* Gcrste., length 4 cm; 4 - *Papdhplana leucocephala* Korotn., 5 - *Baicalobia variegata* Korotn., length 2-3 cm; 6 - *Archicotyius* (?) *stringulatus* Korotn.; length 0.7 cm; 7 - *Graffiella lamelhrostris* Korotn. (?), length 0.5 cm. After Korotnev. 1912.

were studied by Korotnev himself (1912), and by Zabusov (1901a,b, 1903, 1906, 1911).

The first information about Baikalian Rhabdocoela became available as a result of studies conducted by Nassonov (1926, 1930a,b, 1936) and Rubtsov (1929). Detailed investigations resumed in the 1960s by Livanov (1961, 1962); Porfiryeva (1977); Umylina (1977); Timoshkin (1984-1994); Timoshkin & Sabrovskaya (1985); Timoshkin & Porfiryeva (1989). Today, 77 species in seven orders and 11 families are known, and 90% of the species are endemic (Timoshkin, 1994).

Tricladid Paludicola are one of the most interesting groups of Baikalian worms. At present, 37 endemic species are known. They are distributed among 14 genera, with only one species being non-endemic (Porfiryeva, 1977)

In the opinion of Livanov (1962), all Baikalian triclads belong to the Dendrocoelidae, whereas Planariidae are absent in Baikal. Owing to this pre-

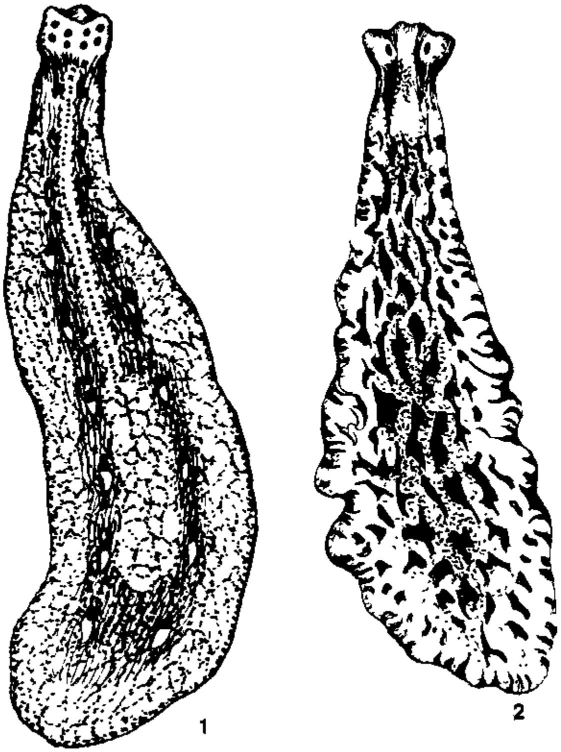


Fig 3 14 I - *Baikalobia guttata* Gerstf, 2 - *Armitla pardahna* Korotn , length up to 2 5 cm After Korotnev. 1912

dominance of the Dendrocoelidae and their marked endemism, there is a parallel between the triclad fauna of Baikal and that of Lake Ohrid. *However,* the latter is much poorer in species than Baikal, and its species belong to other genera (Stankovič, 1960).

Most Baikalian triclads show vivid and varied colourations and often have complicated patterns on the upper surface of the body. Many of them are very large for fresh-water turbellarians. For instance, *Baicaloplana valida,* when straightened out, is up to 30 cm long and 4 to 5 cm wide (Fig. 3.12) Almost all are carnivorous.

Their reproductive period is long. In winter, reproductive processes disappear, the maximum of propagation falling in May-September

One of the species of the Baikalian genus *Archicotylus, A. viviparus* Rubtz. = *A. planus'?* (Porfiryeva, 1977) was described by Rubtsov (1928) from the upper section of the Angara.

This species has never been found again. But. the finding in north Baikal of the viviparous species *Mesostoma? vivipara* (Neorabdocella, Typhloplanoida) by Timoshkin (1985) confirms the assumption that viviparity is a characteristic feature of some Baikalian turbellarians.

Numerically, triclads are common, reaching a particular abundance on stones at depths of up to 1.20 m. Up to a hundred of these worms can often be found on one stone 20 to 30 cm in diameter. The species found most frequently on the rocky bottom in the littoral of Baikal are *Bdellocephala angarensis* Gerstf. (Fig. 3 13), *Baikalobia copulathrix* Korotn., *Baikalobia guttata* Gerstf. (Fig. 3.14); on sandy soil. *Sorocelis mgrofasciata* Gribe (Fig. 3.13) and *Baikalobia variegata* Korotn. (Fig. 3.13) abound

Species such as *Armilla pardalina* (Fig. 3.14,2), *Papilloplana leucocephala* (Fig. 3.13,4), *Sorocelis hepatizon* (Fig. 3.13,2), and others, live both in the littoral and at great depths. Deep-water varieties of these eurybathic species differ from shallow ones by an absence of colouration of the body, and by a complete reduction of the eyes. Three species are genuine deep-water forms: *Baikaloplana valida, Hyperbulbina beckmanae* and *Protocotylus rnagnus.* The maximum depth for Tricladida in Baikal at present stands at 1570 m (Timoshkin & Porfiryeva, 1989).

Baikalian triclads are of great interest from a zoogeographical point of view. Their endemism is striking (100%), with many species constituting distinct Baikalian groups. They live exclusively in the open regions of Baikal, never entering the waters of shallow bays, gulfs, or sors.

Outside Baikal, they have so far only been found in the upper course of the Angara, which is inhabited by several species. Greze (1954, 1956) pointed to the presence of Baikalian turbellarians in the lower reaches of the Angara and in the Yenisei. Here *Baikalobia raddei* occurs, which is not found in Baikal itself (Porfiryeva, 1977), an exceptional situation.

The genetic connection of the Baikalian turbellarians with congeneric groups has been thoroughly studied by Porfiryeva (1977).

Ancestors of the non-endemic genus *Bdellocephala,* living in Europe and East Asia, diverged in Baikal into six genera: *Baikalocotylus, Atria, Sorocelis, Protocotylus, Rimacephalus* and *Bai-*

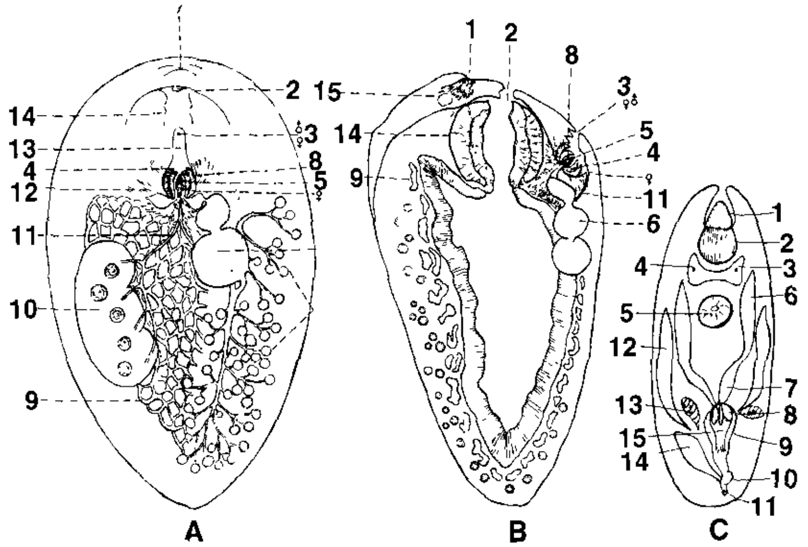


Fig. 3.15. Turbellaria. A,B - *Baicalarctia gulo* Fridm., body length up to 4 cm. The scheme of organisation. A - view from the ventral side: B - sagittal longitudinal section: 1 - frontal gland in the mouth area: 2 - mouth; 3 - genital orifice; 4 - penis; 5 - tongue of penis; 6 - vas deferens; 7 - testicles; 8 - reccptaculum seminis; *9* - yolk sacs; 10 - ovaries; 11 - oviduct; 12 - glands; 13 - athrium genitale; 14 - pharynx; 15 - brain. After Fndman, 1933. C - *Diplosyphon fluvialis* Sib. (?). The scheme of organisation: 1 - terminal cone of probosces; 2 muscules of probosces; 3 - brain; 4 - eyes; 5 - pharynx; 6 - testicles; 7 - vesicula seminalis; 8 - ductus ejaculatorms: 9 - vesicula granulorum; 10 - athrium genitale; 11 - genital, foramen; 12 - yolk glands; 13 - ovaries; 14 - bursa eopu I a thnx; 15 - *chkmized penis.* After Sibiryakova, 1928.

kaloplana. Giant representatives of two last groups occur *at great* depths. The Holarctic genus *Dendrocoelopsis is close to the* Baikah'an genus *Archicotylus,* which in the process of autochthonous evolution formed five genera in Baikal *(Armilla, Papilloplana, Hyperpapillina, Alaoplana* and *Hyperbulhina).*

Remote from other species of Dendrocoelidae is the genus *Baicahbia,* the representatives of which enter the River Angara.

The ancestors of *Baikalohia* might have been forms close to *B. raddei,* whose ancestors, having inhabited the hydrographic zone preceding Baikal, gave off a branch, not abundant in number of species but quantitatively dominant in the stony littoral (Porfiryeva, 1977).

Besides Tricladida, Turbellaria are represented by four orders. The order Macrostomida is still far from being satisfactorily studied. At present only one species is known, described by Nassonov (1926), viz. *Macrostomum auriculatum,* found in south and middle Baikal at a depth of 2-5 m. The fauna of Macrostomida in Baikal is quite likely to contain additional species.

The Baikalian representatives of the order Prolecithophora number four species in two genera *(Timoshkin* & Sabrovskaya, 1985).

The study of Prolecithophora began with Fridman (1933), who described *Baicalarctia gulo* living in the near-bottom layers and on the bottom, at considerable depths, and feeding upon oligochaetes (Fig. 3.15A,B).

The organization of *Baicalarctia gulo* enabled Fridman to single it out as an independent taxonomic unit of family rank, but after the identification of three further species of the genus *Fridmaniella,* this status was reduced to that of a subfamily, the Baicalarctinae (Timoshkin & Sabrovskaya, 1985). Worms of the order Prolecithophora are the most ancient group of Turbellaria of Baikal.

The order Neorhabdocoella is represented by three suborders. Two non-endemic species of the family Typhloplanidae are common along the shores, but need further investigation.

In suborder Dalyelloida five species, united in *Baicaliella* (Nassonov, 1930), have been described. All species *of Baicaliella* are minute worms (0.5 to 2 mm in length) with two black eyes, and a colorless or yellowish, pinky, brown, red or otherwise coloured body. They live among algae in the coastal belt of open Baikal

In that same genus *Baicalellia,* Nassonov (1930) described a species from the brackish waters of the coast of the Peter the Great Gulf in the Japan Sea; he also refers to this genus one species *(B. brevitulus* Luther) from the Gulf of Finland and West Greenland.

The representatives of the family Provorticidae, *to which the genus BmcalieUa belongs, are known* chiefly from seas, brackish waters and only partly from fresh water (Breslau, 1933). Nassonov (1936) considered it possible to trace the origin of *Baicaliella* to marine forms which had become adapted to fresh water.

Turbellaria of the suborder Kalyptorhynchia have been well studied. The worm found at a depth of 80 m in the region of Bolshiye Koty and described by Rubtsov (1929) as *Acrorhynchas baicalensis (^Diplosyphon baicalemis* Evdomin, 1977) initiated the study of proboscideous Turbellaria (Fig. 3.15C).

It is a worm of round-oval form, 2-3 mm long, with a small anterior snout, capable of protruding from a special capsule. When alive, it is bright-red, with the exception of the brownish-yellow anterior end.

Timoshkin (1986a) described six species of *Diplosyphon* (family Koinocystidae), which live at depths of 2-40 m on stony bottoms with sponges and water plants or on soft bottoms (detritus). Living on detritus has led to the formation of an elongated body (for example, in *D ninae),* allowing it to burrow into the bottom. *Diplosyphon* feeds on Oligochaeta, Ostracoda and minute Kalyptorhynchia.

The genus *Opisthocyslis* (family Polycystididae) is represented by six species, one of which was first described as *Polycystis angarensis* from the Angara by Sibiryakova (1928), and the remainder from Baikal by Timoshkin (1986b). Four Baikalian species described by Nassonov are synonyms of *O. angarensis,* according to Karling (1956). Of the family Polycystididae, one cosmopolitan species, *Gyratrix hermaphroditus,* lives in Baikal. The wide distribution of this species in the open lake at depths of 1-30 m is of great interest (Timoshkin, 1986b).

One of the best studied groups from a taxonomic, morphological and phylogenetic aspect is the order Lecithoepithehata, represented in Baikal by the highly specialized family Prorhynchidae, which includes eight species and one subspecies in the genera *Geocenthrophora* and *Prorhynchus* (Timoshkin, 1984, 1991, etc.). The Baikalian Prorhynchidae were first described by Korotneff (1901) as freshwater Nemertina. That author established the new genus *Baicalonemerthes* for them. Timoshkin managed to identify *Baicalonemerthes with* one *of the* species of *the* genus *Geocentrophora,* viz. *G. levanidorum.*

The widespread Prorhynchidae are represented by one-fourth of all its species in Baikal. Prorhynchidae are conservatively organized and characterized by a strict morphological unity (Timoshkin, 1991).

All Baikalian Prorhynchidae are unpigmented, with a yellowish or milky-white nontransparent body, and thus the coloration of worms depends on the intestinal content. Their body is slender, and planaria-shaped, with the anterior and posterior ends enlarged. The most minute species in Baikal is *G. intersticialis (4* mm long), the largest is *G gigas* (15-20 mm long), the largest among the known species of *Geocentrophora.*

The identification of the Prorhynchidae is based on the form and the size of stylet (organ of male sex system). Study of these stylets enabled Timoshkin (1991) to trace the most probable relationships of the Baikalian Prorhynchidae. In tributaries of Baikal, lives the cosmopolitan species *G. sphyrocephala;* close to it morphologically, the Baikalian species *G. intersticialis* lives both in interstitials of gulfs, and of the open parts of Baikal. The morphological similarity of seven endemic species of the genus *Geocentrophora* with *G. baltica,* and the Baikalian *Prorhynchus* with *P stagnalis* are well established too. *G. baltLu* and *P. stagnalis* are cosmopolitan species, not found so far in the waterbasins of Pnbaikalye (Timoshkin, 1991).

Timoshkin (1991) considers *G. sphyrocephala, G. baltica* and *P stagnalis* to be close to the ancestral form of the Baikalian Prorhynchidae, which penetrated the lake from surrounding waterbasins and became subject to adaptive radiation. This process was more intense in *Geocentrophora,* which are distinct from the semi-terrestrial, widespread *Geocentrophora*, and colonize in Baikal the most diverse biotopes, where they are a major component of most biocenoses at depths of from 0 to 120 m.

The present state of knowledge of the endemic turbellarian fauna was recently reviewed by Timoshkin (1994). Problems of freshwater or marine origin, age of endemic groups and asyncronous invasion by ancestral forms were considered.

3.4.2. Monogenea and Trematoda

According to Pronin (in print) up to 89 species of flukes parasites of fish and other animals have been found. Among the Monogena, 30 species have been discovered, four of which are endemic. *Tetraonchus borealis* Olss. parasitizes the gills of the Baikalian grayling. It was originally described by Vlasenko (1928) as *Ankyrocotyle baicalense* Wlass. According to Bauer (1948 a,b,c), *T. borealis* is widespread in Siberian rivers, parasitizing the gills of graylings. Dogel *et al.* (1949), Bogolepova (1950), and Dogel & Bogolepova (1957) established the presence in Baikal of three species of the genus *Dactylogyrus: D tuba* Linstow on the ide, *D cordus* Nybehn on the dace, and the endemic *D. colonus* Bogol., parasitic on fish of the Baikalian genus *Limnocottus* at depths of 500-700 m. Three species of the genus *Gyrodaciylus* have also been described. *G. baicalensis* Bogol from the Cottoidei *Limnocottus* and *Batrachottus, G. bychowskianus* Bogol. from *Cottocomephorus,* and *G comephon* Bogol. from *Comephorus.* Species close to *Dactylogyrus colonus* live on Siberian Cyprimdae; species of the genus *Gyrodaciylus* seem to stand apart.

In addition to the Monogenea species mentioned here, *Diplozoon paradoxum* Nordm., on dace, and *Diclybothrium armatum* Leuck., on sturgeon, also are present.

Among the Digena, species parasitic to the digestive tract of *Coregonus, Thymallus* and also *Cottocomephorus grewingki* Dyb. and *Paracottus kneri* Dyb. are known. Among these, mention can be made of *Crepidostomum baicalense* Layman, which also lives in the intestines of graylings in the Yenisei. Another species, C. *auriculatum* Wedl. *(=Acrolichanus auriculatus* Wedl.), parasitizes the intestines of Baikalian sturgeon. It has also been found in sturgeon and sterlet in Siberian rivers. The fluke *Allocreadium polymorphum* Loos, lives in the intestines of the Baikalian Cottoidei; *A. isoporum* Loos, in the intestines of dace and ide; *Tetracotyle percae fluviatihs* Linst. and *Diplostomulum spathaceum* Rudolphi in Cyprimdae; *Bucephalus polymorphus* Baer. in pike; and *Azygia robusta* Odhner. in burbot.

About ten flukes species parasitic of Baikalian fish are endemic and live in endemic Cottoidei. Dogel *et al.* (1949) consider three of these endemics of the genus *Gyrodaciylus* to be either marine relicts which invaded Baikal together with the ancestors of the modern Baikalian Cottoidei, *i.e.*, palaeoendemics, or neoendemics, which evolved in Baikal itself. The other three species, *Dactylogyrus colonus, Allocreadium polymorphum* and *Crepidostomum baicalense*, evolved, in Dogel's opinion, in Baikal itself from widespread ancestors.

3.4.3. Cestoda

Over 50 species of Cestoda parasitize Baikalian animals: 11 of these in the families Caryophyllaeidae (one species), Lytocestidae (one), Amphicotylidae (one), Cyathocephalidae (one) and Proteocephalidae (four) live in the intestines offish in the mature state. Three species of Ligulidae are parasites of fish-eating birds, and one species *(Schistocephalus sohdus)* of this family lives m seals. Final hosts of the worms from the family Diphyllobothnidae are: *D. latum, D. dendriticum* and *D. ditremum* - fish-eating birds, terrestrial mammaha, and man (for species belonging to other families, see list of species).

The first intermediate hosts of Cestodes are Crustacea or Oligochaeta; the second intermediate hosts can be fish, consumed by final hosts. The life-cycle of *Triaenophorus, Cyathocephalus, Proteocephalus* and Diphyllobothriidae has been well studied.

The definitive host of *Triaenophorus nodulosus* and *T. crassus* is *Esox lucms.* The first intermediate hosts of both species are various species of Crustacea; the second intermediate hosts vary. The host of *T. nodulosus* is *Thymallus arcticus baica-*

lensis and Cottoidei, the host of *T. crassus* is *Coregonus* (Pronin & Pronina, 1981).

Adult *Cyathocephalus truncatus* lives in *Thymallus arcticus baicalensis* and *Coregonus lavaretus baicalensis.* Intermediate hosts of this species are endemic Amphipoda' *Gmehnoides jasciatus, Pallasea cancelloides, P. cancelkts, Poekilogammarus pictus* and *Eulimnogammarus fuscus* (Pronin, 1986).

Of the genus *Proteocephalus,* four to five species are on record: *P. exiguus* (definitive host *Coregonus autumnalis migratorius, C. lavaretus baicalensis* and 14 species of Cottoidei); *P. thymalli* (definitive host *Thymallus arcticus baicalensis); P percae {Perca fluviatilis); P torulosus (Leuciscus leuciscus, Rutilus rutilus lacustris)* (Pronin, 1981). The life cycle of *P. exiguus* has been well studied by Rusinek (1987). Its intermediate hosts are *Epischura baicalensis* and *Cyclops kolensis.*

Paratenic hosts can be pelagic Cottoidei. *Cottocomephorus grewingki* and *C. inermis,* in which the worms grow (insignificantly) but not development (Rusinek, 1989).

In the genus *Diphyllobothrium,* the life cycle of *D. dendriticum* is known. The first intermediate hosts are planktonic Copepoda: *Cyclops kolensis* (Skvortsov & Talyzin, 1940), *Epischura baicalensis* (Chizhova & Gofman-Kadoshnikov, 1960), and *Eucyclops serrulatus, Mesocyclops leuckarti, Macrocyclops albidus, Diaptomus incongruens* (Timoshenko & Rusinek, 1988). The second intermediate hosts are fish (Zaika, 1965; Pronin *et ai,* 1986) The infection of *Coregonus autumnalis migratorius* by plerocercoids of *D. dendriticum* is 70-100%, *Thymallus arcticus baicalensis* 42-50%, *Coregonus lavaretus baicalensis* 30% (Pronin, 1981). The principal definitive host of *D. dendriticum* is a bird, *Larus argentatus,* in which 80% *of* the total recorded numbers *of* adult worms are concentrated. The infection of *Larus argentatus* ranges from 5 to 90% in April-October (Pronin *et al,* 1984, Timoshenko *et ai,* 1985). The role of man in the circulation of *D dendriticum* is insignificant. The infection of fishermen on the Olkhon Island was: 24.6% in 1929, 7.0% in 1938, 5% in 1939 (Skvortsov, Talyzin, 3949), *0 5%* in 1958 (Khodakova & Mamedov, 1960), 9.02% in 1985-1987 (Maiboroda *et al,* 1987), and 2.83% in the population of the Kabansky region on the Selenga River (Timoshenko *et al,* 1987). Humans become infected by eating raw fish. *D. dendriticum* was also found in *Phoca* where, according to Zhalsanova (1992), it does not reach maturity.

Among the Cestoda there is not a single endemic. Cestoda are widespread in the Palaearctic and their parasitism on endemic Baikalian species helps in understanding the evolution of cycle development of such parasites and their adaptation to Baikalian conditions.

3.4.4. Amphilinida

One species of Amphilinida *(Amphilina foliacea* Rud.) is known, parasitizing Baikalian and Yenisei sturgeon. Adult specimens live in the body cavity and not in the intestines. It is thought that its intermediate hosts in the Yenisei are Baikalian gammarids, immigrants from Baikal: *Gmelinoides fasciatus* and *Eulimnogammarus viridis* (Bauer, 1948a).

3.5. Nemathelminthes

3.5.1. Nematoda

Free-living nematoda

All data on the fauna of free-living nematodes of Baikal are recent, although attempts to study them have been carried out repeatedly. In 1940 Vereshchagin wrote that "a brief survey of the material collected suggested that free-living nematodes could display considerable endemism" (p.84). In 1962, Kozhov pointed to the presence of at least ten species of nematodes in the littoral of the Bolshiye Koty region. But only in 1970 did the first list of nematodes identified as to genus appear (Degtyareva, 1970) in the history of studies of Baikal. This included ten genera, with a probable number *of* species but without specific names. In 1972 Kozhov, referring to Degtyareva's work, pointed out that about 30 species of free-living nematodes had been found in the mezobenthos of Baikal. In his last article, Kozhov (1973) pointed to the presence of 30 species of free-living nematodes in Baikal, belonging to ten genera, 20 species being endemic, though still questionable.

A remarkable contribution to the study of Baikal's free-living nematodes was made by Tsaloiikhin (1972, 1974, 1975, 1976a, 1976b, 1977a. 1977b, 1980, 1983). Tsalolikhin discovered 34 species of nematodes, distributed among 17 genera, of which six genera and 25 species were new to science. More recent works (Batalova, 1983; Shoshin, 1988, 1989, 1991) have extended this list to 47 species in 22 genera, of which 39 species and five genera are endemic.

Nematodes are abundant in all bottoms, beginning at the edge of the water and going to the greatest depths. In open Baikal, a rare exception, only endemic species have been recorded. Widespread common species occur in sor zones *(Dorylaimus stagnalis, Ironus tennuicaudatus)* and in the upper littoral *(Tripyla filipjevi, D. stagnalis, Ethmolaimus pralensis, Monhystera pahidieola)* (Tsalolikhin, 1980). Outside Baikal, Baikalian nematodes have so far only been observed in the middle Angara River *(Tobrilus amabihs, Eutobrilus anguiculus, E. selengaensis, E. peregrinator, Tripyla dybowskyi)* (Gagarin & Erbaeva, 1984), and in Lake Khubsugul *(E peregrinator)* (Gagarin & Erbaeva, 1983).

Among Baikalian nematodes, commensals of sponges occur. Species such as *Tobrilus latens, Tectonchus absconditus* and *Eudorylaimus spongiophylus* are only found in sponges and do not occur in benthos in the vicinity of these sponges (Tsalolikhin, 1974).

One of the primary characteristics of Baikalian nematodes is the predominance of the family Tobrilidae, represented, with one exception, by endemics only. At present, of the 47 Baikalian nematode species, *23* and 5 among eight genera of Tobrilidae are found only in Baikal. These worms are highly diverse. Predatory *Paratrilobus,* with a large barrel-shaped stoma, feeds on diatoms. *Eutobrilus fords* and *E prodigiosm,* have a primitive funnel-shaped stoma with reduced onchi. The appearance of such strange forms as *Lamuania orientalis* and species of the genus *Kurikama* (Fig. 3.16) with wide but weakly-armed stoma is probably due to their diet of dying organisms (Tsalolikhin, 1980).

Great diversity is also found in the genus *Tectonchus.* First, it was assumed that this genus was endemic to the lake, but the discovery of *T. absconditus* in Mongolia now suggests that this genus belongs to an ancient South-Asian fauna which has become extinct as the result of the drying up and salinization of Mongolian lakes, and only survived in Baikal and in the isolated Lake Ulagchin-Khara-Nur (Tsalolikhin, 1985).

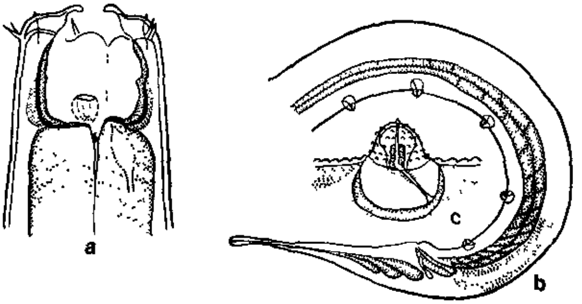


Fig 3 16 Kurikama tsalohchim Shoshin. 1991
a - head end, b - posterior part of a male, c - male supplement After Shoshm, 1991

The genus *Koernena,* belonging to the family Diplogastendae is also rather diverse. All species of this family are active predators, typical *of* the saprobios. Only nine species occur in freshwater water basins, five of which inhabit Baikal (Shoshin, 1989)

The nematodes of Baikal show a predominance of certain groups (with representatives of typical freshwater orders, such as Araeolaimida and Chromadorida, being few in number), which is the result of intensive divergent evolution starting from a limited number of ancestors. An example is the family Tobrilidae, which inhabited fresh waters long before the formation of Baikal. They were the first to invade Protobaikahan waters, where, unconstrained by competition, they occupied ecological niches otherwise atypical of the Tobrilidae. This resulted in the emergence of several strange forms (Tsalolikhin, 1980).

So far, a rather insignificant percentage of the Baikalian nematodes has been described. Scores of new species and genera of the family Tobrilidae, unique species of the order Monhysterida, and several other groups, await description. Further investigations may greatly change our conception of the Baikal nematode fauna.

Parasitic nematoda

Twenty-eight species of parasitic nematoda are known to occur in Baikal *Of* these, only *one* species and one subspecies are endemic *Comephoronema wereschagini,* a small worm of from 3 9 to 7 4 mm in length, parasitizes the alimentary canal of fish, particulary Cottoidei Adult *Contracaecum osculatum baicalensis* parasitize the stomach and intestines of *Phoca sibinca* (in whom the worms reach a length of 24 mm), *Coiegonus autumnahs migratorius C lavaretus,* and *Thxmallus arcticus* (Bogdanova, 1957, Zaika, 1965) The intermediate hosts are *Cottocomephorus grewingki* (a third-stage larva being 6 7 to II mm long) and *Macrohectopus bramcku* (Sudankov & Ryzhikov, 1951) *C osculatum baicalensis* is close to the typical form, *C osculatum,* parasitizing *Phoca hispida* in northern seas (Mozgovoi *&* Ryzhiko\, 1950)

Among non-endemic species, the genus *Cystidicola, C impar* Schn and C *skrjabim* Laym, deserve attention *Cystidicola impar* parasitizes the swim-bladder of the Baikahan grayling, gwyniad, omul and dace, and Yenisei and Taimyr salmomds Bauer (1948a) considers it to be an immigrant from the north *Cystidicola skrjabim* is a small nematode (0 4 to 0 9 mm) of the alimentary canal (the gullet, stomach and intestines) of Baikahan grayling, sturgeon, *Cottocomephorus grewingki, Paracottus knen* and *Procottus* Bauer (1948a) refers this species to the genus *Capillospirura (=Ascarophis*[1]*)* and points out that C *skrjabim* also parasitizes the intestines of salmomds from the Angara section of the Yenisei

The majority of non-endemic parasitic nematoda live in the intestines of fish, and only some of them in the body cavity *(Philonema sibinca),* under the head skin of fish, the mucous membrane of the oral cavity, or the gill covers *(Philometra nschta)* Young *Philometra rischta* live in the walls of the swim-bladder The life cycles of nematoda are associated with Crustacea or Ohgochaeta Six species are parasitic on birds The most species-nch family of parasitic nematoda is that of the Anisakidae Its six species occur in various animals *from* Baikal

Mermithidae

The first data on Mermithidae were published by Rubtsov (1976) and Rubtsov & Bekman (1979) Twenty-nine species belonging to ten genera are now known One genus, *Gammaromermis,* is endemic The genus *Bmcalomermis,* except *m* Baikal, also includes Khubsugul species The morphological peculiarities of the structure of some Baikahan mermithids *(H orbicaudata, L beckmanae)* exceed the species level, according to Rubtsov

All endemic Mermithidae live in the open parts of Baikal, except for *Mesomermis baicalensis (=M melusmae baicalensis),* found in *Prosiuahum* (Simulidae), in a cool rivulet flowing into Baikal

The majority of endemic mermithids were discovered in benthos of various regions and depths of the lake

Hosts are only known for three species of the genus *Gammaromemus* There are widespread Baikahan gammands *Echiuropus ihodophtalmus, E moramtzi, E seidhtzi Micruropus semenovi* and *M ivanovi* Mermithids can attack gammands of small body length For example, juvenile *Echiuropus* have a body length of 2-3 mm, and adult *Micruropus* are 3 mm long Mass infection of gammands by mermithids was observed at a depth of 20-50 m on a sandy-pebble bottom A high degree of infection of the gammands was recorded in both polluted and pure regions of the lake, which contradicts the idea of the high sensitivity of Mermithidae to anthropogenic changes of the environment

The Baikahan Tnchoptera and Diptera, abundant in the littoral, may also be potential hosts of Mermithida

3 5 2 Acanthocephala

Three species of Acanthocephala, from the families Neoechmorhynchidae (one species) and Echnorhynchidae (two species), parasitize the alimentary canal of many Baikahan Cottoidei fish, *Paracottus knen P kessleri* and *P insularis* being especially prone to infestation with *Pseudoechnorhvnchus boieahs* The larvae of *P borealis* develop in Amphipoda *Gmehnoides fasciatus, Micruropus posohku* and *M cihodorsahs* The larvae of *Neochinorhynchus rutih* develop in Ostracoda

Five species of Acanthocephala from three other families - Polymorphidae (three species), Filiedidae (one species) and Gigantorhynchidae (one species) - parasitize the intestines of birds. Their life cycle is associated with endemic Baikalian Amphipoda. No endemics are found among the Acanthocephala of Baikal.

3 5 3 Rotifera

The first studies of the rotifers of Baikal were made by Yakhontov (1904), who only found three species of rotifers *(Asplanchna herricki, Notholca longispina* and *Keratella cochlearis).* Then Voronkov (1925, 1927) and Yashnov (1922) processed data from the Moscow University expedition of 1917. On the basis of these, Zenkevich described the rotifer *Albertia woronkovi,* parasitic to ohgochaetes. Based on data from Yasmtsky, Tikhomirov (1927, 1929) described three new species of the genus *Notholca,* and Yasnitsky studied the ecology and variability of Baikalian rotifers (1926, 1930). In the 1950s, Gaigalas (1958) conducted a comprehensive investigation of the rotifer fauna of Baikal, on the basis of collections from the biological station at Bolshiye Koty.

The list of rotifers compiled by Gaigalas (1958) contains 48 species and 16 forms, distributed among 21 genera. Since the 1960s, more intense taxonomic investigations on rotifers have been conducted (Kutikova, 1964; Vasilyeva & Kutikova, 1969; Kutikova & Vasilyeva, 1982; Kutikova, 1986; Kutikova & Arov, 1985; Arov, 1985, 1987).

At present, the list stands at 198 species and subspecies, pertaining to 39 genera and 20 families, but only 31 species and subspecies and one genus are endemic. There is no doubt that further investigations of the littoral zone of Baikal will enrich this list with more species.

Kutikova (1986) notes that endemic species occur in those genera with the highest number of species. Thus, 18 species of the genus *Cephalodella* are endemic; of seven species of the genus *Colurella,* one is endemic; of seven species of the genus *Dicranophorus,* two are endemic, of four species of the genus *Encentrum,* one is endemic; of eight species of the genus *Euchlanis,* one is endemic; of eight species of the genus *Lecane,* one is endemic; of 24 species and subspecies of the genus *Notholca,* 15 are endemic; and of 16 species of the genus *Trichocerca,* one is endemic.

Most rotifers of the open waters of the lake are not endemic, but belong to Palaearctic and Holarctic species (more than 20), widespread in other cold-water bodies, mostly at Northern latitudes.

Only seven plankton species present in early spring are endemic. Apart from the open lake, they tend to develop in bays and gulfs bordering open Baikal.

In the littoral of the lake (the region of Bolshiye Koty has been most closely studied), 76 coastal and psammon species in eight genera occur. The most common are endemics - *Colurella grandiuscula, Encentrum putonius, Euchlanis ligulata, Lecane aspersa, Notholca kozhovi, N. grandis, N. intermedia* and *N rectospina.*

Shallow parts of the lake, bays, sors and gulfs are, as a rule, inhabited by Palaearctic species. In zones under the impact of river effluents, thermophilic species of the genera *Brachionus, Anuraeopsis* and *Polyarthra,* not typical of Baikal, are present.

Palaearctic species and endemics are seasonally isolated. The former reach a peak in summer-autumn (including several annual species: *Keratella quadrata, K. cochlearis, Filinia terminalis, Kellicottia longispina).* The above-mentioned species, and also *Synchaeta stylata, S. grandis, Asplanchna priodonta, Conochilus unicornis* and *Polyarthra dolichoptera* make up most of the rotifer zooplankton and reach 5 10^6 spec, m$\sim^3$ in the 0-50 m layer in summer-autumn (Pomazkova, 1971), m relatively warm waters (10-11°C).

Endemics live at comparatively low and constant temperatures (4-6°C), reach a peak in early spring, and are not very numerous (maximum 300 10^3 spec, m$\sim^3$ in the 0-100 m layer).

The majority of species in the Baikalian complex develop in the littoral zone Even typical pelagic species of the genus *Synchaeta* (Fig. 3.17), for example, are closely connected with the coastal zone.

Migration of rotifers from the littoral mezobenthos to true sands has resulted in the formation of a rotifer psammon fauna in Baikal. This comprises 58 species and subspecies, in 20 genera, 11 families and four orders (Arov, 1987). The rotifers of the Baikal psammal are primarily widespread spe-

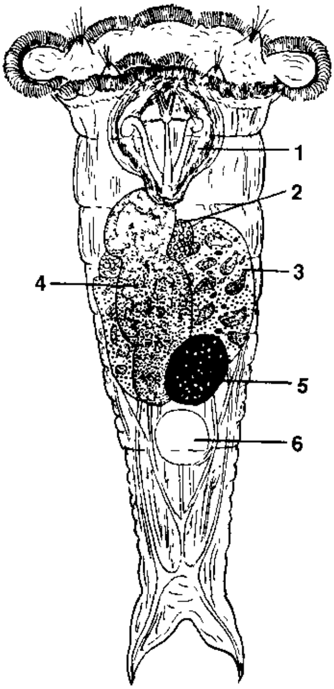


Fig. 3.17 Rotifera, *Synchaeta pachypoda* Jaschn. Body length 0.7 mm. 1 - pharynx; 2 - ovary; 3 - yolk gland; 4 - stomach; 5 - egg; 6 - urinary bladder. After Kozhov, 1963.

cies, inhabiting the limnopsammon of Holarctic waterbodies. Yet, four endemics occur: *Encenlrum impletum*, *Lecane (M.J aspersa*, *L. (M.J pennaki*, *Colurella gradiuscula* (Kutikova & Arov, 1985; Arov, 1985, 1987). Specific features of the rotifer fauna of Baikal are a quantitative predominance of psammophitic and psammophiloid rotifers (60% of species), which is not otherwise typical of oligotrophic waterbodies. and the presence of four species of the genus *Notholca* which do not occur in the limnopsammon of other waterbodies.

Quantitatively, the Baikal psammon is poor: 2.9-22S JO^{3} spec, m ^{3} (typical of oligotrophy lakes). The numerically dominant species is *N. kozhovi*, with up to 167.7 10^{3} spec, m"^{3} (Arov, 1987).

3.6. Annelida

3.6.1. Polychaeta

The study of the Polychaeta of Baikal was started by Nusbaum (1901) who described two species, *Dybowcella baicalensis* and *D. godlewski.* Zenkevich brought these species together in synonymy and assigned them to the genus *Manayunkia* Leidy. Then Dybowsky (1929) described *Trichosobranchella novobaicalensis;* he placed the two species described earlier in different genera. According to Kozhov (1963-1972), Lake Baikal harbors one *Manayunkia baicalensis* with three ecological forms: one inhabiting silts (large animals, up to 15 mm long); one living on sands (individuals of medium size), and one on stones (small animals 2-3 *mm). At* present, a species status has been assigned to these forms: *M. baicalensis* Nusb. (sand form, body length 6-7 mm) (Fig. 3.18a); *M. godlewskii* Nusb. *(=Trichosohranchella novobaicalensis* B. Dyb.) (a silt form), and *M. zenkewitschi* Sitn. (a stone form) (Sitnikova *et al*, 1997). Adult individuals of these species differ by size and number of prehensile palps, the number of hooked setae on segment 3 being almost equal. These species show signs of sexual dimorphism at different sizes. They also differ in fecundity and in their period of reproduction.

The Baikalian *Manayunkia* belong to the family Sabellidae, subfamily Fabricinae. Their head crown includes numerous prehensile palps and a pair of unbranched palps, inside of which is a blood vessel with brownish-green blood. On the first segment, there is a pair of "hearts". Setae are present on the segments of the body but are absent from the first and last ones.

The Baikalian Polychaeta possess sexual dimorphism, displayed in the morphology of the ventral thoracal setae and the morphology of the body: segments 7-9 are elongated in the males, and there are ridges between the 6th-7th and 8th-9th segments in the females. The ridges secrete a cuticle, which forms an incubation chamber, where the complete development of the embryos take place. The sexual dimorphism is also expressed in the karyotype. The females have a diploid number *of* chromosomes equal to 16 (2n = 16), sex determination is homogametic, XX; in males 2n = 15, and sex is heterogametic. XO. The dimensions (from 2 to 7.5 mm) and the number of chromosomes are identical in the three species (Poberezhny & Sitnikova, 1988). *Manayunkia* lives in tubes constructed from silt and sand particles, cemented with a chitinized substance.

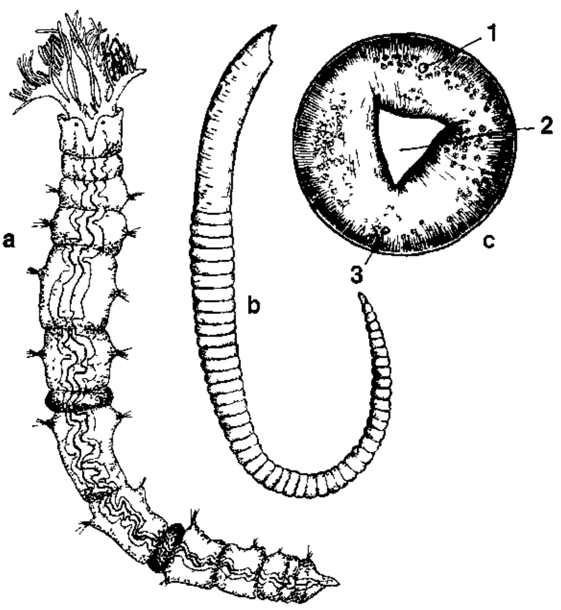


Fig 3.18 a - Polychaeta, *Manayunkia baicalensts* Nusb., removed *from* the tube, body length up to 15 mm. After Kozhov. 1947 b,c Oligochaeta, *Agiwdnlus* *\ermivorus* Michlsn, body length up to 45 mm, c - transverse section through the front part of the body, 1 - blood vessel, 2 - gullet, 3 - abdominal nerve After Michaelsen, 1926

Vast accumulations of *M. godlewskii* can be observed on silty sections of rocks at 15-20 m depth and on silty soils of bays and gulfs. *M. zenkewitschi* occurs in mass quantities among the algae of the genus *Cladophora,* covering stones at depths of 3-5 m. This species is frequently found in the oscular openings of sponges, empty cases of caddisflies, on stones, and on stems and leaves of *Potamogeton,* to which they attach their tubes *M. baicalensis* forms mass accumulations, under ice on sand, and sand between stones and boulders at depths of 0.8-1.5 m.

Polychaetes are marine animals, but some species live in brackish and freshwater, particularly in India, Malaysia and other tropical regions There are also cave-dwelling species, such as *Marifugia* in the Balkans, and *Troglochaetus* in Switzerland. The genus *Manayunkia* is widely distributed in fresh and brackish water and up to ten species arc known. The genus is closely allied to *Fabriciola.* They can be distinguished from other Sabellidnae by the possession of ordinary unplumed brancial tufts.

The *Manayunkia* species closest to the Baikahan species arc *M. polaris* Zcnk. (from the tidal zone of the Murman coast), *M. spesiosa* Leidy. (from rivers in North America near Philadelphia, and the Great Lakes of North America), *M. aestuans* Born, (from river mouths of the Irish Sea, the Channel, the North Sea, the Baltic Sea and the Gulf of Finland) and *M. caspia* Annenk. (from the Caspian and Black seas, the mouths of rivers emptying into the Black Sea). The *Fabriciola* species include *F. atlantica* Fread. (from the Atlantic coast of Canada), *F. pacifica* Annenk. (from the coast of the Komandorskiye Islands, and the Pacific), *F. spongicola* Sout. (from the brackish Lake Chilka in India), *F baltica* Fread and *F. blochmani* Fridnch (from the Baltic Sea) (Zenkevich, 1925; Annenkova, 1930).

Of great interest is the Siberian distribution of forms close to or identical to the Baikalian *Manayunkia.* Thus, *M baicalensis hydani* Slastn. was found in brackish waters of the Gyda Gulf (between the Yenisei Gulf and the Ob Bay) and in freshwater relict lakes of the Gyda drainage in the same region (Slastnikov, 1940, 1941). *Manayunkia* was also found in some sections of the Yenisei, in Lake Taimyr, and in lakes of the Lower *Tunguska* and Pyasina drainage.

Greze (1947, 1953, 1957) believes that in postglacial times these basins communicated with the Yenisei and that the Baikalian polychaete, like other Baikalian forms, penetrated them through the Angara and the ancient Yenisei (Fig. 94). Of still greater interest is the presence of *Manayunkia* in the large running-water lakes of the Lena drainage (Kozhov, 1942; Kozhov & Tomilov, 1949). Large numbers were found in lakes in the drainage of the Vitim and the Olekma, Lena tributaries situated in the area of tectonic depression of the Baikal system (Baunt, Busani, Oron-Vitim, large lakes of the Chara drainage, Davatchan, Leprindo, and others) (Fig. 94). The *Manayunkia* of these lakes are somewhat different from the typical form, and may be a different species (Klishko, 1994).

There are several different opinions about the origin of the genus *Manayunkia* and its dispersal: 1. It is a typical fresh or brackish water genus, and had a broader distribution in Tertiary times (Pliocene) than now. It is an old inhabitant of fresh and continental brackish waters, from where it mi-

grated to marine coastal regions (Berg, 1949b)
2 The genus *Manayunkia* evolved in Tertiary inland seas of Central Asia which gradually turned into freshwater bodies From there, it spread to the Arctic Ocean (Zenkevich, 1935)
3 It is an old genus formerly widespread along the sea shores of the world ocean and was also present in the Paratethys which preceded the Sarmatian Sea *M baicalensis* diverged from the common stock long ago, prior to *M caspia* penetration to Baikal, together with water masses successively connected to basins of a marine relict origin (Vereshchagm, 1940b)

Kozhov (1963) favored Zenkevich's opinion as the most probable

3 6 2 Oligochaeta

Ohgochaetes are one of the most numerous groups of invertebrates of Baikal Their main features became known through Michaelsen's work on of a wealth of material obtained by the expeditions of Korotnev and Vereshchagm (Michaelsen, 1901, Michaelsen & Vereshchagm, 1930) Later, Baikalian ohgochaetes were studied by Burov (1931), Izosimov (1949, 1962) and Burov & Kozhov 1932) Over the last decades more material has been collected and the list of species has gradually become expanded and specified (Semernoy, 1982-1987, Snimshikova, 1977-1993, Akinshina & Lesinskaya, 1978, 1980)

The Baikahan ohgochaete fauna, according to the list of species of Snimshikova & Akinshina, amounts to 207 species and subspecies, belonging to 44 genera and seven families One hundred and sixty *of* these (77%) including 13 genera, *are* endemic, 32 species (16%) are palaearctic, and ten species (5%) are relicts

Baikahan ohgochaetes are the dominant and subdommant elements of all ecological zones In bottom communities, they contribute up to 70-90% of biomass and abundance They occur from the water's edge, where *Mesenchvtraeus bungei* is numerous, down to the greatest depths which are inhabited by *Lamprodnlus bythius* (to a depth of 1131 m), *L inflates* (to a depth of 1073 m), *Baikalodnlus malevia* (to a depth of 1450 m) *B werestschagim* (to a depth of 1410 m), and *Rhvacodrdoides abyssahs* (to a depth of 1610 m) In the littoral belt of open Baikal, at least 20-30% of the total biomass belongs to ohgochaetes With silting of the sands at depths of 10-20 m, the share of ohgochaetes increases to about half the total biomass On silted sands at 15-25 m, they prevail by biomass On silts at more than 50 m they reach up to 90%, and sometimes almost monopolize the benthos In the Selenga Shallows, the most productive region of the lake (enriched by organic matter brought by the river), maximum benthos biomass is 360 g m^{2}, ohgochaete biomass 233 g m^{2}, and their numbers reach 14,460 spec m^{2}

Maximum benthos biomass in north Baikal is 50 g m^{2}, and ohgochaete biomass 28 g m^{2}, with amounts of up to 20,870 spec m^{2} The species richness of Baikahan ohgochaetes is striking (up to 30 species per 0 1 m^{2}) It is at a maximum in sand-stony littoral (depth 5-20 m), with a total of 75 species and subspecies, and on silts (depth 50 m), with 63 species and subspecies With increasing depth, the importance of the benthos biomass decreases to 5 g m^{2}, while the ohgochaete share of total benthos increases to 90%

Few Baikahan ohgochaetes are carnivores *(Agroidrilus vermivorus)*, most of them being detritus-eaters, and they themselves serve as food for other animals

The family Lumbncuhdae has a large number of representatives in Baikal 59 species The Lumbncuhdae is a typical freshwater family of northern (up to Alaska, Karelia, Norway and the Novosibirskiye Islands) and temperate latitudes Baikahan Lumbncuhdae represent one-third of the world's Lumbncuhdae fauna

Lumbncuhdae have nine genera in Baikal, four of which are endemic The genus *Lamptodtdus* alone contains 26 species, only two of which are non-endemic Each of the genera *Agnodrdus Pseudorhynthelmis* and *Pseudolycodrdus* has one endemic species

Agnodnlus vermivorus (Fig 3 18b,c) is a unique species which reaches 45 mm in length and 1 5-2 mm in diameter at the front part of the body Jn this species the perivisceral cavity in the frontal part of the body (the 2nd to 11th somites) is almost completely reduced and filled with interjoined muscles forming the wall of the gullet Because of this, a transverse section of the gullet is shaped like an equilateral triangle, with one of its angles pointing to the ventral cord

The genus *Teleuscolex* has six endemic species, of which *T. korotneffl* is fairly common. It is a large worm reaching 12 cm or more in length and 2-2.5 mm in diameter (at the front part of the body), with ordinary pointed setae. On the dorsal surface and on the sides *of* the front segments it has a characteristic pattern of almost circular black and dark-grey stripes.

The genus *Rhynchelmis,* with five endemic species in Baikal, also has widespread representatives in Europe and Japan. One of the North European species - *R tetratheca* - can be found in north Baikal at a depth of 10 m. *R. brachycephala* is one of the largest and deepest-dwelling species. It reaches 20 cm in length and has a diameter of 4 to 5 mm. The body of a fixed worm has a characteristic tetrahedral form. It occurs from 3 m to the greatest depths.

The genus *Styloscolex* (five endemic species) was formerly regarded as a Baikahan endemic, but two species - *S. kolmakovi* and *S. tetrathecus* - were discovered in China. Both species occur in open water at a depth of more than 150 m.

The genus *Stylodrilus* has nine species in Baikal: only one is non-endemic and is found in Europe. This species - *S. parvus* - occurs in north Baikal and the Maloe More at depths of 10-360 m.

Some of the endemic Lumbriculidae have been discovered in the Angara and Yenisei rivers; among these, *Stylodrilus minis* and *S. opisthoannulatus* occur in the Yenisei and *Styloscolex asymmetricus* and *Lamprodrilus wagnery* in the Angara.

The Enchytraeidae, partially terrestrial and partially aquatic, live mostly in the northern hemisphere. Baikal is inhabited by three species. The genus *Mesenchytraeus,* which is richly represented in Europe and North America, has two species in Baikal. One of these, *M. bungei,* leads an amphibious life and is usually observed at the edge of the water, the other, *Mesenchytraeus* sp. inhabits the depths of the lake (Takhteev *et ai,* 1993). The genus *Enchytraeus* is widespread in Europe and North America.

The genus *Propappus* of the family Propappidae contains only two species: *P volki,* which lives in Baikal, the Elbe, Volga, Dnieper and other rivers of Europe and in Lake Ladoga, and *P. glandulosus,* an exclusively Baikalian inhabitant.

The most widely represented family in Baikal is the Tubificidae, with 21 genera in three subfamilies, and 90 species, 70 of which are endemic.

One of the genera, *Rhyacodrilus,* has 13 species in Baikal. One of the non-endemic species, *R. coccineus,* is represented by a special variety. Outside Baikal this species has an extensive European distribution. To this species, but as a variety, Michaelsen refers a form described from lakes in New Zealand.

Tubifex is a world-wide genus. In Baikal it is represented by ten species, only one of which, *T. tubifex.* is non-endemic.

Teneridrilus hubsugidensis (one of the three Baikalian species of genus *Teneridrilus)* is an inhabitant of Lake Khubsugul (Mongolia), and can be found in open Baikal down to a depth of 200 m.

The Baikalian genus *Baikalodrilus* is the most species-rich, with 20 taxa. A wide spectrum of ecological conditions is a characteristic property of the species of this genus.

The genus *Isochaetides* is also numerous in Baikal and contains 14 species, only one of which is a non-endemic palaearctic animal.

The following endemic species of Tubificidae have been found in the Angara and Yenisei rivers: *Isochaetides arenarius, Lycodrdides schizochaetus* and *Rhyacodrilus korotneffi.* Some non-endemic species, such as *Tasserkidrilus acapdlatus,* inhabit open Baikal, its coastal zones and bays, and also the Angara River and Caspian Sea.

The family Naididae is widespread in freshwater. In Baikal it has 11 genera and 46 species, most of them common in the northern hemisphere. Only the genus *Chaetogaster* has 11 endemic species, which are littoral and occasionally sublittoral.

In the family Aeolosomatidae, two species occur, both endemic. According to Michaelsen (1901), the oligochaetes of Baikal, along with a few phylogenetically young forms, contain a considerable number of archaic forms, which have retained the original peculiarities of the Lumbriculidae. For this reason, this oligochaete fauna should be regarded as of old geological age.

Izosimov (1949, 1962) docs not accept Michaelsen's point of view. The entire Lumbriculidae, represented outside Baikal in alpine bodies of water, subterranean waters and other such places, evolved in the Tertiary period in the mountain belt stretching from the Alps and the Balkans eastward to Baikal, Sakhalin and North Japan. By the Tertiary, such genera represented in Baikal as *Lamprodrilus, Styloscolex, Lumbriculus* and *Rhynchemis* were already in existence. Later, some of these genera acquired a discontinuous distribution, probably because of the cooling connected with the glacial epochs.

In the opinion of Izosimov, the oligochaete fauna of Baikal is both of a relict nature, having evolved long ago (in the Tertiary), and endemic, since in Baikal a number of new species evolved with special adaptations.

More data on the origin and evolution of the Baikalian oligochaetes can be found in Semernoy's review (1987).

3.6.3 Hirudinea

In the waters of sheltered gulfs and bays of Baikal, leech species of a wide Siberian distribution can be seen: *Protoclepsis tessulata* Miiller, *Hemiclepsis marginata* Miiller, *Piscicola geometra* L., *Glossiphonia heterochta* L., *G. complanata* L., *Herpobdella octoculata* L., *Helobdella stagnalis* L., *Haemopis sanguisuga* L., *Acanthobdella peledina, Cystobranchus mammillatus, Acipenserobdella volgensis* (Livanov, 1902; Plotnikov, 1906; Pronin, 1979). There is no doubt that the gulfs harbor other, general Siberian species too. But apart from these, Baikal has several unique species from the Piscicolidae and Glossiphonidae families.

Among the Piscicolidae, Grube (1871, 1872) briefly described four species: *Piscicola multistriata* from Baikalian sturgeons, *P. torquata, P. conspersa* (from the Angara) and *Baicalobdella truncata,* which is parasitic on Baikalian Gammaridae and Cottoidei.

Lukin & Epstein (1960a,b), Lukin (1976), Epstein (1959, 1987) conducted a revision of the Baikalian Piscicolidae and established the presence of only two endemic species: *Baicalobdella torquata* (Fig. 3.19) and *B. truncata* (Fig. 3.20). The former parasitizes gammands and fish in the littoral. It is a small leech, up to 11 mm long and 3 mm broad, with small suckers and a highly variable body coloration, and a predominance of brown pigment in patches or throughout the body. *Baicalobdella truncata* is parasitic on Gammaridae and Cottoidei living at depths of up to 1100 m.

Dogel & Bogolepova (1957) described *Baicalobdella cottidarum (~B livanovi,* Dogel *et al.,* 1949), parasitic on *Cottocomephorus grewingki.*

In 1991, Finogenova & Snimshikova described a new genus and species of fish leeches - *Dagarohdella zelenskiji* - from the benthos of north Baikal. It is a minute animal, up to 3.4 mm long in fixed state, with suckers at the anterior and posterior ends of the body

The Glossiphonidae are only represented by species of the subfamily Toncinae (Lukin & Epstein, 1960b), which includes two species of the endemic genus *Baicaloclepsis: B. echinulata,* briefly described by Grube (1871, 1872) as *Clepsina echinulata,* and *B. grubei* **Lukin** et Epstein. *Torix baicalensis* (Figs. 3.21,2-3; 3.22c), described by Shchegolev, was excluded from the genus *Torix* by these authors, and a new endemic genus, *Paratorix* Lukin et Epstein, was established for it.

All Baikalian Toncinae are of a comparatively large size (up to 40 mm), with a broad and moderately flat body, densely papillated on its dorsal surface. In *Baicaloclepsis,* the pappilae are of various size, running along the body in parallel rows. The ventral surface is either smooth or covered with small papillae (Fig. 3.21,1). There are two pairs of eyes, with a trend towards reduction. The full somite of a leech consists of three uneven rings, the first the shortest, the second very long, and the third short. The stomach has six pairs of processes (Fig. 3.22a,b).

The genus *Torix* with the species *T mirux* Blanch, was established by Blanchard (1893) on specimens collected in Lake Kao Bang (South Asia) from the fresh-water mollusc *Melania.* The genus *Torix* is distinguished by the presence of two rings of uneven size in each somite, the larger one ventrally divided by a furrow into two rings of second order. The second species of this genus, *T. cotylifer,* is parasitic on the turtle *Tryontx.* There are no traces of papillae on Chinese *Torix.*

Lukin & Epstein (1960a,b) concluded that the Baikalian Toricinae are related to a small natural group of leeches, belonging to the genera *Torix* (China), *Oligobdella* (Japan, Korea, North America), and *Oligoclepsis* (Japan), but are far removed

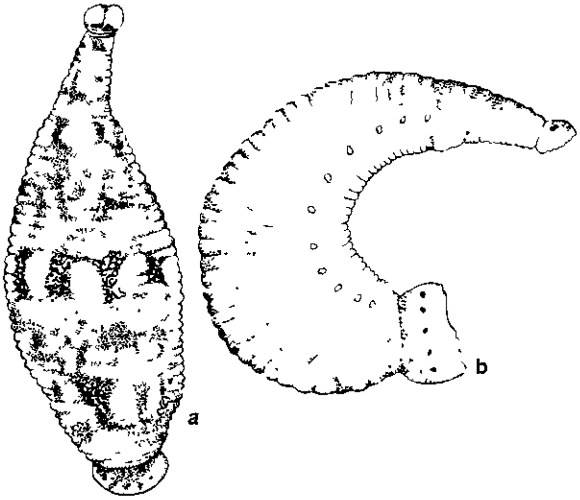


Fig 3 19 Leech, *Batcalabdeila torquata* Grube a - dorsal surface, b - side view, body length up to 11 mm After Epstein, *1959*

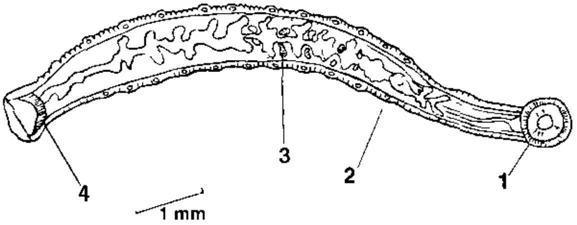


Fig 3 20 Leech, *Baicalubdella truncala* Grubc. taken from a *Cottinella* cottid caught at a depth of 1,000 m 1 - anterior sucker, 2 - lateral vesicles, 3 - testicles; 4 - posterior sucker After Dogel & Bogolepova, 1957

Fig 3 21 Leeches I - *Baicaloclepsis echwttlata* Grube. body length up 40 mm, 2-3 - *Paralorix baicalensu* from the dorsal and ventral sides After Kozhov. 1963

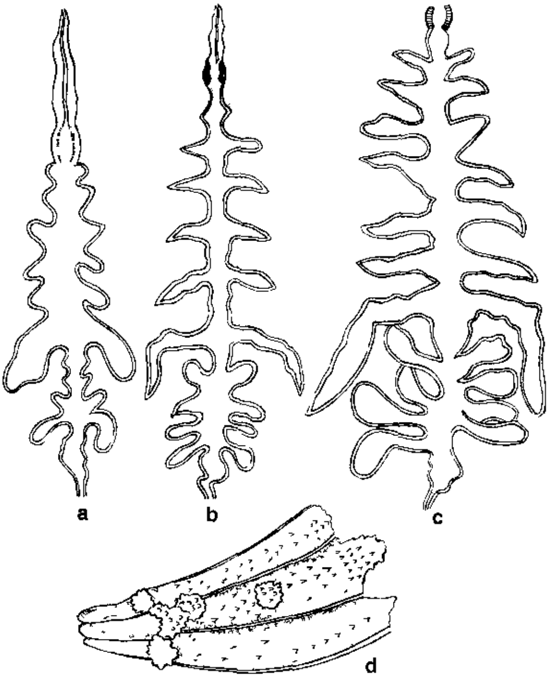


Fig 3 22 a. b, c, - diagrams of the digestive tracts oi leeches a - *Baicaloclepsis grubei;* b - *B echinulata, c - Paralorix baicalensis,* d - total somit of *B grubei.* After Lukin & Epstein, 1960

from the Glossiphonidae currently widespread in Europe and North Asia. The genus *Baicaloclepsis* is the more primitive of the other genera of its subfamily. The Toricinae appeared and spread across East Asia and North America in the Miocene, when the two continents were still closely connected.

The Baikalian Toricinae, *Baicaloclepsis echinulata* Grube, *B grubei* Luk. et Epst. and *Paralorix baicalemis** being closely related, probably evolved in Baikal from a common ancestor.

In the genesis of the Baikalian leeches, *Dagarobdella zelenskiji* (= *Baicalobdella,* according to Snimshikova) is of great interest. From its superficial appearance, it was referred to the Oligochaeta first (Snimshikova, 1987). Direct ties of this leech with other Piscicollidae have not been established.

Thus, today, Baikal has 11 Hirudinea widespread in the Palaearctic, living in sors and shallow gulfs, and seven endemic species in the Piscicolidae and Glossiphonidae. with the endemic generus *Batcalobdella* in the first family, and the endemic genera *Baicaloclepsis* and *Paralorix* in the second. Endemic Baikalian leeches do not occur in sors, shallow bays or tributaries of Baikal. Only *Trackelobdella torquata* is found in the upper part of Angara.

3.7. Arthropoda

3.7.1. Crustacea

Calanoida

Baikal is known to have five species Calanoida, belonging to the genera *Eudiaptomus, Neutrodiaptomus, Heterocope* and *Epischura.* Only *E. baicalensis* is endemic to Baikal.

The genus *Eudiaptomus* is represented in gulfs by *E. graciloides* Lill. In summer, small numbers venture into the open regions. The common European-Siberian *Diaptomus denticornis* Wierz. and *N. pachypoditus* Ryl. also live in sors and gulfs. *Heterocope appendiculata* Sars is typical of the shallows in north Baikal. The maximum number of Calanoids (all stages) recorded in the North-Baikalian Sor in August 1962 was 1.9 10^3 spec. m"^{3}. In other regions *of north* Baikal, *numbers are* usually below 100 spec. m~^{3}. A highly important part in the life of the Baikalian plankton is played by *Epischura baicalensis* (Fig. 3.23).

Its wide distribution in Baikal was noted long ago (Korotnev, 1901), but fuller information was obtained by Yasnitsky (1928, 1930, 1934), Zakhvatkin (1932), Garber (1941, 1946), Kozhov and colleagues (1963), Kozhova (1953) and Afanasyeva (1977).

Adult females are 1.3 to 1.6 mm long (winter generation) and 0.9 to 1.3 (summer generation). Males are slightly shorter. The antennae are thickly plumed, and the caudal filaments are of equal length, long in males and short in females.

Epischura occurs around the year In autumn, it descends to deep layers to reproduce. In January, after the formation of the ice cover, the nauplii rise to the upper layers and gradually accumulate there, and their maximum density is usually achieved in March-April. In May-June this generation matures and the adults descend again (to 100-200 m and deeper) to reproduce. As a result, a new, usually higher number *of* nauplii is observed in *June-Juiy.* On rare occasions, females carry an egg sac attached to the genital segment and containing several dozen eggs As a rule, however, the eggs float freely.

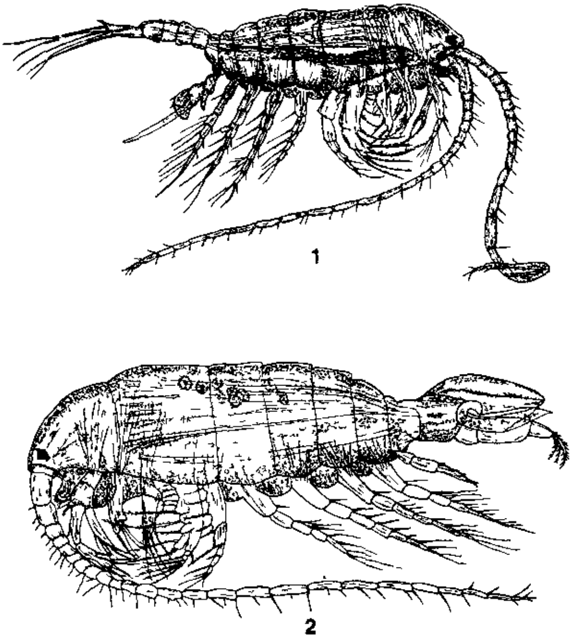


Fig 3 23 Epischura baicalensis Sars 1 - male, 2 - adult female with spermatophore, body length up to 1 6 mm After Sars, 1900

Its biomass in the open waters of Baikal reaches its maximum in August-September, when most specimens of the summer generation reach advanced copepodid stages. During this period, the main feeding time for the planktivorous fish of Baikal, the bulk live in the upper 50 meters of water.

The dynamics of *E. baicalensis* and its spatial distribution have been thoroughly studied and will be dealt with in the chapter "Pelagic Life". On the basis of these data, it is now thought that *E. baicalensis* is composed of various populations (Kozhova & Pavlov, 1985). *Epischura* is the chief consumer of planktonic algae; it can also filter bacteria (Kozhova, 1953, 1956a). The crustacean itself constitutes the staple food of such fish as the omul, *Cottocomephorus, Comephorus* and the young of other fish. The pelagic amphipod *Macro-*

hectopus branickii Dyb. also feeds upon *Epischura* (Vilisova, 1951). In sors and well-sheltered shallow gulfs, *Epischura* occurs individually, and only in the cold period of the year.

Epischura is of a considerable zoogeographical interest (Zenkevich, 1922b; Smirnov, 1929). In the Holarctic region, species of this genus are found only in the following widely separated places: Lake Baikal *(Epischura baicalensis* Sars), and Lake Udyl, which communicates with the River Amur through a gullet *(E udylensis* Boruz). Four or five common species are found in North America (Alaska, California, Newfoundland, North Carolina, the Great Lakes). The Palaearctic species comprise the subgenus *Epischurella* and the American species the subgenus *Epischura.*

Borutsky (1947a) considers the genus *Epischura* to be a remnant of a group which was once widespread in North America and East Asia, and of which some isolated colonies have survived in Asia, hence the discontinuous character of the distribution of the genus.

In North America, species of the genus *Epischura* are widely distributed and constitute a characteristic component of the lacustrine plankton, replacing there the Palaearctic genus *Heteracope,* which is absent in North America.

Cyclopoida

For a long time, only one species of the genus *Cyclops* (C. *kolensis)* was known from the plankton (Yasnitsky, 1923, 1924, 1934; Skabichevsky, 1935; Garber, 1948; Vilisova, 1954; Vasilyeva, 1950). At the present time, numerous studies (Mazepova, 1950, 1952a,b; 1955, 1957, 1962, 1970, 1978; Pomazkova, 1970; Flossner, 1984, Alekseev & Arov, 1986), including the littoral zone of the lake and its psammal have recorded 38 species and subspecies. Of these, 20 species and four varieties (65%) are endemic.

According to Mazepova, all Cyclopoids of Baikal belong to eight genera: *Macrocyclops:* two species, one endemic; *Paracyclops:* two species, one endemic; *Eucyclops:* two palaearctic species and two endemic varieties; *Orthocyclops:* one endemic; *Acanthocyclops* (sensu Rylow): 24 species, two varieties (17 endemic, two endemic varieties); *Diacyclops biceri* Boxsh. et al., 1993 by all evidence is a synonym of *D. euhtorahs* Aleks. et Arov, 1986. *Mesocychps:* two palaearctic species; *Microcyclops:* one palaearctic species; *Cyclops:* two palaearctic species. Rylow (1948) considered that three taxa in *Acanthocyclops, Megacyclops* and *Diacyclops,* described by Kiefer as distinct subgenera (Kiefer, 1927, 1928, 1929) or genera (Kiefer, 1937) are really only one genus.

The most abundant genus is *Acanthocyclops;* its species inhabit the lake from the supra-littoral zone down to extreme depths.

Baikalian *Acanthocyclops* have become adapted to a wide variety of ecological conditions. They are diverse in size, coloration, body structure, and differ only little in the main systematical characteristics. Three well-defined groups can be distinguished (based on females). The first group comprises *A. talievi, A. rupestris rupestris* and *A rupestris signifer* with a 12-segment first antennae and three segmented swimming legs. The spine formula is 2.3.3.3, setae 4.4.4.4, and the distal segment of the fifth pair of limbs is short.

The second group *{A. notabilis, A. similis and A. profundus* with its subspecies) is intermediate: by the number of segments of the first antenna it is similar to the third group, by the structure and armament of the swimming legs it resembles the first group. The distal segment of the fifth pair of legs of the three taxa is short, but in one species *{A similis)* it is lengthened.

A.(D) eulitoralis, from the psammal of Baikal is closer to the third group, but the segmentation of its swimming legs (2.2/3.2/3.2/3.2) and setae formula (4.3.3.4) is peculiar.

The most numerous third group (11 species) differs from the first one by an 11-segmented first antenna, a specific segmentation of the swimming limbs (2.2/3.2/3.3/3.3), and a spine formula (3.3 3.3), and setae (5.4.4.4). The distal segment of the fifth pair of legs is lengthened.

The relative length of the internal spine of the distal segment of the fifth pair of limbs - the main feature established by Kiefer for distinguishing *Acanthocyclops, Diacyclops* and *Megacyclops* - is very diverse in Baikalian species. This spine is attached apically or subapically; it may be equal in length to the segment, shorter, or longer. The length of the spine of the first group is 0.4-1.4 times that of the segment. The second group has a

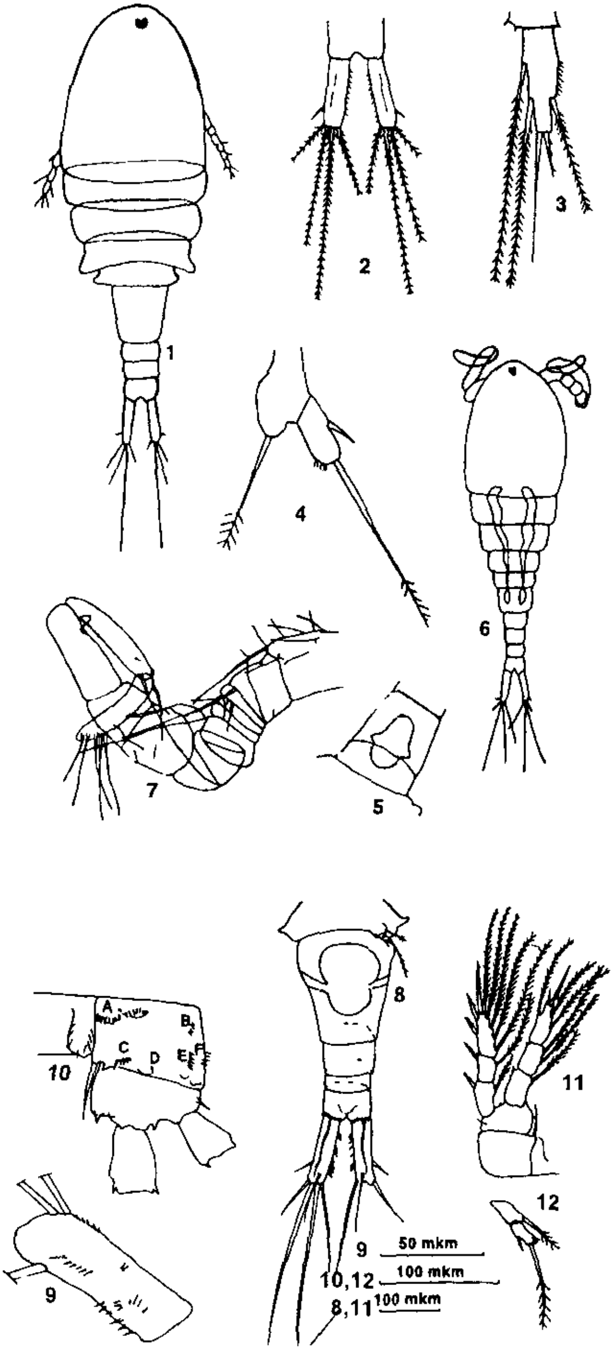


Fig 3 24 Cyclops kolensis Lill from Baikal 1 - female (general view), body length 1 *1* mm, 2 - furcal rami, 3 - distal segment of the exopodite IV, 4 - a limb of the Vth pair, 5 - general segment with receptaculum semims, 6 - male (general view), 7 - antenna of the male After Mazepova, 1960 8 - 1 2 female *Cvclops koiensis* Lill from south Baikal 8 - abdomen ventral, 9 - basipodit of antenna 10 - coxal article ot *a.* 4th pair of legs 11,12 - a 4th and 5th pair of legs After Alexeev, unpublished data

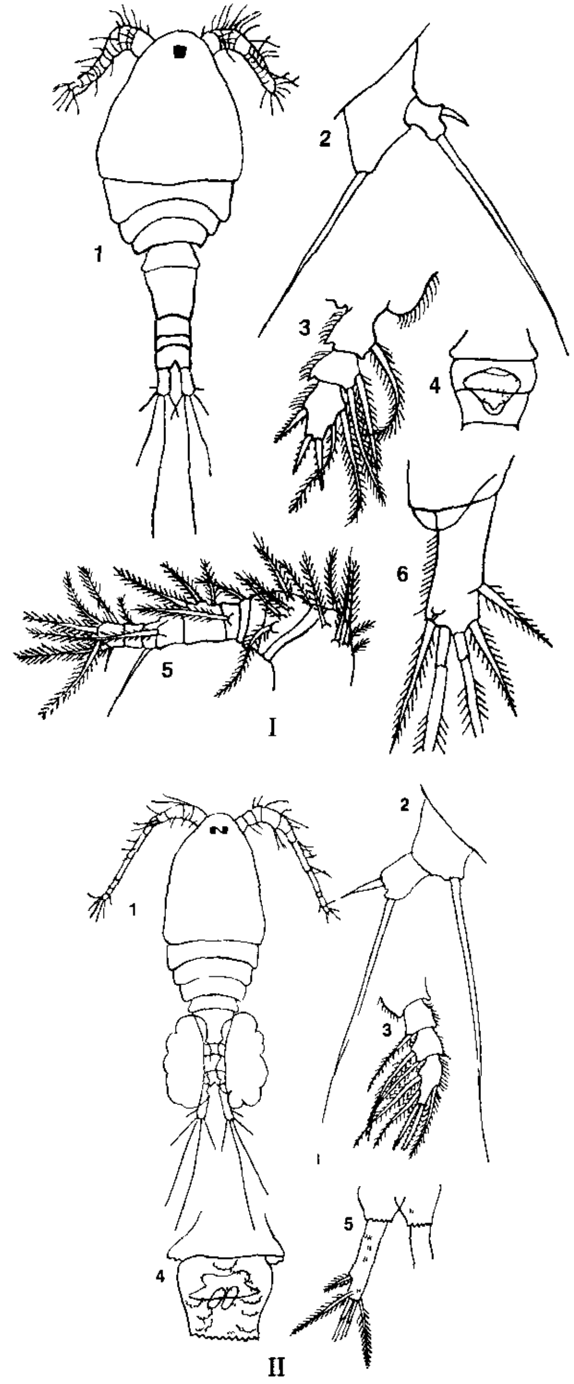


Fig 3 25 I - Acanthncyclops profundus Masep, female body length 1 4-1 5 mm 1 - general view 2 - a 5th pair limb, 3 - endopodite of a 4th pair limb 4 receptaculum semims 5 - front antenna, 6 - furcal ramus After Mazepova 1950

/ / - Acanthocxdops tupesfns Masep, female, body length *3* mm I - general view 2 - a 5th pair limb 3 - endopodite of a 4th pair limb, 4 - genital segment with receptaculum semims 5 - furcal ramus After Mazepova, 1950

spine shorter or equal to the length of the segment. In the third group, one species has a spine shorter than the segment, in two species it is of equal length, and five species have a spine 1.5-2.0 times longer than the segment. The size of the spine varies within one species in the remaining representatives (4). Some species have their internal spine replaced by a long, thin (bare or plumed) seta.

Almost all cyclopoids of Baikal are bottom dwellers; several species are nectobenthic and only one, *Cyclops kolensis* (Fig. 3.24), lives in the water column. Bottom dwellers occur at all depths. The zone down to 40-50 (100 m) is qualitatively and quantitatively rich in cyclopoids; at such depths practically all species can be found, except the abyssal *A. talievi.*

The numerical density of cyclopoids at depths of from 0-50 m in south Baikal is on average 1-3 10^3 spec, m~^{2} (biomass - 20-80 mg m"^{2}), maximum number - 10-20 10^3 spec. ni"^{2}.

The total number of taxa usually observed in the zone of 0-10 m is 13-19, at a depth of 20-50 m, it is 15 species. Of these, no more than three are abundant; in the littoral and sublittoral, they belong to different species. With depth, the species variety quickly diminishes. At 400-500 m, some eurybathic forms *(Eucyclops macruroides macruroides, Paracyclops baicalensis, A. rupestns rupestris, A. profundus profundus)* occur (Fig. 3.25). The upper boundary of distribution of *A. talievi* coincides with the 400 m isobath.

The morphology and coloration of the body is related to the habitat, mode of life and mode of movement of bottom cyclopoids. For example, five species of *Acanthocychps,* dwelling in the open, stony littoral which is greatly affected by the surf, are characterized by strong hooked-curved spines on the second *antenna and* distal segments *of the* endopodite of the first pair of limbs. One of them, *A. spongicola* (Fig. 3.261), living on the sponge *Luhomirskia baicalensis,* has a harpacticoid shape, and reduced armament of the first antennae. Cyclops dwelling on soft bottom soils (burrowing forms) have shortened antennae with numerous setae. Lengthened segments of the antennae and limbs with thin, long setae, a lengthened furcal ramus (these features are the same as in deep-dwelling species) testify to a nectobenthic mode of **life.**

Cryptic coloration is typical of littoral cyclopoids. Sandy bottom species are of a light-yellow colour, with bright patches. Deepwater species are decolorate, but retain the eye pigment. Other specific features of deepwater eurybenthic species are insignificant Only *A. talievi* is more specialized (3.26III).

In general, the open regions of the lake are inhabited by endemic species of Baikalian complex (Vereshchagin, 1935).

The Palaearctic complex in Baikal is represented by comparatively few, "usual" species in Pribaikalian waterbodies (14 taxa in seven genera). They prefer to live in sors, in the Selenga avandelta, in the northern extremity of Baikal (near the Upper Angara and the Kichera, Ajaja and Frohkha bays), in the shallow bays of Chivyrkui Gulf, and in Maloe More. In open regions, only individual specimens can be found, except for few species of the intermediate Sibenan-Baikalian complex (Vereshchagin, 1935), among which is *C. kolensis* **Lill.** Biometric measurements have confirmed the identity of this species, previously mentioned under different names, (Lindberg, 1955; Mazepova, 1957, 1961, 1978).

The species composition in the northern and southern parts of Baikal is almost uniform. Some differences in frequency of occurrence and relative abundance can be accounted for by biocenotic rather than by historical reasons. In Maloe More the species assemblage is the same, but dominant and rare species are different. In the southern part of Maloe More palaearctic forms can be found, penetrating from shallow bays. The Selenga Shallows are dominated by dwellers of soft bottom soils, with palaearctic species prominent and species typical of stony bottoms absent.

By origin, Baikalian cyclopoids are not uniform. The earliest immigrants *v^ere Orthocyclops bergianus* (Fig. 3.26II) (a second species in this genus lives in North America) and, probably, *Macrocyclops baicalensis.* No relatives of these species are known. Supposedly, they are tertiary relicts. The Baikalian *Acanthocychps* are genetically of Tertiar age too, but younger. Their morphological similarity with non-Baikahan species shows that they can be arranged in a series, the extreme members of which are *A. rupestns* (Fig. 3.25) and species of the *konstantini* group *(A. konstantini, A. elegans, A. galbinus, A. improcerus)* are close to

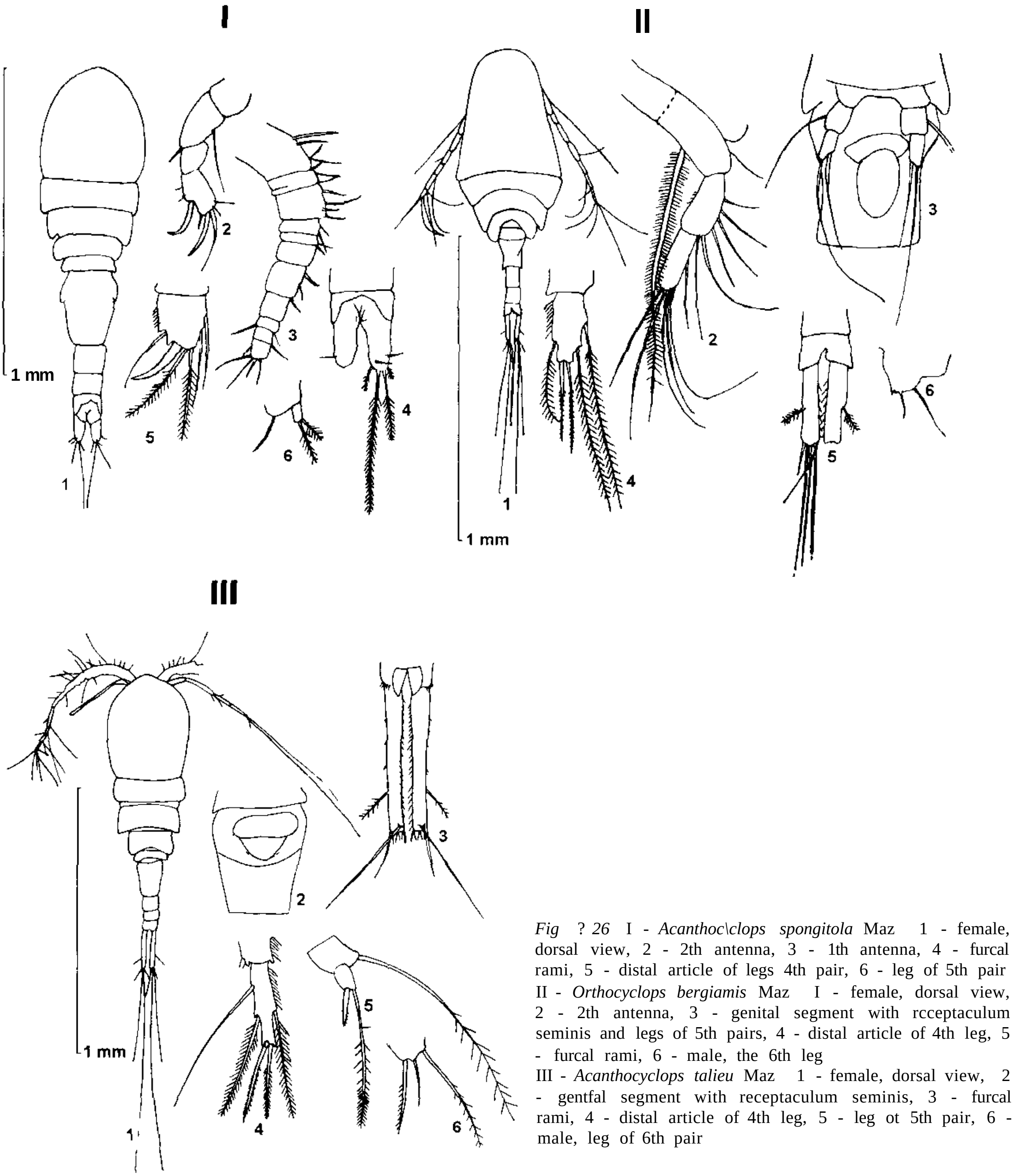


Fig ? 26 I - *Acanthoc\clops spongitola* Maz 1 - female, dorsal view, 2 - 2th antenna, 3 - 1th antenna, 4 - furcal rami, 5 - distal article of legs 4th pair, 6 - leg of 5th pair
II - *Orthocyclops bergiamis* Maz I - female, dorsal view, 2 - 2th antenna, 3 - genital segment with rcceptaculum seminis and legs of 5th pairs, 4 - distal article of 4th leg, 5 - furcal rami, 6 - male, the 6th leg
III - *Acanthocyclops talieu* Maz 1 - female, dorsal view, 2 - gentfal segment with receptaculum seminis, 3 - furcal rami, 4 - distal article of 4th leg, 5 - leg ot 5th pair, 6 - male, leg of 6th pair

the Holarctic polymorphic species *A. venustus* and *A.(D) languidoides.* Relatives of these inhabit the Nearctic and Palaearctic. In the Palaearctic, their total range stretches from Western Europe to the Far East and Japan, with a large discontinuity in the Asian part *of* the range. These cyclopoids usually occur in underground waters. Some species and varieties, *viz. A. languidoides, A. venustus crimtus* and others, only occur in underground habitats.

According to Rylow (1948) all these forms are remnants of a pre-glacial fauna. It is noteworthy that Baikalian species resemble cave forms But neither these features nor other peculiarities of *Acanthocyclops* can be referred to as primitive; on the contrary, many of them - shape and coloration of the body, structure of spines and setae on the appendages - *are* adaptive.

Thus, Baikalian *Acanthocyclops* have relict origin but considerable species variety, individual variability of species and adaptive characters testify to a subsequent autochthonous evolution of this group in the lake.

E serrulatus, E. macruroides baicalensis, E. m macruroides and *C. kolensis* are younger immigrants. The first two already have a deviated morphologically, while *C. kolensis,* although morphologically analogous to Palaearctic stock (Mazepova, 1961), has considerably changed its biology relative to populations from different parts of its range (North Nearctic and the greater part of the North Palaearctic). Within Russia, the species lives from Kolsk Peninsula in the North to the River Volga delta; in the Urals, in Siberia and in the North-East (Kamchatka and Kolyma), and also on the Novosibirsk Islands. These cyclopoids, together with a *few* representatives *of* other faumstic groups of the Sibenan-Baikalian complex, are now assimilating the biotopes of open Baikal, a novel environment for them. Some representatives of Baikalian cyclopoids are shown in Fig. 3.27 by Alekseev (unpublished data).

Parasitic copepoda

Thirteen species of parasitic Copepoda are known in Baikal (Mesyatsev, 1926; Koryakov, 1951, 1952, 1954; Markevich, 1956). They include one species of the genus *Ergasilus: E. sieholdi* Nordmann (= *E. baicalensis* Mark.), parasitic on the pike and roach; three species of the genus *Achtheres: A strigatus* Mark, on the omul, *A. percatum* Nordmann on the perch, and *A. extensus* Kessl, on the gwyniad; three *Salmincola* species: *S. extumescens* Gadd. *on* the omul and gwyniad, *S, cottidarum* Messjatzeff on Cottoidei species (Fig. 3.30), and *S. thymalli baicalensis* Messjatzeff on the grayling and omul; one *Trachehastes* species[1] *T. polycolpus* Nordmann on the dace and roach. Besides, a new species of the Baikalian genus *Coregonicola* has been described, *C. baicalensis* Koryak. (Fig. 3.31), found by Koryakov (1951) in the oral cavity of the abyssal cottid *Abyssocottus bergianus* Tal.

Greze (1951) pointed to the presence *of Paraergasilus rylovi* Mark, in the plankton of Baikal's sors. This species was first described from the Caspian Sea, where it was also found in plankton. Parasitism is supposed to be facultative in the life of this species.

Koryakov (1954) has discovered in Baikal three other species of parasitic copepods: *Ergasilus briani* Mark, on the dace, roach and minnow, and two *Basanistes* species, *B. briani* Mark, and *B. woskoboinikoni* Mark., on the *Branchymystax lenok* and *Hucho taimen.*

Thus, seven out of the 13 species of parasitic copepods are found on general Siberian fish species usually living only in sors and gulfs (Cypnnidae and *Perca fluviatdis);* two species of the genus *Basanistes* parasitize fluvial fish entering the coastal zone of open Baikal *{Branchymystax lenok, Hucho taimen);* five species are parasitic on fish permanently living in Baikal (two of them parasitize endemic Cottoidei species).

The species parasitizing Coregonidae *(Achtheres strigatus, A. extensus, Salmincola extumescens)* must have penetrate into Baikal from the North, together with the omul and other fish (Dogel et al., 1949). Koryakov (1954) considers that only one of the 13 species known in Baikal, *Paraergasilus rylovi,* is undoubtedly a relict of pre-glacial time. Two neoendemics of autochthonous origin, *Salmincola cottidarum* and *Coregonicola baicalensis,* are derivatives of widespread Siberian forms. The other 10 are common Palaearctic species; four of them can be observed also in the Amur drainage.

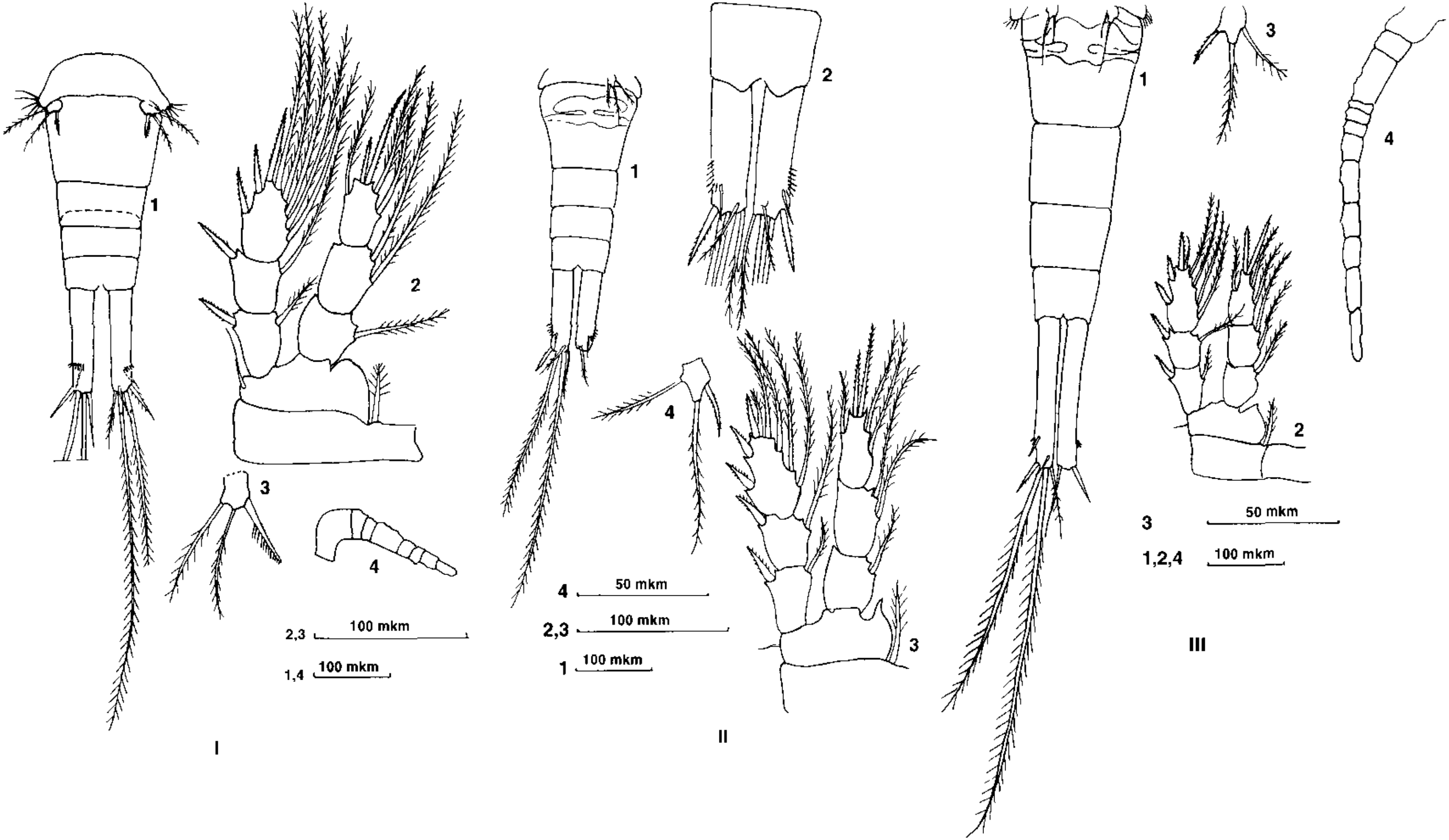


Fig. 3.27. I - female *Paracydops Jimbriatus* ***orientalis*** *s. sp.* **nov.: 1 - abdomen ventral, 2,3** - 4th and **5th pair** of legs, 4 - **antenulle. II** - female *Eucydops baicalocorrepus* Mazepova comb, nov.: **1 - abdomen ventral, 2 - furcal rami dorsal, 3,4 - a 4th and 5th pair of** legs. **Ill- female** *Eucyclops macrurus* (Sars), **notation as in I. After Aleksev,** unpublished data.

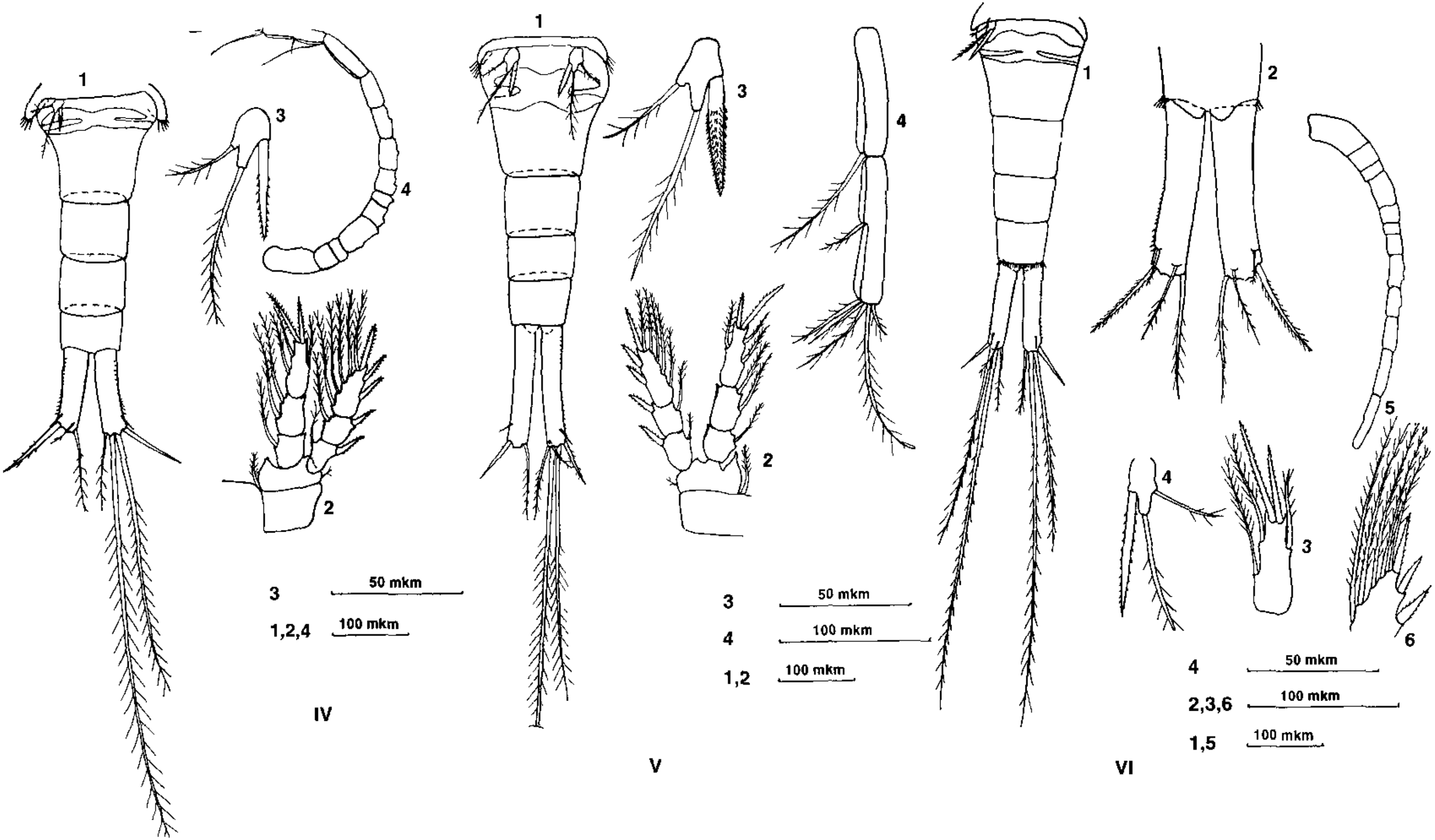


Fig 3 27 Cyclops of Baikal. After Alekseev, unpublished data.

IV - female *Eucyclops arcutius* Alcxecv, notation as m I

V - female *Eucyclops speratus* Gaeter • 1 - abdomen ventral, 2,3 - **a 4th and 5th pair of legs, 4 - distal segments of antennules.**

VI - female *Eucyclops serrulatus proxtmus.* 1 - abdomen ventral, 2 - **furcal rami dorsal, 3,6 - distal** segments of **endo- and exopodites of a 4th pairs of swimming** legs, 4 - a **5th** pair of legs, 5 - antennul

Ostracoda

Ostracoda are abundant in Baikal. They occupy fourth place in number of species, after protozoans, gammands and molluscs.

The lake, including sor zones, harbours 152 species and 22 subspecies (Bronstein, 1930, 1939, 1947; Mazepova, 1970, 1976, 1984, 1985, 1990; Mazepova & Drosdova, 1977).

All Baikalian ostracoda belong to the Cyprididae and Cythendae. The first is a freshwater family, the second is of marine origin. Both are ancient, known from the pre-Mesozoic period; each of them occupies a dominant position due to ecological uniqueness and number of species, and by distribution.

In Baikal 90% of all ostracods are endemic, but in the open lake (without sors) there is a 100% endemicity, and in the coastal-sor sites 55% (there are 20 Palaearctic forms and eight genera there).

The marked species abundance and endemism of the Baikalian ostracoda are in sharp contrast with the low number of genera present (four out of nearly 40 in the whole Palaearctic). Only *Baicalocandona* is endemic. In *Pseudocandona* and *Cytherissa* all or almost all taxa are endemic. (There is a suggestion about the existence of the nominative species, *C. lacustris,* in the sor zone but so far only valves or empty shells have been observed, perhaps of alien origin). The genus *Candona,* besides numerous endemics, includes widespread Palaearctic forms found at coastal-sor sites.

The genus *Candona* in a broad sense (smooth, unsculptured shell, fourth segment of endopodite of second antenna with sensitive setae in males) is one of the most common groups in the Palaearctic. Forty-nine species and five endemic subspecies of this genus, and 11 Palearctic forms, are known to reside in Baikal. Only a sole Siberian species, *Candona inequivalvis* (found in the vicinities of Verkhoyansk town), is represented by an endemic subspecies in Baikal, but even this has to be confirmed

The Baikalian species of *Candona* are morphologically diverse. They do not constitute a single phylogenetic series but form groups, which are likely to be phyletic lines. There are species with elongated-oval shells, tall, trapezoidal- and triangle-shaped *Candona* (the latter are of interest due to features transient *to the* genera *Pseudocandona* and *Baicalocandona),* and a distinctive group of species with narrow wedge-shaped shells. Such shells are not characteristic of freshwater ostracoda of epigean waterbodies, but resemble the shells of Lower Pliocene species of the group of *Candona (Caspiolla) lobata* (Zal.) from the Paratethys in South-East Europe (Rudyakov, 1963; Mazepova, 1970, 1976) and, at the same time, of a number of hypogeous forms of Zakavkazye (Transcaucasus), South-Eastern Bulgaria and Romania *(Mixtacandona Ijovuschkini* (Rud., 1963), *Phreatocandona motasi* Dan., 1978, *M elegans* Dan. et Cv., 1979 and *M. sp n gr Ijovuschkini* (Danielopol & Tsvetkov, 1979)). Some Baikalian species with triangular shells resemble species of Lake Ohnd.

Of the genus *Pseudocandona* Kaufrn., 27 species and three subspecies occur in Baikal. This genus, compared to *Candona,* is characterized by a reticulate sculpture of the valves (at all stages of development in Baikalian species) and by a three-segmented endopodite of the second antenna without sensitive t-setae in males (Fig. 3.32).

For the two first species discovered with such characteristics, *"bispinosa*[*1]" and *"werestschaginF,* Bronstein (1939) established the new genus *Metacandona,* which he later considered to be a synonym of *Pseudocandona* Kaufm. (Bronstein, 1947). The diagnosis and systematic position of the latter are still questionable, but the existence in Baikal of numerous species with features corresponding to author's diagnosis of *Pseudocandona* is evidence of the natural character of this taxon.

Outside Baikal there are several taxa with the same features, *eg.,* in Yugoslavia: *P. delamarei* Dan., 1978; *P. zschokkei* Wolf, 1919; *Mixtacandona juberthieae* Dan., 1978, and *P. pretnen* Dan., 1978. The composition of the genus *Pseudocandona* in Baikal is morphologically more uniform than the previous genus. Nevertheless, a number of species have various valve shapes: kidney-shaped, triangular, and trapezoidal, frequently with tubercules, ears or wings (P. *gajewskajae).*

In the endemic *Baikalocandona,* 14 species and three subspecies are known. It occupies an intermediate position between the two previous genera (sculpture on valves as in *Pseudocandona,* the structure of the endopodite of back antennae as in *Candona).* Of particular interest is the group of species with trapezoidal and triangular keeled shells, which in appearance greatly resemble some hypogean species such as *Mixtacandona* sp. from Bulgaria, and *Caribecandona aunculana* Broodb., *Caribecandona* sp. and C. *ansa* Broodb. from the West Indies. Petkovsky (1969) and Danielopol (1978) do not consider this similarity to be phyletic and attribute it to convergence, which might occur in "physically and biologically stable conditions" (Danielopol, 1972). But, owing to the dissimilarity of conditions in caves and in Baikal, this hypothesis cannot easily be confirmed. It is difficult to talk about the stability of conditions in a lake such as Baikal: the physical environment, particularly in shallow sites, is very dynamic. And historically, Baikahan biocenoses have not been stable.

The genus *Cytherissa* in Baikal numbers 47 endemic species and ten subspecies. The form and sizes of their valves vary from kidney-shaped to rounded, not infrequently with nodes and projections. These sometimes lend the shell a rather peculiar, sometimes quaint outline. Many species have asymmetncal valves usually with the left valve being larger (Fig. 3.33).

The majority of Baikalian species are morphologically distinct and markedly differ from one another. Their outer similarity makes it possible to unite them in groups, but whether these can serve as evidence of an independent origin and evolution in Baikal, remains a subject for further investigation.

All *Cytherissa* of Baikal are dioecious, and sexual dimorphism is the rule, with males greater than females, and their shells lengthened. The size of the shells varies from 0.5-0.6 mm to 1.2-1.3 mm in females, and to 1.8 mm in males (maximum values are for the deepwater populations of C. *tuberculuta)*

At present, the genus as a whole is poor in species (excluding the species in Baikal), and spatially disjunct. Apart from Baikahan endemics, it only includes some species in the Caspian Sea and Khubsugul Lake. One parthenogenetic species, *C. lacustris*, with a wide but discontinuous distribution lives in large lakes of the Holarctic. It also inhabits Baikal. In contrast to other populations, it is dioecious there which is why Bronstein (1947) distinguished it as a specific subspecies.

In the past, the genus *Cytherissa* was more richly represented spatially and at the species level, especially during the Pliocene, and more rarely in the Pleistocene deposits of European Russia, the South Urals, Middle Asia, the West-Siberian Lowland, and North America (the Alaska Pleistocene). In all, about 20 taxa are known. C. *lacustris* is known as a fossil from the Pliocene of Turkmenia and Central Kazakhstan, from Pliocene and Quaternary deposits of the Russian platform, the Volga region, West-Siberian Lowland, India, the Pleistocene of West and South-East Europe, but also from the USA (sediments of Lake Michigan) and Canada.

All ostracods in Baikal are bottom-dwellers, occurring everywhere, and at all depths. Ostracods are most diverse at shallow depths (up to 25-50 m). *Candona* species usually prefer stony and sandy bottoms; *Cytherissa* species inhabit soft bottoms and occur at great depths. Many *Cytherissa* are eurybathic. An impoverishment in species numbers is particularly clear over 100-200 m; at depths exceeding 250-400 m, there are only 12-15 species, some of these are endemics of this zone. At great depths, the eurybathic *Cyt. tuberculata, C sensibilis profunda, P. setosa abissahs, C semilunaris dignitosa,* and the probable only deepwater dwellers *P. profunda, C. gracdenta, C. birsteini, C. longiformis* and C. *limosa* are common.

The maximum number of the "mass" species, *Cyt. elongata,* in north Baikal at a depth of 5-10 m was 9 10^3 spec, m"^{2}; at a depth of 20 m - 3.5 10^3 spec, m"^{2}; in the Selenga Shallows at a depth of 5-10 m 700-900 10^3 spec, m ^{2}; in the depth range of 10-50 m the species *Cyt. sernovi* was dominant (4.5 10^3 spec. m"^{2}).

Differences in faunal composition and numbers in the coastal belt are often fine-grained, even on similar soils. On fine sands in northern Baikal at a depth of 10 m, per m^2 of sandy bottom divided into 25 squares, the number of ostracoda (17 taxa total number 1195 spec. m~^{2}) varied by 12 times between squares The cause of such patchy distributions is probably differences in the quantity of organic detritus available as food.

Spatially, ostracods form two major ecologicgenetic complexes: Baikalian endemics (open lake), and Palaearctic species in common with surrounding water bodies (coastal-sor zone). Compared to other groups, the zone of contiguity of these two complexes is a narrow strip of bottom.

In the majority of geographically and geomorphologically diverse regions (coastal belt in north and south parts of the lake, the Maloye More Strait, the Selenga Shallows, the Academichesky Range and the Ushkany Islands, Bargusin and Chivyrkui gulfs), 70-80% of the fauna are common species. Nevertheless, each region has its own peculiarities. The upper 100 m of north and south Baikal differ by 24 taxa (the total number of species in north Baikal is 102; in south Baikal, 99; *common* species, 86). There are *differences* in the nature of the dominant species according to depth: only six species are equally common in north and south Baikal. In deep waters, no such conspicuous differences in species composition have been observed. The Maloye More is known for its abundance and species diversity, due to the great variety of ecological niches present. In the Maloye More bays, deeply indenting the coast, endemics and palaearctic forms occur side by side. The Selenga Shallows, on the contrary, are poor in species due to the absence of hard bottoms, but their fauna is quantativefy rich, with a considerable admixture of palaearctic species in the outer delta. The Ushkany shallows, characterized by a distinctive geological history, an isolated position and severe conditions, are surprisingly rich in species (more than 80 taxa), and also stand out due to their local endemism. On the coastal site of the Svyatoi Nos Peninsula, adjacent to the Ushkany Islands the number of ostracods is smaller. In the underwater Academichesky Range, geomorphologically related to the Ushkany Islands, ostracoda are represented by deep-water and eurybathic forms.

According to Bronstein (1939, 1947), the Ostracoda of Baikal are morphologically and genetically related to ancient (pre-Phocene), primitive freshwater and (via the fossil *Cytherissa)* brackish-water Ostracoda.

There is a similarity between some Baikalian Candonidae and fossil Tertiary and modern hypogean relict faunas in areas far from Baikal. In this connection, it is of interest to single out endemic species in the monotypic or oligotypic genera *Mixtacandona* Klie, *Cryptocandona* Kaufm., *Pseudocandona* Kaufm., *Nannocandona* Ekman, *Candonopsis* Vavra, *Phreatocandona* Dan., and *Caribecandona* Broodb. These genera are united by their intermediate systematic position, vague diagnosis, and, on the whole, by a wide but disrupted distribution. They differ from other Candoninae by distinctive valve shapes and rare or primitive features of the structure of the body. Features such as narrow, wedge-shaped or tall shells, dorsal keel and sculpture occur in Baikalian and partly in Ohrid Candona, and in fossil Tertiary forms as well.

The hypogean genera under discussion are considered to be relicts of an ancient fauna, the major part of which became extinct, but a *few* forms of which were preserved in sheltered habitats (Danielopol, 1972; Broodbakker, 1983). This may also hold true for Baikalian species, if we admit that their ancestors were more widespread in the past. Direct ancestors of Baikalian Ostracoda are absent not only m surrounding waterbodies but generally as well. The majority of the genera have evolved in the lake itself. After being isolated here, Candoninae went through a long, independent speciation which obscured previous relationships. Hypogean Candoninae also changed considerably, by oh'gomerization of fimbs and reduction of the setiform apparatus, creating deep differences with Baikalian species. The origin in Baikal of the species of *Cytherissa* is even more difficult to identify. A comparison with fossil Tertiary forms from the European part of Russia reveals no close similarity: fossil species are similar to C. *lacustris,* and close to each other. There are no data about Tertiary fossil Cytheridae in the East of the country.

It should be noted that all Baikalian and Khubsugul species are characterized by amphygony, compared to C *lacustris,* which is parthenogenetic. The ancestors of the Baikalian species must also have been dioecious. Amphigony, a more ancient feature than parthenogenesis, testifies to the penetration of Cytheridae into Baikal prior to the onset of the unfavourable climatic conditions of the Pleistocene, when many species of Ostracoda, including C. *lacustris,* developed parthenogenetic populations.

The final conception regarding the origin of the *Cytherissa* of Baikal depends much on future finds of Ostracoda in the continental deposits of Eastern Siberia and the adjacent territories of Mongolia.

At present it may be admitted that the manner, and perhaps, the time of penetration of the Cyprididae and Cythendae into Baikal differed. The Baikalian *Cytherissa* is probably, like the molluscs, a mezolimnic element.

Harpacticoida

A rich and peculiar harpacticoid fauna has been found in Baikal. Ft was studied by Borutsky (1931, 1932, 1947b,c, 1948, 1949, 1952) and later by Okuneva (1972, 1989) and Evstigneeva (1992).

According to Okuneva (1989), the harpacticids of Baikal belong to ten genera in two families. One genus and four subgenera, 58 species and one subspecies are endemic, which makes up 85% of the total. The most numerous family is the Canthocamptidae, which comprises genera at various levels of organization. The highest species richness is in the genera *Bryocamptus* (23 species, 22 endemic) and *Moraria* (25 species, 23 endemic).

The genus *Canthocamptus* is represented by six species, two of which have been placed by Borutsky & Okuneva (1971-1972) in the endemic subgenus *Baicalocamptus* (Fig. 3.28).

Two species of *Paracamptus* are known, one of them is endemic. Three species of *Echinocamptus* (subgenus *Limnocamptus)* and one subspecies *E. hiemahs werestschagini* Borutsky (Fig. 3.29,1) are endemics. Of two species of *Attheyella, A. (Ryloviella) baicalensis* Borutzky is endemic. The genus *Maraenobiotus* is represented by one non-endemic species, *M insigmpes* Lilljeb. Twenty-one species of *Moraria* genus belong to the endemic subgenus *Baicalomoraria* (Fig. 3.29,2). The genus *Morariopsis,* which comprises three species, is endemic to Baikal (Fig. 3.29,3).

Tn the family Harpacticidae, a species abundantly represented in open Baikal and its gulfs, *Harpacticella inopinata* Sars can be found. Most of the genera of this family live in seas, but *Harpacticella* is a freshwater genus which comprises four species: *H. inopinata* in Baikal, *H. paradoxa* Brehm in Lake Tali-fu in Yunnan (China), *H. lacustris* Sewell in Lake Chilka in India, and *H. amurensis* Borutzky in the River Amur.

Okuneva (1972, 1989) studied in detail the morphology of the nauphus and copepodite stages of *H. inopinata.* These juvenile stages are always quantitatively dominant in the population, and the ecology of the juveniles differs markedly from that of adults. The first nauplius stages (I-IV) are benthic, crawling along algal filaments, scraping bacteria, microscopic algae and detritus. The last nauplius stages can move in prebottom waters. Okuneva found that older copepodite stages and adults are capable of rising not only to the prebottom but also to surface water layers at depths of 2-5 m. These crustaceans are observed in the plankton at night, where the> are eaten by *Cottocomephoms grewingkii,* thereby constituting of from 30 to 70-80% of its food volume.

Endemic species of Harpacticoida live mostly in the open sections of Baikal. In its coastal zones and bays Okuneva found nine Palaearctic species: *Mamenobiotus insigmpes* Lilljeb. is peculiar to the Arctic zone of Siberia, *Attheyella dogieli* Ryl. also occurs in China and, furthermore, *Maraenobiotus alpimis, Epactophanes richardi, Paracamptus schmeili, Bryocamptus spinulosus, Canthocamptus gibba, Moraria duthiei* and *M schmeili.* The latter two species live in open Baikal.

Borutsky points out that the Harpacticoida of Baikal are, on the whole, of Palaearctic stock, their roots being situated in the territory of the ancient Angara (Baikal rift zone) Borutsky (1952) sees a confirmation of this hypothesis in the affinities between some primitive forms of North America, East Asia and Baikal *(Brehmiella, Moraria,* etc.).

It is noteworthy that many Baikalian species are close to the North American ones, for instance, *Atteyella (Ryloviella) baicalensis, Bryocamptus (Pentacamptus) incertus* Borutsky, and many others. A similarity between Baikalian species and cave-dwelling species of West Europe is also evident.

Harpacticella inopinata is a mesolimnetic species. Borutsky considers this species to be a remnant of the upper-Tertiary freshwater fauna of North Asia.

The Harpacticioda of Baikal are also quantitatively rich. Among algae and on stones in the coastal belt, large numbers of these minute (0.5-1 mm) crustaceans can be seen. They are especially abundant on sponges and stones amidst water

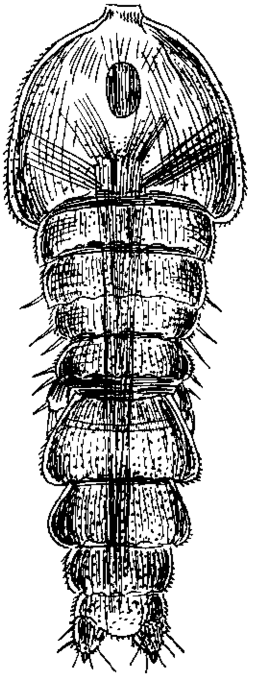


Fig. 3.28. Harpacticidae. *Canthocamptus* (*Baicalocamptus*) *werestschagini* Borutzky, female, body length 0.9 mm. After Borutsky, 1952.

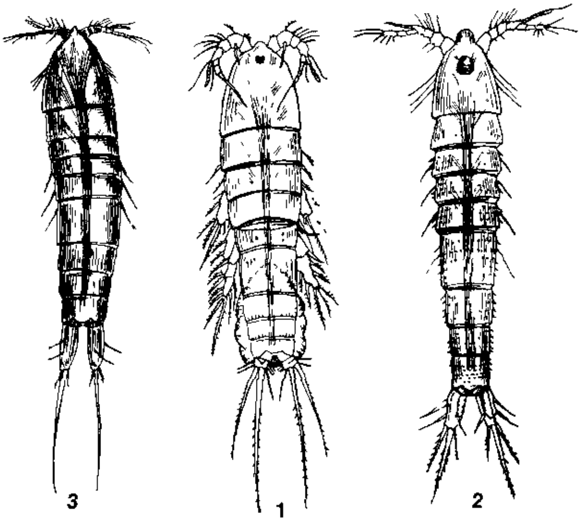


Fig 3.29 Harpacticidae: 1 - *Echinocamptus (Limocamptus) hiemalis* var. *werestschagini Bomtzky, female, body* length 0.6 mm, 2 - *Moraria {Baiculomoraria) baicalensis* Borutzky, female, body length 0.8 mm, 3 - *Morariopsis typica* Borutzky, female. After Borutsky, 1952.

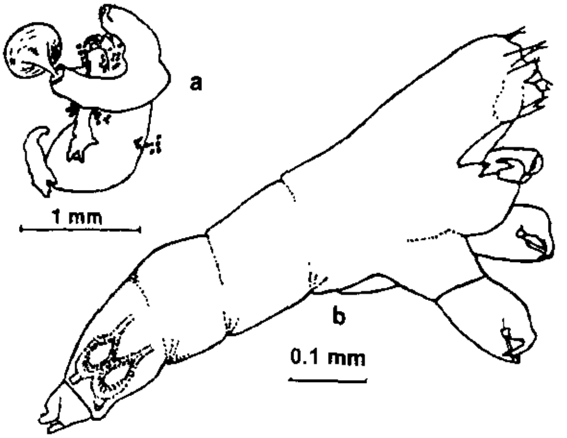


Fig. 3 30 Salmincola cottidarum Messyatzeff; a – female, b – male, body length 0.8 mm. After Koryakov, 1951

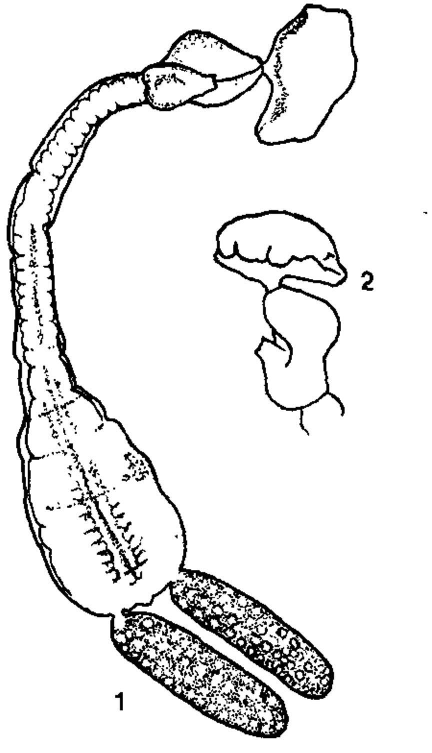


Fig. 3.31. Coregonicoia baicalensh Koryak., a parasite of *Abyssocottus*, body length 15-20 mm. 1 - general view, 2 - sticking apparatus. After Koryakov, 1951.

plants in the coastal belt It seems likely that species living on sponges feed on them They constitute, it is possible the diet of the gammand *Brandtia (Spinocanthus) parasiticus*, large accumulations of which can be found on any sponge

About 40 species of Harpacticidae dwell on soft grounds Okuneva ascribed morphological changes in Harpacticidae to adaptations to certain bottoms Moreover, she found that it is not particle size that defines the population density, but rather interstitial space among particles of sand and silt This permits groups of hthophihc, psammophilic, pelophile and nectobenthic crustaceans to be singled *out*

Okuneva (1989) also established differences between the harpacticoid fauna of the northern and southern parts of the lake These differences are primarily expressed in the coastal zone Such species as *Bnocamptus tuberculatum B longifurcatus B schappuisi Moraria coronata* and *M acuta* are only known from north Baikal, and *B tenuis M spinulosa* and *M gratilipes* from the south Some species occur on western coasts only For example, in the region of Bolshyie Koty, 47 species have been recorded Some of them are rare along the south-eastern coast, other never have been found here Different geographic depth distributions within one and the same species were also detected For example, *Echmocamptus hiemahs werestschagim* lives at 1-20 m near the north-east coast, but at the south-east coast it is only observed at depths of *3-5* m

Cladocera

The Cladocera of Baikal are represented by 48 species, seven of which are endemic (Vasilyeva & Smirnov, 1975, 1978, Smirnov, 1984) Five species belong to the endemic genus *Kozhowia* and two to cosmopolitan genus *Alona*

All other Cladocera are cosmopolitan or Palaearctic In the pelagial, *Daphma galeata* and *Bosmina longirostris* predominate, reaching maximum numbers in the open pelagial in late summer and autumn

The endemic Chydondae inhabit open Baikal and also occur in all large bays of the lake

Bottom Chydondae live in Baikal down to depths of 20-25 m on stony, sandy and silty bottoms The most numerous species are *Kozhowia baicalensis,* followed by *K gajewska/ae* and *K brevidentata*

It is of interest to note that some widespread Palaearctic species inhabit the open regions of Baikal *(e g Chydorus sphaericus)*

The endemic bottom Chydondae occur around the year, with maximum numbers from August to November The numbers of Chydondae are rather small (usually 10-15 10^1 spec m^2, only *Chydorus sphaericus* reaches 80 10^3 spec m^2)

Bathvnelhdae

Bazikalova (1954c) described two species of Bathynelhdae from Baikal *Bath\nella magna* and *B baicalensis,* collected from the epibenthos up to a depth of 1400 meters They were the first Bathynelhdae to be found m Russia Kozhov's studies showed that Bathynelhdae are not rare in Baikal and occur on sandy and silty soils with an admixture ol fine detritus

Bathynelhdae are an ancient, primitive group of Malacostraca (Syncanda) Noodt (1964) considers them to be relicts, which survived in shelters with low competitive pressure Almost all known species are subterranean (wells, caves, subsoil waters) Noodt believes that *B baicalensis* from Baikal is a typical representative of the genus *Bathynella,* close to the European *B natam* For the Baikahan species *B magna,* Birstein & Levushkm (1965) established a special genus, *Baicalobathynella,* which is the most primitive of all Bathynelhdae, since species of this genus have only two pairs of pleopoda instead of one, as in all other genera

The Baikahan Bathynelhdae are the only Bathynellacea living m surface waters, although m the interstitial of the shores one species of *Baicalobathynella* has been found by Veinberg *et al,* 1995, whose taxonomic status has not yet been ascertained

The whole order is considered *to* be an immigrant from the sea, dating back to the Palaeozoic (Noodt, 1964, Tsvetkov, 1966) During one hundred million years they colonized the subterranean waters of almost all continents, forming genera, species and subspecies in different regions Bazikalova considers the Tethys Ocean to be the birthplace of the Baikahan species She assumes that

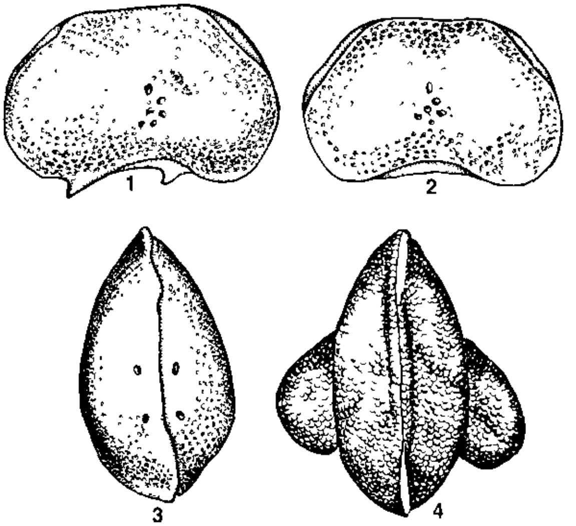


Fig. 3.32 Pseudocandona bispinosa Bronst., 1-2 - side view of male and female lest, 3 - male test from above, length 1 2 mm, 4 - *Pseudocandona gaiev,skaja* Bronsl , male lest from above, length 0 6 mm. After Bronstein, 1947

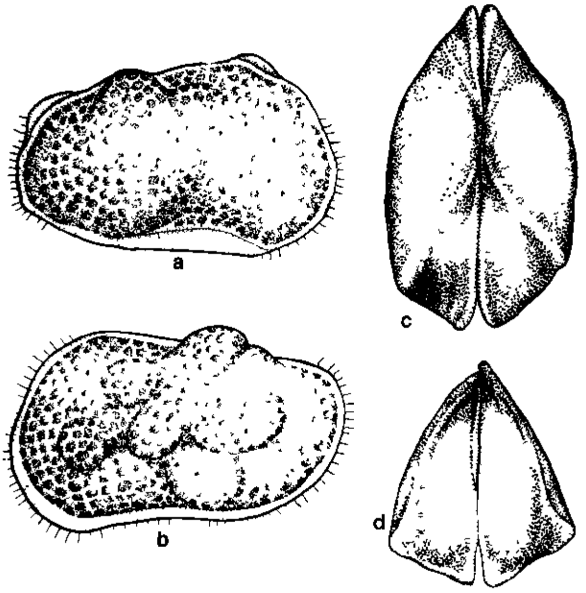


Fig 3 33 a, b - Ostracoda *Cytherissa tuberculata* Bronst, a - female, b - male, shell length 1.16 mm, c.d - *Cytherisia triangulata* Bronst.. view from above and from the front, length 1 1 mm After Bronstein, 1947

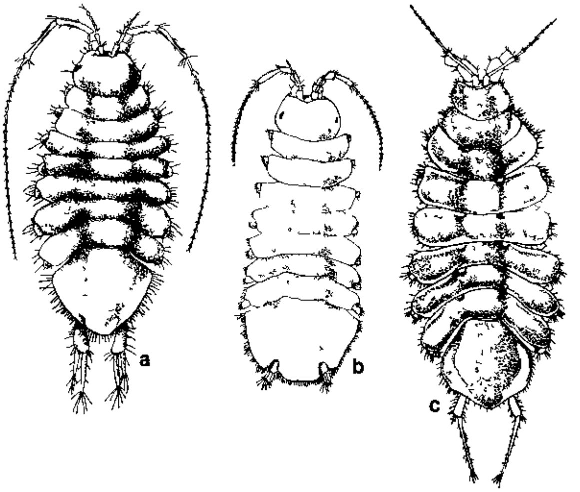


Fig 3.34 a - *Baicalasellus baicalensis* Grube; b - *B angarensis* Grube, body length 5-6 mm; c - *Mesoasellus dyboHsku* Semenk body length 10 mm. lower antennae (removed) are three times as long as the body After Birstem, 1951

the Baikahan Bathynelhdae originally lived on the coasts of Baikal and found themselves submerged in its waters as a result of the gradual subsidence of the site

Kozhov (1972) considered that long before the formation of Baikal, Bathynelhdae were present in the subterranean and interstitial waters of South Siberia. Later, they penetrated to Baikal and its coasts. In view of this, mention should be made of the presence of a subterranean fauna in Mesozoic freshwater found during drilling boreholes at a depth of dozens of meters in the upper valley of the Angara River, not far from Baikal. Such ancient subterranean waters were supposedly connected with Baikal, and probably still are now. In this subterranean Angara waterbody, a blind *Stygobromus* sp. (Syncandae) was found.

Modern Bathynelhdae only live in pure freshwater and cannot endure brackish waters (Noodt, 1964). The presence of Bathynelhdae serves as a sign to paleontologists that the region has not flooded by the sea since the local appearance of Bathynelhdae.

During the last years, representatives of the genera *Parabathynella (P. tianschamca)* and *Bathynella (B. natans)* have been found in the region of Lake Issyk-Kul, in wells which collect water from subterranean springs, as we; as in cave waters in the Caucasus.

Isopoda

Isopods are represented in Baikal by two genera of the family Asellidae (Birstein & Levushkin, 1967): *Baicalasellus,* with four species, and *Mesoasellus* with one species, *M. dybowskii.* Natyaganova *et al.,* 1994 identified *another* species *of the* genus *Mesoasellus,* which differed from *M dybowskii* by its smaller size, almost white colour of the body, and greater mobility. It lives on stony-rocky soils of the littoral and perhaps deeper.

Among Baikalian species, *B. angarensis* Grube (Fig. 3.34b) and *B. baicalensis* Grube are the most numerous (Fig. 3.34a). *B. angarensis* usually inhabits stones in the coastal belt and enters the Angara. *B baicalensis* lives mostly on rocky patches of the open littoral and among algae. It also enters the Angara.

Very distinctive characteristics are displayed by *Mesoasellus dybowskii* (Fig. 3.34c). It has a strongly flattened body reaching 1 cm in length, with unusually long lower antennae many times exceeding the length of the body, thin and long thoracic legs, and almost rudimentary eyes. It lives at 100-1000 m and deeper, but sometimes also in the littoral.

The chromosome numbers of four species of *Baicalasellus* were studied by Natyaganova *et al.*, 1994.

According to Birstein (1951), the subgenus *Mesoasellus* is a relict of a remote past. Species of this group, besides in Baikal, live in the subterranean waters of Japan and California. The subgenus *Mesoasellus,* as the more primitive, could be close to the ancestral form of the subgenus *Asellus,* whose species are rather widespread in Eurasia. Species close to the Baikalian *A. (M.) dybowskii* occur in North America (Virginia), and in Western Europe (subgenus *Proasellus).* Species of the subgenus *Asellus* are also found in the Lena and Amur rivers *{A. hilgendorfi)* and in the lakes of the Tsipa depression of the Baikalian system *{A epi~meralis).*

Since the closest relatives to the Baikalian *Mesoasellus* live predominantly in subterranean waters, Kozhov (1972) assumes them to be ancient inhabitants of Baikal, which penetrated to it from subterranean waters in South Siberia long before the glacial cooling, like the Bathynelhdae. Probably, *A. epimeralis,* living in the Tsipian lakes, has survived there since the period when the Tsipa depression was flooded by the waters of a deep lake connected with Baikal.

Amphipoda

This order is represented in Baikal by the family Gammandae, which has undergone adaptive radiation there.

The first species of gammarids were discovered in Baikal and the Angara by Pallas (1776) and Gerstfeldt (1859a), but the foundations of the knowledge of the Baikalian gammarids were laid down by Dybowsky.

Dybowsky (1874, 1875, 1884) provisionally referred all Baikalian gammarids known to him (97 species) to the genus *Gammarus,* establishing a separate genus, *Constantia,* only for *Macrohectopus bramcku.* Stebbing (1899) distributed these species among 20 genera, four of which *(Pallasea, Brandtia, Gammarus* and the above-mentioned *Constantia-Macrohectopus)* were already known at that time. Garyayev (1901) described a dozen new species and attempted to unite the Baikalian genera in three groups: Pachygammanni, Eugammarini and Acanthogamniarini.

In his work published in 1915, Sovinsky analyzed the rich collections of Korotnev's expedition and supplemented the known species with several dozen others, establishing ten new genera.

After Sovinsky the gammarids of Baikal and the Angara were studied by Dorogostaisky (1917, 1922, 1930, 1936) and Bazikalova (1935, 1941, 1945, 1948b, 1951a,b, 1954a,b, 1957, 1959, 1962, 1975). As a result, the fauna again grew with dozens of new taxa. Of particular importance was the monograph by Bazikalova (1945), in which the system of Baikalian amphipoda was thoroughly analyzed, and the problems of genesis and evolution of this group were discussed.

Later, publications by Karaman (1976, 1977) provided descriptions of four new species of *Pachischesis* and *Cannurus,* Recently, Baikalian gammarids are studied by Kamaltynov (1992), Takhteev (1992) and Takhteev & Mekhanikova

(1993). According to Kamaltynov (1992), there are 259 species and 80 subspecies of Baikalian amphipods, which can be unified into 3 families and 46 genera.

Such a species richness has not been observed in any other continental body of water in the world. About 20 percent of all amphipods inhabiting the fresh and marine waters of the world have been described from Baikal.

It must be said, however, that despite the tremendous amount of work performed on the systematics of the gammands, some genera, and in particular polymorphic ones such as *Eulimnogammarus,* need re-investigation.

At present, this work is being carried out by specialists at the Institute of Limnology and University of Irkutsk. In the list of species, the taxonomic system of Bazikalova is used, although Barnard & Barnard (1983) have made changes in the composition of genera, considerably increasing their number by re-establishing *Boeckaxelia, Dorogammarus, Eucarinogammarus* and *Spinacanthus* (= *Brandtia),* eliminated by Bazikalova, and raising the rank of the four subgenera of *Eulimnogammarus.* Moreover, two new genera were singled out from *Ommatogammarus* and *Parapallasea.*

The problem of taxa of above-species rank still remains unsolved: some scientists even believe that Baikalian amphipods belong to two or three families (Garyayev, 1901; Sovinsky, 1915; Bousfield, 1982; Barnard & Barnard, 1983).

In the tremendous variety of Baikalian gammarids, the least specialized group (not armed with cutaneous outgrowths, such as spines and carinae) is constituted by the genus *Eulimnogammants,* which comprises 70+ species (Fig. 3.35,1). It has a related genus in the deep-dwelling *Abyssogammarus* (Fig. 3.36,2). This central group is adjoined by the specialized but unarmed genera *Ommatogammarus* (Fig. 3.36,1), perhaps by *Macropereiopus,* and the well-defined genus *Odontogammarus* (Fig. 3.35,4). Bazikalova also lists here the genera *Lobogammarus* and *Polyacanthisca.* The common features of this group are: a more or less elongated, smooth, slender, laterally compressed body without or with only rudimentary cutaneous outgrowths, well-developed rudder feet, long antennae, a multiarticulate flagellum on the upper antennae, normally-developed caudal section, and numerous spinules on the caudal and, not infrequently, ventral segments.

Species of this group inhabit a wide diversity of biotopes: they are, as a rule, good swimmers. The size of the body (without appendages) ranges from 10 to 70 mm. Body coloration is: blood-red, green, brown, pink, etc., often with a complicated pattern.

According to Kamaltynov (1992), this group should be united in one family, also including the genera *Abludogammarus, Corophiomorphus, Heterogammarus, Leptostenus, Micruropus* and *Pseudomicruropus.*

More than four species of *Pachyschesis* are external parasites of the large nectobenthic gammarids, inhabiting depths of 100 m or more. These species are restricted to precise sites on their hosts, such as the brood pouch or gill cavity. They feed on host eggs and are resistant to low oxygen (Takhteev & Mekhanikova, 1993). This group stands well apart from all other groups.

The next group unites forms characterized by the presence of cutaneous outgrowths on the body in the form of carinae, spines, denticles, knolls, ridges, etc., situated both on the sagittal dorsal line of all or some of the segments and sometimes on their sides. As in the first group, the species in this group usually have a fairly slender, laterally compressed body, well-developed antennae, strong rudder feet (with few exceptions) and, as a rule, a multiarticulate flagellum on the upper antennae.

This group of "armed" gammarids. which partly corresponds to Garyayev's Acanthogammannae, includes several genera, many representatives of which are the largest in size of the entire gammarid fauna. Examples of these are species of *Acanthogammaras* (Figs. 3.35,5,7), *Garjajewia* (Fig. 3.36,4) and *Paragarjajewia.* They are evidently closely related to the distinctive genus *Hyalellopsis (Boeckaxellia)* (Fig. 3.35,6) and also to *Brandtia* (the range of *Brandtia latissima* forms, Fig 3.37,1), distinguished by a broad truncated caudal section. Also highly distinctive are species of *Spinocanthus,* living on sponges. They are tenacious, spined crustaceans with a vivid, mottled coloration.

The genus *Hyalellopsis* (Fig. 3.35,2) is even more distinctive. Its species, which lead a fossorial life, have a broad, compact body with a strongly

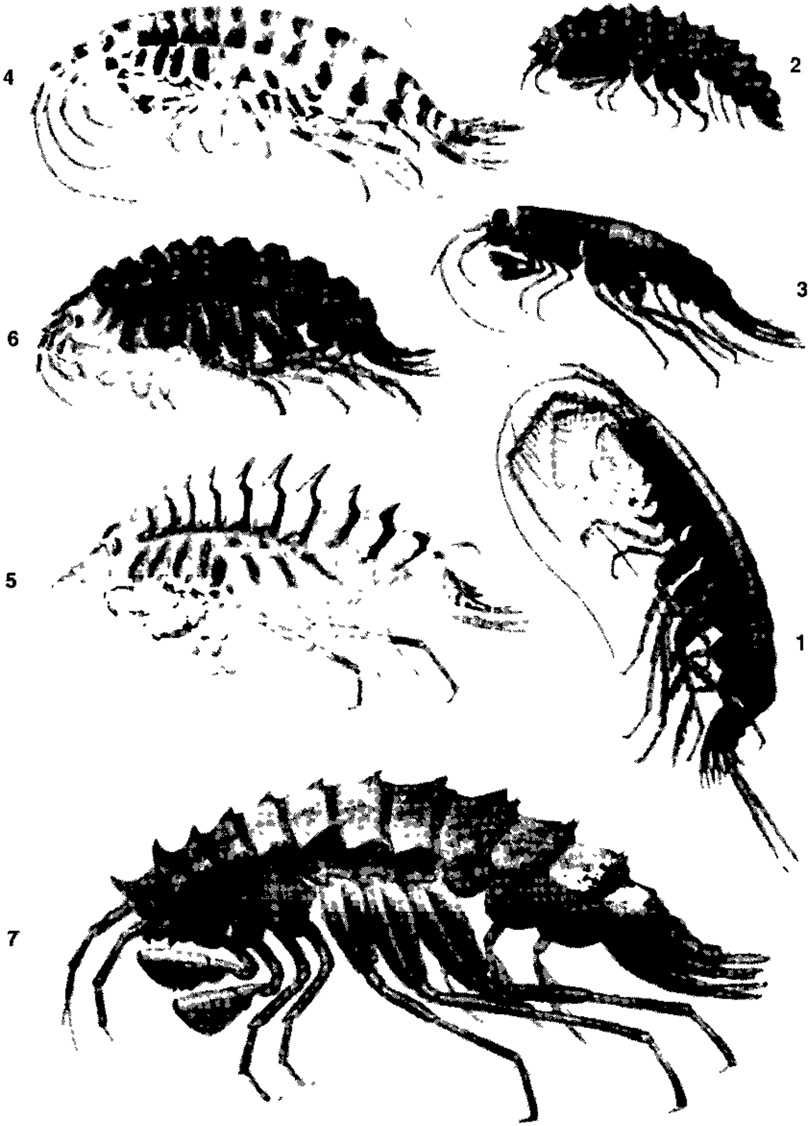


Fig 3.35 1 - *Etdimnogammarm czersku* Dyb.. body length up to 30 mm; 2 - *Hyaletlopsis coslata* Sow., length up to 10 mm; 3 - *Poekilogammarus araneolus* Dorog., length 10 mm; 4 - *Odontogammarus calcaratus improvisus* Dorog., length up to 35 mm; 5 - *Acanthogammarus flavus* Garjajev, length up to 20 mm; 6 - *Hyaletlopsis carpenten* Dyb., length up to 30 mm; 7 - *Avanthogammarus maximus* Garjajew., length up to 70 mm. After Dorogostaisky, 1930.

truncated caudal section and weakly developed knolls, ridges and other cutaneous projections This genus is closely allied U> *Cannurus* and *Comurus*

A special branch of armed gammands is comprised *of the* genera *Pallasea* (Fig 3 37,2), *Parapallasea* (Fig 3 38,2), *Metapallasea*, *Hakonboeckia* and *Ceratogammarus*

According to Bazikalova (1945), the genus *Pallasea* is closely related to the genus *Poekdogammarus* (Fig 3 35,3) from which the pelagic *Macrohectopus bramcku* Dyb (Fig 3 38,1) has diverged The genus *Metapallasea*, established by Bazikalova (1959), in her opinion, combines traits of *Pallasea* and *Poehlogammarus*

The group *Carinogammarus-Echiuropus* presents, as it were, an intermediate stage between armed and unarmed gammands It is characterized by the presence of small cannae or knoll-like protuberances along the sagittal line of the dorsal surface of its segments

A distinct group is formed by the genera *Crypturopus* (Fig 3 36,3), *Micruropus* and *Homocerisca*, characterized by a truncated, relatively broad and smooth body devoid of any projections, usually with short antennae and a uni-articulate flagellum on the upper antennae The numerous species of these genera are predominantly burrowing The genera *Gmehnoides* and *Baicalogammarus* also stand somewhat apart

In the opinion of Bazikalova (1945), all these varieties of Baikalian amphipods can be grouped around a few central genera, namely, 1 *Homocensca-Crypturopus,* 2 *Acanthogammarus-Garjajenia,* 3 *Pallasea*, and 4 *Eulimnogammarus*

Baikalian gammands are very abundant They populate highly diverse biotopes and play an important role m biological processes Some of them are weed-eaters or feed on decaying organic remains, bodies of big animals, etc Many are carnivores, preying on small invertebrates or attacking fish caught in nets, it happens sometimes that, instead of an omul or grayling, fishermen haul up a skin sack literally packed with large gammands Particularly notable in this respect are species of the genera *Acanthogammarus* (Fig 3 35,7) and *Ommatogammarus* {Fig 3 36,1)

The vast majority of Baikalian gammands are bottom-dwellers, populating all zones of Baikal up to its most extreme depths Some are less attached to the bottom and rapidly move about in the above-bottom layers in search of prey, for this reason they are classified as benthonectic *(e g*, species of *Ommatogammarus* and *Abyssogammarus)* The mysidiform *Macrohectopus bramcku* Dyb (Fig 3 38,1) leads an exclusively pelagic life, living in the water column and migrating between the deep layers (150-200 m and deeper), where it stays during the day, to the surface layers, where it preys on zooplankton at night *M bramcku* is the only species of the monotypic family Macrochectopidae Sow (Kamaltynov, 1992)

Concentrating in vast numbers in the littoral, where they often number 30,000 or more specimens per square meter of bottom, gammands constitute an essential part of the diet of Baikalian fish (Bazikalova & Vilisova, 1959)

Gammands living at great depths have a number of interesting peculiarities The eyes of littoral forms are usually black, whereas those of deep-dwellers are red or pink, furthermore, in typically abyssal species, the eyes are deprived of pigment and a deformity in their position is observed The body of deep-dwelling forms is usually pale-yellow and the antennae very long

Depending on time of reproduction, amphipods are subdivided into three groups shallow-water forms, reproducing in summer and spring, forms which reproduce in autumn-winter and dwell at both shallow and great depths, and deep-water forms reproducing throughout the year (Bazikalova, 1941)

The majority of Baikalian gammands is restricted to Baikal Only about 50 species and subspecies also live in the upper section of the Angara About 20 of these penetrate the middle and lower reaches of the river, and into the Yenisei, and some may spread up to its mouth and to the Yenisei Gulf (see list of species)

Gmehnoides fasciatus has been observed by Pirozhmkov (1937a, 1941) in the large running-water Lake Nalimye, other lakes *of* the Yenisei system and in the basin of the River Pyasina The Upper Taimyra River is inhabited by *Eulimnogammarus verrucosus* and the Arctic Lake Taimyr by *E vindis* it is noteworthy that in these lakes Baikalian immigrants live side by side with such relict forms as *Pallasea quadrispinosa* Sars and *Mvsis oculata rehcta* Loven, while in Lake Taimyr they occur together with *Pontoporeya affims*

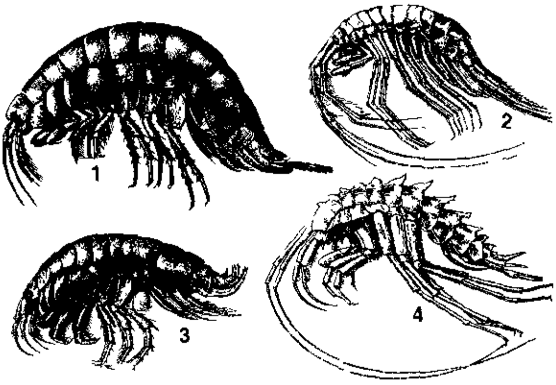


Fig. 3 36. Gammands: 1 - *Ommatogammarus aibinus* Dyb., body length up to 25 mm; 2 - *Abyssogammarus sarmaius* Dyb., body length up to 63 mm; 3 - *Crypturopus pachytus* Dyb., body length up to 18 mm; 4 - *Garjajewia cabanisi* Dyb., body length up to SO mm. After Bazikalova, 1945.

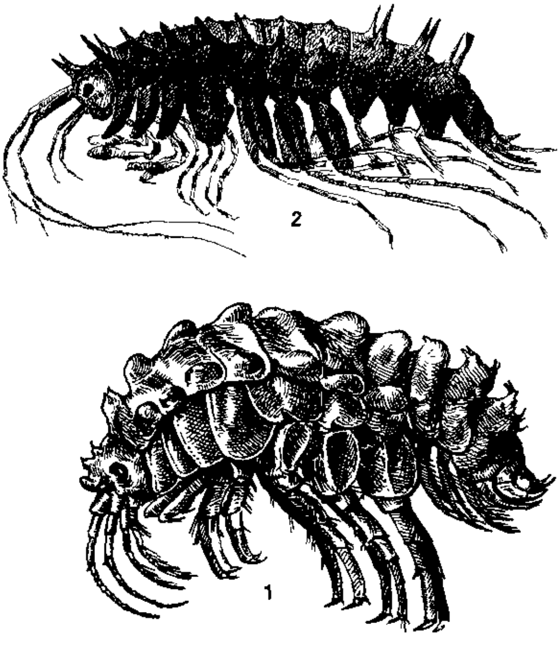


Fig. 3.37 I - *Brandiia iatissima* Dyb., body length up to 18 mm. After Bazikalova. 2 - *Pailasea bicorms* Dorog. After Dorogostaisky, 1930.

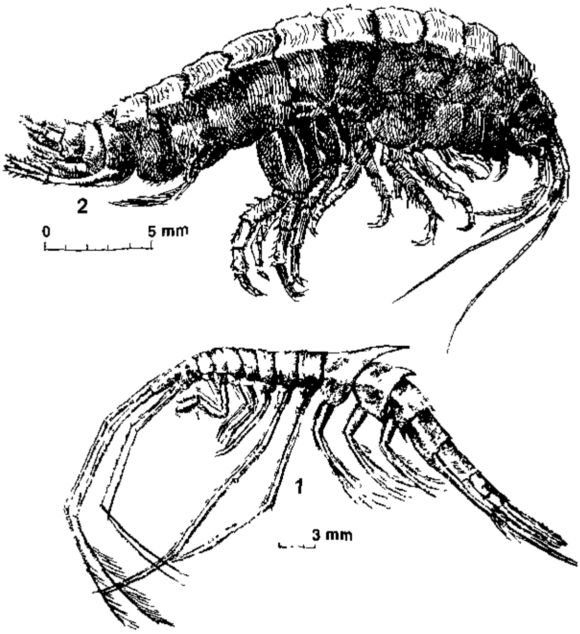


Fig. 3.38 1 - pelagic gammarid *Macrohectopus branickii* Dyb., body length 25-35 mm; after Bazikalova, 1945; 2 - *Parapallasea puzilloi* Dyb. body length up to 30-40 mm; after Kozkov. 1963.

Lindstr. and *Gammaracanthus lacustris* Sars (Greze, 1953, 1957).

It should be noted that the species which spread to the Yenisei live exclusively in the littoral and are more capable of enduring non-Baikalian conditions than other species. For example, *Gmelinoides fasciatus* and *Micruropus wahlii* are often observed in sors and coastal lakes, and also in the lower reaches of large affluents. Moreover, the sors and lower reaches of rivers are visited by such species as *Eulimnogammarus verrucosus, Micruropus possolskii* Sow., *M. talitroides* Dyb., and some others which develop local forms there.

An ability of some species *of* Baikalian gammarids to survive in the Yenisei Gulf and Arctic relict lakes, where they comprise an important component of the benthos, led Greze (1951) to suggest the possibility of their acclimatization in other rivers and lakes of the Arctic seashore of Siberia. Bekman & Bazikalova (1951) also recommended acclimatizing gammarids of the coastal-sor zone of Baikal there. Acclimatization experiments were started in I960. *Gmelinoides fasciatus* and *Micruropus possolskii* were taken from Posolsky

Sor; by 1985 they had colonized 43 waterbodies, including reservoirs of the rivers Volga and Ob, where they became important to the diet *of* commercial fish (Zadoenko *et at.,* 1985; Vizer, 1988).

According to modern data (discounting the Angara and the Yenisei), the Baikalian gammarid genera are only represented outside Baikal by *Pallasea* which, apart from Baikalian species, also includes *Pallasea quadrispinosa* Sars and *Pallasea laevis* Ekm.

Barnard & Barnard (1983) re-allocated the palaearctic representatives *of Pallasea into* a new genus, *Pallasiola,* leaving the endemics of Baikal in the old genus *Pallasea.*

Pallasea quadrispinosa is widespread *in* the large lakes of the coastal regions of the Baltic and White seas *and also in* the Arctic relict lakes of the Siberian coast (Lake Taimyr and others). *Pallasea laevis* is known only from the freshwaters of the coast of Novaya Zemlya. Unlike other relict amphipods *(Pontoporeia, Gammar acanthus), Pallasea* species prefer freshwaters.

The Finnish scientist Segerstrale (1956. 1957, 1958) considers the *Pallasea* species living in the lakes of North-West Europe to be Siberian, migrating to Europe after the Great Glaciation. It can be assumed that the genus *Pallasea* evolved in Siberia.

The inclusion of a number of species from the Balkans, the Caspian Sea, Kamtchatka, etc., into the genus *Carinogammarus* has proved to be incorrect (Bazikalova, 1945). In the same way, it was a mistake to unite the species of *Boeckia* from the Caspian Sea and *Axelhoeckia (=Boeckaxelha)* from Baikal into one genus. There is no confirmation of the presence in Baikal of the genus *Gammaracanthus* which is common in relict lakes and brackish waters of North Eurasia.

According to Bazikalova, the genus *Eulimnogammarus,* which is noted for showing the greatest specific diversity, is closest to the genus *Gammarus* abounding in fresh, brackish and marine basins, and to the subgenus *Marmogammarm,* from which it differs only in the absence of spines on the segments of the metasoma and mesosoma. It also bears some likeness to the subgenus *Gammarus.* Martynov (1935b) found an affinity between *Eulimnogammarus* and the genus *Ostiogammarus* of the fresh and brackish waters of the Balkan Peninsula.

Among armed gammarids, the Baikalian *Acanthogammarus* and related genera, show a certain relation *to* the *rehct* species *Gammaracanthus loricatus* Sabine. Bazikalova (1940, 1945) and Martynov (1935b) point to a similarity between the Caspian species *Boeckia spinosa* and the Baikalian genus *Hyalellopsis.* Schellenberg (1937a,b) considers the Baikalian *Hyalellopsis* to be related to subterranean genera of the *Crangonyx* group.

The genus *Gmelinoides* is related to *Gammarus kusceri* Karam. from the Balkans and to the genera *Gmelina* and *Pontogammarus* from the Caspian Sea.

While studying the origin of Baikalian gammarids Bazikalova *et al.* (1946) measured the osmotic pressure of the body fluid in some species. They found it to vary within a wide range, with species of each systematic group having their own amplitude of fluctuation. The highest osmotic pressure was found in *Eulimnogammarus, Odontogammarus* and *Micruropus,* which seems to reflect the closeness of the former two to a marine ancestor *(Marinogammarus).* The lowest osmotic pressures were found in *Garjajewia* and *Spinacanthus,* believed to have evolved in Baikal itself, and therefore more distant from their marine ancestors.

A low osmotic pressure was recorded in the ordinary lacustrine species *Gammarus (=Rivulogammarus) lacustris,* which does not live in Baikal. This species may therefore be even farther removed from its initial marine progenitors.

Tahev (1955) claimed that the Baikalian and Caspian gammarids had their origin in the northern seas, from which they penetrated first into the Pontocaspian basin and from there, via running waters, into Baikal. Martynov (1935b) supposed that Baikal and the Caspian Sea had received some related or *common* forms from the Sarmatian basin and that the latter had acquired the main nucleus of this marine fauna in the Palaeogene from a more ancient body of water which lay in the place of the Sarmatian basin. These ancestors worked their way into Baikal through running waters and lakes which, he believes, abounded in Siberia and Turkestan in Tertiary times.

In the opinion of Bazikalova (1945), the ancestors of the Baikalian gammarids originated in some unknown body of water, a derivative of the gradually freshening sea with a rich amphipod fauna which included ancestors of the Baikahan and Caspian genera, and also the genus *Gammarus.*

When analyzing hypotheses on the kinship of Baikahan gammands with gammarids from elsewhere, Kozhov (1963) came to the conclusion that, with the exception of the genus *Pallasea,* no unquestionable relation can be traced between Baikalian genera and genera of the Caspian Sea, the Balkans, the seas of the northern hemisphere and other basins, both freshwater and brackish. The existing similarities can all be explained by convergence and are of no serious phytogenetic importance. Evidently, the Baikahan range of genera has formed independently of the Pontocaspian and Balkan centres, and only their most ancient roots might be common.

3.7.2. Arachnoidea

Argyroneta aquatica, a widespread Palaearctic species, occurs only in sors. In the coastal-sor zone, aquatic mites (Hydrachnellae) also occur, but their species composition is still unknown. They appear to be represented only by European-Sibenan forms. In the littoral of open Baikal only *Feltria minuta* and *Pionocercus baicahnsis,* probably washed away from streams, can be found.

The order Halacarae is represented in open Baikal by six species, belonging to the Trombididae and Polohalacaridae. Of the latter, there is the genus *Parasaldanelloni* with three species, of which one *(P baicalensis)* is endemic The two others are also found in subterranean waters of South-Eastern Asia, in lakes of Switzerland, and on the Kolsk Peninsula.

An endemic species and genus of mite is *Pseudasaldanellonix lochmannelloides.* In Baikal, *Soldanellonix chappuisi* can be observed, widespread m mountain streams, lakes, and underground waters of Europe (Sokolov & Yankovskaya, 1970). *Stygothrombidium vermijormis* (family Trombididac) (Fig. 3.39) lives in open waters of the lake, among algae and in clutches of Mollusca. This species is also endemic. Its relatives are known from subterranean waters of Yugoslavia. Thus, Baikal is known to have eight species of aquatic mites, of which Hydrachnellae *(Piomocercus* and *Feltria minuta)* appear to live in its affluents and individuals are occasionally washed into the costal zone. The other six species of the group Halacarae, belonging to three genera, inhabit open waters (the littoral, sublittoral), with one species belonging to an endemic genus and the other three species being endemic too. But the fauna of mites has only been studied fragmentarily. In the littoral of the lake, representatives of the Onbatidae and Tyroglyhidea have been found, the identity of which has yet to be established.

3.7.3. Insecta

Plecoptera

In open Baikal there are two species of Plecoptera, belonging to the Capmidae (Zapekina-Dulkeit & Zhiltsova, 1973, 1977). The distinctive appearance of the Baikalian Plecoptera and the peculiarities of their biology enabled Zapekina-Dulkeit & Zhiltsova to allocate them to *Baikaloperla,* endemic to Baikal.

The Baikalian Plecoptera are small in size *(B. kozhovi:* 5-6.5 mm; and *B. elongata:* 9-11.8 mm) with completely reduced wings, completely or partly reduced eyes, and with stout bristles on the body. From the structure of the thoracic sternites, *Baikaloperla* is somewhat similar to the genera *Eocapnia* and *Allocapniella* from Japan (Zapekina-Dulkeit, 1977).

Plecoptera live under rounded stones on damp sand in the zone of surf, and can be seen from April (on ice) to June.

The embryos of *Baikaloperla* develop internally (in the abdomen or even in thoracic segments). The Capniafemida known from the region of Everest reproduce in a similar way (Kawai, 1968).

In the River Angara, its tributaries and rivers flowing into Baikal, there are 12 (16) species of Plecoptera (Zapekina-Dulkeit, 1957; Golyshkina, 1967; Tomilov *et a!.,* 1977; Akinshina *et al.,* 1988). They are all Siberian rheophilic species, and do not occur in the lake.

Trichoptera

Thanks to Martynov (1909, 1910-1914, 1924), Levanidova (1941, 1964), and Rozhkova (1981, 1994), 122 caddisfly species (imaginal stages) are

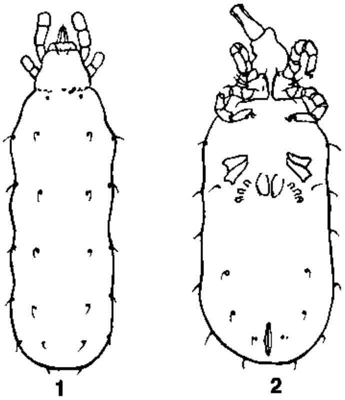


Fig. 3.39. Water mite *Slygothrombium vermiformis* Sokol. 1 - female, dorsal view; 2 - ventral view, body length up to 1.5 mm. After Sokolov, 1952.

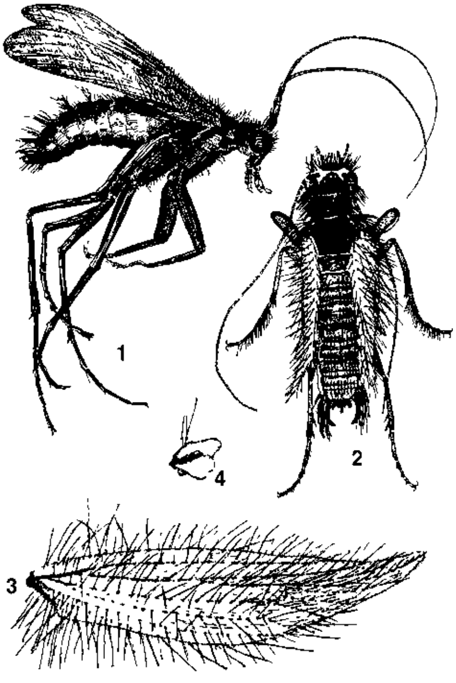


Fig. 3.40. Caddis-flies of the Baicalinini group: 1 - *Baicalina reducta* Mart., body length up to 5-7 mm; 2 - *Thamastes dipterus* Hag., body length up to 5-7 mm; 3 - a right front wing of the same species; 4 - rudiment of a back wing (3 and 4 strongly magnified). After Golyshkina, 1967.

now known from the coasts of Baikal. However, most of their larvae live in coastal lakes and sors, not connected with Baikal's open water. They include Palaearctic species of the Limnephilidae, Phryganeidae, Sericostomatidae, Molannidae, Leptoceridae and others (14 families in all).

A few of these larval stages have been found in relatively open bays and gulfs. Rozhkova found the endemic *Baicalina bellicosa*, and the Siberian *Psychomyia pusilla* to be dominant in the stony littoral (to 6 m) of the region of Utulik-Murino during summer (1977-1981).

In open regions, 17 species of caddisfly belonging to the Limnophilidae and the subfamily Apataniinae have been described (Martynov, 1909, 1910-1914, 1924; Bebutova, 1941; Levanidova, 1964; Lepneva 1964, 1966; Menshutkina, 1986; Rozhkova, 1994). The Apataniinae, in turn (after Martynov), comprises two groups: Apataniini and Baicalinini.

The tribe Apataniini includes *Apatania*, represented in Baikal by three endemic species: *A. baicalensis* Mart., *A. nigrostriata* Mart, and *Apatania* sp.nov.Rozh. The other five genera and 14 species belong to the tribe Baicalinini.

The genus *Apatania* is widespread in Central and East Asia and North America. The Baikalian species of this genus occur, as a rule, in the open littoral.

All species of the Baicalinini are endemic. Thus, this group can be regarded as having evolved in Baikal. The larvae of only six species of caddisfly have been described. The phenology of 13 species has been studied. Depending on the flight period, Menshutkina (1986) divides the Baikalian caddisfly into three groups: vernal *(Radema infernale, R. setosum),* vernal-aestival *(Thamastes dipterus)* and aestival *(Apatania baicalensis, A. nigrostriata, Baicalina bellicosa, B. spinosa, B. reducta,* (Fig. 3.40,1) *B. thamastoides, Baicalinella foliaia, Baicalodes ovalis).*

In the open costal belt, Baikalian caddisfties occupy a place of no small importance. In April, even before ice break-up, the imagos of some species of *Radema* emerge and squeeze to the surface through cracks and thaw pores in the ice. After casting the larval skin, they stretch out their tightly folded wings, run about on the ice and try to fly towards the shore. In broken spring ice scores of dead, frozen imagos can be found which failed to reach the surface. After break-up, the surface of nearshore waters teems with minute (4 to 6 mm) dark-grey or almost entirely black imagos of *Thamastes dipterus* Hag. (Fig. 3.40,2), running about briskly in groups or individually. *T. dipterus* have a normal front pair of wings; the back wings are reduced to small rudiments. The back and middle pair of tarsi are modified for swimming; the body and wings are thickly haired, allowing the insects to hold onto surfaces. Mating and ovisition also take place in water, although considerable numbers of insects also accumulate on stones at the edge.

From the beginning of June until late July, the mass metamorphosis of other species takes place. *Baicahna belhcosa* Mart, is especially numerous. The large bright-yellow larvae of this species (12-17 mm) live on the rocky bottom in the littoral. On calm days in July, preferably in the morning, countless *B. bellicosa* and other caddisflies can be observed, rising from the bottom to the surface, floating about for some time, then changing to the imaginal stage, trying to fly up but landing and rapidly "swimming" shoreward. The larvae of some species crawl along the bottom towards the shore and moult at the edge of the water, crawling onto stones to emerge.

The females deposit eggs in the form of small rounded jelly-like lumps. Some species lay these casts at the edge of the water and even on the shore, releasing them into water-filled pits between stones. These casts become glued to stones and other hard objects. Towards the summer and especially in autumn, due to the gradual rise in lake level, the casts are flooded.

Tremendous amounts of caddisfly accumu/ate at the edge of the water and on coastal rocks in June, which is the period of maximum emergence. Thousands of insects can be counted per square meter, in a layer which is sometimes up to 10 cm thick, rolling down in heaps to the shore at the slightest breeze or when someone approaches them. In the period of mass emergence of caddisflies, the mountain taiga on the north-eastern coast of Baikal is transformed. The branches of larches turn absolutely black with swarms of caddisfly. Young cedars and firs resemble fluffy black conical tents, so thick is the mass of insects covering them (Gusev, 1956).

During the flight period of the caddisfly, graylings converge to the shore, feeding on the pupae and imagines of these insects. The Baikalian omul also eats them and remains near the shores during their emergence. Forest birds, chipmunks, squirrels and even bears are not averse to feasting upon caddisflies in secluded spots.

The Baikalian Trichoptera live in the imagmal stage for a few days only, whereas their larval life in the water lasts for up to three years.

In the opinion of Martynov (1929, 1935a) the family Limnophilidae, which is highly varied, species rich, and to which all Baikalian Trichoptera belong, evolved in Tertiary times in North-East Asia and North-West America, which were linked at this time through Bering Land. During much of the Tertiary period, according to Martynov, the climate of that region was temperate and partially quite cool. A strong impetus for the spread of this heat-loving fauna, in particular to the south (up to the Himalayas) and south-west (the Altai, Turkestan, Iran, Europe), was provided by the Miocene cooling. The early (extinct) ancestors of the Baicalinim group probably lived in running as well as in standing waters; part of this group penetrated into Baikal, where it became isolated and further differentiated. In the Lower Oligocene, Europe was already inhabited by the same Trichoptera genera that live there today. The fossil insects found in Tertiary (Oligocene or Lower Miocene) deposits on the Pacific coast and in the Far East region show that the Limnophilidae already existed in Europe at that time. Martynov considered that the divergence of the Baicalinini group from a stock in common with the Limnophilidae had certainly begun in Early Miocene and probably even earlier. Since the larvae of these genera can only live in Baikal, it follows that, in the Miocene or at the end of the Oligocene, Baikal was a freshwater lake.

It can be assumed (Kozhov, 1963) that, in their entire diversity, the Baikalian caddisflies have originated from no more than two or three ancestral Limnophilids. New species and genera evolved from them in the lake itself. The distinctive conditions of life there made a sharp imprint on the life cycle and organization of both the larval and imaginal stages. Particularly conspicuous among these specific features is the loss of the ability to fly in the imaginal stage. This could only happen in a vast and deep body of water, where winged insects driven by wind far away from the shore would perish without offspring

The other peculiarity of the Baikalian caddisflies is a prolonged period of larval life, resulting from the low water temperatures

Baikalian caddisfhes do not enter the Angara and, in reverse, the Palaearctic species living in the Angara do not appear in Baikal, even in the vicinity of the outflow

Ephemeroptera

Ephemeroptera are not to be found in open Baikal but are present in several tributaries of south Baikal In their lower reaches, they are represented by 14 species *m six* families Heptagemidae (3), Baetidae (3), Siphlonundae (1), Ohgoneunhdae (1), Leptophlebndae (1), Ephemerelhdae (5) Typical rheophiles dominate *Ephemerella thymalh* Tshern, *Cinygmula cava* Ulm and species of the genus *Baetis* Larvae of Ephemeroptera live under stones, in places with rapid currents

Diptera

Among Diptera, a significant part is played by Chironomidac They were studied by Linevich (1948, 1957, 1991), Chernovsky (1949), Levanidova (1948), Kalugina (1975), Samburova (1977, 1982), Proviz & Proviz (1981-1994), Erbaeva (1971) and Kravtsova (1991)

Chironomidae can be observed in large quantities only in the littoral In the subhttoral, and particularly in the deepwater zone, they are extremely rare

In Pribaikalye there are representatives of six subfamilies Podonominae, Tanypodinae, Diamesmae, Prodiamesmae, Orthocladnnae and Chironominae Baikal is known to have five subfamilies The primitive Podonominae are absent, but the larvae of two species of this group live in the pre-estuary regions of its affluents

More than 116 species of Chironomidae have been found in Baikal, 72 of which in its open region One subgenus and more than 20 species are endemic (Linevich, 1991)

The littoral is inhabited by a mixture of endemic and palaearctic species The stony littoral is populated by the endemic rheophiles *Diamesa bmcalensis* (Fig 3 41) *Orthocladius greganus*, and by Siberian species of the subfamilies Orthocladnnae and Diamesmae Some Palaearctic species occur throughout the littoral of the lake, others only near rivers and spring mouths It is not clear whether these species really develop in Baikal, or are passively carried by currents into its coastal zone (Linevich, 1981)

Soft bottoms of open Baikal are inhabited by limnophiles There and in the littoral, the endemic *Paratanytarsus baicalemis,* and the Palaearctic genera *Microtendipes Stictochironomus Cladotanytarsus Limnochironomus* and *Chironomus* and be seen

In the Selenga Shallows, with predominantly soft bottoms, only Palaearctic species are found at depths of up to 10 m Endemic species begin to appear at depths exceeding 50 m (Linevich, 1981)

Below 200 m, endemics of only one genus are found, *Sergentia* (subgenus *Baicaloseigentia),* whose larvae and pupae extend to more than 1000 m According to Linevich (1991), it is possible that not only the larvae live under conditions of high hydrostatic pressure in the abyssal, but the imagos as well

The genus *Sergentia* is represented in the Palaearctic by two species In Baikal, it has an endemic subgenus with more than 29 forms (Linevich, 1981, 1991) Linevich considers the variety of endemic forms of *Baicalosergentia* to be due to a radiation coming from one or two species The most primitive species in her opinion is 5 *(B) baicalensis*

Having analyzed the disk structure of polytene chromosomes of six species of *Baicalosergentia,* VI & LI Proviz (1992) suggested a monophyletic origin for this group The initial ancestral species in Baikal, m their opinion, was close to two species, designated as *Sergentia sp 3* and *Sergentia sp 5* These are inhabitants of the coastal zone The colonization of the littoral zone *(S baicalensis)* and great depths *(S nebulosa Sergentia sp 4)* was accompanied by a gradual sophistication of the chromosome structure The Baikahan species *of Sergentia* are close to the Palearctic species *S longiventris*

The formation of the genus *Sergentia* occurred in Baikal in the Quaternary period and its evolution was rather quick (Linevich, 1991)

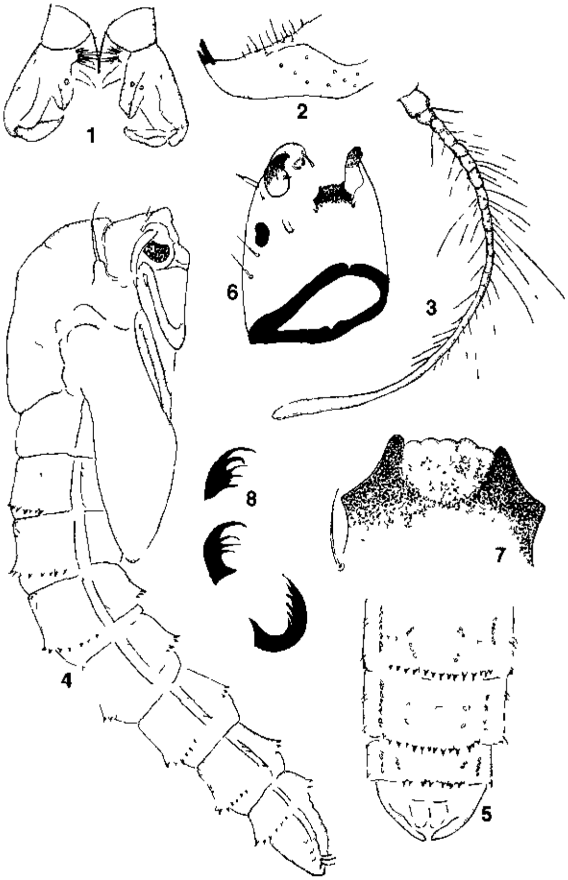


Fig 3 41 Chironomid *Diamesa baitalenais* Tshern. 1 - hypopygium, 2 - gonostylc of hypopygium, distal part; 3 - antenna, 4 - a pupa, side view, 5 - the 6th to 9th tergites of the abdomen of the pupa, 6 - the head of the pupa from the ventral side, 7 - siibmenTum of the pupa, 8 - claws *ot* the anterior pseudopods the larva After Linevich, 1981

Linevich (1991) considers the presence of Palaearctic species in the littoral of Baikal to be the first stage of their invasion of the lake.

Other Insecta

Hemiptera (Hydrometra, Nepa), Odonata and Coleoptera are absent in open Baikal and rare in gulfs and bays, but occur in sors and shallow sheltered bays.

Belyshev (1956) discovered the dragonfly *Orthetrum albistylum* Sells, in a hot spring on the north-eastern coast. At present, this species lives in subtropical countries (Japan, South Korea, etc.), and in the area of Baikal it should be considered as a relict of a thermophilic Tertiary fauna.

Beside the above-mentioned orders of insects whose larval stages lead an aquatic way of life, an external parasite of the Baikalian seal has been described from Baikal: the louse *Echinophthirius homdus* var. *baicalensis* Ass (Ass, 1935).

3.8. Mollusca

We find the first data on the Mollusca of Baikal in Gerstfeld's work, published more than 100 years ago (1859b). With Maack's collections as a basis. Gerstfeld described the following five species: *Benedictia baicalensis, Baicalia angarensis, Pseudancylastrum sibiricum, Megalovalvata baicalensis* and *Choanomphalus maacki.*

In the 1860s, more Baikalian molluscs were collected by B. Dybowsky and Godlewsky, and studied partly by B. Dybowsky himself, but mainly by W. Dybowsky (1875, 1884b, 1886b, 1901, 1902, 1903, 1912). W. Dybowsky described 32 species in *Sphaerium, Pisidntm, Benedictia, Baicalia* and *Choanomphalus.* He also studied some species from an anatomical point of view.

The next step in the study of the molluscs was taken by Lindholm (1909, 1924a,b, 1927), who studied extensive collections from Korotnev's expedition and described 48 species, and by Starostin (1926).

After a revision by Kozhov (1936b, 1945, 1950a, 1951) and Bekman. Starobogatov, 1975; Sitnikova, 1983, 1987; Starobogatov, 1989, based on new collections from expeditions of the USSR Academy of Sciences and the Biological Research Institute *of* University of Irkutsk, 178 species of molluscs are now known from Baikal. They can be divided into three groups: (1) general Siberian fauna, (2) young endemics (allied to the Siberian fauna), and (3) old indigenous fauna

The general Siberian group (Angarskaya Province of Palaearctic; Starobogatov, 1970) is represented by 54 species, mainly inhabiting the sor zone and sometimes entering gulfs deeply indenting the coast. Young endemics are poorly represented: in all 12 species, all bivalves. They inhabit internal parts *of* gulfs deeply indenting the coast *(e.g.,* the Proval Gulf) and regions of open Baikal near river mouths *(e.g.,* the Selenga).

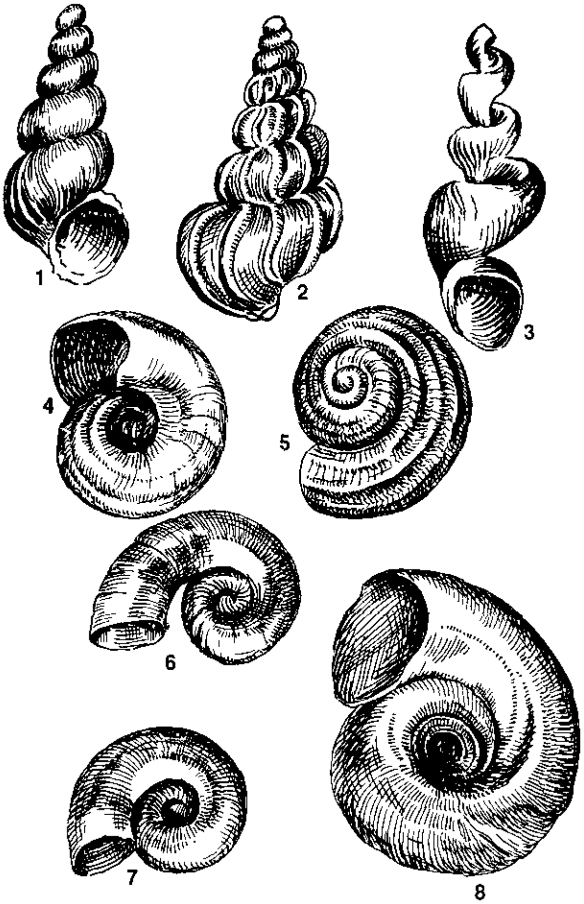


Fig. 3.42 Molluscs: 1 - *Korotnewia korotnewi* Ldh., shell height 15-19 mm; 2 - *Maackia costata* Dyb.. shell height 9-10 mm; 3 - *Liobaicalia stiedae* Dyb., shell height 10-11 mm; 4-5 - *Megalovalvata piligera nudicarinata* Ldh., shell diameter 10-12 mm; 6-7 - *Megalovalvata baicalensis* Gerstf., shell diameter up to 16 mm; *% - Choanomphalus maacki* Gerstf., shell diameter up to 11 mm. After Kozhov, 1936b.

The indigenous fauna of open Baikal and to a lesser extent of its gulfs (but never in sors), includes 125 species. A single non-endemic species, *Lacustrina dilatata,* is widespread in open Baikal. It should be stressed, however, that the study of the molluscs of Baikal is not yet definitive. Thus, among Benedictiinae there is a complex of gyno- or/and parthenogenetic and polyploid forms, generally included in *Benedictia baicalensis,* but probably representing a group of independent species. Lists of species and subspecies of Baicaliidae and *Choanomphalus* are likely to be extended with new forms. Little is known of the small bivalve molluscs. Although there are few endemics among them, two species of the genus *Conventus* and several species in other genera of the Euglesidae may be added. Five new species of Euglesiidae were described by Slugina *et al.,* 1994. The list of general Siberian species entering the sor zone may also be enriched in the future with more forms.

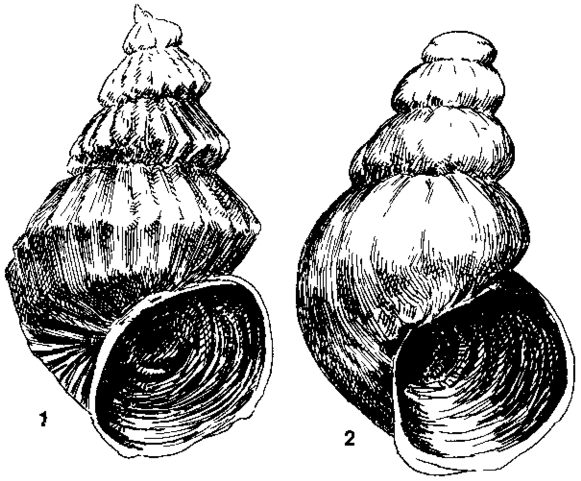


Fig. 3.43. 1 - *Maackia vanesculpta* Ldh., shell up to 8 mm; 2 - *M. herderiana* Ldh., shell height 8 mm. After Kozhov, 1963.

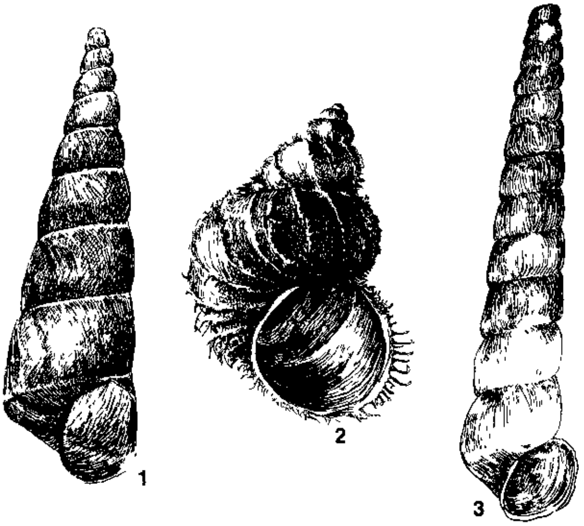


Fig 3.44 1 - *Baicalia carinata* Dyb,. shell height up to 18 mm; 2 - *Teratobaikaha ciliata* Dyb,, shell height up to 10 mm; 3 - *Godlewskia godlewskn* Dyb., shell height up to 20 mm. After Kozhov, 1963.

Molluscs occupy an important place in the bot-

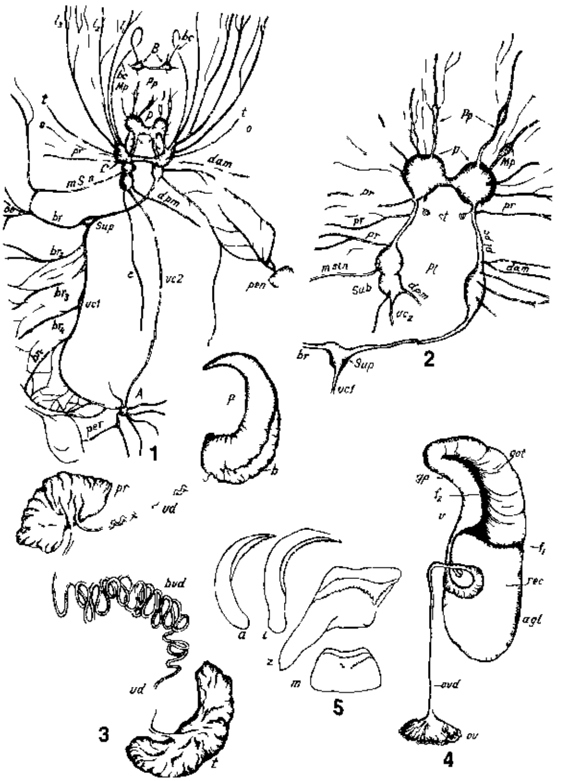


Fig 3 45 1 2-The scheme of nervous system of Baicahidae 1 *Parahaikaha florn 2 P ovijormis* (pedal pleural supra intestinal subintcstinal *ganglion* uith its nerves) A - abdominal ganglion, B - buccal ganglion, be - buccal connective, br - branchial nerves C - cerebral ganglion c - columellar nerve dam - dextral anterior mantle nerve dpm - dextral posterior mantle nerve, Lj$_5$ - labial nerves Mp - mctapodial ganglion m sin - sinestral mantle nerve O - optic nerve os - osphradium nerves P pedal ganglions PI - pleural ganglion pipe - pleuropedal connective per - pericardial ner\es, pen - penis Pp - propodial ganglion pr - lateral nerves, vc,vc$_2$ - visceral connectives Sub - subintcstinal ganglion, Sup - supra-intestinal ganglion t - tentacle nerve, st - statocyst 3 - Genitalia ot the male *Parahaikaha floru* t - testicle \d - vas deferens bvd - ball of the vas deferens (it is rather elastic) pr - prostate p - penis b - glandular swelling 4 - Genitalia of the female *Paiabaikaha ovtfomns* oot - ootype gr - genital pore v - vagina f, - fissure dividing vagina from the ootype f, - fissure dividing ootype from the adventition gland, a gl - adventition gland, rec - receptaculum ond - oviduct, ov - ovary 5 - The plate radula of *Baicaha flom* a - external-lateral I - internal-lateral z - intermediate m - middle After Kozhov 1951

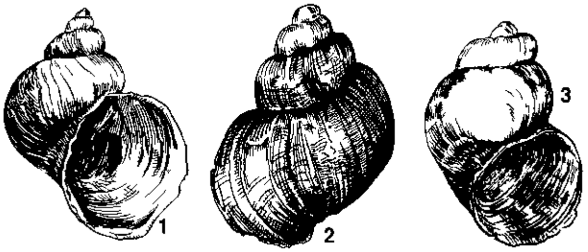


Fig 3 46 1-2 - *Benedictia fragihs* Dvb shell height up to 50 mm 3 - *Benedictia baicalensis* Gerstf, shell height up to 22 mm After Kozhov 1963

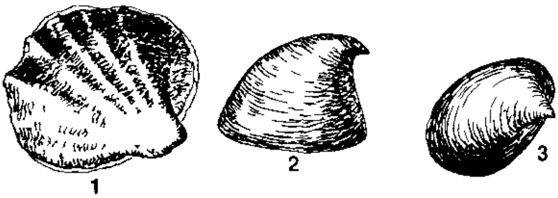


Fig 3 47 Pseudancylastrum kobelti Dyb shell diameter 4 mm 2-3 - *Psettdancvlastntm sibiricum* Gerstf, shell dia meter 8 mm After Kozhov 1963

torn community They are especially numerous in coastal shallows, down to a depth of 15-20 m (with the exception of the surf belt), attaining their highest numerical density on overgrown stones and also on sandy soil enriched with detritus Below 20-30 m depth, the mollusc fauna becomes markedly poorer, dropping to insignificant values on strongly silted soil On silty soil at depths of more than 100-200 m it is conspicuously poor, and at great depths, only individual specimens of abyssal forms, such as *Benedictia fragile B pukhella, B distinguenda B nana, B maxima B shadim, B pumvla Cincinna bathybia C projundicola* C *laethmophila Korotnewia angigyra Choanomphalus planorhiformis* and *C hathybius* can be found

Being chiefly plant- or detritus-eaters, Baikahan molluhcs *play* an important *role in httoial biological* processes, and the places where they live are also abundantly populated by other animals

A specific feature of the Baikahan molluscs is the extreme thinness of their shells In some *(Benedictia fragilis-growp),* the last whorl consists almost entirely of superficial epidermis This is due to the low water temperature of Baikal, and to a shortage of calcium The latter circumstance prevents the evolution of specific, thick-shelled surf-belt forms. The surf belt of Baikal up to a depth of 0.5 m is, as a rule, devoid of molluscs.

A group conspicuous for its abundance of species, and its specific features, is the Baicaliidae (Figs. 3.42-3.45). The shells of these species vary in size and shape and are richly ornamented with carinae, costae, knolls and fine spiral and reticulate striae, often with filaments. Anatomically, they differ sharply from the families Pyrgulidae (=Micromelaniidae) and Hydrobiidae. The nervous system of the latter has a metapodial commissure (Fig. 3 45,1,2), which the Baicaliidae do not have. The female genital apparatus of the Baicaliidae does not contain a bursa copulatrix (Fig. 3.45,4), which is characteristic of the Hydrobiidae and Pyrgulidae. The external similarity between the shell structures of various representatives of these families in Lake Ohrid and Caspian Sea, noted especially by palaeontologists, is certainly due to convergence and not to relationship (Kozhov, 1951).

Ranking second to it in abundance of species are the Benedictiidae (Fig. 3.46), represented by fairly large forms with a smooth rounded egg-shaped or round conoidal shell and a rather distinctive radula

The Baikalian Valvatidae (genus *Megalovalvata,* Fig. 3.42,4-7), giants compared to their relatives elsewhere, are also represented by several littoral species.

Among the Pulmonata, an outstanding role in the coastal belt is played by endemic genera of the Acroloxidae and Planorbidae. The first of these families includes 25 species, grouped in the three genera *Pseudancylastrum, Gerstfeldtiancylus* and *Baicalancylus.* The latter is of special interest since its shell has radical costae (Fig. 3.47,1). The genus *Choanomphalus* is represented by 20 species, densely populating coastal stones and sand. On sandy coastal ground, representatives of the Sphaeriidae, Pisidiidae and Euglesidae are also important.

The question of the relationship between the Baikalian molluscs and faunas elsewhere, including the fossil fauna, is complicated. Links between Baikalian and Caspian forms were first discussed by B. Dybowsky & Grohmalizky (1917), yet the question of whether kinship or parallelism is the cause of similarity remained unsolved. From Lake Biwa on Honshu Island, *Choanomphalus japomcus* was described (Preston, 1916), and from Central China *C. heudeana* (Yen, 1937). Although the anatomy of both species is, so far, unknown, shell peculiarities show that they are close to representatives of the subgenus *Gyraulus* and genus *Anisus,* and in particular, to those of them which possess rapidly growing whorls, such as *Anisus baicalensis* from Pribaikalye. Inhabitants of Lake Ohrid and Prespa show a similarity to Baikalian *Choanomphalus* species (subgenus *Carinogyraulus* genus *Anisus),* and Berg (1910) hypothesized about a kinship between these and *Choanomphalus.* Anatomical data (Starobogatov, 1958) have shown that this kinship is rather remote, despite a noticeable likeness between the shells and even between the radula structure. This also applies to the Tertiary *Anisus (Poecilospira) multiformis.* Moreover, the similarity between *Choanomphalus* and such exotic molluscs as *Acrorbis* from Brazil, and *Carinifex* and *Voriifex* from the West USA, is only superficial, since anatomical investigations (Baker, 1945; Hubendick, 1955; Starobogatov, 1958) have shown that the first of these genera belongs to a different subfamily and the other two even to a different family.

Anatomical data (Starobogatov, 3967) suggest that outside Baikal three subgenera of *Choanomphalus* occur, two of which are absent in Baikal itself and in Pribaikalye. In the west Palaearctic, up to the *Altai,* subgenus *Lamorbis* occurs. *In the* Amur drainage and Far East, subgenus *Vitreoplanarbis* lives. Both have little in common with Baikalian forms as to shell structure, although anatomically, they are close. The third subgenus, *Achoanomphalus* should be considered as subendemic of Baikal since it includes several endemic Baikalian species, but at the same time one *of* its species was found (Anudarin, 1953) in Lake Khubsugul, 200 km from Baikal; this species was described by Kozhov (1946) as *C. mongolians.* The rest of the subgenera are endemic to Baikal.

The distinctive architecture of the shell *of* the Baikalian *Choanomphalus, i.e.,* the raised apex, angularity of the last whorl or presence of a carina around it, are undoubtedly adaptive, for they lend rigidity to the shell Apparently this character could be developed only in large bodies of water, in coastal belts affected by surf. On soft grounds in deepwater regions, lens-shaped shells developed. It is these circumstances that are responsible for *the* similarity of *Carinogyraulus* and *Poecilospira* with *Choanomphalus.* This is indirectly confirmed by species of a subgenus of the same genus. In *Anisus-Andrusovia* of the Caspian, *A.fAndr.) eichwaldi* is reminiscent of *Choanomphalus eurystomus,* and *A. (Andr.) sulcatus* even has a basal groove typical of Baikahan *Choanomphalus* from the subgenera *Sulcifer* and *Kozhovisulcifer* (Logvinenko & Starobogatov, 1969)

It can be supposed that *Choanomphalus* separated from a stock in common with *Anisus* back in the Tertiary, after which it formed two or more non-Baikalian subgenera, while the Baikalians were formed in Baikal itself, and in other large lakes of its system.

Close relatives of the Baikahan Ancylidae (subgenus *Pseudancylastrum)* have not been found so far, either fossil or extant. The similarity of the species *Baicalancylus* and *Acroloxus macedonicus* from Lake Ohnd is probably, as in many other cases, due to parallelism.

Anatomical investigations of *Benedictia* (Kozhov, 1945, 1950a) initially led to the conclusion of an affinity of this genus to *Lithoglyphus.* It must be mentioned that the genus *Lithoglyphus* has been accepted in wide sense almost till now and has included North American genus *Fluminicola* which is nearer to Baikalian *Benedictia* and *Kobeltocochlea* both in shell shape and in the structure of reproductive system. *Lithoglyphus* and *Fluminicola* are often regarded now as the nearest genera in spite of the difference between them. This was based, above all, on common features in their anatomy. A comparison between anatomical data of *Benedictia* (Sitnikova, 1988) *and Fluminicola* (Thompson, 1984) has shown, however, that these two genera should be united in one family, the Benedicthdae, with two subfamilies, the Benedictiinae and Fluminicihnae. For a long time it was believed that *Kobeltocochlea* was represented in Lake Khubsugul in Mongolia - *K. michnoi* (Lindholm, 1929). Further investigations of expeditions by the Research Institute of Biology (Irkutsk State University) have not confirmed this. However, the species is found in Baikal, where it is endemic on stony grounds at depths of from 3 to *30* m (Sitnikova, *1988).*

Fossils representatives of Benedictiinae have *not yet been found, with the exception of some in* Tertiary terraces on the south-eastern coast of Baikal (Martinson, 1956). The *"Benedictia"* species described by Rammelmeyer (1935, 1940) from Lower Cretaceous deposits in the Trans-Baikal area cannot be identified with the modern Baikalian genus *Benedictia,* since the poor degree of preservation of Rammelmeyer's material renders exact determinations impossible.

AH Benedictiinae are so stenotopic that even in the Angara they are restricted to its uppermost part, not far from the outflow. They never enter sors and gulfs.

It is not an easy task either to discuss the ties of Baikalian Valvatidae with modern and fossil species. From the structure of their shells, Valvatidae from Lake Biwa (Honshu Island, Japan), *i.e., Valvata biwaensis* and *V annandalei* (Preston, 1916), are close to Baikalian *Megalovalvata.* The similarity of the shells is so striking that the species from Lake Biwa can be included in *Megalovalvata,* although in an independent subgenus, *Biwakovalvata* (Sitnikova, 1983). There are no sufficient anatomical grounds to regard, as is sometimes done, the American species of the genus *Tropindina (T. tricarinata* and others), as close relatives of the Baikalian *Megalovalvata.* From the structure of their sexual system and radula (Walker, 1918), they are closer to the widespread *Cincinna* (Siberian C. *aliena* and European *C. piscinalis)* than to Baikalian species. Fossil forms unquestionably close to Baikalian *Megalovalvata* have not yet been found- Small endemic Valvatidae of subgenus *Pseudomegalovalvata* are closer to European *Cincinna, i.e.,* to the genera *Cincinna s.str. and Atropidina, than to* widespread Siberian species of the genus *Sibirovalvata,* but Baikalian species are quite separate from European ones.

The numerous species of Baicaliidae were incorrectly placed by Thiele (1929-1934) as were others in the family Pyrgulidae (=Micromelaniidae), represented in the Caspian Sea by more than 60 species, in lakes Ohrid and Prespa by 12 species, and in pre-estuary regions of rivers and lagoons of the Black Sea by 19 species. As already noted above, anatomical studies (Kozhov, 1951) have shown that the initial opinion concerning the close kinship *of the Baicaliidae with the* Caspian Pyrgulidae is not justified. The latter are closer to the Hydrobiidae and specifically to the genus *Hydrobia,* from which they evolved in middle and post-Tertiary time in derivatives of the Sarmatian Sea, whereas the Baicaliidae are anatomically quite separate and are far removed from both the Hydrobndae and *the* Caspian Pyrguiidae, as *well* as from the Pyrguhnae from Lake Ohrid. From Lake Dunkulduk on the Pamirs a mollusc, *Pyrgobaicalia aemgma,* was described which resembles the Baicaliidae not only in shell structure but also in the structure of its embryonic part. As embryonic shells of Baicaliidae are rather distinctive, this species was united with the Baicaliidae (Starobogatov, 1972). However, this needs to be confirmed by anatomical investigations, which it has not been possible to do so far, since the species was described from fresh but empty shells. Fossils from the ancient lake which existed in Tertiary time in Chuiskaya hollow also resemble Baicaliidae by their embryonic shell. They form an extinct genus, also placed in the Baicaliidae, *viz Aemgmapyrgus* (Popova *et ai,* 1970).

In a fossilized state, unquestionable Baicaliidae have been found only in Tertiary deposits on the south-eastern coast of Baikal. The attribution of the Mezosoic *"Cerithium" gerassimowi* Reiss from Jurassic or Lower Cretaceous deposits in the Vitim valley and elsewhere in the Trans-Baikal area to the genus *Baicalia,* by Rammelmeyer (1940), is incorrect, because in spite of a certain outward similarity to modern *Batcaha,* their shell has a structure alien to the latter. Martinson (1949b) has renamed the fossil Mezosoic *"Baicalia"* as *Probaicalia,* but this does not imply a close relationship to the Baikaliidae. An interesting gastropod fauna was found in Tertiary (Miocene-Pliocene) continental deposits of North-West China. The shells of species from these deposits resemble the shells of some species of modern and fossil Baicaliidae very clearly. Martinson (1955a,b, 1956, 1959a,b, 1960) refers some of them directly to the genus *Baicalia.*

In his latest works, this author stresses a possible genetical connection between the Baikahan and Tertiary Pontocaspian ("Balkan") faunae of gastropods. *The central place in the freshwater and* brackish gastropod fauna of the Pontocaspian range and of the Balkans is occupied by Hydrobiidae and Pyrguiidae. These do not have, as mentioned above, a close relation to the Baicaliidae of Baikal. Martinson & Popova (1959) described several species of turriform gastropods from Tertiary deposits of the south of west Siberia which they also designate to the Baicaliidae and even to the genus *Baicalia* However, it is again possible that *the* outward similarity in shelf structure of some turriform Tertiary gastropod species from west Siberia and the Baicaliidae is a result of convergent evolution. It would be natural to suppose that, in Tertiary times, Central Asia had its own center of formation of a distinct, rich mollusc fauna, analogous to the Pontocaspian and Balkan centers, but that the development of this fauna occurred during an earlier epoch.

3.9. Bryozoa

Some Bryozoa pertaining to the genera *Plumatella* (three species), *Cristatella* (one species) and *Paludicella* (one species) live in the coastal-sor zone of Baikal but not in open Baikal, where only one species is known to occur. It was described by Korotnev (1901) as *Eckinella placoides* and is represented by several ecological forms. *Eckinella placoides* in the form of small dark-brownish colonies covers stones, submerged tree branches, and plants in the littoral and sublittoral. It penetrated from Baikal into the Angara and Yenisei up to its lower reaches, and down the ancient Yenisei, into the drainages of the Pyasina and Taimyr rivers up to the Arctic, including Lake Taimyr and other lakes of these drainages.

Some authors *(e.g.,* Annandale, 1911) attributed this bryozoan to the genus *Hislopida,* several species of which live in the fresh waters of India, South China and the Malay Peninsula. Abnkosov (1959) also considers *Eckinella placoides* (Fig. 3.48) to belong to the genus *Hislopida.* It was reinvestigated (Wiebach, 1966, 1967), and on the evidence of its structure, Wiebach concluded that it had wrongly been assigned to *Hislopida,* while *Eckinella,* established by Korotnev, is a good genus, with a peculiar structure of a manducatory *stomach and other sections* of *the digestive tract.* By the presence and structure of a manducatory stomach, *Eckinella* is close to *Hislopida,* and with it, it forms the family Hislopiidae, closely related

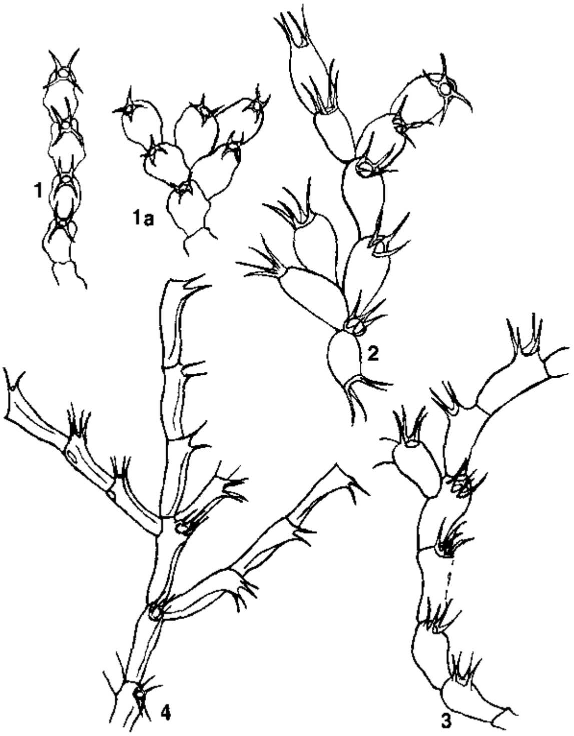


Fig 3 48 Bryozoan *Hislopia placoides* Korotn 1 - forma *ripanensis* Abrik , 2 - forma *intermedia* Abrik , 3 - forma *sabulosa* Abrik, length of zooecia up to 0.5 mm. After Abnkosov, 1924

to the family FlustrelHdae (order Ctenostomata, section Carnosa). According to Wiebach, some archaic features are present in *Echinella,* such as the *small* number *of tentacles, which is not typical of* ordinary freshwater forms.

3.10. Tardigrada

These curious microscopic semi-transparent and weakly mobile animals are common in the open water of the lake. They live on soft bottoms of the littoral and sub-littoral, and occur in mass among algae *(Cladophorct* and *Draparnaldioides),* and occasionally in the empty cases of leeches. In samples collected by Kozhov, four species of Tardigrada were identified (Ramazzotti, 1966). The most numerous is *Hybsibius (Isohypsibius) granuhfer,* with the Baikalian subspecies *baicalensis,* which occurs together with the typical form of this species. *H(I.) augusti* is rather rare. Two other species have not been identified with certainty. One of them belongs to the genus *Hypsibius,* the other to *Macrobiotus.* The species mentioned above are cosmopolitan and live in various biotopes: in swamps, microcavities between grains of sand, coastal fresh-waters, etc. Two new species were described by Biserov (1992).

3.11. Pisces

Pallas and Georgr began the study of Baikalian fish, but the foundations of our knowledge were laid by Dybowsky (1876) and Berg (1900, 1903, 1907, 1948-1949). The Soviet period has seen numerous new studies of the systematics and biology of Baikalian fish, as well as of fishing in the lake, described in detail in the collection of articles "Fish and Fisheries in the Basin of Lake Baikal" (1958), edited by Misharin and Kozhov. During the last decades, the works of Sideleva, Smirnov, Smirnova, Mamontov, Toporkov, Skryabin, Dmitrieva and their collaborators, have contributed much to our knowledge of Baikalian fish.

According to Sideleva (1994) at present, Baikal with its sors and gulfs is known to be inhabited by 56 species of fish belonging to 14 families. Twenty-seven species of the suborder Cottoidei are endemic to the lake. They occur practically at all depths. Their maximum diversity is observed at a depth of 150-300 m, where 20 species of Cottoidei can be found. The minimum number of species (eight) occurs in the littoral (to 25 m). The maximum numbers of all other species of Baikal (24 species or 92%) are recorded at depths of 5-10 m (Sideleva, 1982, 1993).

According to Taliev (1955), the Baikalian Cottoidei are represented by the endemic family Comephoridae and two subfamilies (Cottocomephormae, Abyssocotinae), belonging to the family Cottidae, which is widespread in freshwater. According to Sideleva (1982), ten species of Baikalian Cottoidei are united into two endemic families, the Comephoridae and Abyssocotidae, while 17 species belong to the subfamilies Cottocomephorinae and Cottinae of the family Cottidae. The first of these subfamilies is endemic to Baikal. The family Comephondae has one genus, *Comephorus*, with two species *C baicalensis* Pallas and C *dybowsku* Korotn (Fig 3 49,1) Both of them are characteristic of open Baikal, where they Ine at 0-500 m and deeper The body of these fish, which are not more than 18-20 cm long, is absolutely scaleless and glassy-dull Ventral fins are absent, while the pectorals are very long, reaching almost half the length of the body, the head is large, with a well-developed lateral line In the pelagial, *Comephoiw;* assume a vertical (head-down) position Their movements are rather slow Near the bottom, *Comephorus* usually assume a horizontal position and become very active *Comephorus* move thanks to lateral flexures of the posterior part of the body Pectoral fins are kept away from the body and are at an angle to the direction of movement, keeping the fish in balance (Sideleva *et al*, 1992) Natural buoyancy is ensured by a high content of lipids, lipids constitute more than 40% of total body mass, such that the body density is 1 01 (Tahev, 1955) Lipids in *C dybowsku* and prebottom pelagic *Cottocomephorus* are 4-15%, in bottom Cottoidei only 2 4% Comephondae have a lighter skeleton than other Cottoidei, due to a low mineralization (2 5% versus more than 3%), friability and porosity of bones in which fat accumulates, and by a reduction of the abdominal fins (Sideleva & Kozlova, 1989)

It was established long ago (Dybowsky, 1873) that neither *Comephorus* species spawn but give birth to living fry, numbering 2000 to 3000 per female According to observations by Vereshchagin (1926, 1937), Vereshchagin & Sidorychev (1929) and Koryakov (1955, 1956, 1958), the mating of *C dybowsku* takes place in September-November, and mass fry release occurs in February-April *C baicalensis* mates in April-June, with the fry appearing in September-October Asexual reproduction in *Comephorus*, hypothesized by Tahev (1949, 1951), has not been confirmed

Comephondae are spread all over Baikal, living all year round in open deep-water regions, with a maximum density at 100-300 m (in daytime) and avoiding gulfs, sors and other shallow and sheltered sections Adult *Comephorus* feed on the amphipod *Macrohectopus*, the larvae and young of *Cottocomephorus*, and on their own larvae Juveniles feed on *Epischura baicalensis*

The pelagial is also the major habitat of two species of the genus *Cottocomephorus* - C *grewingki* (Fig 3 50,4) and C *inermis* (family Cottidae) But in the spawning period these species move to the littoral and change to a near-bottom way of life Due to this, they have characters of both pelagic and bottom Cottoidei Unique peculiarities of these fish are the presence of the largest heart among Cottoidei, a specific teeth plate and teeth which enable the fish to catch, select and retain planktomc Crustacea (Sideleva & Mekhanikova, 1990)

Cottocomephotus spawn on near-shore stones Their number of eggs averages 1800 Males select small depressions with large stones and a flat floor for nesting The male urine contains a species-specific pheromone to attract females towards the nest (Dmitneva & Ostroumov 1984) Females deposit eggs on the ceiling of the nest, and after spawning, depart to the deeps Males protect and fan the nest during the whole period of incubation (Fig 3 50,5) The larvae lead a planktomc way of life

Three groups of C *grewingh*, spawning at different periods, are known a March group, which spawns under ice (in February-March), a May group, spawning in the period of ice thawing (April-May), and an August group, spawning in the period of greatest warming up of the water (end of July - beginning of September) The March group includes larger fish which reach maturity later, the August group contains smaller and younger fish, the May group occupies an intermediate position The groups use different regions and depths for spawning They also differ according to the duration of embryogenesis (Koryakov, 1972, Chernyaev, 1984, Sideleva *et al*, 1987) Tahev (1955) identified two subspecies of C *gieningki*, spawning in different regions, and within one of them - the nominative subspecies - two groups differing in time of spawning Other authors (Hohlova, 1959, Koryakov, 1972, 1977) call these groups local, ecological races According to Koryakov (1972), they represent panmixic populations But Zubin *et al* (1993a,b) claim that these intraspecies groups of C *grewingh* are independent populations, since they differ in tolerance, fecundity, size of eggs, duration of oogenesis and onset of maturity Apart from the nominative genus, the genera *Battachocottus* (three species) and

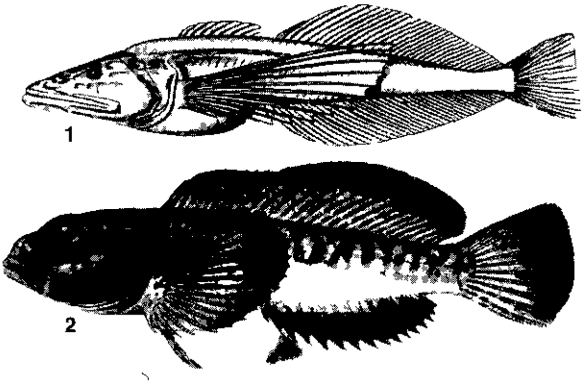


Fig 3 49 f-ishes i - *Comephorus dxbowsku* Korotn body length up to 16 cm, 2 - *Procottm /ettelesi* Dyb body length up to 18 cm After Tahev, 1955

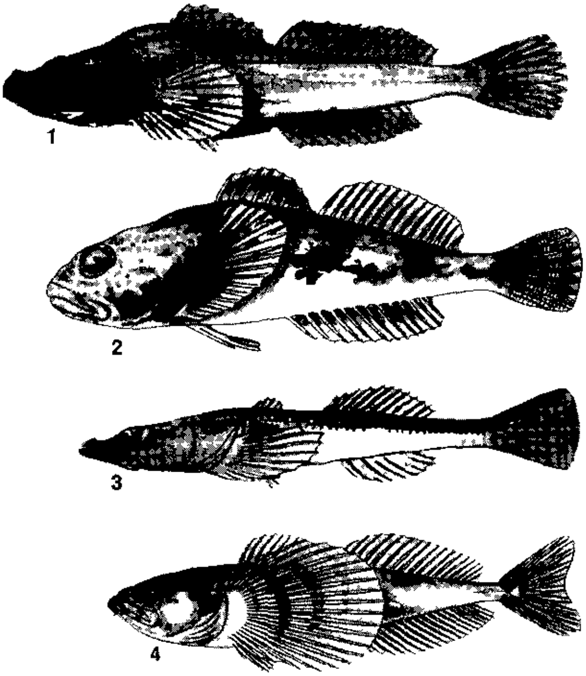


Fig 3 50 1 - *Asprocottus kozhowi* Tal length 10 -15 cm, 2 - *Patacattus kneri* Dyb length 12 cm 3 - *Abxssocottus pallidas* Tal bodv length up to 18 cm, 4 - *Lattotomephoius giewingki* Dvb female, body length up to 12 cm After Tahev 1955

Fig 3 10 5 - Co!tocomephont\ gre^mgh Dvb Photo by V Ostroumov

a - male in a breeding dress occuped the terntir) before spawning

b - initial stage of spawning In the left is a male in the right - a female The male displags a pose of attraching the female and sexual excitement spreads peuoral fins the body quivers The head and the body become dark

Fig 3 50 6 - *tottocomephorus sp* Photo by V Ostroumov

Paracottus (one species) (Fig 3 50,2) belong to the subfamily Cottocomephonnae These fish are benthic Among the Cottidae, *Cottus kessleri* (subfamily Cottinae) deserves attention It is a bottom species, with a pelagic larva which is one of the main prey of pelagic fish The eggs of this species are smaller than those of other Cottoidei and contain a small quantity of yolk The fertility of C *kessleri* is the highest (up to 10^3 eggs) not only of the Baikahan Cottoidei, but of all species of freshwater *Cottus* (up to 1800 eggs) of Eurasia and North America (Sideleva & Nagorny, 1985)

The family Abyssocottidae is the most speciose of Baikahan fish It includes five genera and 12 species (Fig 3 50,3) *Abyssocottus korotneffi* is the most widespread and numerous species in the abyssal of the lake It lives on the bottom at a depth of 400-1600 m Besides a typical form, *A korotneffi* has dwarf males and females, which occur together with immature individuals of the typical form during the fattening period and practically do not differ from them in coloration both forms have a monotonous grey coloration of the body But as distinct from dwarfs, mature individuals of the typical form have a pink-orange body color Individuals of the typical form of *A korotneffi* reach maturity m their sixth year, and have a body length of 90 mm The dwarf form matures in the 4+ year, with a body length of 45-50 mm The typical and dwarf forms differ in fecundity and size of eggs (3 5 and 2 4 mm) (Sideleva & Nagorny, 1985) In all probability,^ *korotneffi* is a conglomerate of two closely related species

During the last years, comparative morphological studies of the seismic-sensory system of Baikahan and other modern and fossil species have been carried out (Sideleva, 1982) The structure of the otoliths has been studied and a correlation between otolith morphology and ecology established (Sideleva & Zubma, 1993) The karyotypes *of 12* species m ten genera have also been investigated All species have the same diploid number of chromosomes (2n = 48), but they differ in morphology (NF from 56 to 74) (Sideleva *et al*, 1994) It has been found that the Baikahan Cottoidei have a visual pigment - rbodopsm - based *on* vitamin *A* (1), which is typical of marine fish (except for Cipnnidontiformes), while freshwater fish have A (2) or a combination of A (1) and A (2) (Bowmeeker *et al*, 1994)

Coregomdae are represented by the omul *(Coregonus autumnahs migratorius* Georgi, Fig 3 51), and by subspecies of *Coregonus lavaretus* L It used to be considered that Baikal was populated by at least four races of the omul the North-Baikahan, which spawns *m* the affluents of North Baikal, the Selenga, spawning in the River Selenga, the Chivyrkm, which breeds in rivers emptying into Chvyrkui Gulf, the Posolsky, spawning in the rivers of the Posolsky Sor (Taliev, 1941, Mukhomediarov, 1942, Misharm, 1953a,b, 1958) According to new data from Smirnov, the mtraspecies structure of the omul (Fig 3 52) should be interpreted differently Smirnov (1992), taking into account the peculiarities of the biology and distribution of the Baikahan omul, calls the North-Baikahan population of omul the Coastal type, the Selenga population of omul the Pelagic type, and unites the Chivyrkui and Posolsky populations into a group of Prebottom deep-water fish

The omul is an exceptionally valuable commercial fish, for both its quality and abundance It matures in its fifth to seventh year, reaching an average of 30 cm in length and 300 to 450 g in weight Maturity of the Baikahan omul populations occurs at different ages females of the Coastal population at age 4+ (Shumilov, 1974), of the Pelagic population, at 5+ (Hohlova, 1967), of the Prebottom-deep-water population, at 6+ (Skryabin, 1979) According to Reshetmkov (1980), the maturation time of the Baikahan omul depends not so much upon age as upon the size (weight) of an individual

In spring and summer the omul concentrates in the shallows It winters at a depth of 200-300 m, mostly near the same regions which serve as spring convergence and summer feeding grounds In winter, it feeds inactively on plankton crustaceans, which survive *m* deep waters, and partly *on* bottom-dwelling gammands and cottids As it moves towards spring convergence grounds, it feeds more intensely, on near-bottom gammands Imagmal stages and pupae of caddisflies and chironomids now make up part of its diet

The *period of the mass shoreward run of* omul shoals in spring is regulated by the warming up of the littoral waters, and therefore, the intensity and

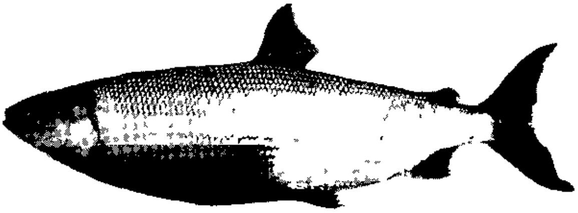


Fig 3 51 Omul *Coregonus autumnalis migratorius* Georgi, length of adult females (5-7 years) up to 40 cm, weight of old specimens (15-17 years) up to 3^4 kg Aftei Misharm, 1958.

period of the spring convergence also vary with years, depending on meteorological conditions.

Towards the middle of July, at maximum development of pelagic crustaceans, the most important component in the diet of the omul, it shifts to more open regions, and feeds in the upper layers of open Baikal. Distribution and feeding of different populations of omul are diverse, as well as the age of maturity.

The same period sees the formation of large shoals of adult omuls which proceed for spawning to the river mounts. Good spawning grounds are sections of rivers with a rocky-pebbly or sandy-pebbly bottom and a moderately rapid current The number of eggs per female ranges, from *10,000*-15,000 to 30,000-40,000, depending on age. The development of the roe lasts for i 80-200 days and ends in April-May. The hatchlings are passively carried into Baikal, where they begin to feed.

In the first two years of life, omul fry (up to a weight of 90-100 g) feed on zooplankton: the fish chase each individual crustacean (Volkova, 1972). The optimum concentration of zooplankton for feeding larvae, according to Kukharchuk (1986), is about 3g rrr^{3}.

In October-November the fattened omuls and the spent shoals migrating downstream move to deep layers for wintering. In autumn the omul feeds intensely, but all energy obtained from food is spent on reproduction; no growth is observed. Some of the Baikahan forms of the gwyniads *(Coregonus lavaretus* L.) are lacustrine, *i.e.*, they spawn in the lake itself. These include, for example, *Coregonus lavaretus baicalensis* Dyb. and *Coregonus lavaretus baicalensis natio Dybowskii* Krog. (Krogius, 1933; Misharm, 1947). The other Baikahan gwyniads are fluviatile and spawn in rivers. The fluviatile forms, according to Krogius (1933), are close to the European *Coregonus lavaretus pidschian* Gmel Baikalian gwyniads reach 5-8 kg in weight and 60-77 cm in length at an age of 15 to 20 years.

The lacustrine gwyniads spawn in shallows, protected against strong turbulence, and rich in underwater vegetation. Spawning takes place in November. Males of *Coregonus lavaretus baicalensis* reach maturity in the fifth to sixth year, females in

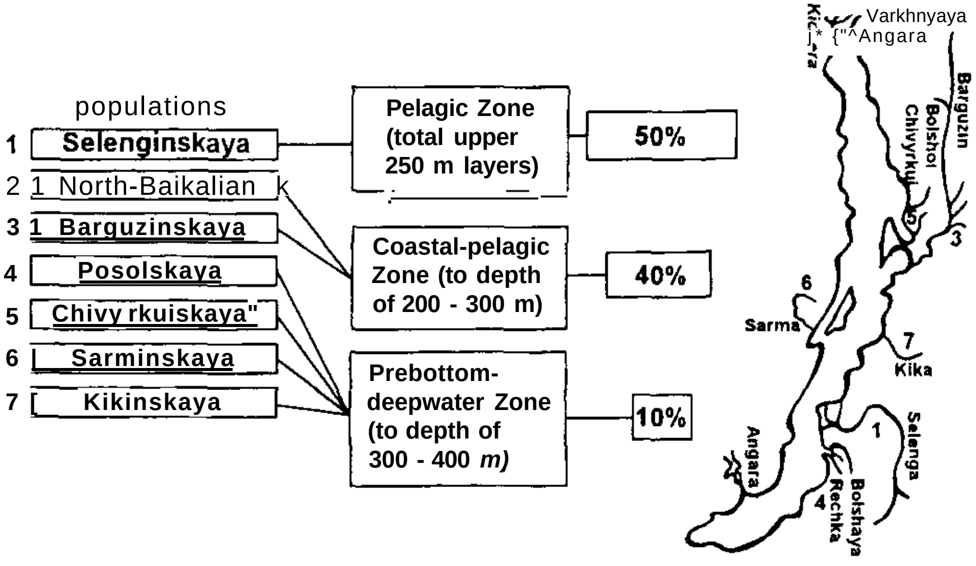


Fig 3 52 Intraspecies structure ot Baikal omul - *Coregonus autumnalis migratonus* Georgi After Smirncv. 1992 the seventh to eighth year. Individual fertility varies from 20,000 to 90,000 eggs. In August the gwyniads gather *m* shoals and migrate towards the shores, while the adults go to spawning grounds abounding in bottom vegetation, where they concentrate in autumn (October-November).

Gwyniads feed upon benthos, chiefly molluscs and gammarids, and therefore keep near benthos-rich sections of the bottom, chiefly at 20-120 m depth, in winter much deeper. In spring, the gwyniads approach the shores together with the omuls, but in comparatively small numbers (predominantly young fish). The shoreward run of fluviatile gwyniads occurs in August.

Of the genus *Thymallus,* two varieties of the widespread Siberian species *T. arcticus* Pall, are known in Baikal: *T. arcticus baicalensis* Dyb. and *T arcticus brevipinnis* Swetov. (Dorogostaisky, 1923, a; Svetovidov, 1931; Tuganna, 1956a,b). Both forms are endemic. The body color of *T. arcticus baicalensis* (the black grayling) vanes, but on the whole it is darker than that of *T. arcticus brevipinnis* Swetov. (the white grayling), which also has a more compressed, larger body and high fattiness. The white grayling lives throughout Baikal, but usually along its eastern shores, preferring sandy sections, rich in food. The black grayling occurs everywhere, chiefly populating rocky soil at shallow depths along the coastal belt.

The black grayling spawns in small affluents of Baikal in early spring. The white grayling prefers larger affluents for spawning It enters such rivers as the Selenga from August onwards, but spawns *m* rapid currents *of* the Selenga and its tributaries in spring.

Both varieties of grayling chiefly feed upon gammarids, larvae of aquatic insects and also molluscs and young Cottidae. Such representatives of the family Salmomdae as *Hucho taimen* Pall., *Brachymystax lenok* Pall, and *Salvehnus alpinus erythrinus* Georgi are rare in Baikal and live predominantly in river mouths. *Salvelinus* can sometimes be observed near the mouth of the River Frolikha which empties into northern Baikal.

Acipenser baeri stenorhynchus Nik. lives in extensive shallows, with large gulfs and the mouths of large rivers, serving as its spawning grounds. In summer and particularly in August, when the near-shore waters of Baikal warm up to 10-15°C, the sturgeons spread in search of food along the shores, far *from* their usual habitat *and occur* individually near the western shore. They begin to enter rivers in early spring, before the breaking up of the ice (Vegorov, 1947). Old sturgeons weigh up to 115 kg, with a length of 120 to 180 cm.

The Cyprinidae are represented in Baikal by Siberian fluvio-lacustrine species, living mostly in sors, gulfs, pre-estuarine regions and shallow littoral areas. Particularly numerous are the roach, *Rutilus rutilus lacustris* Pallas, and the dace *Leuciscus leuciscus baicalensis* Dyb. The ide, *Leuciscus idus* L. also occurs there.

The Percídae are represented by the perch, *Perca fluviatilis* L., which lives in shallow sections of sors and in sheltered gulfs, but in summer - and sometimes in winter - moves to open regions, concentrating principally near river mouths, sors and gulfs. In August it can be observed along the open coast.

The Esocidae are represented in the sor system by *Esox lucim* L. The Gadidae have two populations of the *Lota Iota* L. One population lives along the open coast, the other is connected with rivers and pre-estuarine regions.

Other fish occurring in Baikal are *Nemachilus barhatulus torn* Dyb., *Cobitis taenia sibirica* Gladkov, *Phoxinus percnunts* Pall., *P. phoxinus* L., possibly *P. lagowskii* Dyb., occasionally *Gobio gobio cynocephalus* Dyb., and *Carassius carassius* L.

As pointed out by Berezovsky (1927) and Mukhomediarov (1942), the Baikalian omul *Coregonus autumnalis migratorhts is* closely related to the Arctic *Coregonus autumnalis* Pall. It is generally believed that the omul penetrated Baikal from the Arctic Ocean through the Yenisei-Angara system in the Quaternary period (Chersky, 1877).

Reshetnikov (1980) said out a principled new point of view on the vicinity of Baikalian omul to the North-American species.

Of special interest among the Baikalian fish is the endemic group of the Cottoidei. Taliev (1946, 1955) considers the parental forms of the Baikalian Cottoidei to have lived in the seas washing the eastern shores of Asia. They penetrated Baikal through rivers at the end of the Tertiary period. Their ancestors originated from the genera *Meso-*

coitus and *Trachidermis* from the Far Eastern seas *Paracottus knen* and *P kesslen,* in Tahev's opinion, also sprang from Far Eastern forms Berg considers the Baikahan Cottoidei as relicts of a Tertiary fresh-water Siberian fauna There are no grounds to suppose that *Limnocottus* and the Baikahan Cottocomephonnae are descendants of *Mesocottus* (Berg, 1949a) In Berg's opinion the Comephondae do not ha\e close relatives in either fresh or sea water

The northern part of the Pacific Ocean is acknowledged to be the place of origin of Cottoidei (Schmidt, 1950, Andnyashev, 1939), since it is known to have more than 15 families and subfamilies Sideleva considers that the penetration of Cottidae into Baikal occurred in the Pliocene, since seven coastal Baikahan species of this family have a structure similar to that of fossil Cottoidei from Pliocene deposits of Lake Idaho (USA), studied by Smith (1975) The penetration of the ancestral Comephondae and Abyssocottidae, in Sideleva's opinion, occurred earlier in the Miocene or even in the Oligocene The adaptation of these fish to *the high* content *of* oxygen, low temperatures and high pressure at great depths of Baikal is the result of a long residence in a waterbody with great depths, *i e,* the penetration of Cottoidei into Baikal occurred repeatedly and at different periods of time (Sideleva, 1990)

3.12. Mammalia

Mammalia are represented in Baikal by a single species of the order Pennipedia - the Baikal seal - *Phoca sibirica* Gmel Firstly, *P sibirica* was considered to be a clearly distinguished species of genus *Phoca* together with *P groenlandita P fasciata P vituhna P caspica* and *P hispida* (Flint ef *al,* 1965) Later, *P sibirica P caspica* and *P hispida* were assigned to the genus *Pusa* (Kozhov, 1963) Here we adopt the name *Phoca sibirica* as the more frequently used

Phoca sibirica is a large animal, reaching 1 65 m (from the tip of the nose to the end of the hind flippers) and weighing from 50 to 130 kg (Fig 3 53) Adult seals have a silvery-grey back and yellowish white belly *Phoca sibirica* differs considerably from its relatives in sexual dimorphism, structure of its scull, and axial skeleton One of its distinctive morphological features is found in the position of the teeth with greater and additional molar apexes According to Pastuhov (1978), this can be attributed to natural selection, and results from feeding on small fish (in particular, *Comephorus dybowsku* and *C baicalensis)*

The Baikal seal, unlike other seals, has an increased hemoglobin concentration in the blood (to 22-23 g %), erythrocyte count (more than 5 mln ml ') and hematocntic index (55 to 63%) (Petrov, 1982) This dramatically increases the ox>gen capacity of the blood and permits deep-water dives in pursuit of food (up to 300 m), with the necessity of stopping breathing for up to 60 minutes

P sibirica lives throughout Baikal but prefers its northern and middle parts This pelagic animal keeps far from the coasts almost all through the year Only in July-September does it disperse throughout the lake, penetrate to the shelf zone, but avoid well-warmed shallows In October-November its concentrates in the region with the first ice-cover (bays, pre-delta areas of rivers) In such places, rookeries with greatest number of seals (to 1-2 10^1 animals) occur on the ice Once the ice cover is complete, the seal disperses to deep-water regions Adult animals winter alone, located at distances of about one hundred meters from each other Sexually immature animals form winter groups, numbering several individuals In spring, with the onset of the ice break-up, migrations of seals towards the north begin, following the dnftlce During this period, moult also begins On the ice, numerous seals (sometimes to 2-3 10^3 individuals at any one *place) form aggregations* Only an insignificant number moults on the shore (the Ushkany Islands)

According to Pastuhov (1978, 1987), females reach maturity at the age of two to five years But breeding, followed by pregnancy, usually takes place at the age of three to six years only Breeding occurs in April (under the ice) Pregnancy lasts for 11 months The majority of young is born during two weeks in mid-March in snowy lairs The females lactate for about two months, *ie,* two to three times longer than other species Usually, the seal breeds annually, but for various reasons, 10-20% of adult females remain barren

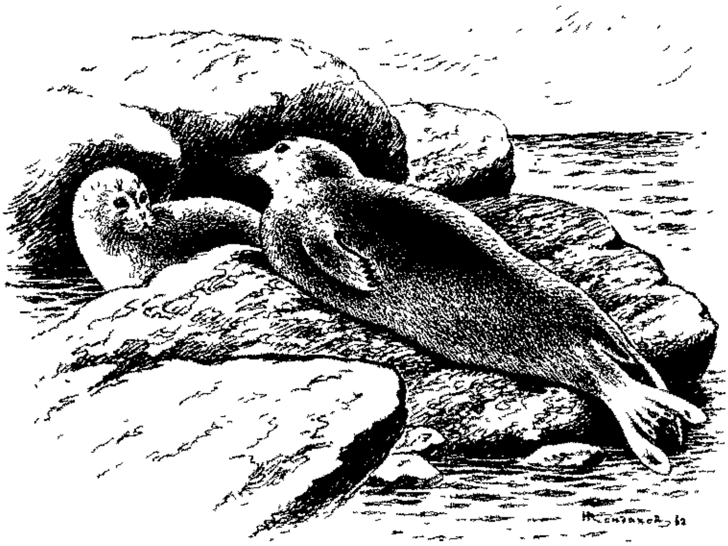


Fig. 3 53. Baikahan seal *Phoca (Pusa) sibinca* Gmelin, body length up to 165 cm, weight up to 130 kg Drawing by N Kondakov

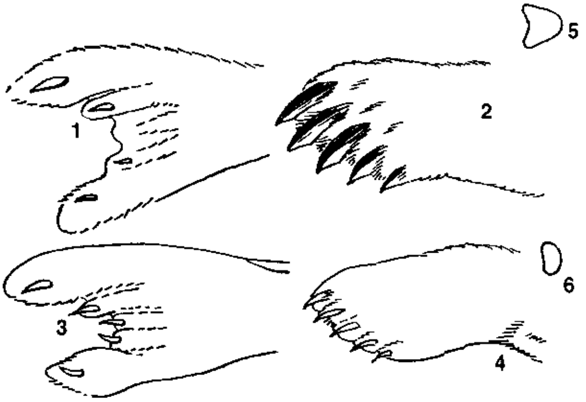


Fig 3 54 Flippers of seals from Baikal, (1 -2), from the Caspian *(Ph caspica)* Gmelin (3-4). 5-6 - transverse section through the claw of forefms of the seal After Kondakov, 1960.

Among the seals of the family Phocidae, *P sibirica* is long lived: female maximum age is 56 years, males 52 years (Pastuhov, 1987). Mature individuals make up about 50% of the population (without newborns); the annual litter of pups amounts to 20% (at the moment of birth).

The seal feeds on fish, mostly *Comephorus dybowskii, C. baicalensis* and *Cottocomephorus grewingki.* The total number of Baikahan seals is estimated at 60-70 10^3 individuals (animals of one year or older). The annual catch at present is 2.5-3.5 10^3 seals. The seals are hunted in early spring.

The systematic position of the Baikalian seal has not, so far, been determined. Ognev (1935) considered it to be close to *P. caspica* by its morphological characteristics. But Taliev (1940), basing his conclusions on the precipitation reaction, stressed a close affinity with the Arctic-marine species (the Novaya Zemlya and White Sea regions), but not with *P. caspica.*

In the 1980s Pastuhov (1993), from an analysis of "genetic similarity" of seven species of Pinnipedia, came to the conclusion that *P. sibirica* is a relict of the Tertiary period. No affinity between *P hispida* and *P. sibirica* could be established (Bogdanov & Pastuhov, 1982). The divergence time of *P. sibinca* (according to Bogdanov & Pastuhov) from the common stem of *Phoca,* estimated according to Nei (1972), was 18.4 10^6 years. As these authors compared *P. sibirica* with *P. hispida* from the Okhotsk Sea, the divergence of the Arctic-Pacific Ocean *P. hispida* populations can be associated with the repeated separation of the Arctic and Pacific oceans in the area of the Bering Strait, as the ocean level oscillated during the last 50 10^6 years.

As far back as the last century, Chersky (1877) supposed that *P. sibirica* penetrated Baikal from the Arctic Ocean through the Yenisei-Angara system in the glacial epoch, simultaneously with *Coregonus autumnalis migratorius.* This supposition is confirmed by parasitological data. Jn particular, Ass (1935) found that *Echinophtinus horridus,* parasitizing the seal, is also typical of seals in the Arctic Ocean. This parasite is absent in P. *caspica* (Mozgovoi & Ryzhikov, 1950).

Of four helminth species recorded in *P. sibirica,* three species of Nematoda *(Contracoccum osculatum, Ostrongylus circumlitus* and *Parafilaraides kraschenіnnkovi)* are also found in *P. hispida* from the Asian section of the Arctic and two species *(S osculatum* and *O. circumlitus)* occur in *P. hispida* from the European section of the Arctic. Only *P. sibirica* and two species of the genus *Phoca (P. vitulina* and *P. hispida),* occurring along the Asian coasts of the Arctic, share the same species of Nematoda *(Parafilaroides kraschenmnikovi).*

Helminth species common to *P. sibirica* and *P. caspica* have not been found. The following data testify to a later origin of *P. sibirica* compared to *P. caspica.* One species of Trematoda, three species of Cestoda and four of Nematoda parasitizing Arctic seals are absent in *P. caspica,* but seven endemic species of helminths have been found (Delyamure *et ai,* 1964). Of 25 species of helminths, parasitizing *P hispida* in the Arctic seas, three species of Nematoda are found in *P. sibirica.* Endemic helminths are absent in Baikalian seals (Delyamure *et ai,* 1982).

If, on the one hand, *P. caspica* lives in *sea* water *(i.e.,* under conditions differing only little from those under which seals from the Arctic and Pacific oceans live), and its helminthofauna has acquired seven endemic species, and if, on the other, *P. sibirica* had no endemic helminths but helminths typical of arctic seals had been preserved, this would suggest that the geographical isolation of *P sibirica* occurred later than that of *P. caspica* (Fig. 3.54). It should be remembered that helminths parasitic on *P. sibirica* underwent a more severe natural selection, due to their transition to life in freshwater.

A hypothesis on the origin of *P. sibirica* from one of the forms of the Arctic species of P. *hispida* appears more credible. The facts discussed are not in contradiction to the hypothesis that ancestors of *P. sibirica* penetrated Baikal *m* the Middle Pleistocene (about 0.2-0.15 10^6 years ago), when the Angara River and the Baikal-Angara-Yenisei-Arctic Ocean system were formed (Palaeolimnological reconstructions...]989).

According to modern conceptions, the separation of the Black and Caspian seas took *place* in the Middle Pliocene (about 3.5-3.2 10^6 years ago). In the Quaternary period, repeated transgressions and regressions of the Caspian Sea linked it to the Black Sea, and, we can consider the geographical isolation of P. *caspica* to be equal to 3 10^6 years. In the course of this period, the Caspian seal acquired seven endemic species of helminths.

Lake Baikal was connected to the Lena River in the Late Pliocene (3.0-2.5 10^6 years ago) (Palaeolimnological reconstructions... 1989). The penetration of P *sibirica* into Baikal and, consequently, geographical isolation for 3 0-2.5 10^6 years, would undoubtedly have resulted in the evolution of endemic species of helminths in P *sibirica.* So far, they have not been recorded. Hence, the hypothesis on the penetration of the seal into Lake Baikal via the Angara and Yenisei rivers in the Middle Pleistocene (0.2-0.5 10^6 years ago) seems to be better substantiated.

3.13. General conclusions on the composition of the fauna of Baikal

As can be seen from the above review, the number of animal species known in Baikal today exceeds 2000. They are distributed among the following groups (without Protozoa) (Table 3.1).

Our knowledge of these groups of animals is not sufficient. Much still remains to be learnt about the systematics of groups such as the Gastrotncha, Nematomorpha, Greganna, and other small animals. Further investigations are also needed on free-living Protozoa and deep-water Nematoda. Moreover, it has to be admitted that even well-known groups of animals (for instance, gammarids, Baicaliidae among molluscs, etc.) need to be thoroughly revised.

Table 3 1 Composition of the Baikalian fauna

	Total number		Endemic	
Systematic groups	genera	species	genera	species
Spongia	3-4	6-7	3-4	6-7
Coelenterata	2(3)	3	—	1
Turbellana	25	77	16	67
Monogened & Trcmatoda	31	**89**	-	4
Ccstoda	32	53	—	—
Amphilinida	1	1	1	1
Nematoda				
free-living	21	47	7	39
Mermithidae	10	29	2	29
other parasitic forms	20	29	—	1
Acanthocephal;l	6-7	10	~	-
Rotifera	41	**198**	2	29
Bryozoa	4	6	-	1
Polychaeta	1	3	-	3
Oligochaeta	44	207	13	160
Hirudinae	12	**18**	2	7
Copepoda-Calanoida	3	5	-	1
Cyclopoida	8	38	-	20
Parasitic Copepoda	7	13	-	1
Harpacticoida	10	67	1	59
Ostracoda	4	**152**	1	130
Cladocera	24	48	1	7
Bathynellidae	1	2-3	1	2-3
lsopodd	2	5	1	5
Gammandae	46	259	46	229
Arachnoidea	7	8	1	4
Tardigrada	3	6	—	3-4
Tnchoptera	12	122	5	17
Plecoptera	3	16	I	2
Chironomidae	30	**116**	—	20
Gastropoda	27	**151**	11	111
BivaJvia	11	31	—	16
Pisces	30	**56**	7	27
Mammalia	1	1	-	1
Total	484-485	1873-1874	122-123	1004-1006
Endemic (%) 54% species				

Chapter 4
History of Lake Baikal and its fauna

4.1. Geological history of Baikal

Most geologists and palaeontologists agree that the Baikal and Trans-Baikal areas entered a continental period of development as early as the Palaeozoic. Only in the Jurassic did the sea extend into the Trans-Baikal area from marine basins in East Asia. In that period, a long sea gulf covered the modern valleys of the Shilka and Onon (the Amur drainage), reaching 115°E., 450 kilometers east of present-day Baikal (Sokolov, 1936; Presnyakov, 1940).

Tn the Jurassic, the East Sayan Range and the south part of Baikal were occupied by a mountainous country from which rivers flowed into an extensive submontane depression, known in the literature as the Irkut coal basin. This basin consisted of a ramified system of shallow lakes and marshes, with a varying regime favorable for the accumulation of plant matter, mostly ligneous, which provided material for the formation of the coal found in the Angara region today. Thick deposits of coarse Jurassic conglomerates at the outflow of the Angara and north of it along the shores of Baikal, lying below the surface level of the lake in places, are indicators of a prolonged period of intense activity of the Mesozoic affluents of the lake.

The foundations of the modern relief of the Trans-Baikal area were thus laid in the Mesozoic, when long mountain ranges began to form, with deep troughs running between them for hundreds of kilometers in a north-eastern direction.

Stretching to the north-east and east of the Baikal and Trans-Baikal mountains for thousands of kilometers, up to the Arctic Ocean, was the so-called Siberian platform which was, as today, an undulating country slightly slanting to the N. and N.E and abounding in shallow lakes and marshes.

Obruchev (1929, 1932, 1938, 1948) and other geologists, consider that the old relief of the Baikal mountains and the Trans-Baikal area, characterized by alterations of mountain ranges and deep intermountain depressions, is the result of fractures in the bulging, rigid block of the "Baikal shield", followed by deep subsidence along the lines of fracture, of huge blocks of the earth's crust, with simultaneous uplifting of adjacent sections. Thus, the Trans-Baikal Mesozoic depressions are grabens, while the ranges present horsts. Other geologists (Florensov, 1948, 1954) claim that old depressions in the Trans-Baikal area chiefly result from folding. "The mountain ranges of the Trans-Baikal area are anticlinal by nature, while the depressions are gentle synclinal downwarps", writes Florensov (1948). In his opinion, the basic elements of the modern relief of the Trans-Baikal area date back to the Cretaceous, but it could also have inherited structural elements of an earlier age, the Low Mesozoic, and even perhaps the Palaeozoic.

"After a certain tectonic calm", Pavlovsky & Florensov (1956, p. 12-13) write, "early in the second half of the Tertiary period, in the Neogene, East Siberia was reached by a wave of vigorous tectonic movements occurring along the periphery of the Pacific and in South Asia. There appeared extensive, slowly deepening troughs in the Baikal area, approximately in the same way as has been outlined for the Mesozoic period. This process was accompanied by the resurgence and rapid formation of anticlines developing into mountain ranges. An alpine landscape was formed. This complicated process led to the development of colossal, sharply defined, intermountain areas of the Baikal type. Lake Baikal is the most typical and graphic expression of the gigantic tectonic process which concentrated all its tremendous force in the mountain belt stretching along the southern fringe of the ancient Siberian platform".

At the same time, depressions similar to that of Lake Baikal were also developing along the eastern margins of the ancient African shield: those of Tanganyika, Malawi, Turkana, Albert and other lakes.

The Baikal system of depressions, *besides Baikal* proper, includes depressions situated to the south-east, east and north-east of it, among them those of Tunka, Tora, possibly also Khubsugul in Mongolia, Barguzin, Upper Angara, Tsipa, Muya, Chara, and Upper Kalar (Pavlovsky & Tsvetkov, 1936; Pavlovsky, 1937, 1941, 1948; Fig. 1.4).

The present-day floors of these depressions lie at different levels: the Barguzin, which is closest to Baikal, is 550-600 meters above ocean level {90-140 meters above Baikal), the Tsipa 1070 meters (more than 600 meters above Baikal), the Muya 700-800 meters, the Chara 700-1000 meters, the Kalar 1120 meters, and the Tunka 800 meters above ocean level. However, the original bottom of many of these depressions lies much lower than the Baikal level and is covered with sediments thousands of meters thick. The oldest in the Baikal system, according to Pavlovsky (1937, 1941), is the basin of south Baikal, which could have been formed as a deep depression in the Mesozoic, whereas the other depressions appeared only in the later half of the Tertiary, when the southern depression was radically transformed, and changed its direction to the south-east, i.e., that of present Baikal.

Dumitrashko (1948, 1949, 1952a,b) also points out that an intermountain depression existed in the south part of present-day Baikal in the Jurassic and that it stretched diagonally with respect to the depression existing today. It lasted throughout the Cretaceous period. The present-day orientation of the southern Baikal depression is connected with the Tertiary rise of the Khamar-Daban Range, which started in the Oligocene and continued throughout the subsequent period. The same period also saw the formation of the Tunka depression and of those neighboring it.

In the opinion of Dumitrashko, the Barguzin depression was not yet in existence in the Tertiary, but there could have been an extensive lake *m* the area of the delta of the River Barguzin. Lakes also existed in the area of the present-day middle depression of Baikal. They were separated from the southern depression by a mountain mass which had arisen in the Jurassic, and traversed the present-day lake diagonally. Northern Baikai was only formed in the Pliocene, at first as a shallow depression. The other depressions of the Baikal area are also of Pliocene age. In that period they were perhaps *linked by rivers.*

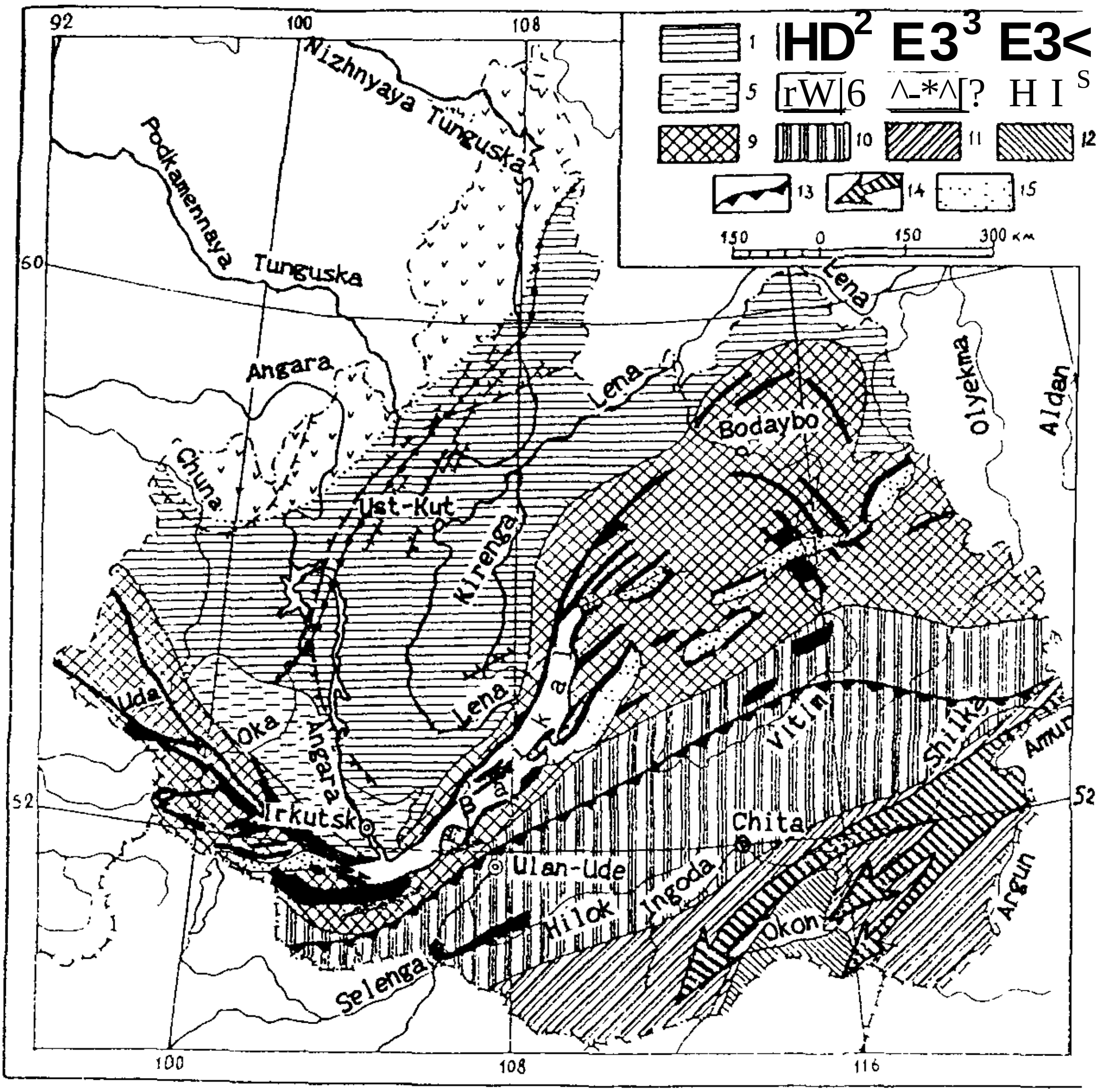
The emergence of Baikal as a deep lake, with borders approximating its present shape, is dated by Dumitrashko to the end of the Pliocene and the beginning of the Quaternary, when the ridges crossing Baikal sunk below its surface level and a single water plane formed in the Baikal trough.

Sarkisyan (1955, 1958) holds that the Baikal trough originated in the Miocene or Pliocene and acquired its present shape in the Quaternary. Boreholes sunk on the southeast shore of Baikal and in the Tunka and Barguzin depressions went through Quaternary and Tertiary sediments and reached Pre-Cambrian rocks, but found no Mesozoic deposits. This means that, in the Jurassic and Cretaceous, dry land still lay in the southern part of Baikal, from which shingle, sand and other debris were washed down into the trough of the Irkut basin and other local depressions. It was only in the Tertiary (possibly in the Oligocene) that the first lacustrine basins appeared in the area now covered by Baikal (Sarkysyan, 1955).

In the opinion of Lamakm (1952, 1955), who paid particular attention to the latest movements of the earth's crust, the whole of Lake Baikal formed in the Tertiary.

Interesting research has been conducted on the Ushkany Islands situated in the middle part of Baikal. To Vereshchagin (1949), Dumitrashko (1952a, b) and others, the Ushkany Islands are summits of the submerged Academichesky Range, once an element of the Jurassic relief of the Baikal area. *In* 1878, Chersky pointed out the existence on the Ushkany Islands *of* well-defined terraces with traces of surf erosion. Lamakin counted eleven such terraces on Great Ushkany Island, the uppermost one extending to the highest point of the island, which rises to 211 meters above the surface of the lake.

The presence of terraces at different sections of the banks of Baikal, with marks of from 100 to 200 meters above the level of the lake and even higher, was noted by all students of the morphology of the



f;g 4/ Scheme of division into districts of Pnbaikalye and Zabaikalyc After Florensov & Olunin, 1965
1 - palaeozoic cover of the Siberian platform, 2 - southern termination of the Tungus synechzia, 3 - southern boundary of spread of Siberian traps. 4 - zone of Jurassic depressions, 5 - Irkutsk *pre-neountaw* trough, 6 - single *anticlinae* folds, mountain-folding belt, 7 - faults of deep location within the ramming of the Siberian plalform, 8 - archean *massivei*, *9* - region of the Proterozoic folding, 10 - the same - Early-Paleozoic, 11 - the same - Late Paleozoic, 12 - Aginsky Paleozoic massif (plate), 13 - boundary region of the Mesozoic Activization, 14 - ways of the lower Mesozoic marine ingression, 15 - Neogene-Quaternary intermountain troughs.

Baikal trough. Chersky (1878), Obruchev *(1932),* Dumitrashko (1952a,b) and Vereshchagin (1949) associated this terracing with a Quaternary fall in water level and with a differentiated rising of the lake's shores. Also important in the subsidence of the water level was the Angara, which is vigorously deepening its bed, as indicated by high terraces along its course.

Some authors associate past high levels of Baikal with the thawing of glaciers that covered the mountains in interglacial and postglacial periods. Dumitrashko (1952a,b) states that this rise in level did not exceed 50-100 meters. Lainakin (1952) attaches little importance to the thawing of glaciers as a factor in the water level of Baikal, but thinks that, in the interglacial period. Baikal waters could penetrate the Lena watershed and fill the Barguzin, Tsipa and other tectonic depressions of the Baikal system owing to a sinking of the watershed.

The above-mentioned views can be summarized as follows:

1. As early as the Mesozoic (Jura) there was an intermountain area on the site of south Baikal. It may, however, not have been the embryo of the Baikal of today. The lakes situated in it were neither deep nor large, as seen from the fact that no Mesozoic deposits, common in the Mesozoic depressions of the Trans-Baikal area, have been found within the confines of south Baikal.
2. The Baikal basins (two or three) began to expand and deepen only around the middle of the Tertiary, or in its first half. The subsidence of the bottom of the depression lasted throughout the Neogene and was especially rapid at the onset of the Quaternary. It has not ended yet.
3. At the threshold between the Tertiary and Quaternary, the basins, which were more or less isolated, began to merge. The present tremendous depth of Baikal developed at the end of the Tertiary and in the Quaternary, but it is possible that they were relatively large and deep already in the initial stage of formation of Baikal, in the middle of the Tertiary.

Contemporary investigators attribute the formation of rift structures to tension stresses in the lithosphere. The main tension stresses are oriented subhorizontally and transverse to the strike. The scales of tension are evaluated differently by scientists. Maximum tensions are close to the breadth of the Baikal depression, moderate tensions are 10-15 km wide. The appearance of tension directions are confirmed by the peculiarities of the morphosculpture of Baikal (Mats, 1990).

At present there are two models for the formation of the Baikal rift: active and passive. According to the model of active riftogenesis (Fiorensov *et ai,* 1982; Logachev & Zorin, 1984;) the formation of an asthenospheric ledge resulted in forming an arched uplift. The spread of the arched uplift on the sides led to tension in the earth's crust. According to the model of passive riftogenesis (Kazrnin, 1987; Mats, 1990), the tension of vast regions of the earth's surface is primary, and rifts are considered to be linear deformations of the lithosphere due to heterogeneity of the substratum. Tension and tapering of the lithosphere lead to subsidence of the earth's surface and formation of depressions, causing a "passive" uplift of the anomalous mantle and growth of an arched uplift (Mats, 1990)

Some authors explain the formation of the Baikalian region by the Indo-Euroasian collision (Zonenstem, 1972; Monin & Mirlin, 1979; Mats, 1987). The structures of the region were formed by the movement of several microplates which appeared when the Euroasian plate split.

Such an approach makes it possible to consider the Baikal rift zone as a separation boundary between lithosphere plates and microplates. Since the first edition of Kozhov's "Lake Baikal and its life" (1963), several new schemes of the geological history of Baikal have been developed (Fiorensov, 1968; Fiorensov *et ai,* 1978; Fiorensov *et ai,* 1982a; Logachev, 1974; Adamenko *et ai,* 1975, 1984; Goldyrev, 1982; Nikolaev *et ai,* 1985; Belova *et al.,* 1983; Mats, 1987, 1990; Popova *et ai,* 1989). These studies single out two or three major stages differing by tectonic regime, climate, and character of sedimentation. The names of these stages and dating of different processes, including the formation of ultra decpwater waterbasins vary considerably.

Fiorensov and Logachev distinguish two main stages in the geological history of Baikal: Early Orogenic and rift proper Late Orogenic (Neobaikalian). The boundary between the stages coincides with that of the Early and Late Pliocene. The first stage is characterized by a relatively calm relief, slow sagging of depressions (sagging of depressions was compensated by sediment accumulation) and a warm climate. The second stage was characterized by considerable tectonic activity, intense sagging of the floors of the depressions, and a more severe climate.

Belova *et al.* (1983) claim that in the Early-Middle Pliocene (Neobaikalian stage) there were large lakes in the south-middle, but not in the north Baikalian depression. Baikal, in its modern outlines, appeared in the Early-Middle Pleistocene. Goldyrev (1982) thinks that activization of tectonic processes in the Baikal rift zone occurred in the Middle Miocene. It was only in the Late Pleistocene that Baikal became a deep water lake.

In the opinion of Nikolaev (1985) and others, the formation of deepwater Baikal took place at the threshold of the Low and Middle Pleistocene.

Mats (1987) distinguishes two megastages in the geological history of Baikal: a pre-rift stage from *the beginning of the Proterozow to the end of the* Mesozoic, and "rift one" comprising the end of the Cretaceous and the Cenozoic. The rift megastage includes two stages: pre-rift and "rift one".

The Pre-rift Stage (Maastrichtian-Eocene 70-30 10^6 B.P.)

Pribaikalye was a weakly uplifted plateau dropping steeply towards the south-east to form a high ledge in the zone of the Selenga-Vitim fault (Upland regions..., 1974). In the region of the future Baikal depression, a subsidence of the relief became occupied by lakes and graben-like morphostructures. There were signs of alkaline-basalt volcamsm. In the regions of the Pnmorsky Range a low arched uplift existed with longitudinal river valleys at the flanges. A large transitory longitudinal valley filled the north of the future Baikal depression (Mats, 1990). Lakes occurred in the regions of the Selenga, Olkhon, Peschanaya Bay, Bayan-Shungen Cape (Popova *et ai,* 1989). Lacustrine deposits of the Selenga region are part of an ancient delta of the Selenga River. Lacustrine deposits on Olkhon Island are represented by fragmentary thin-layered kaolimte brown clays. They are about seven meters thick (Mats & Pokatilov, 1976). These clays could have been deposited in the lake at a depth not greater than few tens of meters, since the layering of the clays is horizontal and well-differentiated. We//-treated quartz pebbie, found in *ths* region of the Peschanaya Bay and dated approximately to the Eocene, according to Mats, testifies to the existence of a lake with an appreciable water mass.

Rift Stage (30-0 10^6 B.P.).

Protobaikalian (Early-Orogenic) stage (30-3.5 10^6 B.P.)

Time of formation of big rift depressions.

The Late Ohgocene-Miocene (30-6.2 JO^6 B.P.)

At the beginning of this period, lakes hundreds of meters deep existed in the Tunka and South-Baikalian depressions. In a pre-flange zone of the South-Baikahan depression, an accumulation of *coarse-detntai sediments took place, deposited* there by big rivers. Coarse-detrital sediments were later replaced by sand-clay-aleurite ones. The south Baikahan lake (lakes) extended to the region of the present Svyatoi Nos Peninsula. A lacustrine basin (or basins) was (were) also present in the Barguzin depression, where drilling exposed sands, aleurites, clays, diatomites and rare interlayers of coal. Sagging of the earth's surface (and deepwater lakes located in them) was framed by plateau-like uplifts rising several hundred meters above the water level (Upland regions..., 1974).

The Early-Middle Pliocene (6.2-3.5 W^6 B P.)

Troughs of deepwater lakes and their biotopes changed considerably due to tectonism and climate. During a short period of time, the height of the south-eastern mountain framing increased. The lakes in the south-and-middle depressions deepened, forming a paleobay (the North-Baikalian depression) in the zone of the Malomorsky rift. Small lakes existed in the region of north Baikal during the Middle Pliocene. Mats calls the lakes existing within the limits of modern Baikal during the Oligocene-Early Pliocene "Protobaikal". A deepwater lake existed in the Tunka depression. It was connected with other lakes by channels passable to aquatic organisms.

Neobaikahan (Orogenic proper) Stage (3.5-0 10^6 B.P.)

A growth *of* the Baikalian arch, deepening and extension of rift depressions, and morphosculptural (including glacial) changes of the relief occurred. Three substages were distinguished:

Early Substage of Neobaikalian stage and the Late Pliocene-Eopleistocene (3.5-0.8 10^6 B P.J

The Late Pliocene was characterized by considerable restructuring of the lake system, which resulted in a reduction of the area of the large lakes of the Tunka and Barguzin depressions, until their disappearance. In the South and Middle Baikalian depressions of modern Baikal, the Late Pliocene-Eopleistocene witnessed a system of deepwater lakes and, connected with them, lakes of medium and shallow depths, located at the flanks of the depressions and on the dikes between deep lakes. Beginning with the Eopleistocene, lakes of medium and shallow depth appeared in the North-Baikalian depression. They covered the major part of this depression in its modern outline. At the same time, in precoastal parts of deepwater lakes, a sharp increase of depth and wider spread of coarse fragmentary sediments was observed. In the Late Pliocene-Eopleistocene, the water flow from the South-Baikalian depression ran into the Lena direction (Goloustnoe-Manzurskoe) (Lamakin, 1960, 1961; Logachev, 1964, 1974; Kononov & Mats, 1986).

Middle Substage of Neobaikalian Stage.
The Early-Middle Pleistocene (0.8-0.15 10^6 B.P.J.
Appearance of ultra deepwater lakes and unification of large lakes within the confines of present-day Baikal.

From the Late Pliocene *or* Eopleistocene to the Middle Pleistocene, the existing lakes were called Protobaikal (Mats, 1990). A high water level of Protobaikal and mass accumulation of sands was observed. A considerable part of the North-Baikalian depression was involved in the process of the formation of depressions. The outflow from Protobaikal in the Early-Middle Pleistocene could have made its way via a water channel cutting between the Baikalian and Bystrinskya depressions and into the Irkut River in the region of the present-day Kultuk and Ilchy rivers (Kononov & Mats, 1986).

The Late Substage of the Neobaikalian Stage
The Late Pleistocene-Holocene (0.15-0 10^6 B.PJ

This period is characterized by dramatic uplifts and subsidence, utmost relief dissection, and formation of maximum depths. Approximately at the middle of the Late Pleistocene, an outflow from Baikal to the Angara appeared.

Questions such as the exact dating of the appearance of contrasting reliefs leading to the accumulation of coarse-detrital materials, dating of the depth increase of the lake, and the depth of the these lakes, still remain open.

4.2. Major results of palaeontological work

Of exceptional importance for determining the age of Baikal and the stages of its colonization is the exact dating of organic remains preserved in ancient deposits, both within the morphological boundaries of the lake and the territory around it.

In the Upper Jurassic and Lower Cretaceous, there were large lakes in the Trans-Baikal area and Mongolia, which filled intermountain depressions. They were populated, as fossils show, by a rather homogenous fauna, the study of which started in the middle of the last century by Middendorf (1867) and was later continued by Reis (1910). Detailed studies were made by Rammelmeyer (1931-1940), Martinson (1940-1982), and in recent years, by Popova (1968-1990). In the so-called Turga formation of the Trans-Baikal Mesozoic basins, remains of peculiar fishes from the family Lycopteridae and the genus *Lycoptera* were found. The latter (Berg, 1949b) stand at the outset of the Teleostei stem and are among the oldest bony fishes, close to the cyprinoids. Gastropod remnants from these deposits resemble the modern Baicaliidae.

The remains of gastropods from Mesozoic deposits of Trans-Baikal, which Rammelmeyer attributes to the Baikalian genus *Benedictia*, are so strongly deformed as to make exact definition impossible, while the species of *"Baicalia " (Probaicalia* after Martinson) from these deposits are not closely related to modern Baicaliidae. The finds in deposits of the Upper Jurassic-Lower Cretaceous lakes of the Trans-Baikal area, include molluscs representing *Viviparus, Lymnaea, Planorbis, Cyrena*, Physidae and Bithyniidae, large Ostracoda, larvae of Odonata, Plecoptera and Trichoptera, aquatic and semi-aquatic reptiles, and the above mentioned *Lycoptera.* An analogous fauna was found in Mesozoic deposits outside the Trans-

Baikal area, in Mongolia and *in* regions adjoining China. This Mesozoic fauna is not related to the modern and Tertiary fossil fauna of Baikal.

An interesting fossil mollusc fauna was found in depressions in Central Asia. This gives reason to suppose that, in Upper Cretaceous times, Mongolia, North-West China, and the Far East, had a fairly extensive continental basin, inhabited together with a typically freshwater fauna by highly original costate lamellibranchiate molluscs of the genera *Trigonoides* and *Sainscihandia.* These formed, as it were, an intermediate link between brackish and freshwater molluscs (Martinson, 1955a,b). By Martinson's *opinion* (1955a), these costate molluscs are indicative of the existence of a system of vast waterbodies extending from the Pacific, through Manchzhuria, to the Gobi area of Mongolia, and on to Central Asia (Fergana, Kara-Tau).

However, no remains of a fauna comparable to the modern or fossil Baikahan fauna have so far been found in any of the Late Mesozoic deposits of Asia, although some gastropods with turreted shells, by the opinion of Martinson, somewhat resemble *Baicalia* and may have been the ancestors of the family Baicaliidae (Martinson, 1955a). The results obtained by the palaeontological expeditions of the USSR Academy of Sciences in Mongolia, which discovered abundant remains of turtles, crocodiles, and dinosaurs, also point to an abundance of waters in Central Asia in the Upper Cretaceous. Where there is desert in Mongolia now, there were extensive boggy lowlands in the direct vicinity of the Cretaceous Sea. Swamp forests occurred almost everywhere (Yefremov, 1954).

It was only towards the end of the Cretaceous, as Martinson (1955a) and others point out, that the great basin of Central Asia disappeared and its fauna either became extinct or changed its habits.

The first half of the Tertiary did not leave clear traces of any large basin in Central Asia and the Trans-Baikal area. Fossils from that period are practically unknown. But an interesting fossil fauna has been discovered in the Middle and Late Tertiary continental deposits of north-western China (the area of Sinkiang), where remains of a varied, typically freshwater fauna were found, including gastropods. These, indeed, strongly resemble modern and fossil Baicaliidae. Thick sedimentary formations and an abundant freshwater fauna m Sinkiang, again prove the existence of numerous continental basins in the Oligocene and Miocene (Martinson, 1955a). A whole system of lakes which covered the territory of Dzungaria and Kashgaria and extended into Mongolia and West Siberia and also into the adjoining regions of Central Asia existed here. In one of the Tertiary formations of Sinkiang, the upper green rock dated by Martinson to the Middle-Upper Miocene, gastropod forms were found which he assigns to modern Baicaliidae. He points out that these Chinese Baicaliidae lived in deeper zones of large Tertiary lakes separately from such lacustrine molluscs as the Unionidae, Planorbidae or Limnaeidae, as is the case with the *molluscs of* present-day Baikal. Martinson (1955b) thinks that the affinity of the Sinkiang and Baikalian forms points to extensive communication between the lakes of China and Siberia, which were connected by lake dykes and river drainage. It was only in the Pliocene, when a violent uplift took place, that the lake systems of Central Asia began to shrink, turning into small isolated bogs, and their deep- and open water fauna was replaced by a fauna of shallow lakes and marshes.

Martinson (1960) and Martinson & Popova (1959) report on fossil molluscs from the freshwater Tertiary deposits of West Siberia in the south of the Omsk region, almost on the border with North Kazakhstan. Continental deposits of Pliocene, Miocene and Upper Oligocene age occur here, underlain by a marine Palaeogene and Early Neogene suite containing foraminifers and ostracods of Lower and Middle Oligocene age. The gastropod remains found in this area were classed by the authors as belonging to the palaearctic genera *Hydrobia, Valvata* and *Bithynia,* and also to the Baikalian genus *Kobeltocochlea* (Benedictudae) and the family Baicaliidae. But, judging from specimens in Martinson's collection, and photographs that have been published, the inclusion of the small turreted gastropods of West Siberia in the family Baicaliidae is not indisputable. They may represent a western branch of the Rissoida, closely related to the modern and fossil Tertiary Hydrobiidae and Pyrguliidae. With regard to *"Kobeltocochlea",* there are equal grounds to ascribe it to the genus *Lithoglyphus* (= *Fluminicola).*

Of great importance for the chronology of the initial stages of formation of the Baikalian fauna, and certainly of the lake itself, is the study of fossils within the modern morphological boundaries of the Baikal depression itself, and in other depressions of the Baikal system.

Highly interesting in this respect are faunal remains in the deposits of Tertiary terraces on the south-east shores of Baikal, which have been known since the 19th century. Among fossil molluscs, a great number of large Bivalvia from the family Unionidae were found, which are closely related to modern Chinese species of the same genera. Moreover, remains of large Viviparidae were found here. But of special interest was the discovery *of* gastropod shells *of* the family Baicaliidae, occurring in present-day Baikal. Some of these are close to modern species.

On the basis of plant remains in the same deposits (and in analogous deposits of the Tunka depression), Rammelmeyer (1940) agreed with Palibin (1936) in dating them *to* the Oligocene.

A detailed paleontological study of these deposits has been conducted by Martinson (1938-1951). The 29 species found of the Bivalvia did not contain a single form close to modern species of Baikal's open waters. In the Viviparidae, new species were found of the genera *Viviparus* and *Tulotoma,* which do not exist in Baikal today. Remains of gastropod shells of the genus *Lithoglyphys* (= *Fluminicola)* (see p. 42, Ch. 3) related to modern Chinese genera, were also found for the first time. It is to be noted that the genus *Lithoglyphus* is close to the Baikahan genera *Kobeltocochlea* and *Benedictia.* Remains of shells which Martinson attributed to the genus *Benedictia* were also discovered. The number of fossil species of the genus *Baicalia* has reached 15. The first recorded finds were made of remains of shells of the Baikahan genera *Liobaicalia* and *Choanomphalus,* common in Baikal today.

The same Tertiary deposits on the south-west shore of Baikal contain siliceous spicules of the Baikahan sponge families Lubomirskiidae and Spongiliidae

Martinson disagrees with Rammelmeyer on the age of the deposits of the Baikalian terraces containing this fauna, and considers them to be of Miocene and Lower Pliocene age. Analyzing the fauna of the Baikalian terraces as a whole, Martinson (1951) differentiates it into two main complexes: Chinese or Chinese-Mongolian, and Balkanian. In the Chinese complex he lists almost all Unionidae and Viviparidae and in the Balkaman, the Baicaliidae, *Lithoglyphus (= Fluminicola)* (see p. 42, Ch. 3) and *Benedictia,* as well as *Viviparus* and certain *Unio.* Representatives of the genera *Pisidium* and *Planorbis* are believed to be remnants of a widespread fauna of the continental waters of Eurasia.

Martinson ascribes the Baicaliidae, *Lithoglyphus* and *Benedictia* to the "Balkanian" group on the basis of an external similarity between some fossil gastropod shells from Pliocene deposits of South-East Europe, the Balkan Peninsula in particular, and the fossil and even modern turreted shell of the Baicaliidae. Many palaeontologists have noted this rather superficial similarity, but it can be explained by convergent evolution in two independent centers of Tertiary speciation: the Ponto-Aralo-Caspian ("Balkanian") and the Baikalian (Baicaliidae). For this reason, the term "Balkaman" when applied to the Baikahan gastropods cannot be regarded as appropriate. As to the numerous fossil Unionidae, it is true that they are closely related to modern and fossil Chinese species

It is noteworthy that sedimentary strata from the Tertiary terraces of Baikal, with remnants of Baicaliidae, contain almost no Unionidae and that, conversely, there are no Baicaliidae where Unionidae prevail. This corroborates the assumption earlier expressed by Kozhov (1936b, 1947) that sediments in the terraces on the south-east shore of Baikal were deposited in the littoral zone in conditions similar to those still found in the littoral-sor region adjacent to the Selenga delta. Evidently, these terraces were alternately inundated by the open waters of the lake and sediments were deposited in them containing remains of typical Baikahan fauna (molluscs' Baicaliidae, sponges: Lubomirskiidae), or turned into sors or even shallow marginal lakelets and were colonized by an ordinary fauna, common in the waters of South Siberia.

Spicules of Baikahan Lubomirskiidae sponges and widespread Spongiiidae were found in Tertiary deposits of the Tunka tectonic depression, Baikal's neighbour (Dumitrashko & Martinson, 1940).

Of great importance for specifying the time of the isolation of the Baikahan fauna from the neighboring fauna of Siberia is the study of fossil remains contained in deposits of old shallow lakes in areas of Siberia outside the Baikal mountain region. In recent years, a fossil Tertiary fauna has been found in the West Sayan Range, in the vicinity of the Tannu-Ola Range (Zaitsev, 1947) and in the area of the Irkut coal basin (Martinson, 1949a, 1954a). The latter contains remains of Planorbidae, such as *Planorbis, Gyraulus, Hippeutis, Spiralina and Segmerttina,* as *well* as *Radix, Stagmcola,* Physiidae, Bithyniidae and the genus *Hydrobia.* Martinson stresses the relationship between these and Pliocene molluscs of Mongolia and China, but this Pliocene lacustrine fauna of South Siberia is not related to the modem or fossil Baikahan fauna. Nor does the fauna of the Pliocene lacustrine deposits of the Tannu-Ola bear any trace of a fauna related to the fauna of Baikal. It consists of *Unio, Valvata piscinalis, Viviparus,* etc. Tertiary (Miocene?) deposits on Olkhon Island (Baikal) contain remains of thermophilic freshwater turtles of the genus *Clemmys* and tortoises of the genus *Testudo,* as well as Planorbidae *(Gyraulus, Hippeutis),* the fish *Amia,* and some silunds and salmonids (Kitainik & Ivanyev, 1958). Pollen of coniferous and broad-leafed trees, but no traces of Baikahan fauna, were found in the Olkhon deposits, which sedimented in a shallow body of water, or in Tertiary Trans-Baikal depressions (Lake Gusinoye and others).

All the paleontological studies cited above show that, already in the Pliocene and perhaps even in the Miocene, the Baikal fauna as a whole was not only extant, but also ecologically distinct from the fauna of shallow Siberian lakes surrounding Baikal. This means that Baikal already was a relatively large and deep lake, or a system of such lakes.

Paleontological data, obtained in the 1960s-1980s, elucidate the history of Baikal and lakes preceding it, and also that of prelacustrme landscapes, improving our understanding of accepted concepts. Below is their systematic interpretation.

Sponges. Spicules of sponges of the family Lubomirskiidae, now endemic to Baikal, have been described from coal-bearing (Tankhoi) strata by Martinson. They occur on the south-east coast of Baikal and in the Tunka depression; they characterize a lower part of the suite, dated to the Late Palaeogene-Early Neogene. *There, Lubomirskia baicalensis* (Pall.), *L baicalensis jusifera* Souk., *Baicalospongia intermedia* (Dyb.), *B. bacillifera* (Dyb.), and *B. fossilis* are found (Martinson, 1940, 1948b). Together with Lubomirskiidae, Spongillidae are observed: *Spongilla lacustris* L., *S. fragilis* and *Ephydatia fluviatilis* L. Spicules of Lubomorskiidae are also present in bottom deposits of Baikal.

Representatives of the Lubomirskiidae in deposits of the *Baikal rift* were a/ways considered to be evidence of a continuous existence here (from the end of the Palaeogene-beginning of the Neogene) of large deepwater lakes, *i.e.,* a zone of development of endemic organisms.

In deposits of the Birofeldskaya depression of Pnamurye (Ushumanskoe brown coal deposits), Martinson found the same Lubomirskiidae: *Swartschewskia papyracea* (Dyb.), *Lubomirskia baicalensis* (Pall.), as well as *Spongilla lacustris* L., *S. stenleyi,* and *Ephydatia fluviatilis* L. This showed that the Lubomirskiidae had a wider range in the Oligocene-Miocene in the south of North Asia than supposed (Popova, 1964). Furthermore, the taxonomy of sponges, defined only by spicules, needs to be substantially revised.

Ostracoda. A fossil *Pseudocandona,* described by Mazepova, was found in Pliocene deposits on the west coast of Olkhon Island (Pliocene..., 1982). Modern species of this genus live in open Baikal (27 species and three subspecies), in Lake Ohrid (one species), and in lakes and subterranean waters of Europe, including Switzerland (five species) (Mazepova, 1990). Since all these species are likely to occur in waters rich in oxygen, the discovery of this *Pseudocandona* confirmed the large size of the Pliocene lake, with a constant high content of oxygen This lake was located in the northern part of the present-day Maloye More and west coast of Olkhon Island.

Molluscs. The 1960s and 1980s have considerably extended our knowledge of the Cenozoic malacofauna of Pribaikalye: the number of species has doubled; practically all isolated suites and deposits have been characterized malacoecologically; an analysis of the biogeographical connections of the malacofauna (both freshwater and terrestrial) of different age and *their ecology* has been carried *out.* As a result, new insights into sediment age, palaeochmate (see section "Palaeoclimate"), character of lakes, and prelacustrme landscapes have been obtained.

In lake sediments of the Oligocene-Early Miocene large lake - the embryo *of* Baikal (south-east coast), a richest subtropical malacofauna existed. Today, of seven families of molluscs categorized in these sediments, only three have survived (Baicalliidae, Benedictiidae, Pisidiidae). The first two are endemic (Popova, 1981). The majority of genera has become extinct; closely related species of these genera now occur primarily in subtropical China. According to Martinson (1961) there was already a division into groups: species of the open lake, and species living in bays and sors. This followed the observation that in some layers Baicaliidae are predominant, while in others only Vivipandae and Unionidae live. However, later excavations have shown that no such distinct division exists, and that it may be due to conditions of burial.

The presence of Baicaliidae in deposits of the Tankhoi suite *confirms the existence of a* large-sized lake. The age of this fauna was established as Oligocene or Oligocene-Early Miocene. This conclusion is of importance to uphold the opinion that the development of the lacustrine drainage *in* the South-Baikalian depression was of a continuous character. Judging from the presence of the genera *Parumo* and *Cuneapsis,* waters of the lake were well mineralized and their $CaC0_3$ content reached approximately 0.5 mg 1^M (Popova, 1964, 1981).

It is interesting that two species of the family Baicaliidae occur in the Albskie deposits in Mongolia (Martinson, 1971). If this is so, conception of the mesolimnic origin of some groups of Baikalian organisms is directly confirmed, since Mongolia is the territory where the Mesozoic break-up of a sea and dispersal of its survivors into lakes took place.

The problem of the location of the outlet from Lake Baikal at any period of time, and its direction, is being given much attention (Kononov, 1985; Kononov & Mats, 1986). A find of *Maackia angarensis* (Gerstf.) in deposits of Angara terrace VI in the region of Ust-Osa (Popova *et ai,* 1967) is of interest as evidence of the existence - already at that time (Tobolskoe?) - of an outflow from Baikal in the direction *of* the Angara (Popova, 1981). In the Eopleistocene, the outflow was to the Lena and the source was located in the region of the Goloustnaya River (Kononov & Mats, 1986).

It is also necessary to deal with new data on the distribution of groups related to Baikalian molluscs of extreme endemism outside Pribaikalye. In the Kizilgirskaya (Miocene-Pliocene) suite of the Altai Ranges, molluscs were found referring to the genus *Aenigmopyrgus* and the family Baicaliidae (Popova *et al.,* 1970). Although rather questionable, this group, found outside Pribaikalye, is undoubtedly the closest from a systematic point of view. This is confirmed by embryonic whorls, noted by Starobogatov. Interest in molluscs from the Kizilgirskaya suite of the Altai Ranges was aroused by the fact that here, as in Baikal, formation of numerous endemic species from a small number of ancestral forms had taken place, and all new species possessed a remarkably expressed sculpture. Attention should be paid to the fact that representatives of widespread families such as the Viviparidae, Planorbidae, and Lymnaiidae were involved in this process. This did not happen in Baikal and in the lakes preceding it, or, if this happened, the results of this process were destroyed by Pleistocene cooling. Lake Chuiskoye in the Altai Ranges was drained earlier - in the Pliocene or Eopleistocene.

Vertebrates. In the Khalagaiskaya suite (Miocene), exposed on Olkhon Island, and in Tangai Bay (Maloye More) remains of *Perca* sp., *Rutrfus* sp., and *Lucioperca* sp. (Logachev *et al.,* 1964) have been discovered, as well as remains of *Rana* sp., *Bufo* sp., *Baicalemus gracilis* Khoz. (= *Chrysemys* sp. (according to Chkhikvadze & Yasmanov, 1981), and waterfowl *{Anser* sp., *Anas* sp., *Brandta* sp., *Nyroca* sp., *Dicerorhinus sp.,Anchitherium* sp., and *Paleomeryx* sp.). The presence of some of these animals *{Perca$_y$ Lucioperca* and *Baicalemus gracilis)* proves the existence in the regions of Maloye More and western Olkhon Island, apart from shallow (a few meters) lakes, of lakes with depths of tens of meters (Palaeohmnological reconstruction..., 1989).

In the 1980s, the study of deposits of Olkhon Island and their faunistic remains added much to the knowledge of the Pliocene and Pleistocene vertebrates of the Baikal coastline and lacustrine system prior to its unification in a unique waterbody, and also of prelacustrine landscapes. In the deposits, Insectivora, Leporidae, Rodentia (Pokatilov, in: Pliocene..., 1982), Cervidae (Vislobokova, in: Pliocene..., 1982); *Gulo* sp. (Sotnikova, in: Pliocene..., 1982), and bones of an ancient horse were discovered.

4.2.1. Bacillariophyta in bottom sediments

Bacillariophyta are a speciose group of algae (700 species and varieties in Baikal). In the past, they did not play a lesser role, as confirmed by diatomite layers ranging from insignificant streaks to several meters in diameter (Goldyrev, 1982).

The first data on fossil diatoms in Baikal sediments were obtained by Kozhova (1959b). She investigated samples of surface layers, and two cores of about 1 m long from sediments in the region of Maloye More. The lower part of these cores contained the species *Stephanodiscus astraea* var. *intermedins* Fricke, not observed in the modern phytoplankton of Baikal. From this fact, Kozhova concluded that a change in the hydrological regime *of* the palaeo-basin had taken place, affecting later diatom composition. This also happened in other regions of north and middle Baikal (Goldyrev, 1982). Other studies have confirmed a maximum abundance of this diatom variety in sandy Pleistocene sediments, and its absence in more ancient sediments.

Patrikeeva (1959) gives a list of Bacillariophyta for the Maloye More, determined by Sheshykova-Poretzkaya.

The vertical distribution of diatoms, showing a constant species composition in the bottom sediments of north Baikal, made it possible to conclude that cores of 1 m of sediment fully pertain to the Holocene (Bottom sediments ..., 1970).

Studies on cores of 10-12 m in length revealed a more complete stratigraphy of the sediments, often going beyond the limits of the Quaternary, and ensured a valid correlation of the Cenozoic deposits of the Baikalian rift zone. This layer of Baikalian sediments is not uniform: the lower part is more ancient ("protobaikalian"), while the upper part comprises sediments of modern Baikal, reflects a sediment accumulation in a deep-water basin, and is called "Baikalian" (Goldyrev, 1982). The thickness of the Baikalian layer varies from 1-3 to 8 meters.

Analysis of diatoms from cores, by Goldyrev, produced 300 taxa. Among these, a dominant role is played by planktonic Centrophyceae, as observed in other deep lakes. These species are represented in Baikal by endemics: *Aulacoseira baicalensis* (Meyer) Sim., and *Cyclotella baicatensis* Skv., and species of *Stephanodiscus,* including some not occurring in the modern lake. They are accompanied by various Pennatophyceae which are, as a rule, not abundant, but diverse in species composition *(Navicula, Pinnularia, Cymbella, Gomphonema, Achnanthes).* This great diversity is attributed to the transparency of Baikalian water; living cells of Bacillariophyta with well-presented chromatophores have been found at depths of 63-115 m (Problems..., 1978). Examples are *Eunotia clevei* Grun., *Gomphonema bergii* Skv. et var., and *Amphora mongohca* Ostr. The number of diatom valves is not equal across the cores, and fluctuates within wide limits- from 10^6 to 100-250 10^6 g^{-1}(air-dry sediment).

Comparing Bacillariophyta assemblages in phytoplankton and sediments, it should be noted that in sediments few valves of *Synedra* and *Nitzschia* occur. This is probably due to the structure of their frustules, allowing them to float for a long time. Due to a comparatively weak silicification, these valves dissolve while sinking, which is apparently the cause of the complete absence of *Stephanodiscus binderanus* (Kiitz.) Krieg and *Asterionella formosa* Hass. According to Cheremisinova (1973), diatom assemblages have been formed since the Pliocene. She came to this conclusion when studying Neogene diatoms of the Tunka depression, adjacent to south Baikal. But data from recent years on diatoms and pollen in the Neogene deposits of the same Tunka depression have allowed the Baikalian complex to be pushed back to the Upper Miocene (Palaeolimnological reconstruction ..., 1989).

Among Bacillariophyta in sediments of the Tunka depression, a considerable amount of ancient relict species, whose development occurred in the Neogene period, were discovered. Some of them *(e.g., Stephanodiscus),* have become extinct, others *{Aulacoseira baicalensis* (Meyer) Sim, *Cyclotella baicalensis* Skv.) have survived until the present time, and have become endemic; many species observed in sediments of Baikal since the Neogene *(Eunotia clevei* Grun., *Amphora mongohca* Ostr., *Navicula semen* Ehr, *N. woromchinii* Jasn., *Cymbella stuxbergii* CI., *Gomphonema quadripunctatum* (Ostr.) Wise and others), have a distribution beyond the limits of Baikal and even Russia. For example, *N. woronichimi* Jasn., JV. aff.

lacus baicali Skv. et Meyer are found not only in modern Baikal, but also in Pliocene-Pleistocene deposits of Belarus. Examples are *G. quadripunctatum* (Ostr.) Wisl. have been found in lakes Teletzkoye and Onezhskoye, in lakes *of* Putoran, and in Lake Khubsugul (North Mongolia). One of the dominant species in the littoral and sediments of Baikal, *Didymosphenia geminata* (Lyngb.) M. Schmidt, has also been found in the River Yenisei, Khantaiskoye waterbasin, and in sediments of lakes of Putoran.

In Hthological composition, an alteration of clays with admixture of sands and diatomites was observed.

A description of the column was made by Goldyrev (1982), from top to bottom:

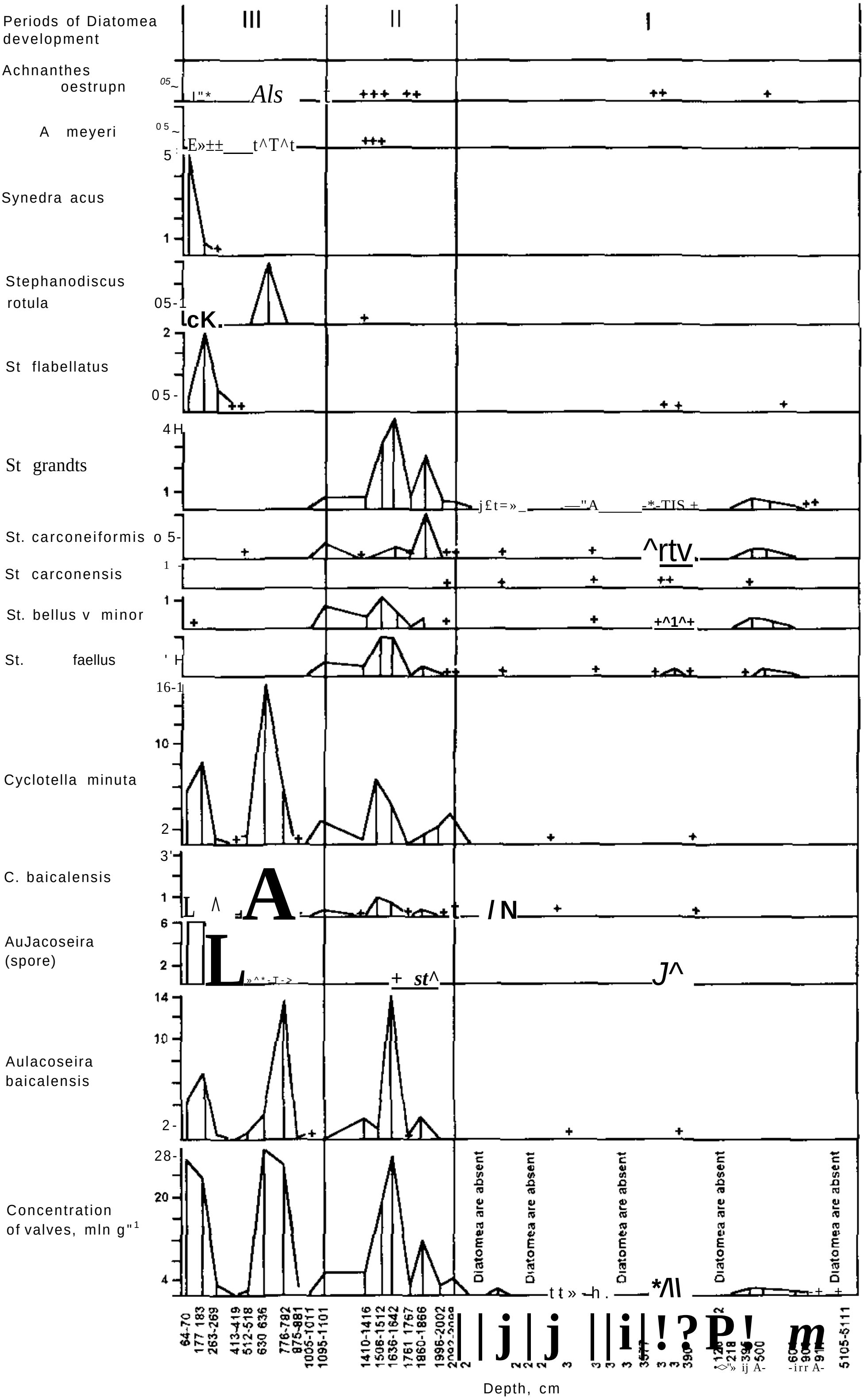
	Thickness (cm)
Light-brown semi-liquid aleuntic silt, at lower 2 cm-pressed, brittle	0-17
Soft greenish-grey thin-layered diatom silt	17-65
Soft hardly pressed blue-grey clay At the base of the interval, a considerable admixture of sand	65-191
Dense blue-grey clay. By density and admixture of sand, the boundary with the above-laying clay is distinct. In the interval there are rare, thin (in mm) inter-layers of sand Single pebbles	191-500
Dense diatomite of greenish-grey color, with yellowish shade	500-610
Dense, brittle greenish-grey clay	610-650
Dense diatomite of yellowish-greenish-grey color	650-720
Blue-grey dense clay	720-930
Dense diatomite of yellowish-greenish-grey color	930-1014

Details of the distribution of dominant and subdominant species of diatoms are given in Fig. 4.2. This distribution is uneven. Very dense clays, some hundreds of meters thick, classified by Goldyrev as "protobaikalian", *do not contain* diatom frustules. Their complete absence (or very low numbers) is also observed at other stations (Dynamics..., 1975). In diatomite layers and in the upper layer of sediment, *Aulacoseira baicalensis* (Meyer) Sim. and *Cyclotella baicalensis* Skv. are present in mass. In the lower part of the column, in "protobaikalian" diatomites, the extinct *Stephanodiscus grandis* Churs. et Log., *S carconeijormis* Churs. et Log., and *S. bellus* Churs. et Log., exceed in number the values of Baikalian species and become rock-forming at different stages of sediment accumulation. The age range of these species is rather wide: from the Miocene (Landigham, 1964, 1967; Gasse, 1975) to the Pleistocene (Gasse, 1975, Mori, 1975). Through these species, the age of these sediments was established as Pliocene for the first time: Early Pliocene (Loginova & Krursevich, in: Lithology. . . 1972) or Late Pliocene (Fyodorova in: Goldyrev, 1982).

In deposits of the south-east coast of Baikal (region of the River Dulikha) the species *Stephanodiscus grandis* Churs- et Log., now extinct, has been identified. It is characteristic of the Lower-Middle-Pliocene deposits of Olkhon Island, and for sediments of middle Baikal (Palaeolimnological reconstruction..., 1989). These deposits have been dated by spores and pollen to the Upper Miocene-Lower Pliocene, and this is not contradicted by their diatom composition. Thus, through paleontological data, the age of the lower part of the sediments collected at station 83 has been established as the Pliocene.

Palaeomagnetic studies on sediments have shown that all columns studied have a direct polarity and belong to the Brynes epoch, *e.g.*, a section of terrace IV (Ludarskaya), referred to the Upper Pleistocene (Mats & Pokatilov, 1976). The other magnetic-stratigraphic analogue was established in a section of deposits of terrace V on the left shore of the River Tyya, referred to the Middle Pleistocene. The deposits of the Nyrgan suite *on* Olkhon Island, by orientation and magnetizability of its

Fig 4 2 Bacillariophyta in bottom sediments of Baikal After Chernyaeva, unpublished data


Periods of Diatomea development
III
II
I
Achnanthes oestrupn
A meyeri
Synedra acus
Stephanodiscus rotula
St flabellatus
St grandts
St. carconeiformis
St carconensis
St. bellus v minor
St. faellus
Cyclotella minuta
C. baicalensis
AuJacoseira (spore)
Aulacoseira baicalensis
Concentration of valves, mln g"1
Diatomea are absent
Diatomea are absent
Diatomea are absent
Diatomea are absent
Diatomea are absent
64-70
177 183
263-269
413-419
512-518
630 636
776-782
875-881
1005-1011
1095-1101
1410-1416
1506-1512
1636-1642
1761 1767
1860-1866
1996-2002
5105-5111
Depth, cm

layers, have also been correlated using sediments. The age of the correlative part of the Nyrgan suite is Lower Pleistocene from palaeontological data. Hence, the age of the sediments of the lower part of the column of station 83 is Pleistocene. The time of sediment accumulation of this deposit is rather disputable, which Chernyaeva attributes to fragmentary studies of bottom sediments, and, in general, to insufficient correlations of the Cenozoic deposits of the Baikalian rift zone

4.2.2. Spores and pollen

In the Eocene-Oligocene in Pribaikalye, coniferous broad-leaf forests (20-25%) grew, with an admixture of tropical and subtropical species: Mirtaceae, *Rhus* sp., Araucariacea, *Nissa* sp., *Magnolia*, Palmaceae, *Cedrus* sp. (Belova, 1975; Bezrukova, 1990).

In the Early Miocene *Picea, Taxodium, Carya, Quercus, Glyptostrobus, Juglans, Ulmus, Castanea*, *Magnolia*, *Fagus*, *Corylus*, *Tilia*, and *Ziriodendron* occurred. In the Middle Pliocene *Alnus, Pinus, Strobus, Pterocarya, Tilia,* and *Betula* appeared; *Magnolia*, Palmaceae and Mirtaceae were absent. In the first half of the Middle Pliocene the terrestrial flora was represented by *Carpinus, Corylus, Tilia.* In the middle of the Upper Pliocene, mixed coniferous broad-leaf forests were accompanied by grass steppe (Adamenko *et al.*, 1975; Belova & Endrihinsky, 1980). On the whole, in the Pliocene the admixture of broad-leaf tree species was still significant, but their number in Pribaikalye was decreasing from south to north (Bezrukova, 1990). In Eopleistocene deposits, pollen of *Pinus silvestris* and *P. sibirica,* and of *Abies* and *Betula* is present. Grasses are represented by *Artemisia* and Chenopodiaceae (Bazarov *et al.*, 1974). In the Upper Angara depression, the Eopleistocene forests contain *Abies, Picea, Betula, Salix, Pinus* and *Podocarpus* (Bazarov, 1986). In the Late Pleistocene, the northern coast of Baikal was grown with *Lanx-Betula* forests with *Picea.* In the south, *Abies-Picea-Pinus sibirica* with an admixture of broad-leaf trees, *Ulmus, Tilia* and *Quercus,* occurred (Bezrukova, 1990).

4.2.3. Palaeoclimate

Climate is a strong factor for shaping the biota of a region, including its waterbasins. The distribution of fauna and flora depends upon it, hence climatic changes lead to shifts in biota. In lakes of the Baikalian rift zone, the tectonic factor and climate were important external factors of species formation. The cooling in the Pliocene-Pleistocene resulted in the extinction or southward displacement of heat-loving fauna and flora of the littoral zone of Baikal and its tributaries. Its unpopulated shallows, represented in the Middle Pliocene by coarse detrital sediments and the outcrop of rocks, under lower water temperatures, and considerable fluctuations - both diurnal and seasonal - served as a focus for the evolution of new taxa.

There follows a short account of concepts about the climate of Pribaikalye in the course of the history of Baikal development, and of the waterbasins preceding it.

Late Oligocene-Early Miocene (33-15 W^6 B P)

The existence of lakes with considerable depth at this time was confirmed by paleontological and geological evidence (Mats *et al.*. 1985), the climate was subtropical with a mean annual temperature of 15-20°C (Popova, 1971); the amount of precipitation exceeded 1000 mm yr^{-1}. At such temperatures, molluscs populating the waterbasins were akin to modern species of subtropical Central and South China. Belova (1975), based on plant remains (primarily spores and pollen), gives a figure of 1500 mm yr"^{1} for the annual precipitation. The same data confirm high temperatures m Pribaikalye: monthly mean temperatures in July 20-25°C, in January 5-8°C. Under such conditions, no ice cover forms and mixing of superficial and bottom water in deep lakes is difficult (Palaeolimnological reconstructions..., 1989).

Miocene-Middle Pliocene (15-3.5 10^6 B.P.)

In the course of this long period, there was a decrease in mean annual temperatures and humidity. This tendency was aggravated by climatic fluctuations, when heat and moisture supplies changed. The same methods, as before (Palaeolimnological reconstructions , 1989) were applied to detect mean annual temperature in the Middle-Late Miocene, temperatures were 10-12°C, and perhaps somewhat higher in the Early-Middle Pliocene Such temperatures are now typical of the northern part of the subtropical climatic zone Humidity decreased as a whole, but in Pnolkhonye, in the rain-shadow of the Pnmorsky Range, it dropped drastically and *semi-arid conditions* arose (Logachev *et al,* 1964)

Late Phocene-Eopleistocene (3 3-0 8 10^6 B P)

This was a time of considerable decrease in heat supply to the region It caused disappearance of many taxa of fauna and flora This is seen in the malacofauna (Popova, 1981, Pliocene , 1982) and in a change of palaeosoils and sediments (Pliocene , 1982) Annual mean temperatures were 5°C at the beginning of the Late Pliocene, and about 5-3°C in the Eopleistocene This was already a preboreal climate In the Late Phocene-Eopleistocene, humidity increased and signs of deep cooling were observed for the first time (Pliocene , 1982)

For the first time, too, a more or less stable ice cover appeared on waterbasins, together with strong seasonal and diurnal fluctuations of water temperature in coastal regions and in the epilimnion Spring and autumn homothermy occurred in deep waters, typical of the present climate, and leading to mixing of surface and bottom waters The Late Phocene-Eopleistocene was a time of considerable restructuring of Baikal biota and of the living communities in the region, and likewise, of the landscape in the coastal zone

Pleistocene-Holocene (0 8 10^6 BP -present time)

This was the time of the highest climatic variations and rates of these variations Over a comparatively short period of time, heat supply and amount of precipitation repeatedly changed In the Early Pleistocene (0 8-0 3 10^6 B P) and during interglaciations and interstadials, the climate was close to that of today During glacial cooling of the Middle and Upper Pleistocene it became much more severe (annual mean temperatures several degrees lower), and humidity varied from considerable in the first half of cooling (which promoted the growth of glaciers) to less in the second half The formation of several taxa of the littoral and subhttoral zone of Baikal (0-25 m) probably occurred during the Pleistocene warming-up It should be borne in mind that the duration of interglaciations was up to 100,000 years, and of glaciations from 30,000 to 50,000 years (Arkhipov, 1958) The same process happened in the Holocene (last 10,000 years), but was too short to allow for development of more species

4 2 4 Glaciation

Maximum glaciation in the mountains was followed by a significant warming of the climate, which made the ice move away from the foothills towards the mountain peaks, although it did not disappear completely In foothills along rivers and lakes free from ice, a coniferous taiga reappeared, with an admixture of broad-leaf plants, although in the Baikahan region, as mentioned above, distinct signs *of* heat-loving plants have not been *found*

Most geologists claim that there are traces of two glaciations in the Baikal area The first and more extensive was represented a complete ice-sheet, while in the second glaciation only the mountain tops were covered by glaciers

Dumitrashko (1952a,b) rejects the idea of repeated glaciations, but sees four phases of one glaciation At maximum, the glaciers reached 80 kilometers in length and were 300 to 350 meters thick The snow line was at 800 or 1000 meters

Lamakin (1950-1959) points out that, in their downhill creep during maximum glaciation, the glaciers reached Baikal and in some places even slid below its water level

According to Kozhov (1963, 1972), the importance of glacial phenomena as a factor in the life of Baikal must not be overestimated

In the second half of the Quaternary, there were several phases of climate cooling, accompanied by insignificant glaciation But even during glaciations, conditions were still favorable for coniferous forests with forest grasses, even with a relatively heat-loving undergrowth Such conditions occurred in regions where winter precipitation was abundant It protected the soil from freezing The regions near hot springs were the most favorable for the survival of fauna and flora Here, some biota from the end of the Tertiary survived (Kozhov, 1972) There is also evidence (Epova, 1955, 1956, Popov, 1954, 1956; Bardunov, 1963; Tyulina, 1964; Malyshev, 1965) of the survival of some species of plants of Tertiary age under other conditions. Tyulina considers subalpine coppices of *Betula* in the Barguzin region to be impoverished remains of the Tertiary Turgaisky forests which survived the glaciation in the same way as did dark-coniferous type forests. Among pre-glacial relicts in the region of Baikal, dozens of species, mainly grasses and mosses, are known, *e.g., Daphne mezereum* (fam. Thymelaeaceae), growing at the mouth of the Angara River, and *Menispermum dahuriciim,* living on rocks of the south-west coast of the lake. In the Tunka depression, the Tertiary relicts *Mannegetteae* and *Megadenia* were preserved, which is convincing evidence, according to Popov, that it was never completely covered with ice. Epova, having confirmed the presence of relict plants on the Khamar-Daban, supposes the Alpine region of the northern slope of this range to be influenced by Baikal, which allowed the preservation of such Tertiary relicts as *Pedicularis longi/Jora* and *Rhododendron dahuricum.* In regions adjacent to the Baikahan mountains, the broad-leafed *Ultnis* has survived since the Pliocene. Another Tertiary relict is *Chosenia arbutifoha,* a large shrub (fam. SaWcaceae) growing on the shores of the lake and *in* the valleys of mountain streams (Popov & Busik, 1966). Malyshev points out that in the Eastern Sayan, near thermal springs, *on* the northern slope of the Alpine zone, and on the Pogranichny Ranges at an altitude of 1500-1560 m, a significant number of plants, rare in Pribaikalye, successfully survived the glacial period. There are also relict groups among the steppe plants of Priangarye. The terrestrial fauna also includes animal species of warmer pre-glacial times, such as, for example, *Orthetrum albistylum* (Belyshev, 1956), *Thermocarus thermobis* (Sokolov, 1936), and the snakes *Elaphe .schrenki* and *Ancistroden halys,* occurring along the coasts of Baikal, particularly near hot spnngs. Formozov (1928) considers *Apodemus silvaticus* to be a relict which spread from the Altai along the south of Siberia, across Zabaikalye, to the Pacific Ocean. It is evident that the beaver, preserved in Mongolia (the River Bulugum in Zaaltaiskoy Gobi) should also be considered a relict (Anudarin, 1948). Shtegman, Gagina, and others cite some southern species of birds which survived the glaciation m the south Siberian taiga. Among the aquatic plants of Lake Frolikha, located near Baikal, *Subularia aquatica* and *Isoetes echinospora* represent pre-glacial relicts (Popov, 1955, 1956; Bardunov, 1963).

In the open waters of Baikal, the fauna that had evolved in the Tertiary was not only preserved, but also continued to develop, gradually adapting itself to a temperature decrease of the water. It may be assumed that the open lake biota below 2-3 m did not lose a single *species* during the ice period. Only in shallow bays and sors did thermophilic Tertiary species disappear (Kozhov, 1972).

4.3. Concepts on the origin and history of the Baikalian fauna and flora

In the early period of studies, the greatest mystery was the presence of the seal and other animals of marine facies in Baikal. Humboldt (1843), the outstanding geographer of the 19th century, considered the presence of closely related seals in the Caspian and in Baikal as evidence of the fact that these lakes had once communicated with each other.

Peschel (1878) believed Baikal to be a former gulf of the Arctic Ocean which, in a recent geological past, could have extended to Baikal and perhaps even to the Caspian and Black seas. Benedict Dybowsky and the well-known malacologist, Wladislaw Dybowsky, also believed that Baikal had been directly linked with the Arctic Ocean, from which it had received its marine forms (Dybowsky, 1884a).

A decisive blow to these hypotheses of a direct communication with the Arctic or with any other sea was dealt by geological and palaeontological studies in south Siberia, which found no traces of the presence of a sea in the Baikal area, even in the most ancient periods of the history of the earth. As far back as 1877, Chersky came to the conclusion that neither the post-Tertiary Arctic Ocean nor the waters of any other sea had reached the latitude of Baikal in East Siberia. To explain the presence of the seal in Baikal, Chersky advanced the hypothesis of an immigration from the Arctic Ocean through the Yenisei-Angara system. Credner (1887-1888) supported Chersky's view that Baikal had received its marine fauna from the Arctic

Ocean through migration rather than by direct communication.

But on the threshold between the 19th and 20th centuries, many scientists still adhered to the hypothesis of a marine origin of some elements of the Baikalian fauna. Korotnev (1901, p.35) wrote: "It is difficult ... to judge of Baikal's association with the Arctic Ocean or the center of the Central Asian basin which existed here in the past, nevertheless, 1 am personally inclined to support the former theory." The same views were expressed by Garyayev (1901), an investigator of Baikalian gammands, and the prominent German palaeontologist Neimeier (1886), both of whom considered the fauna of Baikal as well as that of the Caspian as relicts of an originally marine fauna.

Hoernes (Gemes) (1897a,b, 1898) suggested that the fauna *of* Baikal had originated m an inland sea in which Sarmatian, Maeotian, Pontian and Aralo-Caspian sediments had been deposited. Thus, Baikal received its biota from an Upper Tertiary inland sea and not from the Arctic Ocean. In his initial period of studies, Berg (1900) arrived at a similar conclusion.

In 1902, Andrusov hypothesized that many Baikalian animals might owe their marine habitus to convergence, induced by the unusual depth and size of the lake, similar to a sea. As to the roots of its peculiar fauna, Baikal received them from various basins and zoogeographical regions in different periods of its life. He did not specify, however, from what regions these ancestors originated. Andrusov (1902) attached particular importance to the long geological history of Baikal as a factor of evolution.

The longer the life of a lake, the richer and more varied its fauna. Baikal owes the remarkable variety of its fauna, in Andrusov's opinion, also to the Quaternary shifts of climatic zones, which brought to Baikal organisms now living far away from it. The study of a wealth of faunistic data obtained by the expeditions of Korotnev and others at the turn of this century made it possible to evaluate with greater certainty the origin and history of some important groups of animals of Baikal. Thus, a study of the oligochaetes led Michaelsen (1901) to the conclusion of a prevalence of phylogenetically old forms. In any case, he wrote, this fauna is older than that of European waters. In Michaelsen's opinion, across geological history, Baikal accumulated forms of local origin as well as immigrants from other lakes, which had disappeared long ago, even from the sea. Similar views were held by the malacologists Lindholm (1909) and Sovinsky (1915).

The hypothesis of the indigenous, freshwater character of the fauna of Baikal was defended and developed most consistently by Berg (1910, 1922, 1925, 1928, 1934, 1937, 1949a). In his book "The Fauna of Baikal and Its Origin", Berg (1910) claims that the modern fauna of Baikal consists of two elements: (1) forms which developed in Baikal itself, in the course of geological time (Oligochaeta, Comephoridae, Mollusca), and (2) remnants of the Upper Tertiary, heat-loving freshwater fauna of Siberia and adjacent Central Asia.

He stresses that, in the Upper Tertiary, the aquatic and terrestrial fauna of China, Siberia and Europe differed far less than today and were, on the whole, of the Chinese type. They represented a homogeneous freshwater fauna, remnants of which have been preserved in lakes Ohrid, Baikal, and Tali-fu (China), and in the Caspian Sea. Subsequently, in the glacial epoch, this fauna perished, except for remnants in Baikal, the Amur and some other places. Even the Baikalian and Caspian seal was regarded by Berg in his early work as a relict of this fauna. Later, however, he accepted the possibility of the seal and omul having penetrated Baikal from Arctic regions.

In more explicit form, the hypothesis of the "homogenous heat-loving fauna and flora of the Chinese type which lived all over North Asia, Europe and North America at the end of the Tertiary period (the Pliocene) and became extinct in the glacial period", was formulated by Berg (1909) in his book "The Fishes of the Amur Drainage". This hypothesis became accepted by most zoologists and biogeographers and provided a guide for biogeographical studies and for the development of concepts on the history of the continental hydrofauna of Eurasia, that of Baikal included.

The idea of an exclusive freshwater origin of the modern Baikal fauna was also supported by Dorogostaisky (1923b), the author of the hypothesis that the present fauna of Baikal is in a state of intense speciation. He saw a substantiation of this view in the fact that gradual transitions between species exist in several groups of Baikalian animals, in contrast to the wide gaps observed in the fauna of ancient origin. When still a shallow lake, this scientist believes, Baikal was populated by a sub-tropical fauna which began to disappear by the end of the Tertiary period, surviving only in large waters. In the glacial period, the fauna of Baikal was probably poor, qualitatively and quantitatively. In post-glacial times, under improved climatic conditions, the species that had survived began to spread vigorously, invading the almost unpopulated depths and the littoral regions, bays and gulfs, now freed from ice. In the same period, many aquatic dwellers from the faraway North, such as the seal, omul and others, penetrated Baikal via the deep Angara. This idea of a Quaternary origin of almost all the modern Baikal fauna has been further developed by Taliev (1948).

Despite the popularity of Berg's hypothesis, the idea of a marine origin of some enigmatic elements persisted. In the 1920s and 1930s the polemics on this question flared up with renewed force.

The marine origin of the main elements of the Baikal fauna was defended with great persistence in numerous articles by Vereshchagin (1928, etc.). This author believed in the existence of an extensive marine basin in Central Asia in the Mesozoic, and of a similar basin in West Siberia in Lower Tertiary times. The latter was supposedly connected with the Caspian and the Black Sea, and extended east, to the Yenisei. From these seas, Baikal could have received progenitors of some elements of its fauna. But the idea of an Early Tertiary sea extending to the Yenisei and covering large ares of West Siberia found no corroboration.

In developing his views, Vereshchagin (1930, 1940a,b) identified the following genetic elements:

1. general Siberian: forms currently widespread both in Siberia and in Baikal;
2. ancient freshwater: remnants of a Tertiary freshwater fauna, common in the past, but now occurring only in Baikal and in some large waterbodies in India, China and the Balkan Peninsula;
3. marine: forms having close relatives in the marine fauna and flora and occurring in freshwater, besides Baikal, either as marine relicts or as immigrants from the sea;
4. elements of uncertain origin.

Vereshchagin (1940) attempted to prove that Baikal, or the basins which formed it, began to develop as early as the Mesozoic. At that time it was inhabited by old freshwater elements which left remnants in its modern fauna, *eg.*, some oligochaetes, turbellarians and the Benedictndae molluscs. In the Tertiary, the area of present-day Baikal was populated by a fauna resembling that of North America. That fauna has become almost fully extinct in Siberia, but some elements survived in Baikal and in extreme East Asia. Among such relicts, Vereshchagin lists the Baikalian *Asellus* (subgenus *Mesoasellus),* some Harpacticoids, and *Epischura baicalensis* (Calanoida). In the Upper Tertiary, Baikal was invaded by a heat-loving fauna which has been preserved in South China, India and Indo-China, and in the glacial, by cold-loving biota, such as the diatoms *Aulacoseira baicalensis* and *A. islandica* (Vertebnaya 1929; Skvortsov, 1937). Finally, elements of a general Siberian fauna and flora still keep penetrating Baikal today.

In the 'marine element' Vereshchagin includes the Lubomirskiidae sponges, the majority of the gammarids, and the polychaete *Manayunkia.* The interpretation of the genesis of this group has changed considerably. He stated (1940a) that the problem of "marine elements in the fauna of Baikal can only be solved in connection with the general problem of the origin of young marine immigrants to continental waters; Baikal is only one of the few collectors of this fauna". Vereshchagin thus points to the existence of several sources in Eurasia from which 'young' immigrants from the sea invade continental waters. The main channel for the immigration of such marine forms to inland basins, *m* Vereshchagin's opinion, was provided by the freshening of basins becoming detached from the sea. With regard to active immigration via rivers, this channel was not considered of importance, for it was open only to those marine forms which could actively work their way upstream.

Vereshchagin thought that, of all sources which, since the Mesozoic, contributed to the formation of the fauna of Eurasian basins, marine relict basins in the south-east of the Trans-Baikal area were of special importance for Baikal. The system of lakes which developed in their place since the Mesozoic could have served as an intermediate stage on the way for marine elements to Baikal. Baikal might or might not have been a component of this system, and a recipient, preserving marine relicts in its fauna. In the latter instance some 'marine elements', already modified and adapted to typically freshwater habitats, could have reached Baikal via running waters. Thus, for Vereshchagin (1940a,b), the initial marine elements of the Baikal fauna migrated into the pre-Baikal basins during three different periods: at the end of the Mesozoic (from the relict basins of the Trans-Baikal area), in the Tertiary (from the seas of South-East and East Asia), and in the Quaternary (from the Arctic Ocean), including active migration using rivers (the seal, the omul).

The problem of a freshwater or marine origin of the Baikal fauna was further developed by Martinson (1958, 1967, 1980) and Starobogatov (1970, 1986). Invasion of continental water basins occurred at different periods of time. This circumstance can account for differences in ecological peculiarities and ranges of different species. Primary aquatic species (those which penetrated continental waters from the sea) are subdivided into four groups in the Martinson-Starobogatov's scheme:

1. archeolimnic species, with no close relatives at present among marine biota; these evolved in continental water basins during the whole Phanerozoic, up to the Devonian;
2. palaeolimnic species, rather remotely related to marine ancestors which, in all probability, colonized the continental water basins from the Devonian to the Permian (350-230 10^6 B.P.);
3. mesolimmc species in families close to marine ones or even in isolated genera of marine families; these could have invaded continental waters from the Trias to the Palaeogene (230-65 10^6 B.P.),
4. neolimnic (the Neogene-Anthropogene, less than 65 10^6 B.P.) species: recent immigrants from the sea, belonging to modern marine families.

The representatives of the first and second groups have become adapted to the variety of conditions in continental freshwater basins; the representatives of the third group are typically freshwater and live at a high oxygen content and at relatively constant temperatures; the representatives of the fourth group are oxyphilic and stenothermic, sometimes prefer brackish waters, and occur in areas of Cenozoic marine transgressions.

It should be noted that the degree of differentiation of these groups depends upon their osmoregulatory abilities: the more perfect these abilities are, the wider the range of conditions of continental waters to which these organisms may adapt. The representatives of groups 3 and 4 are subdivided, in their turn, into three subgroups. This system is consistent with the division of primary aquatic species developed by Mayr (1944, 1947) and Banarescu (1975).

Starobogatov (1970) points out that in lakes Baikal and Ohrid, mesolimnic forms are predominant, and in Lake Tanganyika, neolimnic ones. In the brackish Caspian Sea, palaeolimnic forms are totally absent, but a considerable number of neohmnics occur. Beside these gigantic lakes, mesolimnic forms dominate in rapid rivers, streams, springs and underground waters. Secondary aquatic organisms (those which penetrated into continental basins from the land) have also been subdivided by Starobogatov (1986) into groups. The mesolimnophihc group either became assimilated in all the diversity of continental basins or is strictly rheophilic, but the main point is that most of its biota, one way or another, have adapted to the consumption of oxygen dissolved in water. These organisms must have penetrated continental basins from the Carbon-Permian at the middle or end of the Cretaceous. Neohmnophilics include Cenozoic intruders into fresh and brackish waters at shallow depths (the first cm from the water edge), using atmospheric air for respiration.

Table 4.1 shows the correlation between some Baikalian endemics and various groups of intruders of primary and secondary aquatic organisms.

This scheme is of a hypothetical character and its judgment rests with the scientists studying each of the systematic groups involved. It is difficult to extend it to the aquatic plants of Baikal. Nevertheless, Cyanophyta, Chrysophyta, Volvocaceae, Tetrasporaceae, and Clorococcaceae are evidently archeolimnic. Bacillariophyta, Peridiniacea, Ulothrichaceae, Chaetophoraceae, Cladophoraceae and probably Charophyta are mesolimnic (Starobogatov, 1986). Thus, among the endemics of Baikal, mesolimnic species prevail. These were considered to be recent immigrants from the sea and served as an argument in favor of the marine origin of the Baikal fauna. Hence, the answer to the question of

Table 4 I. Palaeolimnic, mesolimnic and neohmmc groups of organisms in Baikal (According to Porfiryeva, 1977, Starobogatov, 1989, Okuneva, 1989; Mazepova, 1990, Sideleva, 1985, Tmioshkm, 1994)

Palaeohmntc	*Mesolimnic*	*Neohmmc*
Hydndae	Lubomirskndae	
Eurotatona	(Spongia)	
(Rotifera)	Gymnolaemata	
	(Bryozoa)	*Phoca sibirica*
Naidomorpha	*Monhvstera*	
(Ohgochaeta)	*Penzanaa* (Nematoda)	
	EthmalaimusJ	
Tobnhdae	*Manayunkia* (Polychaeta)	
(Hirudinea)	part of	
Prorhynchidae	Candonmae	
(Turbellana)	(Ostracoda)	
Bathynellidae	Benedictndae	
Valvatidae	Baicalndae	
Pisidiojdea	(mollusca)	
	Dendrocoehdae	
	(Turbellana)	
	Lumbnculidae	
	(Oligochaeta)	
	Chironomidae (Diptcra)	
	Plecoptera	
	Ephemeroptera	
	Piscicolidae (Hirudmae)	
	Acipensendae	
	Salmonidae	
	Cyprmndae	

the marine or freshwater origin of the Baikal fauna is that it is undoubtedly of freshwater origin (Berg and his followers were right), but at the same time, it is characterized by a prevalence of descendants of late immigrants from the sea-mesolnnnic forms and it contains an insignificant number of neo]imnic *forms,* consistent with Vereshchagin's hypothesis.

According to Martinson (1967), most of the mesolimnic complex originated in the Cretaceous-Palaeogenic inland basins of Central Asia, one of the formative regions of freshwater fauna. In mid-Tertiary times, these species reached Baikal via the Praselenga River and on the threshold of the Neogene and Anthropogene, the most enduring of them became a component of the biota of Baikal proper. This is confirmed by finds of molluscs of the families Benedictndae and Baicalndae in Lower Cretaceous deposits of the Nilgmskya trough in Eastern Mongolia and in Late-Cretaceous deposits of the South Gobi (Martinson, 1982). This thermophilic fauna reached northern latitudes in Asia, confirmed, according to Martinson (1988), by palaeontological finds of molluscs in Eocene deposits of the Kengdei River in the region of the Lena delta (Northern Verhoyanye).

Martinson (1967) also believes that in these Central Asian basins, common roots of the Baikalian and Caspian fauna can be found. In his opinion, the river network of Mongolia and China served as a means of transport for the migration of aquatic organisms, not only towards Siberia but also to the West, including the Ponto-Caspian basin.

Starobogatov (1970) finds it unlikely that the fauna of Baikal might stem from these ancient lakes of Mongolia. Rather, the endemic fauna of large lakes is so well adapted to a lake regime that it can hardly serve as a direct propagule for the colonization of other lakes, and the non-endemic fauna of such basins, as a rule, contains extremely few mesolimnic species. In Baikal the endemic fauna is richly represented by mesolimnic species.

Starobogatov, as well as FCozhov, assumed the species living in streams, springs, and underground waters surrounding these lakes, to be the ancestors of the mesolimnic fauna of both Baikal and the ancient lakes of Mongolia. Therefore, the Cenozoic molluscs fauna of Central Asia is a 'sister' fauna of that of Baikal. Due to the vastness of the Asian continent in the Late Mesozoic, its freshwater fauna, according to Starobogatov, was rapidly becoming heterogeneous. It is difficult *to* specify the region of penetration of mesolimnic elements into freshwater, but for Benedictndae it was supposedly the east coast of Asia. In the Miocene of Siberia, mollusc complexes of East Asian origin reached their peak of development. The extremely rich Miocene fauna described from the south Baikal trough and the Angaro-Lena watershed (Rammelmeyer, 1940; Martinson, 1951, 1956; Popova, 1964, 1981, etc.) is fully represented by modern Chinese and Amur species and genera.

In the Pliocene, the East-Siberian fauna was enriched by forms of European and North-American origin. As a result of the Late-Pliocene-Quaternary climatic changes, the freshwater fauna of the vicinity of Baikal became wholly extinct, the ancestral forms of mesolimnic Baikal species disappeared, and the Baikal fauna became zoogeographically isolated from that of Siberia Starobogatov, on the basis of anatomical data (Radoman, 1967; Starobogatov, 1958; Logvinenko & Starobogatov, 1969) considers the affinity between the malacofauna of Baikal, Caspian and Ohrid to be convergent.

Lukin (1986) believes that the genetic affinity of the Baikal endemics is primarily limited to the Palaearctic or Holarctic. He assumes that there were two faunas in Baikal: an ancient one, which became extinct by the Pleistocene due to rapid riftogenesis, and a young one which replaced the first one. Its representatives moved into Baikal from mountain streams, occupied empty ecological niches and quickly evolved.

Taliev's view (1948, 1955) of the evolution of the Cottoidei in Baikal in the recent Quaternary period was later revived by several studies (Koryakov, 1964; Chernyaev, 1973: Karasev, 1977).

According to Cherepanov (1989), the average time of divergence of Baikal organisms to genus level is c. 8-15 10^6 years, maximum 13-19 10^6 years. This time interval is close to the Miocene-Oligocene period, which can be considered as the initial historical boundary of formation of the Baikal fauna (Table 4.2) (the rate of evolution of the Baikal fauna was estimated from morphological distances between 27 genera of endemic Gammaridae, Mollusca and Cottoidei).

The heterogeneous origin of the fauna of Baikal is now accepted by all scientists (Mazepova, 1990; Timoshkin, 1994; Porfiryeva, 1977; Tsalolikhin & Shoshin, 1989).

Tsalolikhin & Shoshin (1989), based on an ^{4}endemism rank', subdivide the Baikal fauna into three groups, according to the timing of their arrival in Baikal (without geological dating): archeo-, middle- and neobaikalian. The archeobaikahan group is characterized by an above-species rank of endemism, the middle-baikalian group by a species rank of endemism, and the neobaikalian group by species inhabiting the coastal-sor zone, which only recently penetrated the lake, overcoming the 'immiscibility barrier'.

All groups distinguished include representatives of palaeo- and mesolimnic complexes (with the latter prevailing in the archeobaikahan and the former in middle-baikalian group). The neobaikalian group also includes representatives of the neolimnic complex.

Tsalolikhin & Shoshin, as well as Martinson, think that the ancestors of the Baikalian mesolimnic fauna developed across millions of years in large waterbasins in Central Asia. They attribute the affinity of several Baikalian species with those of the Caspian Sea, Lake Ohrid and Far East to the wide range of their ancestors in these large waterbasins during geological time. The evolution of the palaeolimnic species of the archeobaikahan group is only connected with Baikal. They did not occur in the mesozoic basins of Central Asia. The representatives of the palaeolimnic complex of the middle-Baikalian group are still close to species inhabiting the basins of Eastern Siberia today.

Summing up the modern conceptions of the origin of the Baikal fauna, and the time of penetration of ancestral species into Baikal, we note that researchers have often interpreted differently (frequently the same) data on morphological similarity of taxonomic groups, zoogeographical ties between animals, and material of palaeontological nature.

4.4. Main genetic groups in the biota of Baikal and their origin

Proceeding from present-day knowledge of the composition and distribution of the Baikalian biota

Table 4 2 Rate of evolution of Baikal fauna After Chcrepanov, 1989

Group of animals	*Number of genera*	*Morphological distance in %*		*Divergence (W years)*	
		average	*maximum*	*average*	*maximum*
Gammandae	14	28 2	38 6	14.1	193
Mollusca	2	30 4	–	15.2	–
Pisces	11	160	27 4	8 0	137

and from biogeographical and palaeontological research, Kozhov divided the biota of Baikal into the following genetic groups (Kozhov, 1963):

Representatives of modern Siberian-European fauna

In this complex, heterogeneous in origin, ecological groups can be distinguished.

Limnophiles, This group comprises forms which are identical or closely related to forms now living in shallow lakes around Baikal and other eutrophic waters. Siberian limnophiles in Baikal inhabit almost exclusively *littoral* sections: sors, sheltered bays, and enclosed parts of gulfs. On the whole, they correspond to the category which Vereshchagin (1935) called the Siberian complex. This consists of Spongillidae sponges, lacustrine Siberian-European species of Mollusca, Oligochaeta, Hirudinea, Rotifera, Copepoda, Cladocera, Trichoptera, Chironomidae, and Gammaridae *(Gammarus lacustris).* The fish include *Rutilus rutilus lacustris, Leuciscus idus, Phoxinus, Perca fluviatilis, Esox lucius,* and other lacustrine species which, according to Nikolsky (1947, 1955) belong to the Siberian plains complex. For reproduction, they either enter marginal lakes or spawn in Baikal's sors and gulfs. But in summer, and in some parts in winter as well, they spread along the shores to more or less open shallows of the lake. In summer, Siberian species *of* planktonic Rotifera, Copepoda, Ciliophora and algae are carried by currents from sors and sheltered gulfs into the open waters of Baikal But there they are dispersed, and quickly perish.

Limnorheophiles. A fairly large number of forms are closely related or identical to species common in Siberia's large and deep lakes, rapid rivers and streams and partially in eutrophic waters, but only in the cold season. Immigrants from such waters in Baikal inhabit the open *littoral, rarely* the sublittoral zone, constituting part of the open-water biocoenoses together with indigenous Baikalians. In littoral-sor regions they occur only in the cold season. In other words, their habitat in Baikal resembles that of their relatives.

As a rule, those forms of this complex which live in deeper zones of Baikal (the sublittoral or the lower littoral) have deviated to some degree from their parental stock and comprise endemic varieties, whereas the littoral and plankton forms differ little from their ancestors. This group includes, in all probability, species of chironomids and oligochaetes from the genera *Mesenchitraeus* and *Nais,* possibly some littoral nematodes, freshwater hydras, etc. The fish include *Thymallus arcticus baicalensis* and *T.a. brevipinms, Lota Iota* with its Baikalian deepwater variety, and the Baikalian form of bottom-living gwyniad, *Coregonus lavaretus,* with its parasites. The dace, *Leuciscus leuciscus,* probably belongs in this group as well. Some members of this group pertain to the submontane complex of Nikolsky *(Thymallus),* others were originally migratory species which settled in Baikal (the sturgeon, gwyniads). Their closest relatives live in mountain and big valley rivers of Siberia (grayling, gwyniad, sturgeon, dace, burbot), and in the littoral of its deep mountain lakes.

The pelagic organisms belonging to this group apparently include ciliates and flagellates which live in the open littoral, Baikalian forms of such widespread rotifers as *Notholca longispina, N. striata acuminata, Keratella quadrata, K cochlears* and *Fihnia longiseta,* and perhaps the copepod *Cyclops kolensis,* which sporadically occurs in North Europe and Siberia.

It was this group of Siberian limnorheophiles that Vereshchagin (1935) had in mind when he established the Siberian-Baikalian biogeographical complex among the inhabitants *of* Baikal. But he also referred to it a number of elements which should be identified with other genetic groups discussed below. Vereshchagin considered the Siberian species in Baikal's open waters as being genetically young, still in the process of being incorporated into its fauna. This cannot be accepted without reservations. Siberian limnorheophiles, fish included, have undeniably lived in Baikal and the waters around it since the initial stage of its history, *i.e.,* in the Tertiary and later periods. The reason for their insignificant deviation from *modern* Siberian species does not lie in their being 'young' immigrants to Baikal, but in the fact that conditions in the Baikal littoral do not differ much from those of other Siberian lakes and rivers. With regard to the fish (gwyniad, grayling, burbot), it should be borne in mind that their Baikal populations, which need rivers for spawning, can mix there with ordinary fluviolacustrine populations, another obstacle to speciation.

Descendants of inhabitants of the Tertiary Holarctic region

This group includes those inhabitants of the open waters of present-day Baikal whose closest relatives do not live in waters adjacent to it, but occur in broad disjunction, chiefly within the confines of the Siberian-European subregion of the Palaearctic, and partly in North America.

In Baikal, this complex is represented by endemic varieties, species, and sometimes genera. They inhabit all kinds of biotopes, but chiefly the open littoral, sub-littoral and deeper strata, up to extreme depths. Among them are many Baikalian oligochaetes, some species and genera of turbellarians, leeches of the family Piscicolidae, the crustacean *Epischura baicalensis* (Copepoda-Calanoida), which is one of the most typical inhabitants of the pelagic, the isopods *Mesoasellus* and *Baicalasellus,* some species of Harpacticoida and Ostracoda, as well as Trichoptera of the group Baicalinini, Chironomids of the subgenus *Baicalosergentia,* and some endemic pelagic ciliates. This complex probably also includes endemic peridineans of the genus *Gymnodinium,* and the diatoms *Cyclotella baicalensis, C. minuta* and *Aulacoseira baicalensis.*

The extreme age of this complex can be illustrated by the example of the Baikalian Trichoptera. Their endemism is distinct; they have lost connection with their nearest relatives, and their separation from the stem in common with limnophilids was dated by Martynov to the middle of the Tertiary. Since then, they have been broken up into several species and genera and have acquired distinct morphological and biological characters, which developed under the conditions of the lake.

It also took much time for the development, in the Baikal deeps, of such an endemic genus as *Baikaloplana valida,* a giant turbellarian with hundreds of lateral suckers.

Baikal and other lakes of its system were colonized by this group, chiefly during the Pliocene and Miocene cooling of the Siberian climate and the retreat of the fauna of northern regions to the south. The influx of immigrants from the north increased gradually at the end of the Pliocene and the beginning of the Pleistocene. In that period even high-Arctic elements, such as *Salvelinus alpinus enthrinus,* could work their way to Baikal and other waterbodies of the Baikal mountain region.

Descendants of dwellers of ancient Central Asian basins

This group includes some enigmatic elements, whose endemism is expressed most vividly. It incorporates endemic species, genera and even families. They are remotely related to the fauna of the running waters of China (molluscs of the genus *Kobeltocochlea* related to *Lithoglyphus),* the fossil faunas of the Tertiary Central Asian basins (Baicaliidae molluscs), the modern dwellers of the large lakes of South Siberia and Mongolia (the Lubomirskiidae sponges of Lake Dzhegetai, the *Choanomphalus* molluscs in Lake Khubsugul), and, finally, to some species inhabiting South Asia (the leeches Toncinae, the bryozoan *Hislopia).*

It is possible that gammarids, too, may be part of this group.

It was this complex that was regarded by Vereshchagin (1940b, etc.) as chiefly marine, and by Berg (1949a,etc.) as a relict of a thermophilic freshwater fauna, widespread in Eurasia and North America at the end of the Tertiary. Using palaeontological data, Martinson (in his early works) called approximately the same group of molluscs 'Balkanian'. At present, as mentioned above, he prefers to call it mesolimnic.

So far there is no possibility of clearly distinguishing the Central Asian complex from Tertiary Siberian-Holarctic forms. In any case, it can be asserted that, in the first half and middle of the Tertiary period, North Siberia (the geologists' Siberian platform) harbored two independent centers of origin of aquatic and terrestrial faunas. The part of Siberia north and north-east of the South Siberian mountain systems, drained by the great Siberian rivers, abounded in shallow lakes. There, in a temperate climate, the hydrofauna which served as a foundation for the modern Holarctic fauna had been evolving for millions of years.

At the end of the Mesozoic and in the Tertiary, Central Asia, as distinct from Siberia, was a tectonically active land of mountain structures and lacustrine basins Evidently some of these often approached extensive semi-marine basins which intruded deep into Asia from the east, or onto remnants of the Tethys Ocean in the west

The dissected relief of the country, climatic contrasts, and the nearness of marine basins favored the development of a fauna differing from the North Siberian fauna of the Tertiary From its origin until the Pliocene cooling, the region of Baikal fringing on the northern outskirts of Central Asia must have been under a stronger influence from the Central Asian and also perhaps, to some degree, East Asian fauna, as well the valley and heat-loving fauna, than from the more cold-loving fauna living in mountain basins, rivers, and cave waters

The colonization of the lakes of the Baikal mountain region by the Central Asian fauna must have taken place in the earliest stages of the formation of Baikal, in the first half or middle of the Tertiary, and certainly before the Tertiary fauna had begun to penetrate there from North Siberia This explains the particularly pronounced endemism of its descendants in Baikal

The outward similarity between some modern species of Baikahan gammands and gastropods and Caspian species (Bazikalova, 1940, 1945, Martinson, 1958) is not proof of a close kinship Today, it has been well established that, in the Tertiary, the Pontocaspian and adjoining areas, as well as the Balkans, were an independent center of origin of hydrofauna, not connected with the Siberian and Central Asian center characterized above Of course, the faunas of these widely separated regions influenced each other, but without loosing their distinctive features (Komarek, 1953, Stanković, 1932, 1955a,b, 1960)

As stated above, the Baikal fauna contains a number of species whose closest relatives occur in underground waters and springs in Western Europe, the Balkans, Japan, North America and other regions *of* the world, *far* away from each other Among these are Bathynelhdae, water mites of the genus *Cerebrothombidium*, and Cyclopoids in the genera *Acanthocyclops* and *Orthociclops* Evidently, this fauna is a remnant of an ancient, partially pre-Tertiary fauna that inhabited Asia and Europe during a warm climate They and their descendants are only extant in few places Baikal is one among them

Information has accumulated about the presence of genera, related to Baikal forms, among turbellanans, ohgochaetes, leeches, Toncmae, Isopods, and other groups inhabiting the drainage basin of the Amur, the regions of China adjacent to it, and Japan It can be supposed, therefore, that the old faunas of Central and East Asia considerably influenced each other A channel for this intercourse may have been the ancient Amur and the extensive chain of ancient basins cited by Martinson (1955a), which stretched from Japan to Central Asia

Immigrants from the Arctic Ocean and basins on its coast

This group includes *Coregonus autumnahs migratorius* and the seal *Phoca sibinca*, together with their parasites They must have penetrated Baikal during the great advance of the Arctic Ocean in the Quaternary, as pointed out by Chersky back in 1877 During this advance, the waters of the ocean covered the vast territory of the modern Arctic coast, and the great Siberian rivers had to cover much shorter distances before emptying into it Moreover, during the retreat of the glaciers, they carried much more water than now The omul and the seal, having penetrated Baikal via these rivers, found conditions there resembling those of their distant birthplace

The origin of the progenitors of the modern Baikahan Cottoidei, including the Comephondae, has not been sufficiently elucidated Tahev (1955) thought that their progenitors penetrated Baikal along the Amur system from the Far-Eastern seas in Quaternary or even post-Quaternary times These ancestors then diverged from the Far-Eastern marine Cottoidei If this supposition is confirmed, a group of animals of marine extraction should indeed be distinguishable in Baikal But there are no grounds for the idea that they appeared in Baikal only *in* post-Pliocene times They could not have penetrated there later than the progenitors of gammands and other distinct endemics of Baikal (Kozhov, 1962)

Sideleva (1990) supposes that the Cottoidei of Baikal originated from freshwater ancestors which occupied the waterbasins of Eastern Siberia at different times Only some of them (for example, *Batrachocottus)* have retained features typical of marine species. The endemic families Comephondae and Abyssocottidae are descendants of immigrants in the Tertiary, and the Cottidae - of Late Pleistocene times.

In a later work, Kozhov (1972) summarized various concepts on the origin of the fauna of Baikal. He doubted the direct kinship of the Lower-Cretaceous fauna of Central Asia and that of South Siberia, and inferred that, as early as the Palaeogene, these faunas had evolved independently. At the beginning of the Palaeogene, there was a thermophilic South Siberian fauna of 'Palaeolimmc' facies (according to Martinson). It colonized shallow eutrophic lakes, regions of large valley rivers with slow currents and other similar sites, and was much richer and diverse than at present. Its representatives invaded the coastal area of Baikal. With climatic cooling, many of these heat-loving species became extinct and, outside Baikal, were preserved only in South and South-East Asia.

The ancestors of the overwhelming majority of modem species of Baikal inhabited cool or even cold waters before penetrating the lake; oligotrophy mountain lakes and underground basins which existed in the Palaeogene in the region around Baikal. Beginning with the Oligocene, the fauna that colonized Baikal gradually acquired its specific features and became Baikalian proper, isolated from adjacent eutrophic lakes. Kozhov pointed out that it was not depth, but the long history of the lake that made the formation of its endemic species possible It is known that, in young lakes, even very deep ones, the fauna is not endemic. Such large, deep lakes as Teletskoe in the Altai, Ladoga and Onega in Karelia, the alpine lakes of Switzerland, the lakes of the Laurentian system in North America, having existed for only a few thousands or tens of thousands of years, have no endemic species. They are inhabited by the fauna of the *surrounding rivers and lakes.*

Kozhov also stressed the existence of species not endemic to Baikal. They include not only young immigrants, but also more ancient forms which never lost their ecological and genetic links with 'continental[1] populations.

No new hypotheses on the origin of the Baikal fauna, refuting Kozhov's point of view, have appeared in the last ten years.

4.5. Evolution of the fauna of Baikal

As shown in the preceding pages, Baikal communicated with different biogeographical regions across its long history, and received immigrants from them. This type of colonization of old lakes, islands and other isolated areas by migrants is referred to in the literature as multiple colonization, and some authors hold it chiefly responsible for the variety and abundance of the fauna in old lakes. (Vfayr (1944, 1947), for instance, considers that *old* freshwater lakes are, for freshwater fauna, what old islands are for terrestrial fauna. They permit the survival of old elements which have long become extinct in surrounding areas. In Mayr's opinion, such old lakes as Baikal, Tanganyika, Malawi and others became populated by multiple colonization.

But the variety of life in ancient lakes cannot be explained by colonization alone. Students of their fauna have come to the conclusion that the majority of species inhabiting them today have evolved *in situ.* With regard to African lakes, this opinion was first voiced by Worthington (1954). Identical views on the fauna of ancient lakes in central Celebes were published by Woltereck (1931), on the fish of Lake Lanao, Philippines, by Herre (1933), on Lake Ohrid by Stankovič (1932, 1955a,b, I960), and on Lake Baikal by Dorogostaisky (1923b), Berg (1949a), Vereshchagin (1940b) and modern students of its fauna.

The scope of this autochthonous evolution in Baikal can be judged from the following data.

Intense speciation is also observed among the benthic Cyclopoida, Chironomidae, and many other groups. At the same time, a peculiarity of the Baikal fauna is that many major taxonomic groups are missing. The open waters have no large Unionidae; Ephemeroptera are rare; there are no gastropods of the families Vivipandae and Bithyniidae, *no Plecoptera, Decapoda, Branchiopoda and other* groups common in the waters of Siberia and Europe. Therefore, the conditions of Baikal seem suitable for only a few representatives of the hydrofauna that inhabit the adjacent regions. Also noticeable is the high individual and group variability of Baikalian species, especially those belonging to speciose families and genera. For example, Taliev (1948, 1955) emphasizes the strong individual variability of the Baikalian Cottoidei, while

Table 4 3 Number of presumed parental species for some groups of the fauna of Baikal and number of species and genera which have evolved from them *in situ* After Kozhov, 1963

Groups	*Number of presumed ancestors (parental species)*	*Evolved from them in Baikal*		
		Species	*Genera (subgenera)*	*Families and Subjam **
Porifera				
fam. Lubomirskndae	1-2	6	**3**	**1**
Turbellaria				
Tncladida, Dendrocoehdae	3	37	**13**	-
Prolecithophora	I	7	**3**	1*
Lecithoepithehata, Prorhynchidae	3	7	-	-
Ostracoda				
Candoninae	3-4	86	**1**	-
Cythendae	1-2	46	-	-
lsopoda				
gen *Baicalasellus*	1-2	4	**1**	-
Amphipoda				
Gammandae	4-5	257	**34**	-
Trichoptera				
gr Baicalmmi	2-3	15	**3**	-
Mollusca				
Gastropoda, Baicalndae	3-5	37	**8**	**1**
Benedictndae	2	15	**2(2)**	**1**
Valvatidae	2	11	**(2)**	-
gen *Choanomphaius* (Planerbidae)	2	22	**(7)**	-
Pisces				
Comephondae	1	2	**1**	**1**
Abyssocottidae	2	20	**6**	**I***
Cottidae	2	5	**1**	**1**

Bazikalova, in a number of works, points to the exceptionally high individual and group variability among gammarids. Among the Mollusca, too, we find numerous species which vary strongly and differ only slightly from one another.

It should also be noted that numerous species from groups where differentiation has been particularly rich, unite around a few basic types in what may be called series of similar forms. For instance, the molluscs of the family Baicaliidae are represented by 37 species differing in size, number of whorls and ornamentation of the shell. But in anatomical characters such as the nervous, genital and digestive systems, all of them form a single, closely related group (Kozhov, 1951, etc.). Bazikalova (1945) records the same phenomenon, in Baikalian gammarids. Taliev (1940), studying the Baikalian Cottoidei by serodiagnostic methods, established that differences between them are insignificant, much weaker than the generic and specific serodiagnostic indices among the Salmonidae.

These peculiarities of the Baikal fauna bear a strong resemblance to analogous features in other ancient lakes (Tanganyika, Malawi, and others), and oceanic islands. Baikal has an 'insular' fauna, with its own specific features, such as profound endemism, high variability, and slight interspecific differences.

Since Baikal consisted of an extensive body of water or a system of such waters in the middle of the Tertiary, there has been sufficient time for the evolution of its fauna. To substantiate their hypotheses, Dorogostaisky (1923b), who insisted on the Quaternary age of the entire Baikal fauna, and Taliev (1948), used the popular mutation theory. Taliev (1948) wrote: "Is it not that Baikal has, in view of its young tectonic age and deep position in the hthosphere, specific features conducive to the mutational variability of deep-water dwellers?'". Yet, Kozhov (1963) thought that it was perfectly possible to do without such assumptions in explaining the evolution of the Baikal fauna.

Two main views explore the process of divergence of species into groups of new species:

1. Ailopatnc speciation (in Mayr's terminology, 1944), with spatial isolation of the populations of an initial species as starter for the development of new subspecies and species.
2. Sympatric speciation, without isolation of populations by geographic *obstacles, i.e.*, in a non-dissected lake. In its broad sense, this includes parapatric speciation, where isolation is achieved by horizontal or vertical zoning.

Mayr (1944) states that the evolution of new species can only be allopatric, *i.e.*, induced by geographic isolation. Sympatric speciation, in his opinion, is rarely possible. He is supported by Brooks (1950), who attempts to prove that, in ancient lakes, Baikal included, species were formed chiefly by spatial isolation of populations of parental species in separate lake sections. Every new taxon, in the opinion of these scientists, becomes hereditarily stable only after spatial isolation from congeneric forms. New forms can retain their originality when conditions change, *i.e.*, when barriers break down and contact with allied forms is regained.

In lakes Tanganyika and Nyasa (= Malawi), Brooks points to the existence of spatially isolated sections of shore, inhabited by isolated populations. Among such biotopes, he mentions shallow bays, gulfs separated by deeps, and other obstacles. Special importance is attached to marginal lakes, into which the fauna of the main lake can penetrate and remain isolated for a long time. Resettling later in the main lake, the new forms find suitable biotopes there and can diverge further, but already on the basis of biological relationships. This picture of allopatric fauna formation is exactly what Brooks tries to draw for Baikal.

At the present time, we have sufficient data to confirm that the development of taxa in Baikal on the basis of isolation did and does indeed take place.

As shown above, the modern zoogeographical zoning of the lake stems from differences in the composition of the fauna inhabiting its various sections. We have seen that differences are especially marked between the north and south, which can only be explained if we assume that the lake recently consisted of at least two parts, separated by an above-water threshold. There are topographic and biological grounds for such an assumption. Local forms exist in areas with a distinct habitat, such as the Ushkany Islands, the Maloye More, the Selenga Shallows, some sors, etc. The great length of the shoreline itself (more than 2000 km) is also conducive to the isolation of separate populations of given species, occurring in one depth zone all along the shoreline. Here are a few examples. A common species among Baikalian molluscs is *Choanomphalus maacki*, which inhabits the littoral of the whole lake A study of the populations of this species shows that the shape of its shell varies from place to place. In the south-west, where the littoral is predominantly rocky, *maacki* has a tall, almost turreted shell and a wide, funnel-shaped umbilicus with steep and flat walls (var. *andrussowianus* Ldh.). Further north along the south-west shore *(the Goloustnaya section), its she)) becomes* shorter and correspondingly broader (f. *typica).* In the Maloye More and north of it, where sandy bottoms predominate, the shell is entirely flat, with a wide umbilicus (var. *elatior).* This \ariety is typical in northern Baikal and along its south-east shore (the north Baikal section), while to the south of the Selenga we again find the tall south Baikalian var. *andrussiwianus.* A similar picture is observed for *Ch amauronius.* The difference in the form of the shells of these (and many other) species from various habitats is so conspicuous that the majority of local *forms* were formerly described as separate species.

The mollusc *Maackia herderiana* abounds on the rocky bottom of the littoral along the southern shore, where its cone-shaped shell has well defined costae lying across the whorls In the littoral of the northern half of Baikal, it is replaced by a closely related species, *M. variesculpta,* whose shell is characterized by the conversion of the costae into rows of knolls. But at the meeting point of the two, along the west shore in the area of the Anga-Buguldeika, forms can be found that are clearly transitional.

The species *M. angarensis*, which is close to *M. herderiana*, lives in the Angara. Its shell is entirely devoid of costae and is much smaller than that of *M herderiana*, and these characteristics are apparently explained by conditions of life in a rapidly flowing river.

Allopatric speciation must also have been favored by the fact that at one time Baikal was at the center of the giant system of tectonic troughs situated west, east and north-east of it and which, as noted above, contained extensive lakes. There may have been contact between the littoral faunas of these lakes. Remnants of Baikalian fauna still survive in the large, running-water lakes now filling these troughs.

But a deeper analysis of the composition and distribution of the Baikal fauna, in the lake itself and outside it, suggest that its evolution, starting from relatively few parental forms, was controlled by a gradual deepening of the lake, the resulting appearance of new biotopes, their colonization and, as a consequence, the gradual splitting of species into littoral and deepwater forms without marked participation of spatial isolation between diverging populations.

The subsidence of the bottom gradually changed the physical outlook of the lake, which was developing into a vast, deep reservoir. The thermal and chemical regime of the lake, seasonal rhythms, composition and quality of its bottom, light-intensity, etc., were also changing. All this in itself served the inhabitants of the lake, adapting to the new conditions, as a factor of physiological isolation from the inhabitants of ordinary lakes or rivers. Thus, the deepening of the trough and the appearance of new biotopes inside the lake created conditions for a separation between littoral and deepwater populations. These subsequently evolved into varieties and species without geographical obstacles.

That spatial geographical isolation may have played only a secondary part in the evolution of Baikal, can be illustrated by the following examples. As shown above, some Baikalian forms penetrated far to the north and settled in such Arctic waters as Lake Taimyr and the lakes of the Gyda watershed (between the Yenisei and the Ob) via the Angara, the Yenisei, and ancient arms of the latter. There, they were fully isolated from the initial Baikalian and even Angara-Yenisei populations of the same species. Apparently, they lived there in isolation for many millenia, but remained close to the Baikal species, to the point of remaining identical to them. Despite a still longer period of isolation from the initial species, 'Baikalian' species which survived in the vestiges of old lakes of the Baikal system and in the drainage area of the Vitim and the Chara (the Lena watershed), also differ from them only slightly, if at all.

An essential fact, in Kozhov's opinion, for a correct understanding of autochthonous speciation in Baikal is that the greatest number of endemic forms is observed, not in the shallow littoral area, but at depths of eight to 200 meters This zone harbors all sponges, and 65% of the ohgochaetes and turbellarians. Only eight of 29 forms of Cottoidei live in the 5-25 meter zone, whereas the 150-500 meter zone is inhabited by 20 forms; 16 forms live below 500 m (Taliev, 1948; Sideleva, 1982, 1994).

According to Mekhanikova *et al.* (see list of species), 92 species and varieties of gammarids live in the 0-5 meter zone; 160 in the 5-20 meter zone; 162 m the 70-150-300 zone; and 80 in the 300-500 meter zone.

The Bathynellidae, some Cyclopoida, Harpacticoida, Ostracoda and Nematoda, also live beyond the littoral. Yet, it should be remembered that the deepwater fauna of Baikal {*e.g.,* the Nematoda) has not been studied as carefully as the fauna of the littoral. In future, the number of deepwater species is likely to increase considerably.

The deeper and more comprehensive our knowledge of the Baikal fauna becomes, the more we become convinced that the zones between 5-10 and 100-200 meters were the birthplace of the vast majority of Baikalian endemics.

Vereshchagin (1935) considered the fauna at depths of below 500 meters to consist solely of old endemics, while the fauna of lesser depths is a mixture of old *endemic* and younger elements. Kozhov (1963) did not agree with this. According to him, old parental forms at great depths can only be an exception. As shown by detailed morphological studies of series of related species succeeding each other vertically, the colonization of deep zones of Baikal started from the shallows and was accompanied by a divergence of littoral forms settling in new deepwater biotopes. Thus, the majority of abyssal species of gammands is closely connected to modern littoral and sublittoral species.

Pnmarity littoral and sublittoral genera of gammands	*Sublittoral-supra-abyssal genera and subgenera that diverged from them*
genus *Euhmnogammarus* (subgenera *Euhmnogammarus, Ph\loitmnogammariu)*	subgenera *Eutybiagammarus,* and *Corophtomorphus,* genus *AbysiOgammarui*
genus *Crypturopus* subgenus *Acanthogammarus*	genus *Homocensca* subgenus *Brachuropus*

It is interesting that the burrowing abyssal gammarids are closely related to burrowing forms inhabiting the shallows. For example, according to Bazikalova (1945), the abyssal species *Homocerisca caudata* is closely related to the shallow-water//, *perla; Carinurus reissneri* to *C. solskii,* etc.

Analogous series of species are also found among molluscs. The initial form for the gastropods of the subgenus *Benedictia,* which includes seven species and several varieties, was probably *Benedictia litoralis,* which abounds at between two to three and 15 to 20 meters, or *B. limnaeoides,* which is anatomically close to it and inhabits the zone between ten and 30-60 meters. Giant *B. fragihs,* lives at 50 to 200 meters and deeper, and, finally, *B nana* is common in the 300-400 meter zone and deeper (Starobogatov & Sitnikova, 1990). The abyssal fauna of oligochaetes, according to Izosimov (1949) and Semernoy (1987), is also young, still in formation and allied to the shallow-water fauna. Sponges occur chiefly m the littoral and sublittoral, but they, too, form a series of species succeeding each other vertically, *Lubomirskia* is a littoral and sublittoral genus, while *Baicalospongia* reaches depths of 400 and 500 meters and more. Possibly, some abyssal species have already lost their roots. With regard to the Bathynellidae found at great depths, Bazikalova (1954c) assumes that their ancestors colonized ever greater depths parallel with the progressive subsidence of the bottom of Baikal. Nor is it *accidental that tt* is precisely that part of the fauna with the greatest radiation of species that populates Baikal from the water's edge to its greatest depths (Gammaridae, Turbellaria, Oligochaeta, Cottoidei, Cyclopoida, Nematoda).

With the gradual deepening of the lake and increase of its water mass, a distinct pelagic fauna evolved from original bottom and near-bottom forms at great depths, The genus *Poekilogammarus* diverged from the benthic genus *Pallasea,* while the nectobenthic but deepwater species of the latter gave rise to the genus *Macroheciopus* (with one species, *M. branickii)** which leads an exclusively pelagic way of life. First nectobenthic and later typically pelagic species, comprising the endemic subfamilies Cottocomephorinae and the endemic family Comephoridae, evolved from the originally benthic and then semi-pelagic species of Cottoidei.

How, then, in what spatial isolation, in what bodies of water or their parts, could the abyssal benthic and pelagic species, genera and families inhabiting Baikal today have evolved?

If it is assumed that abyssal species could have formed outside Baikal in deep lakes in the Baikal area, it remains a mystery as to how they could penetrate its depths, being absolutely incapable of surviving in rivers and shallow lakes. It should rather be supposed that, as depth increased and empty biotopes appeared, populations of various littoral species moved in from densely populated habitats. In the deep zone, they found a new environment, especially with regard to temperature, light intensity and bottom type, which triggered a change in the characters of these immigrants.

The new thermal and light conditions must have directly affected the physiology of such new settlers. Their growth and development were inhibited because of lower temperatures and insignificant seasonal changes; the seasonal rhythm of their life cycle and especially of their reproduction began to disappear; life span grew longer; the period of immaturity lengthened, and so on. All this was bound to encourage a physiological deviation of the immigrants from the parental littoral zone and, consequently, an evolution into new forms.

After millions of years, and under the influence of natural selection, the cycle of reproduction and growth in the abyssal descendants of littoral species became greatly protracted, while some of them acquired the ability to multiply around the year. The colder water retarded the development of the embryo in the body of the mother, which caused some species to become viviparous (Comephoridae, some turbellanans, etc.). As a result of these low temperatures (especially in the glacial period), Bazikalova (1948a, 1951a, 1954b) and Bekman (1958) claim that some species of Baikal gammarids have become neotenic They permanently retain juvenile features

Also conspicuous is the 'gigantism' of many abyssal species Among molluscs of *the* genus *Benedictia* the largest species, *B fragihs,* lives at a depth of up to 200 meters The abyssal species of gammands and oligochaetes are also, as a rule, larger than their littoral relatives The largest turbellanan, which reaches 30 centimeters in length, only occurs beyond the littoral The largest isopod species, *Baicalasellus dvbowskn,* lives at great depths, while the largest Baikahan oligochaetes, *Limnodrdus inflatus, L bvthius* and *Rhynchelmis brachycephala,* are also abyssal Gigantism is also observed among abyssal Cottoidei Yasnitsky (1952) points out that a specific feature of Baikal algae is the greater size than that of related forms from ordinary lakes Yet, the opposite phenomenon, 'nanism', is also observed among abyssal species the mollusc, *Benedictia nana,* which is the smallest of all presently known Benedictndae, lives down to great depths There are also small-sized species among deepwater burrowing gammands, especially those of the genus *Micruropus*

Changes induced by low light intensity are also obvious Practically complete darkness at depths of more than 200 meters reduces the value of sight In abyssal species of Gammandae, Turbellana, Mollusca, Chironornidae, and Cottoidei, the eyes are useless Abyssal gammands have retained only recesses on the sides of the head, where the eyes used to be They orient themselves in space and find food with the help of the antennae, which have become extraordinarily long The eyes of the abyssal Cottoidei are reduced as well

It is interesting that, in parallel with the disappearance of the eyes' ability to perceive light, the eye sockets of gammands lost their regularity of shape, a feature observed by Korotnev back in 1901 The irregular variability of such 'eyes' can only be explained by the fact that, having become useless, they were no longer subject to natural selection

The absence *of* light *also had effects on* body pigmentation, which lost the pattern and variety of colors so characteristic of shallow-water species, and turned pale-pink or dirty-grey all over In shallower water, vivid color patterns are obviously of protective importance Littoral species of gammands and turbellanans can even be determined by color pattern and body pigmentation In abyssal species, the characters needed for survival evolved in different directions, such as the perfection of tactile organs (antennae in Gammandae and the lateral line in Cottoidei), compression of the body and adaptation of the legs to movement on tough substratum in some gammands and *Baicalasellus dvbowsku,* extraordinary elongation of the ventral seta m the Oligochaeta, etc

This process of speciation proceeded in almost all groups settling in deepwater zones, but was especially intense among the Gammandae, Cyclopoida, Turbellana, Mollusca and Cottoidei Thus, new biocoenoses formed in the depths of the lake, in which species entered into new, often contradictory relationships (struggle for food and for the preservation of offspring, parasitism, commensalism)

With regard to types of food and feeding, the deepwater fauna evolved into detritus-eaters and predators Among gammands, bottom-dwelling and pelagic carnivory developed, with species moving about briskly, or lying passively in ambush waiting for food Some species of deepwater gammands, attacking weak fish, get under the skin and eat away the intestines Taliev (1947, 1948, 1955) points out that the feeding habits of deep-dwelling Cottoidei also vary widely For instance, *Cottinella boulengen* and *Abvssocottus nerestschagim* mainly feed upon plant and animal matter and burrow in the upper layer of sediment The bathypelagic predatory *Limnocottus bergianus* and *Batrachocottus multiradiatus* as well as *Abyssocottm gibbosus* partially burrow in soil and snap up at everything that swims by with their large mouths *Limnocottus godlewsku* and *Abyssocottus korotneffi* actively hunt for prey, but they also burrow in silt with their duck-bill snouts to catch amphipods *Batrathocottm mkolsku* waits for prey in narrow slits on rocky patches Taliev (1955) writes that this species is not only bottom-dwelling but also bathypelagic, and has become adapted to feeding *on* species of *Comephorus* Thanks to its extremely low specific weight (1 028), equalling that of *Comephorus,* it passively rises to above-bottom strata and floats there, snapping at prey that passes by (Taliev & Koryakov, 1949).

In reply to this adaptation to a predatory way of life, prey developed a diversity of defence mechanisms. Some species of gammarid bear long, sharp spines of different shapes; their ability *to* sense the approach of the enemy becomes sharper; they burrow better, and so on. Mention should also be made of an interesting adaptation, developed by caddisflies (Tnchoptera). The 17 species of endemic Tnchoptera are doubtlessly descended from winged members of the ancient Limnophilidae. But in a deep, large lake like Baikal, their progeny have lost the ability to fly. In some species *(Baicalina reducta, Thamastes dipterus),* the wings turned into 'paddles', used for swimming. Why and how has this happened? In imaginal caddisflies, the wings are used for mating flights, when thick swarms form along lake shores, where females deposit fertilized eggs. In shallow waters, winds can facilitate dispersal of specimens and thus play a positive role. But in Baikal, where the shallow zone is very narrow, if an insect flies or is driven more than 50 to 100 meters offshore by the wind, its offspring will perish. Consequently, as with wingless insects on oceanic islands, reduction of wings (or their muscles) resulted from selection for individuals with an impaired faculty of flight.

The further divergent evolution of the Trichoptera must have been influenced by temperature. Some species deposit clutches at the water's edge, with their larvae developing close to the shore; others do so in deeper zones. There are species *(Radema injernale)* which mate early in spring, before the ice has melted. Their pupae squeeze themselves to the surface through cracks in the ice, where mating takes place. Eggs are also deposited in cracks in the ice.

Of course, it was not temperature alone that influenced the isolation of species. This may have also been induced, at least among fish, by differences in location of spawning grounds. For instance, the omul *(Coregonus autumnahs migratorius)* has already become divided into a number of types or populations, depending on place and period of spawning. Bottom-dwelling Cottoidei also differ in spawning habits; different periods of spawning separate the pelagic *Comephorus* into two distinct groups.

These few examples do not exhaust the possible pathways which determined speciation in Baikal. But they show that sympatnc-parapatric speciation in deep zones of Baikal, not dissected horizontally, played an important role in its evolution.

The formation of the Baikal fauna began in a climate warmer than today. It is likely that some species which evolved in the Tertiary did not survive the cooling, particularly the glacial period. The fossil fauna of the Tertiary terraces of Baikal offers many examples of a deep modification of the fauna between the Miocene and today. Such species of molluscs as *Baicalia duthiersioides* Mart., *Baicalia kozhovi* Mart, and *Choanomphalus fossilus* Mart., remains of which are plentiful in Tertiary deposits, no longer exist.

But the influence of the glacial cold on the living world of Baikal should not be overestimated, for even before it, the temperature of Baikal's deep waters could not have been much higher than today. The temperature of the bottom strata in Lake Ohrid never exceeds 6°C (Stankovič, 1960). At present, this lake enjoys approximately the climatic conditions of South Siberia in the latter half of the Tertiary period.

The world of Baikalian organisms is sharply divided into two main ecological complexes: littoral-sor and Baikal proper. The littoral-sor complex consists, genetically, of Siberian limnophiles, but also includes a few native Baikalians: about a dozen species of gammarids, the oligochaete *Isochaetides arenarius* Mich., and (partly) the Polychaete *Manayunkia "baicalensis".* The Baikalian complex proper populates the open waters of the lake. In turn, this should be differentiated into the following ecological groups:

The littoral community, from the edge of the water to a depth of 15 to 20 meters. It is described in detail in the chapter on the distribution of the benthos. The vast majority of species in this group are descendants of inhabitants of Siberian Tertiary waters (Tertiary Holarctic forms). Yet, it also incorporates a multitude of species of the modern Siberian limnorheophilic fauna.

The bathyal community, which occupies the sublittoral and supra-abyssal zones and, by its specific composition, forms a link between the littoral and abyssal groups Almost all species in this group are descendants of Tertiary north Holarctic forms, and all of them are endemic, with only a few Siberian limnorheophiles

The abyssal community, at depths below 250-300 meters It is represented exclusively by descendants of ancient Holarctic genetic complexes, exhibiting clear adaptations to abyssal life

The pelagic community, in the open water of Baikal Its specific composition is species-poor, and includes Siberian limnorheophiles with weakly expressed endemism, immigrants from large running-water Siberian and Siberian-European mountain lakes *(Rotifera, Cyclops, Epischura),* and recent immigrants from the Arctic *(Coregonus autumnahs migratonus* and the seal)

So, Kozhov substantiated in detail, that gradual colonization by animals of the lake depths (up to maximum) and adaptation to them led to the appearance of new endemic species in Baikal Besides, Kozhov gave examples indicating that in speciation endemics in Baikal the following factors should be considered geographical isolation of populations, differentiation of species by their preferences to food and eating method, relationships "predator-prey", adaptation to *low* water temperature and prolonged stay of ice

According to Popova (1981, 1990), molluscs inhabiting small depths (to 5-10 m) are young species The appearance of these species is attributed to migration of eurybathic species, which survived under unfavourable conditions in the Eopleistocene-Pleistocene cooling at 15-20 m depths (or a bit deeper), I e alongside with colonization of great depths of the lake in the Pleistocene-Holocene there occurred colonization by animals of small depths, which brought about the appearance of endemic species

Starobogatov & Sitmkova (1990, 1992) on examples of Baikalian molluscs showed that besides species divergence by geographical regions of the lake and its depths, speciation occurred owing to colonization of different bottom soils by initial species Changes in the morphology of a shell were of adaptive character For instance, transition of a form close to *Megalovalvata kozhovi* (smooth inexpressive shell) from silty grounds of the littoral to sandy-stone ones (at the same place at depths to 20 m) resulted in appearing longitudinal lirae on the shell of *M demersa,* which protect the shell from wave disturbance Close to the last, *M pihgera pihgera* living on sandy grounds has on its lirae penostracum hairs, and some specimens have an increased whorl height which lends the shell a ball-shaped form Rolling of such ball-shaped shell on sand during storms does not destroy it Having shown that the main way of mollusc speciation in Baikal is allotopic speciation (I e divergence by biotopes - according to Starobogatov's terminology, 1985) Starobogatov and Sitmkova point out that evolution ot Baikalian endemic animals occurred simultaneously with evolution of the ecosystem of the whole lake, and a complex of different factors was responsible for the formation of new species

Below Sitmkova adds some examples more to Kozhov's concept about possible processes and causes of the origin of Baikalian endemic species

Multiple colonization A comparison of the shell of endemic Pisidioidea with Siberian representatives permits them to be grouped into species pairs the first species is Siberian, the second is endemic to Baikal *Amesoda asiatica* (West) - *A korotnexni* (W Dyb), *Sphaenum westeriundi* (Oess) - *S baicaleme* (W Dyb) *Pisidium decuriatum* Ldh - *P baicaleme* (W Dyb), and others Such arrangements reflect the independent penetration of each of these Siberian species into Baikal (Starobogatov & Sitmkova, 1990) Molluscs of the family Valvatidae in all probability invaded Baikal more than once during various periods There are three groups endemic *Megalovalvata* (six species), *Pseudomegalovalvata* (five species), and Siberian *Sibirovalvata* (five species) which have different gill systems Moreover, *Megalovalvata* (by the structure of their genital system) are close to *Bmacovalvata* of Lake Biwa in Japan and are united, as subgenera, into one genus The subgenera *Pseudomegalovalvata* (characterized by shell morphology), and *Sibirovalvata* of the genus *Cmcinna* are closer (by structure of the genital system and gills) to European *Cincinna* s str than to Siberian *Sibirovalvata* (Starobogatov & Sitmkova, 1992) The links between the Valvatidae in Lake Baikal and those of Lake Biwa were severed before the Phocene, whereas the European Valvatidae could still penetrate Northern Asia after the Pliocene (Starobogatov, 1970) According to Timoshkm (1994), species of the genus *Geocentrophora* also colonized Baikal three times

Macromutagenesis and hybridization The majority of species of the Benedictndae have a diploid chromosome complement (2n=34) Four littoral species of the genus *Benediclia* include polyploid individuals with 3n=5I and 4n=68 Tnploids occur more often than tetraploids, and polyploid males are rarer than females Tnploid females, reproducing parthenogenetically or by gynogenesis, seem to form independent populations and differ only slightly from diploids and tetraploids by shell morphology (Poberezhny *et al*, 1983, 1988, Sitmkova *et al*, 1992)

Macromutagenesis in the genus *Benediclia* probably began comparatively recently, since it is difficult to identify the polyploids by shell morphology They sometimes combine features from two species The origin of this polyploidy is still vague There are facts in favor of both allopolyploidy and autopolyploidy But the existence of tnploid populations (not single individuals) testifies to speciation processes which are different from a species divergence in distinct regions of the lake Another example of mutagenetic speciation is the family Baicahidae, in which, besides species with a diploid number of chromosomes (2n=28), there is species with 2n=30 These karyotypes occur jointly, under similar ecological conditions According to Natyaganova *el al* (1994), three of four species of the Isopoda (genus *Baicalasellus)* studied karyologically, have a different chromosome complement from diploids (2n=8, 16 and 24) A comparison of chromosome number and morphology permitted the authors to hypothesize that the species *Baicalasellus baicalensis (2n=24)* resulted from a hybridization of *B angarensis* (or *B korotnenu)* (2n=16) and *B minutus* (2n=8)

Divergence according to period of reproduction
Example 1 The spawning cycle of two species of Comephondae, *Comephorus d\ bow sku* and C *baicalensis* is protracted But the spawning peak of *C dybowsku* occurs in December-June, reaching a maximum in February-March, and of *C baicalensis, m* August-September (Sideieva & Nagorny, 1985) These two species are the only pelagic Cottoidei

Example 2 The coastal pelagic *Cottocomephoius grewingki* forms three spawning shoals, separated by time of spawning March (water temperature 1-2°C), May (spawning at 11-17°C) and August (spawning at 10-17°C) The breeders of these shoals differ in morphology, fecundity, duration of embryogenesis and spawning ecology (Tahev, 1955, Hohlova, 1959, Koryakov, 1972, Chernyaev, 1984, Sideieva & Nagorny, 1985, Sideieva *et al*, 1987) The temperature tolerance of the shoals is different too March shoals are cold stenothermic, May shoals are eurythermic, August shoals are warm stenothermic (Zubm *et al*, 1993a) The spawning grounds of the shoals are located at different depths (2-5, 0 1-3, 3-10 meters) These populations (Zubin *et al*, 1993b) are now assumed to undergo a speciation act based on an adaptation to different conditions of reproduction

Evolution due to neoleny (ability to spawn at earh stages of development)
According to Sideieva & Nagorni (1985), besides the large typical *Abyssocottus korotneffi*, a second, dwarf form exists Dwarf forms have low fertility (five to 13 eggs), small eggs (1 8-2 5 mm in diameter), and mature rapidly A typical *A korotneffi* deposits 20 to 32 eggs, 3 0-3 7 mm in diameter, and becomes mature in the fifth to eighth year Fattening and spawning periods of this and of the dwarf form practically coincide But the coloration of dwarfs is light grey, similar to that of immature individuals of the typical form which, when adult, are bright orange

Clearly, the evolutionary processes mentioned are not over, but keep unfolding Because of this, Baikal is rich in closely related forms, whose taxonomic status is difficult to determine

4.6. Why do the faunas of Siberia and Baikal mix so little?

Baikal is inhabited by two genetically and ecologically different complexes One is of Euro-Siberian extraction, the other is 'Baikahan' and is responsible for the distinct character of the lake's fauna and flora (Korotnev, 1901; Kozhov, 1931a, 1936b. 1947; Vereshchagin, 1935, 1940b).

The Siberian complex populates the littoral-sor zone, and is distinct from the open waters of the lake, inhabited chiefly by Baikalian elements.

The fauna and flora of the sors does not differ, in fact, from that of other Siberian lakes. The waters of shallow gulfs, too, are penetrated by this fauna, although some forms are absent or rare, *e.g., Gammarus lacustns, Limnaea stagnalis, Stagmcola palustris,* and *Physa fontinalis.* As conditions become more Baikalian, Siberian elements are replaced by indigenous ones.

A careful study of the benthos distribution in various sections of Baikal has shown that the lacustrine-sor fauna forms colonies, rarely occupying large areas, often separated by dozens of kilometers. In regions where these colonies are not so widely separated, owing to deep indentations of the coastline, a superficial study might lead to the conclusion that the whole coastal belt is populated by a mixture of Siberian and Baikalian elements. But on a closer look, it becomes clear that the lacustrine-sor species *of* some enclosed gulf, if they spread outside it at all, become increasingly scarce with distance and do not venture beyond 15-20 meters of depth. The same holds true for the flora: endemic species do not live in sors and sheltered bays, while ordinary lacustrine flowering plants avoid the open lake.

In the border zone between the littoral-sor belt and the open water, a mixture of Siberian elements and Baikalian endemics can be found. Among the Siberians, the molluscs *Gyraulus gredleri* and *Radix auriculana* penetrate the open regions of Baikal further than others. Active swimmers among Siberian fish and planktonic organisms, given favorable conditions, also temporarily spread beyond the gulfs and bays.

In turn, the endemic Baikalian fauna avoids sors and shallow gulfs, with the exception of few eurytopic species. Examples of these are the oligochaetes *Limnodrdus arenanus, Propappus volki* and *Peloscolex injlatus;* the gammarids *Gmehnoides fasciatus, Micruropus wahlii, M possohhi, M. talitroides, M httoralis* and *Eulimnogammarus viridis,* the bryozoan *Hislopia* and, more rarely, the molluscs *Korotnewia korotnewi* and the polychaete *Manayunkia baicalensis.*

A more detailed account of the community of the littoral-sor zone and its conditions of life will be given.

Much has been written on the immiscibility *of* the Siberian and Baikalian elements. It is known that living conditions characteristic of ecologically distinct groups are a major factor in determining the distribution of organisms. Such groups thrive only in the complex of conditions to which they have become adapted in the course of evolutionary time, thereby evolving the physiological and morphological characters that correspond to these conditions. The general Siberian fauna, inhabitant of shallow bodies of water, and the fauna of a unique lake such as Baikal, have developed in basically different ecological conditions. In the sors and ordinary lakes, the summer warming intensifies biological processes, and reduces dissolved oxygen content; in winter, under ice, the oxygen content of these waters is *still lower.* This complex of conditions, typical of shallow waters, is unsuitable for Baikalian endemics, but lacustrine forms are well adapted to it. On the other hand, the complex of conditions of a typically Baikalian type is unfavorable for lacustrine forms (Kozhov, 1936b).

In the open regions of the lake, the temperature of the bottom layers in summer rarely exceeds 12-13°C, even at three to five meters in the littoral, and remains at this level for only ten to 15 days (August). Outside the littoral, it is lower still. In sections with a narrow shore, water temperature during strong winds drops to 5-4°C, even in summer. This is because of the emergence of hypolimnetic waters and the driving away of warm, superficial water from the shores.

An entirely different regime exists in the sors and sheltered gulfs. In summer, the bottom temperature there at three to five meters may reach *22*-23°C, and a temperature exceeding 12-13°C (the maximum Baikalian temperature) is sustained for at least three and a half to four months. In winter, thanks to thick silt deposits, the bottom temperature does not drop below 2-3°C. The average number of day-degrees in such littoral-sor regions in the zero-to-five-meter layer is twice the number of day-degrees at the same depths in open Baikal, as noted before.

It is therefore obvious that the low water ternperatures in open Baikal are a powerful obstacle to colonization by Siberian-European fauna and flora. The reason is not the individual capacity for survival of specimens of these species, but the adverse effect of low temperature on their reproduction and embryonic development. This hypothesis has found indirect support in the observation by Kozhov that, in early spring, in the southern and central parts of the shallow Mukhor Gulf (the Maloye More), egg clusters and young of the ordinary lacustrine mollusc *Radix auricularia* abound, but that outside it, their number drops sharply.

A similar picture was observed in Boguchan Bay (north-east Baikal), where egg clusters and young of lacustrine molluscs occur only in shallow and well-sheltered sections, together with adult specimens. However, few egg clusters and juveniles occur in more open parts of the bay, and adults of such ordinary species as *Radix auricularia, Cincinna (Sibirovalvata) ssorensis*, and others, are much smaller there than in neighboring lakes.

Siberian-European Tnchoptera do not develop in the open regions of Baikal either, and there are no Plecoptera and Ephemeroptera there, although some species undoubtedly oviposit in sors and adjacent lakes. Kozhov caught some females of lacustrine chironomids, such as *Chironomus plumosus*, over the water of open Baikal, but never found larval stages of these species there. The amphipod *Gammarus lacustris* lives in lakes and sors, but it never occurs in open Baikal, although it has been used as bait in ice-hole fishing for decades.

The low temperature, which adversely affects the reproduction and development of the Siberian fauna and flora, also inhibits the development of ordinary lacustrine plankton in the lake. This will be dealt with later, in the review of the plankton.

It is necessary to stress that the ecological barrier which prevents the heat-loving inhabitants of eutrophic waters from settling in open Baikal is not, contrary to Vereshchagin's opinion (1940b), impervious to some cold-loving eurytopic species, typical of oligotrophic, cold, deep mountain lakes. Thus, cold-loving chironomids of the genus *Sergentia*, and Orthocladiinae, survive in open Baikal, while the molluscs *Gyraulus gredleri*, an eurytopic, and *Radix auricularia*, which forms small varieties beyond sheltered bays and gulfs, can also be observed in open waters, but never far from the sors. Oligochaetes from the genus *Nais*, freshwater *Hydra*, grayling, gwyniad, and burbot, have also succeeded in establishing themselves.

The thermal and chemical regime of the sors and shallow lakes, in its turn, is obviously unfavorable for indigenous Baikalian fauna. Beside high temperatures and low oxygen content, pollution with organic substances, to which Baikalians are not accustomed, inhibits their physiological processes. The importance of this factor becomes clear after a study of the distribution of Baikalians in zones directly adjacent to sors and other littoral sections, *e.g.*, the Mollusca. In Chivyrkui Gulf, almost no Baikalian molluscs occur south of Baklany Island, in the vast shallow stretch between the island and the south shore of the gulf. This section is populated with lacustrine-sor species. Occasionally, adult living specimens of *Baicalia dybowskiana carinatoides* can be found there, but more often dead shells are encountered. Evidently, the specimens penetrating there perish without leaving offspring

In Mukhor Gulf (the Maloye More), only the Baikalians *Koroinewia korotnewi* and *Sphaerium baicalen.se* reach the central part of the gulf. The nearer to the middle, fewer specimens are found, suggesting that they do not reproduce there. In addition, these specimens are of poor appearance, and form dwarf varieties.

The water of the upper part of Angara, as in Baikal, is cold, and prior to the construction of the dam, its rapid flow prevented it from warming up to more than 10-12°C over the first 80 to 100 km. Due to these thermal and chemical conditions, it was inhabited by a fairly large number of Baikalian species, primarily littoral fauna. A certain number of Baikalian species, especially gammarids, even reach the Yenisei, the Yenisei Gulf and other waters of the Arctic.

What makes the Angara acceptable for Baikal species is, firstly, moderate summer temperatures characteristic of river waters. The lower the summer temperatures (the upper sections of the Angara), the more the Baikalian species living there, and, conversely, the higher the temperature (the lower reaches), the fewer surviving. A similar chemical regime, especially an abundance of oxygen and an absence of pollution, contributes as well.

The influence of high summer temperatures on

Baikalian species assists in controlling the maturation of genital products, or the development of young A study of the ripening of genital products in the Benedictiinae (Kozhov, 1928, 1945) has shown that the trigger for the ripening of spermatozoa is provided by a water temperature of 8-10°C. This is the maximum value of bottom layers in the littoral of Baikal's open regions in August. As genital products ripen, mating takes place, usually in August-September, after which the females deposit egg cocoons throughout autumn, the latter part of the winter, and in spring. Animals placed in a tank with running Baikal water maintained at 8-10°C also mate, and the females deposit egg cocoons. When the temperature is raised to 14-16°C, cocoons are not deposited, although the animals will live on for months if fed. If the temperature is raised to 18-20°C, the animals perish within weeks. Similar experiments have been conducted with the mollusc *Megalovalvata baicalensis.* In a tank with running water, it will deposit cocoons even at temperatures higher than in Baikal (14-15°C). The eggs develop normally, but after two or three weeks, the embryos die, and the cocoons become covered with a fungus.

These data confirm that the temperature and chemical regimes are powerful regulators of physiological processes and serve, therefore, as decisive factors in the distribution of animals.

The combined influence of chemical factors and the thermal regime is also illustrated by the behavior of roach, perch and other fish in sors and coastal lakes. In summer, most of them live in the inshore belt of Baikal's shallows, where they find food and where the water temperature in July, August and September differs little from that of the sors. In Autumn, when storms rage and the shallow inshore belt open to winds becomes too uncomfortable to live in, the fish withdraw to the sors, rivers and marginal lakes and stay there until January-February. Towards this period, the sors become oxygen-poor, and the fish return to Baikal, now covered with ice, where they remain until spring. After the ice breakup, they re-enter the sors for spawning and feeding until July-August, when the cycle begins again. But while active organisms like fish can migrate between sors and Baikal, poorly mobile and sessile animals die when adverse conditions set in. That is why Kozhov found accumulations of dead shells of molluscs in the zone of contact (in the narrow sense) between the Siberian and Baikalian faunas.

In discussing the causes of the immiscibility of the Siberian and Baikalian faunas of Baikal, Kozhov also turned to differences in sources of food, especially that of herbivores. He found that Baikalian and Siberian species are more or less indifferent to the type of plants consumed, even over long periods of time.

There is no doubt as well that constant turbulence and strong surf in the inshore belt of Baikal present a formidable obstacle to its invasion by species from sors, marginal lakes or quiet sheltered bays

The causes of the relative immiscibility of the Siberian and Baikalian faunas, therefore, reflect the fact that they have evolved in different environments.

The ordinary continental freshwater fauna (that of lakes, bogs, rivers) has developed in a variable environment, both with regard to seasons of the year and in the course of the history of these waterbodies. A rapid warming in spring, high temperatures in summer, a long duration of the warm period, followed by an abrupt cooling, sometimes even complete freezing and sharp changes in oxygen conditions, induced a number of adaptations in the mode of reproduction and embryonic development. The propagation period of the vast majority of these animals is timed for early spring, allowing their young to grow up during a short, hot *summer* The wide diversity of these waterbodies and their conditions leads to the development of eurytopic forms Stenotopic elements evolved only in cold mountain waters, springs, cave waters, and thermal springs. But in duration of existence and in constancy of conditions, these are no match for the deep zones of Baikal.

A different view on the immiscibility of the Baikalian and Siberian faunas was held by Vereshchagin. In 1935, he pointed out in his work "Two Types of the Biological Complexes of Baikal", that the ecological distinctiveness of the Baikal fauna was not related to the great age of the lake, and the influence of a constant temperature and dissolved gases. Instead, he hypothesized the presence of water "with a changed molecular structure" (Mendeleyev, 1935). He wrote (1940b, p.2l 1); "It is possible that precisely owing to this peculiarity that, since the formation of great depths, the water of Baikal has been detrimental to many organisms, and that is probably why this admixture of abyssal water in the superficial layers of Baikal in some regions and in some seasons of the year presents one of the obstacles to the penetration of the Siberian complex into the Baikalian one... It seems very likely that, not only for Baikal, but for Lake Tanganyika as well the presence of great depths with a peculiar composition of water is a factor which prevents the modern population surrounding these lakes from mixing with the more ancient population which has gradually, with the progressive formation of the great depths of these lakes, accommodated itself to these specific features of water." Similar views were held by Berg (1949a, p.291-292): "The population of the Baikal waters hardly mixes with that of the local rivers and lakes supplying their waters to Baikal. Aliens usually perish in the lake. This is probably explained by the chemical composition of the Baikal waters, which has not been sufficiently studied yet as regards micro-elements, *i.e.*, elements which occur in very insignificant amounts but are vital for certain organisms."

In his later work "The Origin and History of Baikal and its Fauna and Flora" (1940b), Vereshchagin categorically objected to such environmental factors as temperature and water chemistry. He maintained that if temperature were an important factor, Baikalian elements should spread to cold Siberian lakes, where in reality they are not found. It would be wrong, however, to view the thermal factor in isolation from other environmental factors, especially dissolved gases, which in such cold mountain lakes as Frolikha or Kulinda differ considerably from those in Baikal. The bottom layers of these lakes are poor in oxygen even in summer, the water is acid, and autotrophic organisms scarce. Therefore, their trophic value is low (Kozhov, 1950b).

Vereshchagin also considered that Baikal species are more or less indifferent to thermal and gas conditions. He relied on Bazikalova's experiments with gammands (Bazikalova, 1941), which supposedly showed that not only littoral, but also deep-dwelling gammands of Baikal withstand a drop in oxygen content to 0.5-1.0 cm^3 per liter. But it follows from Bazikalova's experiments that this drop is only endured by a few, relatively eurythermal species, such as *Gmelinoides fasciatus,* while most Baikalian species only survive when the oxygen content is comparatively high. The most important thing, however, is that these experiments were conducted in tanks and their duration did not exceed 100 hours, whereas in natural conditions the problem is to survive for a lifetime. Examples of this have already been cited.

More investigations devoted to the problem of immiscibihty were conducted by Levanidova, 1948; Bekman, 1952; and Koryakov, 1959. Bekman tried expenmentally to find out whether Baikal water had an inhibitive effect on organisms not adapted to living in the lake. She used *Gammarus lacustris,* adults of which were put in pails and exposed to the lake, from the littoral zone to a depth of 1000 meters. They lived there for many months, and even deposited eggs, but egg development was very slow. For its embryonic development, this crustacean needs 360 day-degrees; the effective temperature for growth and development of its young should not exceed 25°C (the optimum is above IOX); and the sum of temperatures up to the moment of maturity should not be less than 1800°C. In the case of Baikal, the thermal regime, even of the littoral, rules out the possibility of normal growth and development of juveniles.

Taliev & Koryakov (1947, 1948) conducted experiments on the degree of sensitivity of Baikalian Cottoidei to the thermal and gas regime. These experiments revealed an extremely low heat resistance of the latter, which perish at temperatures in excess of 8-9°C. The highest heat resistance was observed among species of *Paracottus (P. kneri, P kessleri),* as well as in the pelagic *Cottocomephorus grewingki* (19-21°C) and in *Batrachocottus baicalensis.*

Levanidova (1948) undertook a comparative study of the distribution of the fauna in some sors and bays and ranked the abiotic factors influencing the distribution of organisms in the 'zone of contact' as follows: thermal regime, seasonal and diurnal gas regimes, salt content, and turbulence of the surf.

At the same time Levanidova proposed the biocoenotic factor to be one of the causes of immiscibihty, although she did not develop this idea on the basis of specific observations. The biocoenotic factor does play a part, of course, but should not be overestimated. In Baikal, we do have instances of seemingly alien faunal elements easily colonizing biocoenoses that have developed there over the course of centuries, if conditions favor this invasion *(e.g.,* the omul, and the seal).

Thus, all observations available prior the 1960s point to the untenability of hypotheses reducing the ecological distinctiveness of Baikal to the influence of some special properties of the water itself, whether this be water with a changed molecular structure, or still unknown micro-elements. Newer investigations permit the problem of the immiscibility between the faunal complexes to be considered somewhat differently.

According to Sitmkova (in print), there are three groups of Baikalian endemics. The first comprises species closely related to ancestral forms The ancestors of this group colonized Baikalian lakes before the Late Pliocene. They often coexist with non-endemics in 'transition zones[1], occur in coastal-sor regions, and respond to spring-summer increases of water temperature by mass reproduction. The second group contains young endemics, descendants of the endemics of the first group. The formation of the species in this group began in the Eopleistocene-Pleistocene; they are cold-loving, oxyphilic, and reproduce around the year.

The third group also includes young endemics, but their ancestors invaded Baikal much later (in Pleistocene and Holocene). The ecological demands of this group differ only slightly from those of the general Siberian species.

For the second group, temperature is a major obstacle for penetrating the warm sors, bays and gulfs of Baikal. In winter they cannot live there due to low oxygen. These species have a narrow interval of ecological possibilities.

For the endemics from groups 1 and 3, temperature is not a strict barrier, although, with an oxygen regime, it plays a definite role.

Two other factors are of importance: competitiveness and an absence of niches, or 'licences' (a licence, according to Starobogatov (1985), is a place and function which an ecosystem presents to a species).

Among the endemics from the first group, only relict species have low competitive power, occur in insignificant numbers, have a disrupted or small area of distribution, and they have exhausted their potential to produce many offspring. The remainder of this group is highly competitive, and able to withstand attempts of general but related Siberian species to intrude into open Baikal. In sors, bays, gulfs it is the general Siberian fauna that is so competitive that only few endemics from groups 1 and 3 can colonize these waters. As such, species belonging to different groups of the fauna, which have different 'licences', usually coexist.

Long-term evolution of the ecosystem of Baikal with prolonged periods of isolation from adjacent water bodies since the Late Pliocene has resulted in almost complete absence of free 'licences' in open Baikal. This prevents the interpenetration of two faunistic complexes. It is quite probable that the absence of free 'licences' is a major factor in the non-penetration into Baikal of the non-endemic, cold-loving oxyphilic fauna of mountainous rivers emptying into the lake. Other isolating factors are, probably, morphological peculiarities which limit the mobility of animals, such as in imagos of Plecoptera and Ephemeroptera, incapable of long-distance flight. Secondly, different hydrodynamic processes in rivers and in the littoral of Baikal prevent animals, adapted to the unidirectional currents of river waters, from surviving the turbulence caused by surf.

In conclusion, we present some expressive examples of the relative immiscibility of Siberian and endemic Baikalian complexes. The endemic flatworm *Geocentrophora intersticialis* occurs in the interstitial of both open Baikal and in sheltered bays of the Maloye More (Timoshkin, 1984). Several cestodes, widespread in the Palaearctic parasitize - in practically unchanged form - endemic Cottoidei and *Epischura baicalensis* (Rusinek, 1989). The bivalve *Lacustrina dilatata,* inhabiting the rivers of Eastern Siberia, including rivers flowing into Baikal, (e.g., the Barguzin River), occurs in sors and bays of open Baikal in depths of up to 40 to 50 meters (Starobogatov & Sitnikova, 1990). *Gmehnoides fasciatus* and *Micruropus wahlii,* endemics of Baikal and the Angara River occur, besides in open Baikal, in the coastal-sor zone, and have also adapted to many waterbodies in the European and West-Siberian parts of Russia. These examples show that, given free 'licences' and absence

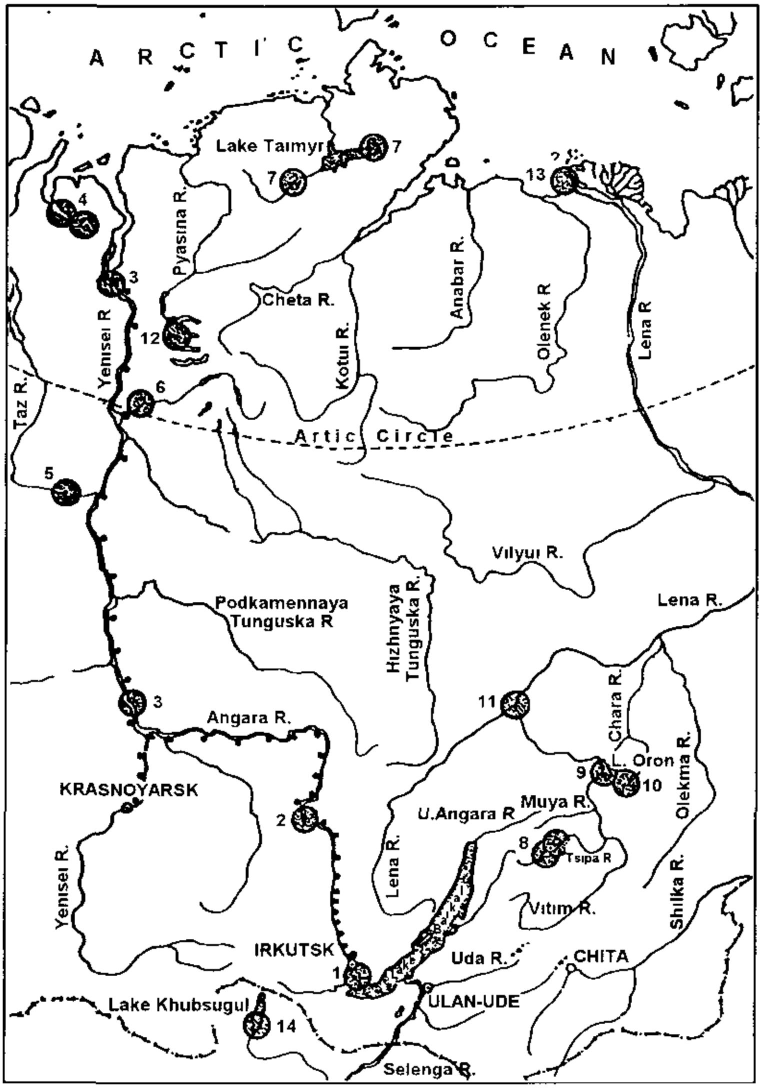


Fig 4 3 Outline map of the distribution of the Baikalian fauna outside Baikal 1 the upper section of the Angara, inhabited by up to 50 littoral species of Baikal. 2 - the middle section of the Angara, where up to 20 Baikalian species live, 3 - the River Yenisei, populated by 10 to 15 Baikalian species, inclulding molluscs of the genus *Choanomphalus,* gammands, the Bryozoan *Hislopia,* the polychaeta *Manayunkia baicalensis,* Ohgochaetes, cts , 4 - relict lakes of the Gyda Gulf drainage, where the polychactc, *M baicalensis* and Baikalian species of *Euhmnogammarus* have been found, 5-6 - lakes of the Yenisei drainage, which have been found to be populated by *M baicalensis* and bryozoan *Hvslopia,* 7 - relict Lake Taimyr, where two *Euhmnogammarus* species. *Manawmkia* and *Hislopia* have been found, 8-10 - big running-water lakes of the drainage of the Vitim and Olekma. tributaries of the Lena, where *Manavunkia baicalensis* and the cottids *Paracolitis* and *Asprocottus* have been found, 11 - the middle reaches of the Lena containing the Baikalian species *Paracolitis kessleri* and its parasite *Salmincola coindarum,* 12 - the Norilsk lakes, inhabited by *Manavunkia baicalensis,* the Bryozoan *Hislopia* and *Eulimnogammarus,* 13 - the Olcnck Gulf, where *Manaxunkia baicalensis* (?) has been found Black circles show the distribution of the Baikalian fauna in the Angara and Yenisei After Kozhov, 1963

of competitors, species (both endemic and non-endemic) with a wide ecological valency (change of temperature, oxygen and hydrodynamic regimes are not very significant for them), and a morphology that does not limit their mobility, can inhabit regions different from their ordinary habitats.

4.7. Dispersal of Baikalian species outside Baikal

Data on the distribution of some species outside the lake have already been cited in the chapter devoted to the fauna. Here, we shall try to summarize them and evaluate their biogeographical importance (Fig 4.3).

Several indigenous Baikalians are capable of living *not* only in the littoral-sor region, but also in continental waters outside the lake. For instance, some Baikalian gammarids enter the lower reaches of Baikal's affluents and settle in adjacent running-water lakes, *e.g.*, *Gmelinoides fasciatus*, *Micruropus possolskii* and *M. wahhi.* But none spread to any length upstream into the continent, nor are they found in the mountain lakes around Baikal (Zhadin, 1937; Kiselyov, 1937; Kozhov, 1950b).

At the present time, emigrants from Baikal are especially abundant in the great waterway linking Baikal with the Arctic Ocean, the Angara and Yenisei rivers. Prior to damming, the upper section of the Angara was populated by about 50 species of Baikalian gammarids, *Baicalasellus, B. angarensis*, about ten species of molluscs *(Choanomphalus, Pseudancylustrum),* a considerable number of turbellarians and oligochaetes, the polychaete *Manayunkia baicalensis*, the sponge *Lubomirskia baicalensis,* the bryozoan *Hislopia placoides,* Baikalian Chironomidae and Cottoidei, such as *Paracottus kneri*, *Paracottus kessleri* and *Batrachocottus baicalensis* (Kozhov, 1931b). In Baikal, all these forms live predominantly in the littoral zone. In the Angara, they occur in open sections with a relatively rapid flow.

The successful colonization of the upper part of Angara by these Baikalians is due to the thermal and chemical regime of its water, close to that of the lake. Prior to the construction of the Irkutsk hydropower dam, its water temperature did not exceed 9-11°C, even in August-September. The water was fully oxygenated; the bottom, composed of boulders and gravel, was almost fully overgrown; in some places there were patches of sand. Silted soil occurred only in bays with a quiet flow. In open sections of the upper part of Angara, general-Siberian lacustrine species were rare, with Baikalians predominating. Ecologically, this part of the river was a continuation of the littoral zone of Baikal.

Today, after the building of the hydro-power station near Irkutsk, the upper part of Angara has virtually become a gulf of Baikal. The fauna of its upper section is still composed of Baikalians, while the gulfs and bays and the middle and lower sections are populated by Siberian lacustrine and fluvio-lacustrine biota. No Baikalian species occur today in the lower section adjacent to the dam.

As a result of the construction of three dams on the Angara River (Irkutsk, Bratsk, Ust-Ilimsk) and the formation of reservoirs, and also due to heavy pollution by industrial waste waters, not only the bottom fauna but the whole structure of bottom and planktonic communities have dramatically changed (Kozhova, 1970).

Downstream of Irkutsk, the Angara receives the large tributaries Irkut, Belaya, Kitoi and gradually acquires features of an ordinary Siberian river. But even there, over a stretch of 600 to 800 km, rapid-flow sections occur, *e.g.,* in the area of Bratsk These rapids are populated by Baikalian species: the mollusc *Mauckia angarensis,* up to ten species of gammarids, *Baicalcasellus angarensis, Manayunkia baicalensis, Hislopia placoides,* Baikalian littoral oligochaetes, and turbellarians. Some of these species have even settled in the lower Angara and in the Yenisei, up to Yenisei Bay. Pirozhnikov (1937a,b, 1941) and Greze (1954, 1956) offer an extensive list of Baikalian forms found in the Yenisei. The 2500 km stretch between Krasnoyarsk and the Yenisei Bay contains the gammarids *Eiilimnogammarus viridis*, *Micruropus* sp. and *Gmelinoides fasciatus,* in the lower reaches of the Yenisei and its delta, in addition to the above-mentioned species, *Pallasea kessleri, Micruropus glaber, M vortex*, *Hyalelopsis* sp., *Eulimnogammarus* sp., *E lividus*, *Brandtia lata,* the molluscs *Choanomphalus amauronius* and *Pseudancylastrum sibiricum,* the Baikalian bryozoan *Hislopia placoides,* up to ten Baikalian species of oligochaetes, and the fish *Paracottus kneri* have been found.

In the lower Yenisei, Baikalian gammarids mix with marine relict forms and comprise a sizeable part of the benthos there. Pirozhnikov (1937a) writes: "Occurring frequently and in large numbers, marine and Baikalian forms present a characteristic element of the fauna of the lower Yenisei and lend it a highly distinct colour."

Slastmkov (1940, 1941) found Baikalian species in the drainage area of the Gyda, which opens into the Gyda Gulf of the Kara Sea, situated between the mouths of the Yenisei and the Ob. The polychaete *Manayunkia baicalensis* and the gammarid *Micruropus wahlii* are abundant in the fresh, running-water lakes of the Gyda drainage, 100 to 150 km from Gyda Gulf. Slastnikov, referring to geological data, maintains that Baikalian forms discovered in these lakes penetrated there from the Yenisei through its ancient link with the Gyda Gulf and the watershed of the Gyda. The same lakes also contain such marine relicts as *Mesidothea entomon* L., the amphipod *Pontoporeia affinis* Lindstr., *Mysis relicta* Low., *Senecella calanoides* Juday **and** *Limnocalanus grimaldi macrurus G* O.S. In view of all this, Slastnikov regards them as relict lakes.

In Nalimye Lake, which lies on the divide of the Taz and the Yenisei drainage areas, Pirozhnikov (1937a) found *Pallasea quadrispinosa,* which he considers an immigrant from Baikal. *Mysis relicta* has also been discovered there.

According to Greze, Baikalian elements also occur in lakes of the Lower Tunguska, a tributary of the Yenisei: Lake Munduiskoye, 60 km from the *outflow of the Kureika,* and *Lake Nalimye, 70 km* upstream of the outflow of the Lower Tunguska. There, *Manayunkia baicalensis* and *Hislopia placoides* have been found. Lake Munduiskoye also has the amphipod *Pallasea quadrispinosa* and the copepod *Cyclops kolensis.* As Greze points out, these lakes are situated in the area of an ancient bed of the Yenisei; they are fairly large (Munduiskoye has a surface area of 10,450 hectares and Nalimye of 1190 hectares), deep, running-water lakes. Their Baikalian species are to be regarded as relicts of the ancient Yenisei.

In the Angara, the Yenisei and the Arctic lakes of the Yenisei, Gyda and Pyasina drainages, these immigrants from Baikal differ little from true Baikalian forms. Most of them are evidently identical to the latter. The amphipod *Gmelinoides fasciatoides* Gurjan. has been described as a separate species (Guryanova, 1929), but seems to be only a variety of the Baikalian *Gmelinoides fasciatus* Stebb. (Bazikalova, 1957).

The comparatively small degree of divergence of the Angara-Yenisei complex of Baikalian immigrants gives reason to suppose that Baikal's communication with the Arctic Ocean through the Angara and Yenisei originated in a relatively recent past.

On the question of the time and method of penetration of Baikalian gammands to the delta of the Yenisei and the polar lakes disconnected from it, Bazikalova shares the opinion of Pirozhnikov (1937b). The North of Siberia was repeatedly inundated by sea water, with a transgression of the Arctic Ocean around the mid Quaternary, extending south to 65-63°N. Traces of it can be detected along the Yenisei up to the mouth of the river Yelogui. That transgression coincided with the maximum mid-Quaternary (Samarovo) glaciation, when the southern fringe of glaciers extended beyond the Arctic Circle. In Pirozhnikov's opinion, the ice barrier at that time was so thick that it blocked the passage of the great Siberian rivers to the ocean. After merging, the East-Siberian and West-Siberian glaciers formed a continuous ice barrier and cut off the section of the Boreal Sea which extended to the south in the form of a great gulf. Thus, a Quaternary Central Siberian basin was formed. By discharging directly into that basin, the *Ob and Yenisei freshened it Its fauna must have* consisted of euryhahne and cold water marine forms and of Baikalian and freshwater species. Pirozhnikov presumes that, at its highest level, that sea communicated with the Aralo-Caspian basin, which made invasion of the Caspian by northern elements possible, including marine relicts of the Glacial period, close to those which still occur in the coastal Arctic Ocean and relict lakes of its shores.

In this connection, brief mention should be made of the history of the so-called relicts of the Glacial period. This group includes the seal *Phoca hispida* (and the forms related to it which live in Lake Ladoga and the Caspian Sea), the Cottoidei *Myxocephalus (Coitus) quadricomis* **L.,** the **amphipods** *Gammaracanthus lacustris* G.O.S., *Pontoporeia affinis, Pallasea quadrispinosa* and *Pallasea laevis* Ekman, the isopod *Mesidothea entomon,* the mysid *Mysis relicta, and* **the** copepod *Limnocalanus grimaldi* Guerne.

These usually live in waters which were or are closely connected with glacial dammed lakes of North Eurasia, freshened sections of sea gulfs, or relict fresh or brackish water bodies. Relict species are widespread in lakes along the Arctic coast as well as in the Baltic basin, and even in some lakes of Ireland and Scotland. In the Caspian, they are represented by the seal *Phoca hispida caspica* and crustaceans of the genera *My sis, Pseudahbrotus, Pontoporeia, Gammaracanthus, Limnocatanus,* and by *Mesidothea entomon.* They have changed slightly since, and produced a few new forms (Mordukhai-Boltovskoi, 1960).

In Siberia, relict forms have been found in the above-mentioned Arctic lakes of the drainages of the Yenisei, the Gyda and the Pyasina and in the Yenisei and Gyda gulfs. *Mesidothea entomon* occurs in the Lena drainage to the south of its confluence with the Aldan, and in the upper reaches of the Indigirka; *Pallasea quadrispinosa* has been found in the mouth of the Lena. The amphipod *Pallasea quadrispinosa* Sars is of special interest. Its close affinity to the Baikalian species *Pallasea kessleri* Dyb. was noted by Dybovsky. Bazikalova writes (1945): "These two forms have an absolutely identical structure and distribution of cutaneous protuberances, which are slightly less pronounced in the case *of P. quadrispinosa,* and a common structure of the limbs, differing in insignificant detail only." Another Arctic species of the genus *Pallasea*, *P. laevis* Ekman, lives on Nov ay a Zemlya only and is simply a variety of *P. quadrispinosa* (Segerstrale, 1957).

The genus *Pallasea* can be regarded as having evolved in Baikal long before the Quaternary. It is represented by more than a dozen species there. According to Bazikalova, it is ancestral to other Baikalian genera: *Parapallasea, Metapallasea, Poekilogammarus, Macrohectopus.* Thus, an immigrant from Baikal related to *Pallasea kessleri,* which still lives in the Angara, and the Yenisei, could really have been the ancestor of *Pallasea quadrispinosa.*

Relying on Pirozhnikov's hypothesis, Segerstrale (1956, 1957, 1958), who devoted much effort to ascertaining the migration routes of relicts of the Glacial period in Europe, put forward the idea that almost all European glacial relicts had their birthplace in the "Central Siberian glacial dammed sea-lake" of the middle reaches of the Ob and Yenisei. Marine species, ancestors of the modern relict group, penetrated there from the Arctic Ocean. Finding themselves in a new environment, they adapted to freshwater conditions, and spread to the east (the Lena, the Indigirka) and, in the west, to Europe. *Pallasea quadrispinosa* also evolved there, not from a marine species but from the Baikalian *Pallasea kessleri.* It should be noted that modern investigations in the West-Siberian Lowland have revealed no trace of the extensive dammed basin portrayed here by Pirozhnikov & Segerstrale. Neither are there any indications of an ancient outlet towards the Caspian Sea. But there is no doubt that dammed glacial lakes, including very large ones, could have existed in North Siberia in Glacial times.

We must also take into consideration the possible influence of extensive transgressions, which stretched into south Siberia over more than 1000 km from the modem coast of the Arctic Ocean. These transgressions undoubtedly left behind relict basins in which marine species could adjust to brackish and freshwater. The numerous glacial lakes, the readjustment of hydrographic communications, the transition of river systems from one drainage to another, and the important changes in the position *of* the mouths *of* Siberian rivers, must all have promoted the dispersal of relict species from their birthplace to the east and west along the Arctic coast.

Large freshwater bodies of the Glacial period were invaded simultaneously by immigrants from the northern seas and from Baikal. Thus, at the point of contact of Baikalian and relict forms, distinct biocoenoses appeared, which are still preserved in freshwater gulfs of the northern seas and in relict lakes.

It can be assumed that, in the Quaternary, not only species of the genus *Pallasea,* but also some other immigrants from Baikal dispersed far to the east and west along the Arctic coast. Among these is, for instance, the polychaete *Manayunkia baicalensis,* which is perhaps the progenitor of the *Manayunkia* forms occurring in some Arctic coastal waters. In their turn, some northern active elements could have worked their way into Baikal and other lakes of the Baikal mountain regions during maximum transgression of the sea and advance of glaciers. They include the omul, the seal, possibly the gwyniad, and also *Salvellinus alpinus erithrinus,* which still inhabits cold mountain lakes in regions of Siberia where glacial phenomena were particularly pronounced

In modern times, the powerful waterway of the Angara-Yenisei has provided, as in the Quaternary, a channel for the dispersal *of* Baikalian fauna northward to the Arctic coast In a more remote past, Baikal's communication with the Ocean was evidently ensured by another great Siberian river, the Lena, as shown by finds in the catchment areas of the Vitim and the Olekma, tributaries of the Lena

Remnants of a Baikahan-type fauna have been found in large running-water lakes of the Vitim drainage, such as Baunt, Busam and Oron, lying m the Tsipa tectonic depression, and in Lake Oron-Vitimsky (the Vitim valley), as, well as in lakes Davatchan, Lepnndo and Leprindakan in the drainage of the Chara, a tributary of the Olekma, and in the area of the Muya-Chara tectonic depression (Kozhov, 1942, 1949, 1956; Kozhov & Tomilov, 1949, Tahev, 1946, Tomilov, 1954)

The only explanation for the presence of Baikalian elements in these lakes is that there was a period in history when the lake was connected with the Lena basm (Kozhov, 1949, 1950b) Geological data, too, point to the young age of the modern run-

Table 4 4 Dispersal ot Baikalian endemics outside Baikal After Kozho\a, Erbaeva, unpublished data

Species and subspecies	*Angara Rner*			*Yenisey Rivet*	*Lena drainage*	*Khubsugul Luke*	*Reservoirs of River Angara*		
	up pet	*middle*	*lov.*				*1*	*2*	*3*
Family Lubomirskndae									
Lubonwskia baicalensis	+	+	–	–	–	–	–	–	–
Class Turbe liana									
Ordo Tnclada									
Family Dendrocoelidae									
Archicotylus decoloralus	+	-	–	–	–	–	–	–	–
A stungulatus	+	-	–	–	–	–	–	–	–
A viviparus	+	-	–	–	–	–	–	–	–
A planus	+	-	–	–	–	–	+	+	–
Papilloplana leucocephala	+	-	–	–	–	–	–	–	–
P gusea	+	-	–	–	–	–	–	–	–
P zebra	+	-	–	–	–	–	–	–	–
Aioplana sublanceolata	+	-	–	–	–	–	–	–	–
Bdelocephala angarensis	+	+	+	+	–	–	+	+	–
B baicalensis	+	-	–	–	–	–	+	+	–
Baikahbia guttata	+	-	–	–	–	–	+	+	–
B copulatnx	+	+	+	–	–	–	+	+	+
Class Nematoda									
Tnpulu dybonskyi	-	+	–	–	–	–	–	–	–
Tobnhfi amabrfts	-	+	–	–	–	–	–	–	–
Eutobrdus pei egrmator	-	-	–	–	–	+	–	–	–
Class Polychaeta									
Manai unkia baicalensis	+	+	+	+	+	–	+	+	–
Class Ohgochaeta									
Family Naididae									
Nais baicalensis	+	+	–	–	–	–	–	+	–
N bekmani	+	+	–	–	–	+	–	+	–
N koshovi	+	+	–	–	–	–	–	+	–
N tigrina	+	+	–	–	–	–	–	+	–
Vncinais minor	+	+	–	–	–	–	–	+	–
Amphithaefa magna	-	+	–	–	–	–	–	–	–

Table 4 4 Continued

Species and subspecies	*Angara Rivei*			*Yenisey Rner*	*Lena drainage*	*Khub-sugul Lake*	*Reservoirs of River Angara*		
	upper	*middle*	*low*				*1*	*2*	*3*
Family Tubificidae									
Rhyacodnlm coccineus inaeguahs	+	–	–	–	–	–	–	+	–
R multispimis multiovata	+	–	–	–	–	–	–	–	–
R multispinw; liptca	–	–	–	–	–	–	–	+	–
R korotneffi	–	+	–	–	–	–	–	+	–
Isochaelides arenarms	–	+	–	–	–	–	–	+	–
I baicaknsis	–	+	–	–	–	–	–	+	–
Peloscolex injlatus	–	+	–	–	–	–	–	+	–
Tubifex hubsugulensis	–	+	–	–	–	+	–	–	–
Family Lumbncuhdae									
Lamprodrilus satyriscus f decatheca	–	–	–	+	–	–	–	+	–
L isoporus	–	+	–	–	–	–	–	+	–
Teleuscolex grubei	–	+	–	–	–	–	–	+	–
Siyloscolex asymetricus	–	–	–	–	–	–	–	+	–
Stdodrtlus opisthoannulatus	–	–	–	+	–	–	–	–	–
Family Lycodnhdae									
Lycodrilus parvus	–	+	–	–	–	–	–	+	–
L schizochaetus	–	+	+	+	–	–	–	+	–
L dvbouskii	–	–	–	+	–	–	–	–	–
Family Enchitraeidae									
Ptopapput glandulosus	–	–	–	+	–	–	–	–	–
Class Hirudmae									
Family Ichtybdelhdae									
Baicalobdella torquata	+	+	–	–	–	–	–	–	–
Class Bryozoa									
Family Hislopidae									
Echinella platoaies	+	+	+	+	–	–	+	+	–
Class Arachmda									
Ordo Hydracanna									
Family Limnohaldcandae									
Parasoldanellonyx baitalensis	–	–	–	–	–	+	–	–	–
Class Crustacea									
Ordo Isopoda									
Baicalasellus angaren s is	+	+	–	–	–		–	–	–
B baiLalensis	+	+	–	–	–	–	–	–	–
Ordo Amphipoda									
Family Gammandae									
Crypturopus pachytus	+	+	–	–	–	–	+	–	–
C tuberculatum	+	–	–	–	–	–	–	–	–
Crugosus	+	–	–	–	–	–	+	–	–
C in flat us	+	–	–	–	–	–	–	–	–
Micrmopus wahlu	+	+	+	–	–	–	+	+	–
M kluki	+	–	–	–	–		–	–	–

Table 4 4 Continued

Species and subspecies	*Angaia River*			*Yenisev River*	*Lena drainage*	*Khubsugul Lake*	*Reser\oas of Rner Angara*		
	upper	*middle*	*low*				*1*	*2*	*3*
M tali tro ides	+	–	–	–	–	–	+	–	–
M ushkani	+	–	–	–	–	–	–	–	–
M httorahs	+	–	+	–	–	–	+	–	–
M httorahs crassipes	+	–	–	–	–	–	+	–	–
M ciltodorsahs	+	–	–	–	–	–	–	–	–
M laeviusculus	+	–	–	–	–	–	–	–	–
M gurjanowae	+	–	–	–	–	–	–	–	–
M glaber	+	–	–	+	–	–	+	–	–
M vortex	+	–	–	+	–	–	+	–	–
M vorticellus	+	–	–	–	–	–	–	–	–
M koshoHi setosus	+	–	–	–	–	–	–	–	–
M mimttus	+	–	–	–	–	–	–	–	–
Gmehnoides fasciatus	+	+	+	+	–	–	+	+	+
Brantia lata	+	+	–	–	–	–	–	–	–
B lata acera	+	–	–	–	–	–	+	–	–
B lata dicera	+	–	–	–	–	–	+	–	–
B lata intermedia	+	–	–	–	–	–	+	–	–
B lata latiisima	+	+	–	–	–	–	+	–	–
Hyalellopsis czyrniansku	+	+	–	+	–	–	–	–	–
Pallasea cancellus	+	–	–	–	–	–	+	–	–
P cancelloides	+	+	+	–	–	–	+	+	–
P kessleri	+	–	–	–	–	–	–	–	–
P grubei	+	–	–	–	–	–	–	–	–
P brandti	+	–	–	–	–	–	–	–	–
P d} how skit	+	–	–	–	–	–	–	–	–
Euhmnogammarus verrucosus	+	+	+	–	–	–	+	+	–
E hvidus	+	–	–	–	–	–	+	–	–
E maacki	+	–	–	–	–	–	+	–	–
E cyanoides	+	+	–	–	–	–	+	–	–
E vindiformis	+	–	–	–	–	–	+	–	–
E grandimanus	+	–	–	–	–	–	+	–	–
E vindis canus	+	+	+	–	–	–	+	–	–
E vindis ohvaceus	+	+	+	–	–	–	+	–	–
E viridulus	-h	+	–	–	–	–	+	–	–
E man tup.	+	–	–	–	–	–	–	–	–
E vittatus	+	+	+	–	–	–	+	–	–
E testateus	+	+	–	–	–	–	–	–	–
E cyaneus	+	+	+	–	–	–	–	–	–
E cyanellus	+	+	–	–	–	–	+	–	–
E fuscus	+	–	–	–	–	–	+	–	–
E proximus	+	–	–	–	–	–	–	–	–
Class Insecta									
Family Chironomidae									
Diamesa baicalensis	+	+	–	–	–	–	+	+	+
Orthuc ladius '•eto sus	+	+	–	–	–	–	+	–	–
0 compactus	+	+	–	–	–	+	+	–	–
O gregarius	+	+	–	–	–	+	+	–	–
Pa? a/a# J *torsu* r *haic a Jem.'* f	–	–	–	–	–	–	V-	+	–
Neozavrelha minuta	+	+	–	–	–	–	+	–	–
Sergentia baicalensis	–	–	–	–	–	–	+	+	–
S kozhovi	–	–	–	–	–	–	+	–	–
S flavodentata	–	–	–	–	–	–	+	+	–

Table 4 5. Continued

Species and subspecies	*Angara River*			*Yenisei River*	*Lena drainage*	*Khubsugul Lake*	*Reservoirs of River Angaia*		
	upper	*middle*	*low*				*1*	*2*	*3*
Class gastropoda									
Choanomphalus maacki	+	+	−	−	−	−	+	−	−
Ch maacki var andrussovianus	+	+	−	−	−	−	−	−	−
Ch amauromus	+	+	−	+	−	−	+	−	−
Ch amauromus var valvatoides	+	+	−	−	−	−	+	−	−
Ch amphalocnpla	+	+	−	−	−	−	+	−	−
Ch mongohcus	−	−	−	−	−	+	−	−	−
Ch anomphalus	+	+	−	−	−	−	−	−	−
Megalovalvata pihgera var. midicartnata	+	+	+	−	−	−	−	−	−
Pseudancylastrum sibiricum	+	+	−	−	−	−	+	−	−
P dybowsku	+	−	−	−	−	−	−	−	−
P werestchagint	+	−	−	−	−	−	−	−	−
Baicalancylus (Pseudancylastrum) kobelti	+	−	−	−	−	−	−	−	−
Gerstfeldtiancvlus benedictiae	+	−	−	−	−	−	−	−	−
Maackia herdenana	+	−	−	−	−	−	−	−	−
M angarensis	+	+	+	−	−	−	+	−	−
Class Bivalvia									
Sphaerntm baicalense	+	+	+	−	−	−	+	+	−

Note 1 - Irkutsk, 2 - Bratsk, 3 - Ust-Ihmsk reservoirs

off from Baikal via the Angara, and to an ancient connection with the Lena basin.

As established by Pirozhnikov, Greze and others, Baikalian immigrants form a considerable part of the biomass of the lower reaches of the Yenisei. For this reason, the possibility of stocking waterbodies in North Siberia with Baikalian species has been raised. This question has assumed particular importance in connection with the construction of large reservoirs, where some Baikalian species might constitute the bulk of the benthos and plankton. Among pelagic fish, the Baikalian gwyniads and especially the omul may prove quite valuable in this respect.

The dispersal of Baikalian organisms outside the lake is illustrated by Table 4.5.

Chapter 5
Benthic life

5.1. Horizontal distribution

In a comprehensive study of the distribution of molluscs, a clear distinction between the fauna of north and south Baikal was found, the boundary lying in the region of the mouth of the River Turka *on the eastern coast* and in the region south of the Olkhonskiye Vorota Strait on the west coast, *i e* , almost central Baikal The differences are quite clear, with many species and varieties entirely restricted to the north or south of the lake *Maackia vanesculpta, Pseudobaitaha jenttet icina, Korotnewia angigyra, Tetrabaikaha macrostoma* and *Choanomphalus annuliformis* live only in the north, whereas *Liobaicaha stiedae, Maackia herdenana* and *Baicalia turriformis* only occur in the south (Kozhov, 1936b, 1947)

Similar differences occur in the gammands (Dorogostaisky, 1923b), with approximately the same boundaries the area of the Anga on the west coast and the fringe of the Selenga Shallows on the east Based on the distribution of gammands, Bazikalova (1945) divided Baikal not into two, but into three zones, corresponding to the troughs (south, central and north) of Baikal today But the transitional character of the gammand fauna in the central part of the lake should be stressed, while faunal differences between the three depressions were chiefly restricted to the coastal zone and inconspicuous in the deep zones The southern trough is characterized by *Poekdogammarus lydiae, Leptostenus leptocerm, Abyssogammarus sarmatus echinatus,* and *Euhmnogammarus parvexiformis,* and the northern by *Euhmnogammarus rachmanom, Lobogammarus latm, Abyssogammarus gracdts, Ceratogammarus acerus, PaUasea meissneri* and *Hvallelopis carpenten profundahs* (see list of species)

Among small bottom animals, differences between south and north Baikal have been identified in the Harpacticoids (Okuneva, 1989) and Ostracoda (Mazepova, 1990) Harpacticoids endemic to north Baikal are *Bryocamptus tuberculatus, B longisetosus, B schappuisi, Moraria (Baicalomoraria) coronata*, ostracods *Pseudocandona ceratina, Candona iwanovi, C walukam, Cytherissa latiundata* Differences in distribution also exist between the east and west coasts For instance, *Acanthogammarus flavus turtus, A/ sowmskit, A brevispinus, Macropenopus muus, Micruropus macroconus* (see list of species), and the molluscs *Megalovalvata parvula,* and *M lauta,* live on the east coast but almost never on the west coast The frequency of occurrence and abundance of Cyclops (Mazepova, 1978) and Harpacticoids (Okuneva, 1989) also vary between the west and east coasts

The differences in nearshore bottom fauna of north and south Baikal can partly be explained by differences in physical-geographical conditions The ice in the north half breaks up a week or two later than in the south, and the annual cycle of temperatures in the north is slightly different as well But these differences are not large enough to be solely responsible for the differences m fauna For instance the Maloye More differs more sharply from the open regions of north Baikal than from the south part, but its fauna is of a distinctly northern nature Consequently, the causes of this differentiation should be sought not only in present-day ecological conditions, but also in geological history, discussed in detail in the chapter on the evolution of the Baikal fauna Yet, the differences in faunal composition and dominant species between the eastern and western coasts are sufficiently explained by geomorphology of the slopes and composition of the bottom

Detailed work has now made it possible to establish a number of faunal subsections within the confines of the two main parts of Baikal Of special interest among these are the Maloye More, Selenga and Ushkany sections

The fauna of the Maloye More area is rich and represented, apart from widespread species, b> north Baikahan species and local endemics, such as the molluscs *Megalovalvata pihgera piligera, Maackia wereschagim, Godlewsha nrzesmowski olchonensn,* the amphipods *HyaleUopsis depressirostris, H irinae,* and *Poekilogammarus jedorensis* The so-called Malomorsky gwyniad *(Coregonus lavaretus baicalensis)* lives almost exclusively in the Maloye More Similar examples can be cited for the area of the Ushkany Islands, as pointed out by Dorogostaisky (1923b), Bazikalova (1945), and Tahev (1955) The Ushkany prcisland shallows (terminology of Mazepova, 1990), faunistically close to north Baikal has its own endemics, *eg,* the Cottoidei *Batrachocottus uschkam* and *Paracottus insulans* These have not been found in other regions of Baikal, whereas *Batrachocottus baicalensis, Paracolitis knen,* which are widespread in other regions, are absent here A similar picture exists in other groups The molluscs *Choanomphalus maacki maacki* and *Tel atobaikahu ahata,* widespread in Baikal, do not occur in the region of the Ushkany Islands, but *T macrostoma* dwelling in north and middle Baikal, are numerous there The endemics to the Ushkany region are the amphipods *Micruropus macroconus tenuis, M pupilla* and *M uschkam* (see list of species) Of 130 endemic species of ostracods, 20 species and subspecies are endemic to the Ushkany shallows, including *Pseudocandona onduoltory'ensis, Baicalocandona ushkani, B borutsku, Candona longula C /Java,* and *Cythenssa placida,* all characterized by rare, distinctive features (Mazepova, 1990) The peculiarity of this fauna lies in the fact that it was isolated from the coasts of Baikal and developed disjointedly for a long time

The bottom fauna of the Selenga region has the following peculiarities coexistence ot Siberian and Baikahan complexes, with a gradual replacement of the Siberian by the Baikahan complex with increasing depth (Bazikalova, 1971), and extension to considerable depths of species which occur predominantly in shallows elsewhere (Mazepova, 1990) Major endemics of the Selenga region are *HyaleUopsis latipes selengensis, Micruropus mozi, Pallasea baicah ineimis, P gtubei arenicola,* and *Korotnewia korotnewu gracilis,* (see list of species) Starobogatov (1970) singles out seven faunal provinces, four of which have extensive shallows (0-100 m)

The south Baikahan shallow province is bounded to the north, along the west coast, by the mouth of the Buguldeika River and along the east coast by the Sukhaya settlement

The west Baikahan province is bounded by the mouth of the Buguldeika River, Zama Cape, and comprises the west coast of middle Baikal and the Maloye More Strait

The north Baikahan province is bounded on the west coast by the Zama Cape, and on the east coast by the Chivyrkui Gulf

The east Baikahan province lies along the east coast, from Chivyrkui Gulf to the Sukhaya settlement (north of the Selenga delta), and embraces the region of the Ushkany Islands and the coast of middle Baikal

Two supra-abyssal provinces occupy the zone of depths of 100-250 meters One of them is comprised of north and middle Baikal, the other of south Baikal The pseudoabyssal province, finally, embraces the whole trough of Baikal at depths exceeding 250 meters Starobogatov (loc cit) gives a list of endemic molluscs for each province Such zoogeographical zonation, implying a division according to lake depth, does not reveal the peculiarity of the fauna of the littoral and subhttoral zones and leads, in the end, to a multiplication of the number of provinces New data on the horizontal distribution of the fauna of Baikal single out only two large provinces north Baikahan (north of the Anga on the west coast and north of the Selenga River on the east coast), and south Baikahan (south of these places) The middle trough of Baikal has a mixed (transitory) fauna along the west coast, from the Buguldeika River to the Olkhonskye Vorota and along the east coast from the Sukhaya settlement to the Academichesky Range It is also reasonable to conserve separate sections in the north Baikahan province the Maloye More Strait and the Ushkany preisland shallows, and in the south Baikahan province, the section of the avandelta of the Selenga River

In the zoogeographical classification of continental waterbasins of the world, Lake Baikal occupies a different status according to various authors the Baikahan sub-region of the Holarctic (Berg, 1909, Kozhov, 1936b, 1963) or the Baikahan region (Starobogatov, 1970) Mazepova (1990) considers it unnatural to qualify Baikal Lake, located in the center of the Eurasian continent, as a separate zoogeographical region

The considerable isolation of the fauna of Baikal from other continental waterbasins and its high degree of endemism, give it a high rank in the zoogeographical classification The dispute on its status - whether region or subregion - is not as important

5.2. Vertical zonation of open Baikal

Various factors, such as temperature, chemistry, light intensity, water movement, and properties of the bottom, depend on depth and cause a vertical zonation in the bottom fauna of the waterbody The zones and their boundaries however, are largely arbitrary, serving to facilitate the description of their biocoenoses A distinguishing feature of the biological zonation in Baikal is that the contrasts from the coastal shallows to the extreme depths are uncommonly great

Property of the bottom is an important factor in the distribution of benthos The distribution of bottom types, in turn, depends on many factors, such as the degree to which a nearshore section is protected against prevailing winds, currents, turbulence, the steepness of the underwater slope, the composition of the shores subjected to erosion, and the nearness of the mouths of large rivers In view of this, separate patterns of biological zonation should be worked out for every area with characteristic features (extensive shallows, gulfs, open sections with rocky shores and a steep underwater gradient, and so on) There is not yet enough information in this field, and in describing the distribution of benthos, we are still compelled to use a generalized pattern (Kozhov, 1931a, 1934a, b, 1947, Yasmtsky 1928) The bottom vegetation in open Baikal is distributed as follows The belt of *Ulothnx zonata,* a green alga which thickly covers beach stones in the area of most violent turbulence, extends from the edge to a depth of 1-1 5 meters, at times somewhat deeper Many species of epiphytic diatoms are found in these *Ulothnx* growths The second belt (from 1 5 to 2 5 meters) is represented by a phytocoenosis dominated by *Tetraspora cyhndrica* var *bullosa* In the third belt (from 2 5 to 15-20 meters), rich in bottom vegetation, the phytocoenosis is defined by nine endemic species of *Draparnaldwides* During summer (the second half of June to September), a three-times repeated replacement in dominant species is observed The fourth (from 11-16 to 30-35 meters) and the fifth (from 30-35 to 70 meters, occasionally to 100 meters) belts are formed by shadow-loving, slow-growing endemic Chlorophyta *(Cladophora meyeri, C pulvinata, Chaetodadiella microscopica, Chaetomorpha curta)* and Cyanophyta *(Microcoleus baicalenus, Gloeothithia pisum)* The phytocoenosis of belts 4 and 5 differ by species (and dominants) in different seasons of the year The composition of algae is very diverse in belts 2 and 3 on solid bottoms, and in belts 3 and 4, on soft bottoms (Izhboldina, 1990)

In winter (January-March) perennial algae are dominant in all five belts They occur in the littoral in other seasons, under the cover of larger algae In spring (April-mid June), algae with a short period of vegetation begin to develop In summer they reach a peak phytomass In autumn (October-December) dying-off occurs

Example of spatial distribution of bottom vegetation is given in Fig 5 1

The structure of the bottom phytocoenoses along the open coasts is heterogeneous, particularly along the east and west coasts Phytocoenoses are formed both by endemic and widespread species and depend on bottom type and morphometry of the bottom The number of genera, species and intraspecies taxa of algae of macro- and meiophytobenthos of Baikal, are the following (Izhboldina, 1990)

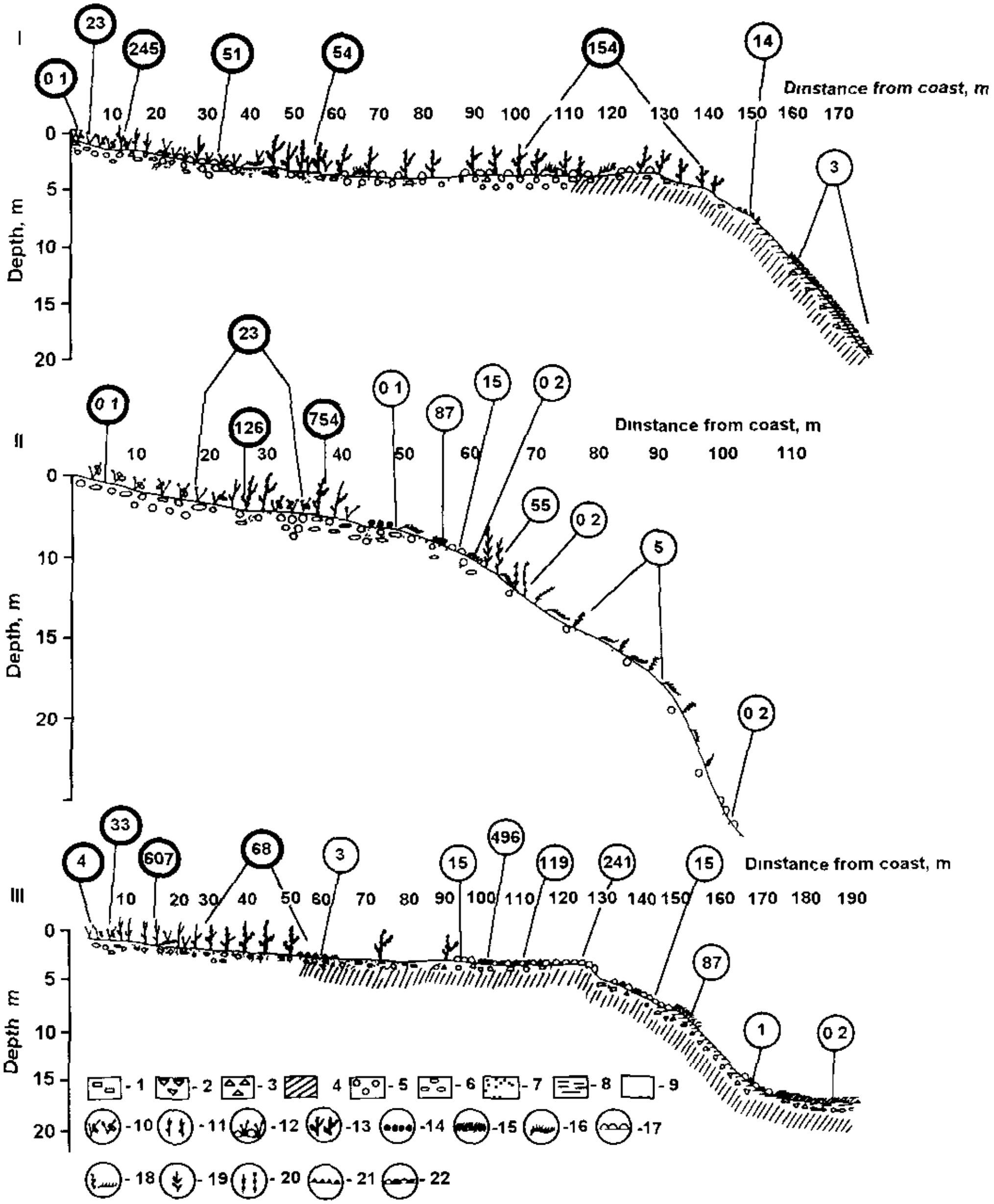


Fig 5 1 The vertical distribution of phytobcnthos in \arious transects of western coast South Baikal, Bolshiye Koty September 1988

Substatcs 1 - fragments, 2 - road-metal 3 - decay wood 4 - rocks, 5 - boulders, 6 - pebbles. 7 - sand, 8 - silt, 9 - gravel Associations 10 *Tetrasporopis sp* + *Didymosphema geminata,* 11 - *Draparnaldioides pumila,* 12 - *Didymosphema geminata* + *Cladophai a t ompac (a,* 13 - *Di apai naldioides baicalensis,] 4 - Slratonoi toe v erruc osum, } 5 - Cladophora flocco <ta* + *Cladophora kuisano\n* + *Cladophora compacta,* 16 - *Myriophvllum spicatum,* 17 - *Cladophora compacta,* 18 - *Fonttnahs sp* + *Myriophyllum spicatum,* 19 - *Elodea canadensis,* 20 - *Nitella sp* 21 - *Calothnx brattnu,* 22 - *Cladophora kiirsano\u* + *Cladophora compacta* Normal circles - in the community dominate species \egetating in summer period, bold circles - m community dominate perennial species In centre of circles average phytomass of phytobenthos (g m ^{2})

1 - III - transects

Data of the Research Institute of Biology

		Total			hndcmics	
	Genera	*Species*	*Vane ties*	*Geneia*	*Species*	*Varieties*
Cyanophyta	12	40	4	-	1	-
Chrysophyta	2	2	-	-	1	-
Baallanophyta	2	*2*	1	–	1	-
Chlorophyta	12	36	8	5	24	6
Charophyta	2	5	-	-	-	-
Rhodophyta	1	2	-	-	-	-
Total	31	87	13	5	27	6

In bays and sections protected from prevailing winds, some of these algae, characteristic of open Baikal, disappear and are replaced by *Nostoc, Potamogeton, Myriophyllum, Ceratophyllum,* and *Chara.* Baikal also abounds in bottom diatoms, which can be traced to depths of 50-70 meters.

The shore is adjoined by a strip of clean sands, while a belt of boulders and pebbles stretches along rocky shores. From 8-12 meters, the sands begin to be silted, and are replaced at 15-20 meters by fine silted near-shore sand. Strong near-shore silting is observed only opposite the mouths of big rivers and in areas isolated from currents. The sharp drop in density of vegetation, and the marked change in soil properties and in the thermal regime of the bottom layers, are responsible for the qualitative and quantitative increase in fauna which is usual along open shores at depths of about 15-29 meters. This outlines a coastal zone analogous to the littoral of other lakes But even within this zone, the fauna and flora gradually alter with conditions. We can distinguish a surf subzone, with fairly distinct life conditions, a subzone of shallow depths stretching to 4-6 meters, where the waves lose their destructive force and bottom plants develop on a large scale, and deeper still, the lower sub-zone of the littoral.

Beyond 20 meters the transition to deeper zones begins The upper part of this region extends to approximately 70 meters (the limit of bottom diatoms). In this zone, the subhttoral, the effects of lower summer temperatures, low light intensity, low content of particulate organic matter, and a predominance of silted sands over rocky and sandy bottoms, begin to be felt. Together with littoral species, supra-abyssal and sometimes abyssal fauna begin to occur here. The zone beyond the sublittoral, reaching the 250-300 meter-isobath, is called the transitional, or supra-abyssal zone. Its lower limit lies in the layer where temperature remains practically stable around the year. Its bottom is composed of strongly silted sand or silt, while bare rocks predominate in sections with a steep gradient. The abyssal zone embraces the underwater slope and the whole main trough of Baikal below 250-300-meter depths. Its bottom is covered, with rare exceptions, with deepwater diatom ooze. Its regime is characterized by constancy; temperature is about 3.4-3.6°C around the year; dissolved oxygen ranges from 75 to 90% saturation; light is practically absent. The fauna is represented almost exclusively by deep-dwelling species.

Two subzones can be distinguished: the upper abyssal, to a depth of 500-600 meters, and the lower, extending to the extreme depths, the domain of typical deepwater species.

The pattern of vertical zonation outlined here is similar to that of Stankovič (1960) for Lake Ohnd, vertically divided into the littoral (0-18-20 meters), subhttoral (20-40-50 meters), and deep zone (from depths of more than 50 meters to the bottom). There is no true abyssal zone in Ohnd, its maximum depth being only 286 meters.

Our version of the vertical zonation of open Baikal is not generally accepted. Other attempts to define zones have been made by Lmdholm (1909), Sovinsky (1915), Dorogostaisky (1923b), Vereshchagin (1949), Bazikalova (1945), Tahev (1955), and Bekman (1959). Without going into a detailed analysis of all these, Table 5.1 summarizes those variants which have been more thoroughly elaborated. We will now review the distribution of benthos in the zones outlined above.

5.2.1. Littoral zone (0-20 meters)

The width of the surf subzone strongly varies in different sections of Baikal; in sections with rocky shores it does not exceed 10-15 meters, but in other places it reaches hundreds of meters. The bottom is chiefly covered with pebbles, large stones, and fragments of coastal rocks. Sands predominate near river mouths and on sandy beaches in bays.

Table 5 I Vertical zonation (m) of the distribution of zoobenthos

Zone	*Kozho\ (1931a, 1947)*	*$o\in$k\ (19 IS)*	*Dorogoslaiskv (1923 b)*	*Bazikalova (1945)*	*Vereshchagin (1949)*
Littoral	0-20 Upper section or surf subzone, 0-1 5 Middle section 1.5-5 Lower section, 5-20	0-10	0-5	0-5	Surf zone 0-1 5 Zone of small depths, 1-1 5-10-15
Subhttoral	20-70	10-15	5-50	5-70-150	10-15-100
Supra-abyssal (transitional)	70-250 (300)	Transitional, 50-200	Transitional, 50-300	Transitional, 70-150-300	Transitional, 100-250
Abyssal	Deeper than 250 Upper section, 250-500 Lower section, deeper than 500	Subabyssal. 200-500 Abyssal deeper than 500	Abyssal deeper than 300	Deep, 300-500 Abyssal, deeper than 500	Subabyssal *250-500* Abyssal. deeper than 500

Life in this subzone is distinctive. Strong surf rolls stones and pebbles and shifts sands; only-heavier stones remain motionless. Sand, debris, remains of plants, insects and other small animals are washed away from the shore and are either carried away, settle on the bottom, or are redeposited on the shore. During strong storms, the surf zone becomes turbid, especially in sandy areas. On calm days, the water at a depth of 0.25 meters is heated to 5-7°C in early June and to 12-16°C or more at the end of June and in August. But during strong winds from the mountains, the water temperature near the leeward shores drops sharply and rapidly. In summer, diurnal temperature fluctuations at the water edge may reach 2-3°C.

Water chemistry also varies considerably over 24 hours; during summer days, the water can be over-oxygenated (up to 120-150%), whereas at night a deficit may be observed (Yasnitsky *et ai,* 1927), with an oversaturation of free $C0_2$. The surf belt constantly shifts, owing to fluctuations in water level of within a range of one meter or more per year. In winter the inshore belt freezes to a depth of one meter. Macrophytes are not found in the surf belt in open sections, where constant turbulence prevents them from becoming fixed. Animals are represented by the tiny yellow oligochaete *Mesenchitraeus bungei,* large numbers of which populate the sands at the edge of water and on the surf-wetted shore. In summer, the stones of the surf belt are covered with a thick green mat of *Ulothrix zonata,* which appears in spring at the very edge, and later, with a rise in water level, covers the bottom to a depth of 1-1.5 meters.

The most characteristic animals in rocky sections of the surf belt are the oligochaete *Mesenchitraeus bungei*, between and under stones, the large gammarid *Euhmnogammarus verrucosus,* the tiny light-blue *E. cyaneits, E. viridis, Gmehnoides fasciatiis* and *Brandtia latissima.* In *Ulothrix* growths, masses of Harpacticoida can be found. Turbellarians are represented by *Baikalobia guttata, B. copulathrix* and *B variegata.* The algal beds are densely populated by larvae of *Orthocladiinae* and *Tanytarsini* and by the oligochaete *Nais* sp. During strong surf, the animals hide between stones, in algal growths or in the sand.

Microzoobenthos and mesozoobenthos in the *Ulothrix* growths reach 190,000 specimens m"^{2}, with *Flagellata* dominant (Okuneva, 1990). In August, macrozoobenthos reach 22,400 specimens m ^{2} and 15.3 g m"^{2}; in September, 21,100 specimens m ^{2} and 60.1 g m^{-2}, with Amphipoda dominant (Vemberg *et ai,* 1995).

In early spring, vast numbers of mating Trichoptera accumulate in the surf belt. There are no sponges in this subzone, and only individual molluscs enter it on quiet days. Towards autumn, *Ulothrix* disappears and the animal population moves to the deeper adjacent zone. Only the oligochaete *M. bungei* stays, burrowing deep in the sediment. The surf subzone is best developed along the shores of open Baikal and in its bays and gulfs. In summer its fauna is fairly rich, especially on the rocky bottom, among algae. Life is particularly abundant in spring and in the first half of summer. In this period the grayling, *Thymallus arcticus baicalensis,* often aggregates at the very edge of the water, attracted there by food, and Cottoidei are also usual. In contrast, the surf belt of sandy soils in open, shallow regions, especially along the east shores (the Selenga Shallows), is thinly populated. Life conditions beyond the surf subzone become more favorable. The influence of surf waves weakens and the seasonal fluctuations in bottom temperatures decrease

The predominant bottoms along the open shores, far from large rivers, are pebbles and comparatively clean coarse sand, which, starting at 5-6 meters, is replaced by fine sand with an admixture of mud. In bottom hollows, considerable accumulations of coarse detritus brought by rivers can be seen, and dead weeds washed away from the shores.

In the pre-estuarine regions of large rivers, the littoral is usually composed of sand, pebbles, or is strongly silted; in sheltered sections of pre-estuarine regions, silted sands sometimes directly follow the surf subzone. Vegetation is concentrated chiefly on rocky patches of the bottom. On sandy soils, especially in areas protected by long promontories, small growths of *Myriophyllnm* can be seen. In sheltered areas, *Potamogeton, Polygonum amphibium,* and Characeae are found The surf zone can be divided into two subzones: 0-0.3 meters (water's edge) and 0.3-1 meters. Seasonal changes in the zoobenthos of these subzones (Table 5.2) result from different periods of reproduction, horizontal and vertical migration, flight (of insects), wave kinetics, water level, and soil granulometry (Arov, 1987; Kaplina, 1974)

Maximum numbers and biomass in the one-meter zone are recorded in periods of wave impact, with input of littoral waters. Maximum amounts of zoobenthos on stones, located on sand at a depths of 0.6-1.5 meters are recorded during ice cover, at minimum hydrodynamic activity (Veinberg *et al.*, 1995).

The dominance order between macrozoobenthos groups depends on the size of the interstices. Coarse-grained, pebble-boulder bottoms are dominated by Amphipoda, fine-grained sands by Oligochaeta. A common biotope of the littoral is rocky bottoms. These are populated by a rich and varied fauna. As a rule, any stone taken from a depth of 2-10 meters is covered on top, on the sides and sometimes even below, with the algae *Didymosphenia, Cladophora, Chaetomorpha, Draparnaldioides, Tetraspora,* as well as the sponge *Lubomirskia baicalensis. Lubomirskia baicalensis* may occur in particularly large numbers. At 4-10 meters, thickets of this bright-green branching sponge abound. In Listvenichny Gulf, they occupy at least one-fourth of the bottom area (Gavrilov, 1950a,b).

In the region of river mouths, sponges do not find favorable habitats. Their greatest density is observed at depths of more than five meters on steep rocky slopes. Most present bark-like morphs, specimens of which appear from 1.5-2.0 meters onwards. Sponges of up to 5 cm high appear at around three meters, and of 5-50 cm high at depths of four to 30 meters. Sponges of more than 50 cm in height are rare. They appear at 6-8-meter depths.

Oligochaetes, chiefly *Lamprodrilus nigrescens,* live under the base of the sponge; hundreds of tubes of the Baikalian polychaete *Manayunkia zenkewitschi* often stick around the edges of the base and at the oscular openings; larvae of caddisflies, which construct their cases from coarse grains of sand, live in the hollows of stones. Typical commensals of sponges are Nematoda - *Tobnlus latens, Tectonchus absconditus* and *Eudoryiaimus spongiophylus* (Tsalolikhin, 1974), and the cyclopid *Acanthocyclops spongicola.* A 'harpacticoid' form of the body allows *A. spongicola* to move on the sponge surface (Mazepova, 1962). On the sponge surface we always find large amounts of the minute emerald-green gammarid, *Brandtia parasitica.* This tenaciously clings to the sponge even when it is lifted from the water. Kamaltynov *et al.* (1993) note that *B. parasitica* is the dominant animal living on *Lubomirskia bai-*

Table 5 2 Distribution of zoobenthos biomass (g m^{-2}) in the surf zone (I-subzonc 0-0 3 m, H-sub70iie 0 3-1 m) South Baikal, Bofshiye Kot>, 1963-1968 After Kapima, 1974

	Spring		*Summer*		*Autumn*		*Unite i*	
Group	/	*11*	/	*11*	/	//	/	//
Amphipoda	41 1	3 9	35 7	*9* 6	04	3 1	0	0.2
Mollusca	0	66	0	1 6	0	06	0	11 2
Ohgochaeta	<0 1	<0 1	0 5	1 4	02	0 6	0	<0 1
Turbellana	03	1 1	0 2	*0 3*	0	2 0	0	2 5
Chironomida	<0.1	0 1	1 3	4.3	0	04	0	02
Tnchoptera	2 6	1 5	1 0	05	0	0 8	0	1 8
Total	44 2	13 3	38 7	17 7	06	75	0	160

calensis. Its maximum number and biomass (B) on the sponge can reach 1895 specimens m"^{2} and 20.6 g m ^{2}, respectively. Such species as *Megalovalvata baicalensis* (max B = 5.27 g m~^{2}), *Eulimnogammarus violaceus* (max B = 1.38 g m ^{2}) and *E cruentus* (max B = 0.38 g m ^{2}) are also important. The amphipod *Poekilogammarus erinaceus* Tach. jumps over the surface of the sponge and in its vicinity.

A rich fauna also occurs on overgrown stones at a depth of 1-5 meters. Bare parts of stones are inhabited by turbellarians, including *Baikalobia copulathrix*, *B guttata* and *B. variegata;* the ohgochaetes *Propappus glandulosus* and *Lamprodrilus nigrescens;* the leech *Baicalobdella torquata;* large numbers of small *Kalyptorhynchia;* the isopods *Baicalasellus angarensis* and *B. baicalensis;* larvae of caddisflies (Baicalmini), and chironomids. Masses of g-mmands hide in cracks, algal growths, and undei stones, etc Especially numerous are *Eulimnogammarus grandimanus, E. cyaneus, E. viridis, E. maacki, Brandtia latissima, Gmelinoides jascialus* and *Baicalogammarus pullus.* We also find a wealth of molluscs, especially *Choanomphalus amauronius, C. maacki, Maackia (Eubaikaha) herdenana, M. (E) bythiniopsis, Teratobaikaha ciliata* and, in the north, *T. macrostoma* and *M.(E.) vanesculpta.* On and between stones, Baikalian cottoid fish can often be seen, particularly *Batrachocottus baicalensis, Paracolitis kessleri* and *P. kneri,* and in spring, *Cottocomephorus grewingki,* spawns there (Table 5.3).

It is believed that the biomass of zoobenthos on sponge-covered rocky ground in the littoral at a depth of 2-3 meters averages 100 g m"^{2}, excluding the sponges, whose weight often exceeds 1 kg tn~^{2}.

A comparison between various rocky sections shows that the depths directly adjoining the surf zone are more scantily populated than the 3-8-meter zone, where life is particularly abundant. With increasing depth, a change in dominant groups occurs: Amphipoda are replaced by Mollusca. In May the surf zone is dominated by Amphipoda of the species *Eulimnogammarus verrucosus,* in June-July *E cyaneus* is particularly numerous. The molluscs *Choanomphalus amauronius* and *Benedicts baicalensis* are rare at that depth. At 2-5 meters, *Choanomphalus amauronius* and *Maackia herdenana* are dominant (with a predominance of the first or second at different sections of the rocky bottom). Oligochaetes and small Bivalvia live between and under stones. In calm (waveless) periods, abundant *Manaynkia baicalensis* can be seen there.

The rocky littoral has been studied by the Limnological Institute of the Siberian Branch of the Russian Academy of Sciences, in the region of the Zhilishe canyon (south-west coast) (data not published). The south flank of the canyon is characterized by high numbers (22,448 specimens m~^{2}) and biomass (417.8 g m~^{2}).

Maximum values, recorded on the ceilings of hollows were 64,220 specimens m"^{2} and up to 982.72 g m"^{2}. Minimum values, recorded on a boulder in the bed of the canyon, were almost identical *to* those on rocky ground. The dominant group was Gastropoda (90-99% of the total number and biomass of the zoobenthos). Dominant taxa, in decreasing order, were *Maackia herderiana, Teratobaikalia ctltata^ M(E.) bythiniopsis,* *Baicalia turriformis,* and *Maackia costata.* Other animals of the south flank of the canyon were insignificant. An exception being the biota of horizontal shelves with silt, detritus and plant remains where colonies of *Manayunkia godlewskii* completely covered the shelf surface (Kamaltynov *et al.,* unpublished data).

Zoobenthos biomass on stony bottoms of the littoral of south Baikal is given in Tables 5.4 and 5.5.

Rocky grounds in the littoral of open Baikal are favored sites of the Baikalian black grayling, *Thymallus arcticus baicalensis,* and of many Cottoidei.

Coarse littoral sand, at depth of 2-10 meters along the open coast, is usually embedded in rocky sections, in patches of about m^2 to several hectares, or occupies large areas opposite sandy shores and in pre-estuarine regions. In the Selenga delta, and on both sides of it, sands spread over a vast territory, reaching into open Baikal beyond the 10-meter isobath, up to a distance of 8-10 km from the delta. Extensive areas are also taken up by sands in the vicinity of the mouths of the Upper Angara, Kichera, and Turka rivers. These sands are populated by a distinct fauna. Turbellanans are represented by the characteristic pink *Archicotylus plana* and *Sorocelis nigrofasciata.* Among oligochaetes, different species of Naididae, Enchytraeidae and Tubificidae are numerous. A sandloving form of the *yoXycn&Qtt Manayunkia baicalensis* and Piscicolid leeches may also often be found here. But a particular density is attained by gammarids, whose colors blend well with that of the sand. Special mention should be made of the genus *Micruropus,* most of which are typical burrowing sand-dwellers, *eg., M wahlii, M talitroides,* and *M. littoralis crass ipes*

The genus *Hyalellopsis* is also typical of the sands, with the tiny, yellowish *H variabilis* and *H. czyrnianskn* as the most common species. Representatives of other gammarids frequently found on the sands include the red-eyed dingy-brown *Echiuropus rhodophthalmus, E. rhodophthalmus microphthalmos, E macronychus, and Poekilogammarus araneolus.* Among molluscs, we should mention *Choanomphalm aorus\ C. schrenki, C. gerstfeldtianus, Parabaikalia oviformis, P. elala, P. florii, Baicalia dybowskiana, Maackia bythiniopsis, Korotnewia semenkewitschi, Pseudobaikalia pulla, P. contabulata, Benedictia hmnaeoides, Sphaerium baicalense, Lacustrina dilatata, Englesa korot-*

Table 5 3 Fauna of stones covered by algae and sponges (rrr^2) at a depth of 3-4 meters in south Baikal, Bolshiye Koty (microfauna not included). After Kozhov, 1931a

Group	*Numbet of species*	*\itmber of specimens*	*Fresh weight, ''•i>*	*Predominant forms*
Spongia	2	15 (colonies)	—	*Lubomirikia baicalensis*
Turbellana	6	95	1 3	
Polychaeta	1	200	0 2	*Mana\iinkia zenke-witschi*
Oligochaeta	4	100	0 7	*Lamprodrilus nigrescent*
Hirudmea	2	77	0 2	*Trachelobdella*
Assellidae	1	55	0 1	*Baicaloaseiius angarensis*
Amphipoda	20	972	25 0	*Eulimnogammarus grandimanus*
Mollusca	9	2066	80	*Maackia herderiana* *Choanomphalus amauromus.* *Ch maackt*
Tnchoptera	2-3	785	7 8	Baicalinini
Chironomidae	2-3	143	0 3	-
Total.	up to 50	4508	115 6	(without sponges)

newt, and *Megalovalvata baicalensis.* The number of species of this biocoenosis reaches 50, excluding small-sized forms (not retained by a one-millimeter sieve), of which many are molluscs (about 20 species) and gammarids (more than 20 species). The number of specimens (without microfauna) *per* m~^{2} sometimes exceeds 2000. Biomass is lower than on rocky bottoms, but still fairly high, 15 g m"^{2} on average. Molluscs account for the greater part of it. On these sands, considerable numbers of Cottoidei fish can also be found, especially *Paracottus kessleri.* In north Baikal, the zoobenthos biomass of the littoral sands average 15 g m ^{2}. Quantitative characteristics of the zoobenthos of the littoral sands of south Baikal are given in Table 5.6 and Fig. *5.2.*

Available data suggest that the zoobenthos biomass of sandy soils in the littoral of open regions is approximately 12-20 g m~^{2}.

Silty, fine sands with detritus at a depth of 8-20 meters are more richly populated, both in quality and quantity, than clean sands. Here, not only typical sand dwellers can be seen, but also other forms, which prefer detritus. For instance, the oligochaetes include, beside *Lycodrilus dybowsku, Lamprodrilus stigmatias, L. wagneri,* and *Styloscolex baicalensis,* large numbers of *Manayunkia godlewskii* (a polychaete). The amphipods include many *Crypturopus pachytus, C inflatus, C. tuberculatus, Echiuropus rhodophthalmus,* and *Hyalellopsis carpenten; Pallasea brandti* is frequent at depths of 20-25 meters. Molluscs are abundantly

Table 5 4 Average biomass (B, g m^{-2}) and number (N, 10^3 specimens m^{-2}) of zoobenthos on stony substrates of the littoral of south Baikal, Bolshiye Koty, June-July 1977 After Kozhova & Kravtsova, 1994

Group of animals	*Depth 0-15 m*				*Depth / 5-2 5 m*			
	B		*N*		*B*		*N*	
	VI	*VII*	*VI*	*VII*	*VI*	*VII*	*VI*	*VII*
Ohgochaeta	0 1	04	0.4	4.9	0.1	0.7	0.9	2.5
Amphipoda	106	7 8	68	44	6.2	13.9	3.7	3.7
Chironomidae	95	7 3	17.1	8.0	23	6.1	4 5	5 6
Mollusca	1 8	2 5	0.3	0.4	3 5	3 3	0 6	06
Total	23 2	196	25 1	190	28.3	31.1	26.5	26 2
Sample number	18	36	18	36	5	11	5	11

Table 5 5 Average number (N, specimens m^{-2}) and biomass (B, g m^{-2}) of the zoobenthos on stony substrates of the littoral of south Baikal, Bolshiye Koty, 16-21 September, 1988 Data of the Research Institute of Biology

Group of animals	*Pebbles, depth 0-10 m*		*Boulders, depth 0-6 m*		*Rocks, 4-10 m*	
	S	*B*	**	*B*	*,V*	*B*
Turbellana	120	0.5	217	1.2	606	1 0
PoJychaeta	1144	03	6847	1.0	1304	0.3
Ohgochaeta	1838	0 7	1389	0.5	1465	1 2
Hirudinca	3	<0 1	22	O.l	83	0 8
Isopoda	71	0 1	153	0.1	138	0 2
Amphipoda	1797	40	2017	8.6	6806	195
Mollusca	1425	19 8	2010	15.5	6565	118 0
Tnchoptera	175	05	*779*	*4.8*	926	4.4
Chironomidae	142	<0 1	575	<0.1	273	<0 1
Total	6716	25 9	14008	31.8	18168	145 5
Sample number	23	23	44	44	17	17

represented by *Lacustrina dilatata, Baicaha cañula, Pseudobaikalia contabulata, P. pulla, Parabaikalia jlorii, Godlewskia pulchella,* and *G. wrzesniowskh.* The number of species exceeds 50, and is more or less evenly distributed among molluscs, gammands and ohgochaetes. Population densities reach 2500-5000 specimens m"^{2} (without microfauna), and biomass 15-25 g m"^{2}, with molluscs outweighing all other groups.

Opposite the mouth of large rivers, the communities on sandy and sandy-silty soils are similar to those of other sections of the same bottom type, but their biomass varies strongly, depending on the amount of detritus. This, in turn, is determined by distance from the shore and degree of protection against turbulence.

The growth of Characea, *Potamogeton, Myriophyllum* and other water plants in areas protected by promontories is, as a rule, rich in life, which is even more varied than that described above. We cite the molluscs *Choanomphalus amauromus, Maackia herderiana,* the gammands *Eulimnogammarus grand'imanus, Baicalogammarus pullus, Echiuropus rhodophthalmus, Crypturopus tuberculatum, Micruropus littoralis^* and other sand-loving, detritus-eating forms. The water plants in the open littoral of Baikal are rich in micro- and meiobenthos. According to Okuneva (1990) a regularity exists in its distribution. In the *Ulotrix* belt of Boishiye Koty Bay, occupying the 0-1 meter zone, the total number of animals was estimated at 190.7 10^3 specimens m ^{2}. At depths of 1-2 meters, in the *Tetraspora* belt, the micro- and meiobenthos increased by two to three times, and in the zone of *Draparnaldioides* (2-5 meters) the number of hydrobionts was 9.5 10^6 specimens m"^{2}, 50 times greater than that in the first belt. The extreme branching of *Draparnaldioides* greatly contributes to the abundance of animals there, and results in an accumulation of detritus, which serves as food for small animals. Common inhabitants of such macrophyte growths are Protozoa (Flagellata, Cihophora), *Hydra,* Tardigrada, Turbellana *{Geocentrophora,* and Kalyptorhynchia), but the dominant forms are Nematoda and Harpacticoida.

The highest density of the latter is recorded in periods of vegetation and dying-off of algae (summer-autumn). Silted soils or fine strongly silted sands occur at a depth of up to 20 meters, chiefly opposite river mouths, in sheltered sections. Sometimes they lie near the shores, bounding surf sands. They are rich in organics and have a dark color.

Life conditions in bays differ markedly from those along open shores, chiefly by their protection against turbulence. The bottom water layers are calmer, sediment resuspension is less, and the water is more or less isolated from nearshore currents. Therefore, as a rule, bays show sandy, sandy-silt and silted sediments deposited in troughs, whereas rocky grounds are of secondary impor-

Table 5 6 Average number (N, m-2) and biomass (B, g m ^{2}*)* of zoobenthos on soft substrates of the littoral of south Baikal Boishiye Koty 16-27 September, 1988. Data of the Research Institute of Biology

Group of animals	*Sand*				*Silled sand*					
	18-3 9 m		*15-20 m*		*5-6 m*		*8-10 m*		*12 5-20 m*	
	V	*B*	*N*	*B*	V	*B*	*N*	*B*	*N*	*B*
Turbellana	107	0 4	161	5 3	15	<0 1	78	0 2	114	0 6
Polychaeta	2713	1 8	1870	1 1	2317	0 6	1371	0 4	1899	2 7
Oligochaeta	2377	3 1	4059	5 8	3080	3 8	5777	3 2	2773	4 0
Hirudinea	10	<0 1	2	<0 1	-	-	-	-	5	0.1
Isopoda	35	<0 1	114	<0 1	22	<0 1	4	<0 1	173	0.1
Amphipoda	4566	10 3	3668	4 7	3168	3 0	3609	1 6	2063	2.2
Mollusca	1619	18 6	1197	10 4	2500	30 0	1746	22 7	981	14.8
Tnchoptcra	260	1 1	126	0 3	169	0 4	37	0 2	221	0.3
Chironomidae	1812	0.1	233	<0 1	418	0 1	294	0.3	155	0.1
Total	13499	35 5	11430	27 7	11689	38.0	12916	28.6	8384	24.9
Sample number	13	13	6	6	6	6	34	34	15	15

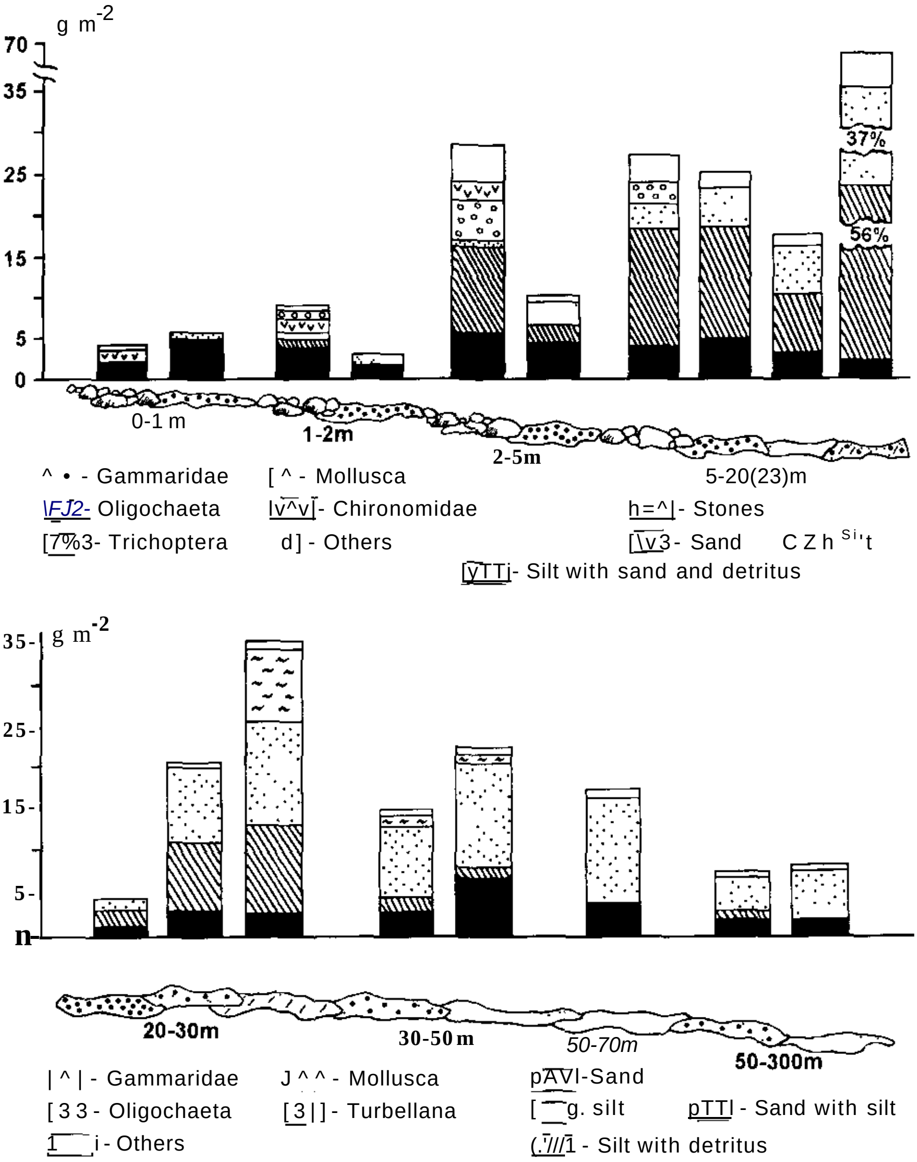


Fig. 5.[illegible] Composition (%) and biomass of macrozoobenthos (g m^{-2}) along the south-eastern coast of Baikal, a - the 0-23 m layer, b - the 20-300 m layer. After Kozhov, 1972.

tance, only important opposite rocky promontories. Bottom plants find favorable conditions for rooting and growth in such conditions. The load of the rivers and streams flowing into these bays is not carried far into Baikal, but is deposited *in situ*, providing food for benthic animals. There are many such bays in Baikal, *e.g*, Peschanaya Bay, Babushka Bay, Anga Bay, and Zavorotnaya Bay.

The surf belt in the bays is clearly defined along the promontories only, and the animal community of the sands and rocky bottoms covered with *Ulothrix* is the same here as in open Baikal. Pebbles, large, round stones and boulders occupy comparatively large areas near the promontories, at depths of 5-10 meters and more. The spaces between the stones are filled with sand. On stones we find the common Baikalian macrophytes *Draparnaldioides*, *Tetraspora* (to depths of 5-6 meters), and also *Cladophora* and *Chaetotnorpha,* which occur at depths of up to 20-25 meters. They are distributed in belts in the same order as in the open regions.

The fauna of these stones is typically littoral, sponges, vivid multi-colored gammands, oligochaetes, and the same species of turbellanans as on stones in the open regions.

The littoral of some large gulfs will be described in a special section. Zoobenthos fresh weight (without microbenthos, sponges and fish) per square meter of littoral in open regions of the lake and in open bays averages not less than 25-30 g m"^{2}. The area of littoral of Baikal (depths of 0-20 meters) excluding the Maloye More, the Chivyrkui and Barguzin gulfs and the sors is approximately 120,000-150,000 hectares.

In abundance and variety of life, the littoral of Baikal can be compared with that of Lake Ohrid (Stankovič, 1960). However, in Baikal the vast majority of littoral species is endemic, whereas in Ohrid the proportion of littoral endemics is low. In contrast to Baikal, the sediment in the lower zone of the littoral is enriched with shells of dead molluscs, forming a belt there. There is no such belt in Baikal, where dead mollusc shells are rapidly dissolved.

5.2.2. Sublittoral zone (20-70 meters)

The sublittoral of open Baikal extends over the upper sections of the bottom slope, the gradient of which varies strongly. Along the open west coast this gradient reaches 30-40°, and sometimes more. On more gentle slopes, the rocky bottom of the sublittoral is covered with a thin layer of sand, often slightly silted. Along the east coast and especially opposite the mouth of large rivers, the gradient is still less, and the bottom is covered with silted sand, often with an admixture of detritus, giving it a dark color. Large areas of this type occur in the Selenga Shallows. Over more than 90 kilometers along the delta, and on both sides of it, this belt of silted sands is, in places, five to ten kilometers wide. Silted sands are extensive also in north Baikal, near the mouths of the rivers Kichera, Upper Angara and Tyya, at a distance of one to two kilometers offshore. But clean sands may be found in the sublittoral as well, primarily in areas with near-bottom currents.

The water of the bottom layer in the sublittoral is subject to weaker seasonal temperature fluctuations than in the littoral. At a depth of 50 meters, its annual amplitude does not exceed 5-6°C. Turbulence is practically imperceptible. Light is insufficient for the development of macrophytes, but immediately near the littoral zone, on clean or slightly silted sands or stones, colonies of shade-loving green algae and diatoms can still be found. Skabichevsky (1936) points out that some species of *Cladophora* and *Chaetomorpha* can live at a depth of up to 36-60 meters, but apart from these, only scant evidence of living diatoms is found.

The sublittoral still experiences a strong influence from the nearshore fauna, and quite a few littoral forms can be found there, but there are also many species living only in the sublittoral. Density and biomass vary strongly, from insignificant on rocky slopes and clean sand to very high on silted, detritus-rich sand.

The animal communities of the sublittoral habitats have been insufficiently studied, and we can only give an approximate description of the most widespread ones.

The study of the biota on rocky sections of the sublittoral, is indeed handicapped by the fact that none of the standard hydrobiological instruments work satisfactorily there.

The most frequent sponges are *Baicalospongia, Swartschewskia* and *Luhomirskia abietina. Lubomirskia baicalensis* and *L. fusifera* can also be found. The gammands include such large-sized species as *Poekilogammarus pictus, Carinogammarus wagi* and *Odontogammarus calcaratus brevipes,* which, however, are common on sandy soils as well. *Eidimnogammarus proximus* inhabits the rocky sublittoral of Ushkany Islands. Isopods are represented by the distinctive, flat *Baicalasellus dybowsku* and molluscs by *Godlewskia godlewskii* and *Maackia costata.*

Population densities are low, but no reliable figures are available. Slightly silted sands are populated by a fairly varied fauna, although this is somewhat poorer than on silted sands enriched with detritus. Biomass ranges from 5.0 to 10.0 g m"^{2}, but in areas close to the life-rich littoral, this reaches 12.0-15.0 g m"^{2}. As noted above, the pre-estuarine regions of rivers and streams are always silted and dark colored. Silted sand with detritus is also found near the littoral, in hollows where plant material, washed out from the littoral, is redeposited. The fauna of silted sands with detritus is rich and varied, with the turbellanans *Baicalarcta gulo, Fridmaniella rufula* and *Archicotyhis plana;* the ohgochaetes *Chaetogaster ignotus, Tubifex bazikalovae, T. eximus, Baicalodrilus exilis, Lamprodrilus achaetus, L. wagneri, Styloscolex chorioidalis,* the gammarids *Acanthogammarus korotnewi, A. maximus, A. victori, Cannogammarus spp, Carinurus obscurus, Hyalellopsis carpenter} elegans, Micruropus parvulus,* the molluscs *Liobaicalia stiedae, Benedictia maxima, B. distinguenda, Pseudomegalovalvata tenagobia, Korotnewia angigira,* and *Godlewskia baciliformis.*

The polychaete *Manayunkia godlewskii* and larvae of the chironomid *Baicalosergentia* are often found as well. An impressive number of genera and species of gammarids and oligochaetes share comparatively small areas *of bottom* here. Biomass on silted sands ranges from 3 to 35 g ni"^{2}. The sublittoral is also the home of a considerable number *of* Cottoidei fish. Sandy-silted soils have gwyniads, burbots and the grayling *Thymallus arcticus brevipinnis.*

The ecological conditions and fauna *of* the sublittoral of deep bays differs little from that of open Baikal (Table 5.7).

Oligochaetes and gammarids are predominant in the zoobenthos of sandy soils of the sublittoral of bays, with molluscs playing a secondary part.

Summing up, we can make the following generalization: sands with various degrees of silting are the most characteristic and widespread bottom type of the sublittoral. Its fauna and flora differ markedly from that of the littoral, and have a number of typical forms, but the influence of the littoral is still considerable. The predominant groups are oligochaetes, gammarids and molluscs, with molluscs disappearing and being replaced by oligochaetes with increased silting. Turbellarians, the polychaete *Manayunkia* and larvae of chironomids are also frequent. About 120 species and subspecies of amphipods, 120 oligochaetes, 70 molluscs, *30* harpacticoids and 30 turbellarians typify sublittoral Baikal.

The richest communities occur in pre-estuarine regions on silted sands with detritus (average biomass up to 30 g m~^{2}), on similar soils in troughs in bays, where the biomass approaches 20 g m~^{2}, and in underwater valleys and hollows opposite river mouths (15-20 g m^{-2}). The fauna of clean sands low m organic matter, lying far from the littoral or on steep slopes, and on accumulations of pebbles and stones (5-10 g m~^{2}), is poorer. Bare rock on steep gradients is even more poorly populated.

Table 5 7 Biomass of zoobenthos (g m $^{-2}$) on silted sediment with an admixture of sand in Boguchan Bay (bottom-grab samples taken at 60-65 m in summer 1931) After Kozhov, 1931a

Group of animals	*g m* $^{-2}$
Vermes	7 5
Mollusca	0 9
Amphipoda	5 2
Total	13 6

The average zoobenthos biomass for the whole sublittoral of Baikal can be put at 35 grams per square meter of bottom. The total area of the sublittoral (without the Chivyrkui and Barguzin gulfs and the Maloye More) is approximately 150,000 hectares.

5.2.3. Supra-abyssal (transitional) zone (70-300 meters)

The steepness *of* the bottom slope varies in the supra-abyssal zone. Along the open west shores, it continues to be very steep and is usually composed of rock, bare or covered with a thin layer of silty sand. The width of the supra-abyssal zone in this area is, as a rule, rarely more than 200-500 meters.

Opposite the deltas of large rivers and especially along the east chores of south Baikal, the slope is gentler and the supra-abyssal zone extensive. Predominant m such regions are fine silted sands, often supplanted by silt. Wherever the coastal flat is well developed and the slope is gentle, the sands *are* strongly silted at 30-40 meters, with wedges of fine viscous silt which broaden with distance from the shore. Silting is particularly strong in pre-estuarme regions, where silts occupy almost the whole of the sublittoral and supra-abyssal zones.

Seasonal fluctuations in water temperature are perceptible only in the upper parts. At a depth of about 100 meters, the water reaches only 5-5.5°C;

this maximum usually occurs in mid-October and lasts for only 15-20 days The temperature of the 200-meter layers remains practically constant at 3 6-4°C The amount of light reaching the supra-abyssal is so insignificant that plants are completely absent

The bottom fauna of the supra-abyssal region has not been studied sufficiently, and we can only give brief characteristics of some biotopes from which a few bottom-grab samples have been taken In areas influenced by fluvial outwash and in bays, silted sands and silts contain detritus and arc dark colored Far from rivers and shores, the sediment becomes poor in organic matter The biomass here does not exceed 3-5 g m^{2} The density and biomass of the supra-abyssal benthos varies with sediment type, and is lowest on silted sands and silts on slopes far from rivers, bays and gulfs, from where organic debris could be brought in by currents and waves The biomass here is usually not more than 1-4 g m^{2}

Similar figures have been obtained from silt extending, in some places, to the supra-abyssal zone The average for ten Petersen bottom-grab samples taken in north Baikal at from 100-200 meters was 3 5 g m^{2}, with gammands accounting for 1 3 g, ohgochaetes for 0 5 g and chironomids for 0 1 g

A richer fauna is found only m areas opposite river mouths and in the belt of currents from pre-estuanne regions There, the biomass on silted sand and silt ranges from 20 to 50 g m^{2}, predominantly due to ohgochaetes, which account for more than 50% of fresh weight According to Bekman (1983), the zoobenthos biomass of the pre-estuanne region of north Baikal does not exceed 10 g m^{2} Higher values are restricted to sections of the supra-abyssal, opposite open bays The biomass of the macrozoobenthos at 225 meters in the Murinskaya Shallows is 98 g m^{2}, with amphipods being the dominant group (64 g m^{2}) Nematoda are dominant in the microzoobenthos Their species composition remains to be studied Grey silt has been traced in open Baikal down to extreme depths The gammand *Macropereiopus wagneri*, which *is* dominant both *m number and m biomass,* is the most typical bottom-dwelling animal living there

More than 160 species of gammands, 70 ohgochaetes and 30 molluscs occur at depths of 70-300 meters Characteristic species are *Acanthogammarm albus, Carinurus belkini^ C bifrons, Echiuropus pulchellus, E seidhtzi, Euhmnogammarus brachycoxalis, E macrophtalmus, Odonthogammarus catcaratus, Poekilogammarus rostiatus, P mkaczewi* and genus *Plesiogammarus,* the ohgochaetes *Isochaetides arenarius, Phyacodnlus propus, Baicalodnlus discolor acinacifer,* and the molluscs *Cincinna (Pseudomegalovalvata) bathybia, Benedictia fragihs, Godlewskia pulchella, B maxima, Baicahella clandestine!, B nana,* and *Battalia carinata* The zoolenthos biomass of deep-water silt (80-140 meter) in bays is fairly high, as seen from the following data (Table 5 8)

Tabic 5 8 Biomass of zoobenthos (g m^{2}) on silt in the Bouguchan and Senogda bays in summer 1931 After Koz ho\ 1934a

Group of animals	*Bouguchan Ba\ 80 140 m*	*Senogda Bay 82 m*
Amphipoda	10 8	2 0
Ohgochaeta	2 2	M
Mollusca	0 1	20 0
Chironomidae	-	0 1
Total	13 1	23 6

The silts of the supra-abyssal zone along open shores are more poorly populated The fish found on silted and sandy-silted soils include a considerable number of Cottoidei species Moreover, this zone is also visited by the deep-water form *of* the burbot *(Lota lota),* and by gwyniads As seen from these data, sections of the supra-abyssal zone opposite the mouths of large rivers, and some bays, have a fairly rich fauna The average biomass in these sections is approximately 15-18 g m^{2} at 80-200 meters in pre-estuanne regions, and 15-20 g m^{2} at 80-150 meters in troughs of bays and gulfs

Since these sections, relatively rich in zoobenthos, occupy extensive areas, the average zoobenthos biomass of the whole supra-abyssal zone is about 10-15 g m^{2}, compared to 20-35 g m^{2} in the subhttoral The total area of the supra-abyssal zone (without the Maloye More and the Barguzin and Chivyrkui gulfs) is approximately 150,000 hectares

5.2.4. Abyssal zone

Upper subzone (250-500 meters). The upper subzone of the abyssal extends over the slope into the main trough of Baikal. In many places it is very steep, and therefore this subzone is not broad (0.5-1 km), especially in the west. But in some regions, depths of up to 500 meters occupy considerable areas. Opposite the Selenga delta, they cover a vast territory between both coasts. They also occupy large areas in the northern extremity of the lake, and in its central part along the Olkhon Island-Ushkany Islands line (the Academichesky Range). Temperature here is 3.4-3.6°C throughout the year, and oxygen content is 75-90% of saturation. Light is practically absent. Most of the sediment is viscous silt of a greyish or pale-blue colour, often with ferro-manganese nodules. But in the vicinity of shores, the silt often contains a considerable admixture of clay. Bare rock with patches of silted sand or brown mud accumulating in hollows has been detected on the steep slope between underwater valleys along the west shores. Opposite river mouths, we again come across extensive areas of strongly silted sands alternating with patches of mud, and in some places pebbles and stones as well.

The rocky slopes with patches of silted sand and mud accumulated in hollows seem to be thinly populated. Sometimes, bottom-grabs and trawls tear away from stones colonies of the sponges *Baicalospongia bacilli/era, B. intermedia,* and *Baicalasellus dybowskii,* and deep-water forms of *Abyssogammarus sarmatus, Acanthogammarus nassonowi, Garjajewia cabanisi, Ommatogammarus flavus, O. albinus,* and *O. carneolus,* but in small numbers. The fauna is undoubtedly richer on silted sands Here, in south Baikal, the gammarids *Macropereiopus albulis, Acantogammarus grewingki, A reicherti, Ommatogammarus albinus, Parapallasea puzylloi, Abyssogammarus sarmatus, A. swartschewskii* and *Garjajewia cabanisi* occur. In all, 82 species and subspecies have been recorded.

In addition to typical deep-dwelling gammarids, the upper subzone is visited by species of the coastal complex, in a broad sense: *Poekihgammarus pictus, Eulimnogammarus ussolzewi abyssorum, Parapallasea borowskii, Eulimnogammarus aheneoidei,,* and *Echiuropus rhodophtalmus microphtalmus.*

Catches at 250-500 meters yield a considerable number of near-bottom forms of gammarids, such as species of *Ommatogammarus* and *Abyssogammarus,* which are also caught in plankton nets. The molluscs there include *Benedictia nana, B. pumila, Cincinna (Pseudomegalovalvata) bathybia, C. (P.) profundicala,* the oligochaetes *Lamprodrilus wagneri, Phynchelmus brachycephala, Limnodrihts arenarius* and *Teleuscolex baicalensis* and the turbellarians *Baikaloplana valida, Rimacephalus arecepta,* and *Sorocehts hepatizon.* The meiobenthos of this zone is rich, and includes Nematoda, Harpacticoida, Cyclopoida, Ostracoda and Bathynellidae, with Nematoda dominant (Table 5.9.).

The fish in the upper abyssal zone are only represented by Cottoidei: *Abyssocottus korotneffi, A. godlewskii griseus, A. pallidus, Batrachocottus nikolskii, Asprocottus gibbosus,* together with *Asprocottus megalops, A. herzemteini, Batrachocottus multiradiatus,* and *Procottus /ettelesi* Density and biomass at these depths vary greatly. Opposite large rivers, in hollows where organic outwash sediments, and in the belt of currents from river mouths to open Baikal, the biomass is rather high and can reach 20-50 g m"^{2}. This can be illustrated by a bottom-grab taken at 320 meters in a hollow opposite the northern mouth of the Selenga (specimens irr^{2}):

Gammandac	550	specimens	weighing	6 6	g
Oligochaeta	1780	specimens	weighing	42 7	g
Chironomidac	20	specimens	weighing	0 0]	g
Total	2350	specimens	weighing	49 3	g

But far from the shore and from rivers, where the rain of dead plankton is the only source of food, the faunal density is very low. Data on the biomass of Barguzin Gulf, at 250-400 meters on silt with an admixture of sand, are given in Table 5.10, and of Maloye More (200-300 meters) in Table 5.11. In Barguzin Gulf, the influence of fluvial outwash is evident, although the fauna at a depth of 250-400 meters in this gulf is much poorer than in the area opposite the Selenga

Table 5 9 Number of zoobenthos (specimens m~^{2}) at depth 255-400 m After Takhteev *et al,* 1993

Group of animals	*Depth, m*				
	225	*275*	*279*	*400*	*4verage*
Macrobenthos					
Oligochaeta	56	83	97	4	60
Gammaridae	69	167	14	64	79
Mesobenthos					
Nematoda	*653*	778	97	4	383
Harpacticoida	694	97	14	0	201
Cyclopoida	347	292	42	0	170
Ostracoda	236	236	69	0	135
Neorhabdocoela (Turbellana)	0	28	0	0	7
Arachnoidea	0	28	0	0	7
Total	2055	1709	333	72	

The biomass at 200-300 meters in Maloye More approaches 8-9 g m''^{2}, but falls to 5 g *m~^{2}* with an increase in depth and distance from the shore

At a still greater distance from the shore, bottom grabs bring up only single organisms, even when full of silt, which indicates that population density is extremely low. For instance, eight bottom-grab samples taken in 1931 from silts at 250 to 400 meters in north Baikal resulted in 785 mg of oligochaetes and 325 mg of gammarids. This adds up to 1.4 g m''^{2}.

Lower subzone (deeper than 500 meters). The lower abyssal subzone partially embraces the slope of the bottom and the entire central part of Baikal. In some steep places, bare rock can still occur, but the whole *of* the main trough is covered with viscous blue mud, with a large admixture of valves of planktonic diatoms. This area is characterized by a constant temperature (2.3-3.6°C), absence of light, and a somewhat reduced oxygen content {about 10 mgl-').

The fauna consists almost entirely of abyssal forms, such as the harpacticoids *Echinocamptus parvus,* and *Moraria longicaudata,* (15 species in total), the ostracods *Candona sensibilis sensibihs, C. longiformes* (14 taxa in total), the Tricladida *Baikaloplana vahda bathybia, Protocotylus magrnts, P. flavus, Rimacephalus arecepta,* Turbellaria of the order Kalyptorhynchia; the oligochaetes *Tubifex bazikalovae, T. taediosus, Baicalodrilus malevici, B. werestchagini, Lamprodrilus bythius. Stylodrdus cherepanovi,* (total number 20+ species), the gammarids *Abyssogammarus sarmatus sarmatus, A. swartschewsku, Acanthogammarus nassonowi, Carinurus reissnen, Odontogammarus margaritaceus, Ommatogammarus albinus* (total number 80+ species); and the mollusc *Cincinna (Pseudomegalovalvata) laethmophila.* Nematoda is the dominant group, but their species composition is not known. Some quantitative data on the abyssal zoobenthos are presented in Table 5.12.

Data on biomass and population density at depths of more than 500 meters are very incomplete, even though these depths occupy five-sixths of the entire bottom of Baikal. Its supply of organic material is extremely limited, and life can be sustained only by dead plankton and fish sedimenting to the bottom. These remains attract abyssal gammarids, most of which are excellent swimmers. There is no doubt that the zoobenthos biomass in the lower abyssal equals only a fraction of that of the coastal and upper abyssal subzones.

This zone is also inhabited by Cottoidei typical of the upper part of the abyssal. Abyssal Cottoidei usually have a flabby body, covered with a tender skin easily gathering in folds. The lateral line is

Table 5 10 Biomass of zoobenthos (B, g in''^{2}) on grey silt with an admixture of sand (250-400 meters), Barguzm Gulf (summer 1931) After Kozhov, 1934a

Gioup of animals	*B*	*%*
Gammaridae	2.9	**26.5**
Oligochaeta	7.9	71.7
Turbellana	**0.2**	1.8
Total	**11.0**	**100**

Table 5 11 Biomass of zoobenthos (g m^{-2}) on deep silts at 200-300 meters, and more than 300-400 meters, in Maloye More (summer 1940) After Kozhov. 1947

Group of animals	*Depth of 200 300 m*	*Depth of more than 300-400 m*
Turbellana	0 2	< 0 1
Oligochaeta	3.6	2 7
Gammaridae	4 8	2.3
Chironomidac	< 0 1	< 0.1
Mollusca	<0.1	<0 1
Total	8 6	5 1

well developed; eyes are mostly reduced. The body is colorless or light pale-yellow and, as a rule, there are no spots (Taliev, 1955). The eyes of abyssal gammarids lack pigmentation or are pale pink, but their antennae, as a rule, are very long. Body coloration is usually whitish or pinky-white. All abyssal species are characterized by morphological adaptations to extreme depths. Examples may be found in reviews by Mazepova (1962, 1990), Okuneva (1989), Sideleva (1982), Bekman & Starobogatov (1975), and Timoshkin (1994). Bekman & Dengina (1969) characterize the zoobenthos of Baikal as follows: the littoral, by bottom slope, predominance of sediment types, and river flow is divided into eight zones. The fauna of rocky soils is variable, but high on average (63 g m"^{2}). Sampling in 1963 in different parts of Baikal using scuba-divers showed that neglect of this fauna (and, likewise, partially of the sandy fauna), underestimates the average biomass of this zone. Highest values were obtained for the littoral (25-35 g *m~^{2})*. The biomass in open Baikal was invariably lower than at corresponding depths in bays and in the Selenga region, and in north Baikal *compared* to south *Baikal There was* a *tendency* for the biomass to decrease with depth, which was more distinct in open Baikal than in its bays (Table 5.13). Ratio of groups m zoobenthos of open Baikal at different depths and substrates is shown in Table 5.14.

Cherepanov (1978) published data on the zoobenthos biomass in various deep-water zones (Table 5.15). He made estimates of zoobenthos production (Table 5.16) and the intensity of destruction of organic matter by zoobenthos (Table 5.17). These estimates are tentative, and await further, more accurate work.

The frequency of different biomasses at different depths is shown in Fig. 5.3.

5.3. Littoral-sor zone

As stated above, the littoral-sor zone is composed of the sors and enclosed, sheltered shallow bays and guffs. In degree of isolation from open water, the sors can be divided into the following groups (Cozhov, 1947):

1. *Lake-son:* bodies of water connected with Baikal proper by narrow gullies only, cutting their way through the sands spits separating them from the main lake. The large Lake-sor Rangatui, situated in the south-east of Chivyrkui Gulf belongs to this group.

The waters of Baikal have little influence on these of the lake-sors. In the course of long fluctuations *of water-level in Baikal, the sors became* fully detached and turned into ordinary lakes; their water level may even be higher than that of Baikal, as is the case, for example, with Lake ECotokel, which covers 16,000 hectares on the east coast, in the drainage of the River Turka. Once, this lake was undoubtedly a gulf, then it became a sor, and now it is 7-8 km away from Baikal. It lies 10 to 12

Table 5 12 Number of zoobenthos (specimens m^{-2}) of the ab>ssal zone After Takhteev *et a!,* 1993

Group of animals	*Depth (meters)*						
	660	*820*	*925*	*1375*	*1465*	*1520*	*Average*
Macrozoobenthos							
Ohgochaeta	0	28	24	0	0	28	13
Gammandae	14	0	16	0	14	0	7
Mesozoobenthos							
Nematoda	250	**514**	**272**	472	2083	333	654
Harpacticoida	208	**139**	0	153	389	806	283
Cyclopoida	153	69	32	83	194	69	100
Ostracoda	28	42	32	0	14	56	29
Neorhabdocella	0	28	0	14	42	28	19
Arachnoidea	0	**14**	0	28	0	0	7
Bdthynellidae	0	0	8	0	0	0	1
Total	653	834	384	750	2736	1320	

Table 5 U Average: biomass of zoobenthos (g nv^{-z}) according to depth (m) After Bekiman & Dengina, 1969

Region	*Litto-ral*	*Subhi-toial*	*Bat hi a!*		*Ab\i,±al*	
			upper	*low ei*	*upper*	*lowei*
	0-20	*20-100*	*100-250*	*250-500*	*500-1000*	*>I000 m*
Open Baikal						
South*	22 2 (184)	14 1 (89)	124 (30)	7 1 (32)	4.4 (24)	3 3 (35)
North	19 6 (213)	107 (13S)	7 8 (54)	3 4 (28)	3.0 (36)	-
Total data average	**21	12 [±0 6	9 5**	5 5	3.3	3.3
Selenga region	23 6 (495)	25 3 (418)	195 (31)	-	-	-
Maloye More Bays.	35.0	32.2	22.3	-	-	-
Barguzin	20.0	33 2	20 4	-	-	-
Chivyrkui	28.0	195	-	-	-	-
Proval (0-4 m)	**18.2**	-	-	-	-	-
Posolsky Sor (0-3 m)	22.6	-	-	-	-	—

In brackets number of samples
*Without Selenga region
**Loganthm of data is taken In the series obtained, the log-normal distribution of the mean ranged between 14 and 20%.

Table 5 14 Ratio of groups of animals (in % weight) in the zoobetithos of open Baikal (without Selenga region) After Bekman & Dengina, 1969

Zone (meters)	*Soils*	*Amphipoda*	*Ohgochaeta*	*MollW'ta*	*Othei*
0-20	stones	20	5	63	12
	sand	24	41	31	4
	silted sand	24	68	4	4
20-100	silt	28	52	15	5
100-250	silt	25	66	4	5
250-500	silt	**18**	80	0	2
>500	silt	9	90	<1	<1

meters above Baikal and is connected to it by a system of small rivers. Such bodies of water cannot only get detached, but can even lose all connections with Baikal and become, temporarily or permanently, endorheic, as was the case with some lakes on the north-west coast.

2 *Typical sors,* connected to Baikal by a more or less broad gullet. Baikal water may penetrate such sors during inshore winds. The Posolsky and Upper Angara sors are typical examples.

3 *Gulf-sors,* not fully detached, but connected by channels broad enough to cause a considerable hydrological influence by Baikal's open waters, especially during inshore winds. The large Proval Gulf, situated north of the Selenga delta, serves as an example. The isolation of some sors changed after the water-level rose in Baikal, due to the construction of the hydroelectric; power station on the Angara River. The sandy spit, separating Posolsky Sor, was flooded.

The gullet, connecting Baikal with Lake-sor Zagh-Nur, became ten times wider. Studies by the Institute of Limnology also showed changes in the bottom biocoenoses of these sors ("Limnology of

Table 5.15 Distribution of zoobenthos biomass (g nr^2) in south Baikal After Cherepanov, 1978

Group of animals	*Depth (m)*					
	0-1	*1-10*	*10-25*	*25-50*	*50-250*	*250-1400*
Ohgochaeta	0.2	6.2	11.0	11 6	103	2.7
Mollusca	0.2	22.5	15.6	4.2	0.5	< 0 1
Gammandae	8.3	6.0	3.8	2.8	2.7	0 3
Insecta (larva)	0 5	1.4	0.4	0.1	0.1	< 0.1
Ponfera	-	56.8	30.4	-	-	-
Others	< 0.1	0.6	0 4	0.5	0.2	< 0.1
Total	9 1	93.4	61 6	192	137	3 1

Table 5 16. Zoobenthos production (kcal m ^{2} day$^-$') in south Baikal during July-October After Cherepanov, 1978

Group of ammah	*Depth (m)*					
	0-1	*I-10*	*10-25*	*25-50*	*50-250*	*250-1400*
Ohgochaeta	0.7	19.5	23 1	21.4	13.6	1 6
Mollusca	1.4	74.0	41 0	11 7	1.2	< 0 1
Gammandae	99 8	52.0	24 0	11.4	10.5	0 5
Insecta (larva)	5.6	9.2	2 2	1.0	0.2	< 0 1
Ponfera	-	4.9	2 3	-	-	-
Others	0.2	3.4	1 4	1.9	0.5	< 0 1
Total	107.7	163.0	94 0	47.4	26.0	2 2

Table 5 17 Intensity of organic matter destruction by zoobenthos (kcal m : day$^-$') in south Baikal during July-October After Cherepanov, 1978

Group of animals	*Depth (m)*					
	0-1	*I-10*	*10-25*	*25-50*	*50-250*	*250-1400*
Ohgochaeta	1.5	44.9	58 6	47.4	34 4	6.1
Mollusca	2.4	182.0	100 3	27.3	3 0	-
Gammandae	205.4	108.2	53 4	28.3	25 1	1 8
Insecta (larva)	103	22.3	4 6	1.9	1.3	< 0.1
Ponfera	-	8.7	5 0	-	-	-
Others	0.3	7.8	4 1	2.7	1 0	< 0 1
Total	219.9	373.7	226 0	107 6	64 8	8 0

the Coastal-Sor Zone of Baikal", 1977).

During the last 20 years, no other similar studies have been carried out. The total area of the littoral-sor is small compared to that of the lake itself. It is no larger than 40,000 to 50,000 hectares. Nevertheless, sors play a role in the productivity of the regions of the lake adjacent to them. As an illustration, we will describe the benthos in Lake-sor Zagli-Nur, in the shallows Posolsky Sor, and in Proval Gulf.

Lake-sor Zagli-Nur (west coast of Maloye More), occupying an area of about six hectares, is up to seven meters deep. The area occupied by silts increased, but the area with bottom vegetation was reduced to a narrow coastal band (Gagarin, 1977).

In the 1950s, this lake differed from other sors by high oxygen concentrations under the ice (Bekman, 1959). In winter 1973, it did not differ from typical eutrophic waters in photosynthesis and decomposition processes (Kulagin & Pomazkina, 1977). Reduction of the macrophyte zone resulted in a decrease of the zoobenthos biomass in

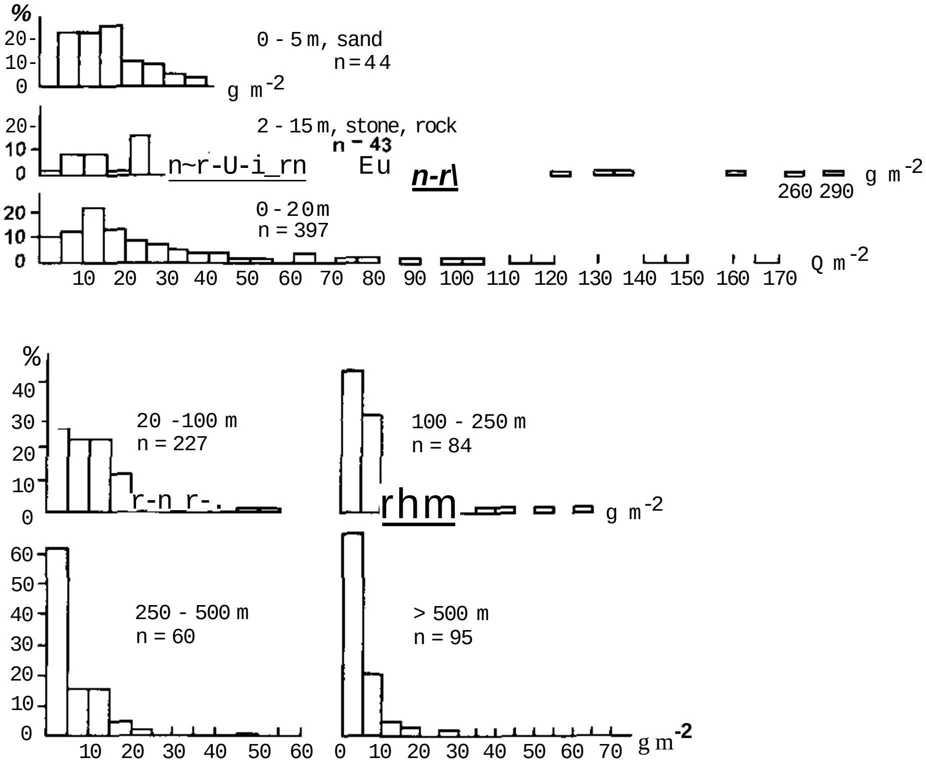


Fig 5 3 Occurrence frequency (%) of zoobenthos biomass (g m^{-2}) (without sponges) in various deep-water zones (m) of Baikal After Bekman & Dengina, 1969
n - number of samples.

this zone (from 56 g m^{-2} in 1950-1952 to 24 g m^{-2} in 1974), but the biomass on silted sand remained unchanged (16-17 g m^{-2}). Simultaneously with the increase of water exchange, a decrease in salinity occurred together with a temperature fall in the region of the channel. This stimulated the penetration of Baikalian forms: four species of amphipods immigrated to the lake (Bekman, 1977).

Endemic Amphipoda are the main component of the phytophilic communities of Lake-sor Zagh-Nur (Bekman *et al*, 1977), but the remaining fauna of the lake is represented by ordinary Siberian species. The fish include *Esox lucius, Rutttus rutilus lacustris, Leuciscus leuciscus,* and *Perca fluviatilis.* Posolsky Sor, located south of the delta of the River Selenga, covers an area of 3500 hectares, is 3-3.5 meters deep, and receives four small rivers. Its bottom consists of sand in the coastal belt, opposite river mouths and along open shores, silted sand in its south part, and viscous grey silt with much organic material, in the central, deep part of the sor.

In early June, vegetation is still scant in Posolsky Sor. Its development begins in mid-June. In summer, areas protected from waves become almost fully overgrown with *Potamogeton, Sparganium, Nymphaea, Nuphar, Polygonum amphibium, Myriophyllum,* and other common lacustrine plants. In the central part of the sor, *Potamogeton* can be found to a depth of 2-3 meters *on* patches of sandy-silty bottom, sometimes covering an area of several dozens of hectares. The distribution of bottom deposits and vegetation in Posolsky Sor is shown in Fig. 5.4. Table 5.18 provides data on the quantitative composition of the fauna of various types of sediments.

Among bottom invertebrates, ordinary Siberian species represent about 60% (Bazikalova, 1971). The Baikalian amphipods *Micruropus possolskii, M. wahln, Gmelinoides fasciatus* and *Hislopia pla-*

coides are dominant in the aquatic plants and on sandy soils. Baikalian Ohgochaeta (about 12 species) occur on silted sands (Snimshikova, 1989). Changes in the zoobenthos biomass of Posolsky Sor, and dominant groups are shown in Table 5.19.

The zoobenthos biomass on all types of sediment increases from spring until autumn, peaking in August and early September. This increase is due to chironomids, whose biomass rises greatly towards autumn, to gammarids, and partly to molluscs, whereas the number of oligochaetes remains, on the whole, at the same level throughout. During the whole summer, a particularly high density of organisms characterizes a silty sediment.

The biomass on silty sediment in August-September 1943 reached 38.6 g m ^{2}, in 1972 this was 34.3 g m ^{2}. In 1938 and 1943, Mollusca *(Sphaerhim corneum, Pisidium subtruncatum* and *Cincinna aliena)* and Chironomidae *(Chironomus reductus, Ch. semireductus, Procladius)* (Kozhov, 1963) were dominant. In the 1950s and 1960s, Chironomidae and Oligochaeta *{tsochaetides sp,, Lycodrdus schizochaetus* - endemics) prevailed, while Mollusca were rare (Bekman, 1977). The biomass on coastal sand with aquatic vegetation is quantitatively poorer than that on silt. Only in June 1955 was the biomass on sands with vegetation higher than on silty sediment (Table 5.19). In 1938-1962, the dominant Amphipoda were *Microropus possolskii* and *Gmelinoides fasciatus* on sands with vegetation. In 1972, *Micruropus wahlii* was commonest. However, in 1974, the number of the first two species increased again (Bekman, 1977).

More scantily populated sands have a biomass ranging from 4.7 to 5.5 g m~^{2}, reaching 8 g m"^{2} in sections influenced by rivers. The dominant taxa are the same gammarids and molluscs characteristic of sandy-silt. The total average biomass of the zoobenthos changes with seasonal changes, as expressed in the following average values;

Among fish, *Rutilus rutilus lacustris* is widespread in the sor itself and in the shallows of the neighboring region of Baikal. *Perca fluviatilis* also occurs throughout the sor. *Leuciscus idus* is not numerous. *Esox lucius* lives in the sor around the year. *Leuciscus leuciscus baicalensis* enters it for spawning in the second half of April and the first half of May. In summer, it returns to Baikal. In autumn it migrates to the sor again, but in winter it prefers to live in Baikal. *Lota lota* and *Thymallus arcticus baicalensis* are rarely seen. *Coregonus autumnalis migratorius* (the omul) enters the sor on the way to its river spawning grounds from late August until autumn. In spring, large numbers of juvenile omul descend through the sor. Periodically, sturgeons, chiefly young, are seen. In 1944 the Amur carp, *Cyprinus carpio haematoptettts,* was released into the sor. In recent years, both adults and young have been found there and in lakes of the Selenga drainage.

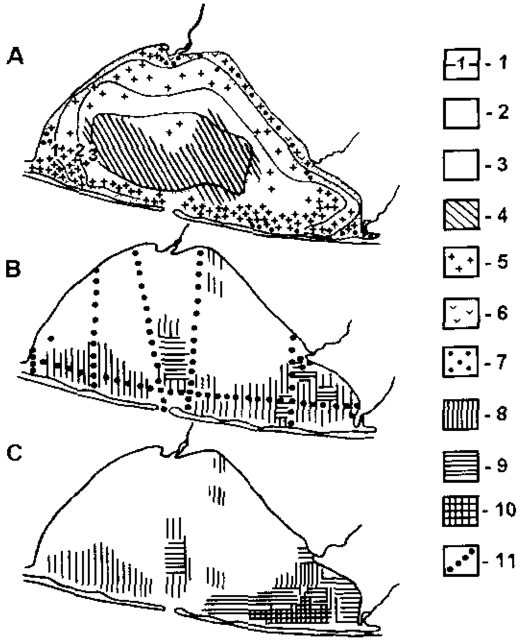


Fig 5 4 Distribution of sediments and plants (A) (after Kozhov & Spelit, 1958) and of *Elodea canadensis* phytomass (B - June 1984, C - September 1984) in the Posolsky Sor After Kozhova & Izhboldma, 1993.

A 1 - isobaths, 2 - sands, 3 - silted sands, 4 - silts, 5 - *Potamogeton perfoltatus, Mynophyllum sp, Ceratophyllum sp* , 6 - *Carex sp.*, 7 — *Pohgonum sp* , *Spargamum sp* , *Nuphai sp* B, C - fresh (wet) weight of *Elodea canadensis* (g in"^{2})' 8 - 0.1-10, 9 - 10-100, 10 - 100-1000, 11 - transects

Proval Gulf, with an area of 18,500 hectares, lies north of the Selenga delta. Depending on wind direction, the waters of Baikal can freely enter and leave it through broad channels. The arms (gullets) of the Selenga flowing into the gulf import much suspended material, which settles to the bottom. Owing to constant winds, shallowness and stirring of the bottom mud, the water of the gulf is always turbid. Its depth hardly exceeds 4.5-5 meters. A

Table 5 18 Biomass (B g m^2) and number (N specimens m^2) of zoobenthos in Posolsky Sor in Jluly-August 1938 After Kozhov 1962

	Sand		*Sand & silt*		*Silt*	
Group of animals	*N*	*B*	*N*	*B*	*N*	*B*
Oligochaeta	150	1 4	328	3 1	229	2 4
Hirudinea	-	-	18	2 3	36	2 6
Mollusca	147	1 5	451	10 2	485	22 9
Amphipoda	437	7 9	460	6 2	138	2 2
Chironomidae	7	0 2	32	1 1	125	4 0
Others	2	< 0 1	16	-	4	0 4
Total	743	5 4	1305	11 9	1020	18 1

narrow strip of clean sandy sediment lies along the island separating the gulf from Baikal, such sediments also abound near its eastern and southern shores, open to Baikal

The composition of silt varies Tn some places it consists of particles of peat washed out of the old peat deposits along the shore In the central trough it is predominantly of a mineral nature, material brought in by the Selenga Closer to Baikal it becomes richer in organic matter Its thermal regime shows a rapid warming in spring In summer, temperatures in the internal parts of the gulf reach 20-26°C, and in the open part, 13-16°C Vegetation is developed chiefly in the pre-estuanne and southern parts

Proval Gulf, by its diversity of biotopes, has representatives of almost all general Siberian freshwater biota Exceptional densities of the bivalve *Anodonta* (= *Colletopterum)*, which thickly populates sandy-silty sediments rich in organic matter, occur Ordinary Siberian species of *Pisidium,* Chinnomidae, Oligochaeta *(Stylaria latustus* and others) are also widespread

In areas adjacent to the channels, there is an abundance of Baikahan Gammandae, particularly *Micruropus possosku, M wahlu, M tahtroides, Crvpturopus pach\tus,* and *C inflatus,* which occur almost throughout the gulf In all, a score of Baikahan Gammandae are found in Proval, which is not the case in any other sor The Baikahan polychaete *Manayunkia baicalensis,* the bryozoan *Hislopia placoides,* and the oligochaetes *Rhvacodrdm coccinaeus, Isochaetides arenarius* var *inaequaliH* and *Propappus volki* have also been noted

There is no doubt that the presence of so many Baikahan elements in Proval is connected with the year-round high oxygen content of its waters, and the low summer temperature in the regions adjoining Baikal

In 1939-1943, the average summer biomass on silt in Proval Gulf amounted to 37 g m^2, with *Anadonta* accounting for 23 g m^2 The fish of the gulf include *Rutdus rutilus lacustns, Perca fluviatdis, Esox lucius, Leuciscm leuciscus baicalensis, L idus* and *Acipenser baeri stenorhynchus,* for which Proval presents the main feeding ground In autumn, most sturgeons leave for Baikal and overwinter there, returning towards summer In September and October *Lota lota, Phoxinus* and Cottidae can be found in Proval

In addition to these species of fish, the gulf also harbors *Thvmallus arcticus brevipenms,* and in August, *Coregonus autumnahs migratonus,* as it enters the Selenga for spawning

5.4. Large gulfs

The water of the gulfs and the Maloye More is warmed up more rapidly than that of open Baikal and reaches higher temperatures Warming begins in the coastal shallows and gradually spreads to the open parts of the gulfs

In Chivyrkui, which is Baikal's second largest gulf, the bottom is predominantly sandy, and it is only at the outlets of the gulf, at depths of more than 20-30 meters, that it is replaced, first by silted sand, and then by grey silt Black or brown silt covers the bottom of the bays Rocky bottoms are poorly represented

The bottom vegetation, consisting of flowering plants and algae, is rich and covers the littoral al-

Table 5.19 Biomass of zoobcnthos (g m ^{2}) of Poi,olsky Sor in various years

	Group of animals					
	Ohgo-chaeta	*Gamma-ndae*	*Moll usea*	*Chirono-midae*	*Others*	*Total*
Kozhov, 1962						
1938 (VIII)						
sand	0.8	3.6	*0 1*	0.2	0	5.3
sand & silt	0.9	*4.3*	*40*	1 0	1.6	11.8
silt	1.5	1.7	8 9	3.8	0.1	16.0
1943 (VIII)						
sand	0.4	2.2	0 8	0.1	0.1	3.6
sand & silt	0.2	2 7	2 7	2.0	0	7.6
silt	0.7	1 6	3 1	9 8	1.1	16.3
Bekman, 1977						
1955 (VI)						
sand	1.6	22.2	2 2	2.4	0.2	28.7
silt	6.4	0.5	7 0	5.3	0.2	19.4
1956 (IX)						
sand	4.9	11.1	2 1	1 2	0.3	19.6
silt	8.2	5.1	5.0	14.4	0.5	33.2
1962 (X)						
sand	5.8	8 2	2 1	0.7	3.2	20.0
silt	4.8	4.0	2.7	8.0	8.0	27.5
1972 (X)						
sand	1.0	1.4	0 0	0 2	0.6	3.2
silt	7.1	0.0	0.0	27 1	0.1	34.3
Kuzmich & Simtsin, 1988						
1984						
sand & silt	-	-	_	-	-	J6.7
silt	_	-	-	-	-	13.5
1987						
sand & silt	-	-	-	-	-	24.0
sift	-	-	-	-	-	17 3

most everywhere, reaching depths of 20 meters and more. All this, plus the presence of considerable amounts of organic matter in the soil, greatly favors the zoobenthos (Burov, 1935). The southern part of the Chivyrkui Gulf with depths of not more than four to five meters and the middle of the bays much resemble the littoral-sor zone, inhabited by a general Siberian fauna and flora, as characterized above.

The Baikalian species occurring here include the gammarids *Gmelinoides fasciatus, Pallasea cancellus, P. cancelloides, Crypturopus pachytus, C. tuberculatus, Micruropus talitroides, Eulimnogammarus fuscus, E.verrucosus* var, and *Pallasea grubei.* Large numbers of the mollusc *Baicaha dybowskiana cannatoides* are also found. On fine sands in the southern part of Chivyrkui Gulf, the biomass reaches 33 g m"^{2}, while it is lower on black or brown silt in the bays of the gulf. Molluscs, gammarids and oligochaetes usually comprise the bulk of the zoobenthos on sand, while gammarids account for the greater part of the biomass on silt in bays.

Flora and fauna are rich, particularly at the boundary between the southern and central parts of the gulf, where thick growths of macrophytes and a motley fauna of Baikalian and ordinary lacustrine species lives. Molluscs are represented abundantly by the Baikalian forms *Baicalia dybowskiana cannatoides, B. carinato-costata, Korotnewia korotnewi, Sphaerium baicalense,* and *Pisidium* and *Euglesa spp.* There is a wealth of *Radix auricularia.* A dozen gammarids, ordinary inhabitants of sheltered shallows of the lake, also occur.

Table 5 20 Mean biomass (B, g m^{2}) of zoobenthos in Posolsky Sor during different months

1943 (Kozhov 1963)			*1972 (Bekman 1977)*		
Month	*Number oj samples*	*B*	*Month*	*Number of sample*	*B*
May-June	10	3 4	June	28	4 0
July	12	4 1	July	14	7 3
August	13	8 0	August	15	9 6
September	10	14 3	September	17	11 1
October	6	36 9	October	13	18 6

The fish permanently residing in this area are gwymads, *Thymallus arcticus bawalensis,* roach, sturgeon, ide, perch, pike and many Cottoidei species Large herds of seal appear in autumn In the central part of the gulf, sands at depths of 1 to 10-15 meters are densely populated too The specific composition of this benthos is, on the whole, the same as on sandy sediments in the littoral of open Baikal, but its biomass and population density are much higher The average biomass of zoobenthos approaches 30 g m^{2}, mainly oligochaetes, gammarids and molluscs

A rich community has been found on silts in the exterior parts of bays at depths of two to ten meters, where the biomass reaches 34-50 g m^{2} Only brown silts in the middle of bays, which already belong to the httoral-soj zone, are populated more sparsely (up to 12 g m^{2}) Data on the biomass of zoobenthos in Chivyrkui Gulf are given in Table 5 21

Sandy sediments in the central part of the gulf, especially those with a large admixture of detritus, abound with the molluscs *Pisidium korotneui, Baicaha dybowskiana, Pat abaikaha oviformis, Korotnewia korotnewi, Cincinna ssorensis, Megalovalvata pihgera minot* and Pisidioidea

Other animals found here in large numbers are the gammands *Acanthogammarus victon maculosw>, Parapallasea puzylhn, Pallasea cancellus,* and many littoral species of *EuUmnogammarus* and *Micrmopus,* as well as multitudes of oligochaetes, the polychaete *Manayunha* turbellanans, leeches, caddisflies and chironomids

The richest life has been observed in areas adjoining the bays of the central and exterior parts of the gulf, where conditions are at optimum for the existence of Baikahan endemics the water regime is close to that of Baikal proper, and the sediment is rich in nutrients from decaying plants, constantly delivered there by currents from neighboring bays Inside the bays, strong silting prevents the development of a rich fauna of molluscs and gammands An analogous picture is observed in other regions life is abundant at the outlets of all sheltered bays while lacustrine-sor forms are absent there, with the exception of *Gyraulus gredlen boreaJis*

The fauna on sand at a depth of 20-30 meters is much less dense than in the littoral The biomass (f w) averages only 12-12 5 g m^{2} there Widespread species among the local molluscs are *Euglesa korotnewi, Choctnomphalus dvbowskianus, Korotneuia semenkewitschi, Pseudobaikalia contabulata* and *Baicaha cannata* Gammands are abundantly represented by *Acanthogammarus victon maculosus* and others Silts in the sublittoral of the gulf at depths of 40-50 meters are still populated fairly densely Their biomass averages 27 g m^{2}

At depths of more than 70-80 meters, the sediment is chiefly silty The animal density at these depths falls to 5 3 g m^{2}, although sections with a higher biomass can still be found All the above-cited data show that Chivyrkui Gulf is one of the richest regions of Baikal The average biomass for the whole gulf at depths of up to 50-70 meters, is about 30 g m^{2}

In Barguzin Gulf, the distribution and properties of the sediment is strongly influenced by the River Barguzin, causing the bottom of almost the whole shallow part of the gulf near the mouth to be blanketed with sand and silt enriched with detritus The sediment of the deep part of the gulf is composed of typical deep-water mud

Rocky strips in the surf zone of the littoral of the gulf are populated by the same species (primarily turbellanans, gammarids, sponges, molluscs, insects, oligochaetes, etc.) as in the open lake.

The biomass of zoobenthos on sandy and silty sediments in Barguzin Gulf is shown in Table 5.22. The animals most frequently occurring on littoral sands are the gammarids *Micruropus cristatus, M. talitroides, M wahlii, Crypturopus pachytus, C. tuberculatum, Echiuropus macronichus, Acanthogammarus godlewskii, A. flavus, Hvallelopsis czyrnianskii, Pallasea viridis, Gmelinoides fasciatus, Poekilogammarus araneolus* and numerous *Eulimnogammarus; the molluscs Sphaerium* baicalen.se, *Pisidium baicalense,* and species of *Euglesa, Parabaikalia oviform is, P. elata, Baicalia cannata, Korotnewia semenkewitschi, Godlewskia godlewskii, Maackia variesculpta* and *Megalovalvata lauta;* and the oligochaetes *Lamprodrilus pygmeus, L. glandulosus, Teleuscolex korotneffi.* Often, the polychaete *Manayunkia* and the turbellanan *Archicotylus planus* can be seen. Caddiesflies and chironomids are also frequent.

Highly characteristic of dark, silted sand at a depth of about 50 meters are the gammarids *Macropereiopus wagneri dagarskii, Micruropus cristatus, Crypturopus inflatus, Carinurus platicarinus, Echiuropus macronychus* and *Baicalogammarus pullus Macropereiopus wagneri dagarskii* and *Micruropus cristatus* dominate in biomass and in number of specimens. Common molluscs are *Euglesa korotnewi, Korotnewia semenkewitschi, K. korotnewi, Pseudobaikaha pulla, Baicalia carinato-costata* and *Benedictia baicalensis;* the most frequent oligochaetes are *Lamprodrilus pygmeus, Teleuscolex korotneffi,* and *Lycodrilus dybowskii,* while *Archicotylus planus* and *Sorocelis sp.* are common among the turbellarians.

The *gammarids of* the dark, heavily silted sand occupying the entire north-east part of the gulf at depths of 50-100 meters are *Macropereiopus wagneri dagarskii, Micruropus cristatus, Crypturopus pachytus, Carinurus platicarinus* and *Echiuropus macronychus.* Up to 200 specimens of such species as *Macropereiopus wagneri dagarskii* and *Micruropus cristatus* may be found in one bottom-grab sample (0.1 m^2). Among molluscs, which are scantily represented, *Pisidium baicalense, Korotnewia korotnewi, K. semenkewitschi,* species of genus *Sphaerium* and *Euglesa, Benedictia limnaeoides, Baicalia carinata,* and *Godlewskia pulchella* should be mentioned, with the first two predominating.

Among oligochaetes, we would mention *Lycodrilus schizochaetus, hochaetus baicalensis, Lamprodrilus korotneffi, L. pygmeus,* and *L. glandulosus.* Turbellarians are represented by *Sorocelis hepatizon,* and the polychaete *Manayunkia baicalensis* is also fairly common.

On deep-water silt the same organisms occur as

Table 5 21 Biomass of zoobenthos (g m ^{2}) in Chivyrkui Gulf in 1932 After Kozhov, 1947

Zone	*Littoral*					*Sublitloial and supia-ab\s$ai*		
	Open part		*Ba\s*					
Sediment	*Sand*	*Sand*	*Sand mth black-iil!*	*Black silt*	*Bi o\\ n silt*	*Sand*	*Silt*	*Sill*
Depth, m	*i-iO*	*10-20*	6-17	*2-((l*	f *5-4*	*20-30*	40-50	*70-25*
Gammandae	4 2	3 8	15 6	12 2	5.8	0 9	5 7	*2* 0
Annelida	5 9	4 3	22 4	7 9	0 6	0 9	20 1	3 2
Mollusca	168	21 2	10 4	9 3	2 5	105	0 1	<0 1
Turbellana	2.1	0 1	0 2	0 3	0 4	-	0 9	-
Hirudinea	<0 **1**	-	1 5	3 2	2 2	<0 1	<0 1	-
]m>ecta	0 2	0 4	–	*08*	*05*	-	-	-
Total	29 3	29 8	50 1	33 7	12 0	124	26 8	5 3

in the abyssal zone of Baikal, *i e*, many gammands, such as *Macroperewpus wagnen dagarsku* Molluscs are represented only by *Korotnewia korotnewi,* and ohgochaetes by *Rhynchelmis brachcephala* In the table below, we give a summary of Barguzm Gulf (Table 5 22) Additional data are given in Table 5 23

The zoobenthos biomass is particularly high in the interior part of the gulf, and on silted sand with detritus it approaches 62 5 g m ^{2}, distributed as follows

Amphipoda	-	21 6 g m^2
Mollusca	-	1 6 g m ^{2}
Ohgochaeta	-	37 0 g m ^{2}
Others	-	2 3 g m ^{2}

The fish fauna of the gulf is fairly rich In addition to the omul, it includes gwyniad, sturgeon, roach, perch, pike, ide and other fluvio-lacustnne and Baikahan species

5.5. Maloye More

Maloye More covers an area of approximately 80,000 hectares Its bottom is gently inclined from south to north The depth of the southern extremity (the Mukhor Gulf) does not exceed 5 m, whereas in the northern part the depth reaches 200-300 meters The bottom is chiefly composed of silted sand with various degrees of silting, and silt proper (Kozhov, 1936a, 1947, Patnkeeva, 1959, Bekman, 1959) Mukhor Gulf is open to north-easterly winds The winds drive colder waters into it from the open and deeper regions of Maloye More, which mix with the water of the gulf and cool them, especially in the outer half Consequently, the summer temperature of the gulf rarely rises above 20°C

The gulf freezes at the end of October or November It takes a long time for the ice-cover to form because of strong north-westerly storms, which are particularly violent in autumn The thickness of the ice at times exceeds one meter

The bottom of the gulf is almost fully overgrown with ordinary flowering plants, as well as Characeae and *Nostoc* Practically the whole central part is covered with *Potamogeton,* which forms extensive and rich underwater beds there The distribution of vegetation in Mukhor Gulf is shown in Fig 5 5

The fauna of the southern and central parts of Mukhor Gulf differs sharply not only from the open regions of Baikal, but also from the fairly shallow southern half of Maloye More There, as in the sors, ordinary lacustrine species predominate The Baikahan fauna is represented by few species, including five or six molluscs, *eg, Korotnewia korotnewi* and *Sphaenum baicalense* However, these species do not penetrate into the innermost shallow part of the gulf and its sheltered bays The Baikahan gammands entering the gulf include a considerable number of species also occurring in sors, namely *Crypturopus pathytus, C inflatus, Micruropus httorahs, M tahtroides, M possolsku, M wahlu, Gmelmoides fasciatus* and some species of *Pallasea,* such as *P kesslen* The polychaete *Manayunkia* is present, but does not penetrate deep into the gulf Nearer to the neck of the gulf, Siberian species gradually disappear and the number of Baikahans increases The biomass of zoobenthos on silted sediments averages 88 g m ^{2}, and is dominated by molluscs, including big bivalves

On silted bottoms, the fauna is also rich quantitatively A poorer community is present on coastal sands, where biomass is about 16 3 g m ^{2} on average, with molluscs ranking first and ohgochaetes second According to available data, the average biomass of zoobenthos in Mukhor Gulf is about 42 1 g m ^{2}

The faunal density on the bottom of the gulf is very high Gammands of the genus *Micruropus* are especially numerous there *M wahlu* reaches 16,180 specimens per m^2, *M possolsku* 16,180, *M littorahs* 15,400, *Gmelmoides fasciatus* 19,200, *Pallasea kesslen* 4,420, and *Euhmnogammarus vuidis* 4,000 (Bekman, 1959) Because of this abundance of benthos, Mukhor Gulf is a rich feeding ground for benthophagous fish, such as perch, dace, roach, ide, pike and Cottidae The gulf is also visited by grayling, and the malomorsky gwyniad spawns there

The fauna of other bays of the Maloye More is also quantitatively rich Zagh and Khann Irgi bays contain two species of Baikahan sponges, 15 species of ohgochaetes, up to 30 species of molluscs (among which only *Radix auricularia* is fluvio-

Table 5 22 Biomass of zoobenthos (g m^{-2}) in the Barguzin Gulf. After Kozhov, 1934b

Sıte	*Sedimerit*	*Depth, m*	*Croup of animate*						
			Turbellaria	*Oltgochaeta*	*Polychaeta*	*Gammai idae*	*Insecta*	*Mollusca*	*Total*
Along open east coast (4)	Sand	2-3	–	0.3	–	2.0	–	*0.2*	*2.5*
Central part of *gulf (6)*	Sand with *silt*	up to 10	< 0.1	1 8	1.8	2.3	< 0.1	16	7 5
To the mouth of Barguzın (9)	Sand	8-15	–	8.0	–	3.8	02	0 5	12.5
Along south-east coast (10)	Sand	10-22	< 0 1	11 8	–	27	04	1.7	16 6
In bays of south-east coast (3)	Sand	4-10	–	26 0	–	9 6	14 5	214	715
Central part of gulf (21)	Silted sand	up to 50	03	20 0	3.3	111	0.6	1.3	36 6
North-east part of gulf (18)	Dark strongly silted sand	10-60	4.1	11.6	2.0	174	0.2	0.3	35.6
Central part of gulf (5)	Silted sand	50-120	–	20.0	–	42	–	0 2	24.4
Along south-east coast (13)	Silted sand	50-160	–	9.2	0.4	6.3	–	0.3	16 2
	Grey silt with sand	100-240	0 1	14 5	–	9 8	–	0 2	24 6

In brackets - number of samples

lacustrine), and about 40 species of gammarids. The open littoral of central and north Maloye More is much more poorly populated than the bays and the south. The biomass of zoobenthos there does not exceed 14-16.5 g m~^{2}. Conspicuous everywhere on the soft soils of the littoral is the preponderance of oligochaetes, molluscs and gammarids.

The bottom of the sublittoral of Maloye More is composed chiefly of sand with various degrees of silting. The greatest benthos density on sublittoral sands occurs in the south, where the biomass reaches 30-35 g m"^{2}, almost half and sometimes even three-fourths of which are oligochaetes.

Qualitatively, the fauna of the sublittoral is highly varied. The animals most frequently found there include the oligochaetes *Lycodrilus schizo-*

Table 5 23 Zoobenthos biomass (g m ') in Barguzin Gulf (July 1959) After Bekman, 1986

Depth (in) *sediment t\pe*	*Group oj animah*				
	Amphipoda	*MoIIusca*	*Oltgochaeta*	*Other*	*Tola!*
5, sand	4 0	–	2 9	0 2	7 1
18, sand	0 1	0 5	11 8	1 4	14 0
21 sand	**2 0**	3 7	20 4	3 9	30 2
24, sand	0 8	1 7	16 6	1 I	20 4
28, sand	8 7	2 5	13 4	1 1	29 9
33, silty sand	2 6	**3 0**	19 1	0 7	25 6
41, silly sand	**10** 0	1 6	24 4	0 3	37 5
55, silty sand	2 3	0 7	15 2	0 1	18 5
84, silty sand	2 5	-	8 0	1 0	11 3
110, sand} silt	2 4	0 5	6 6	0 2	9 7

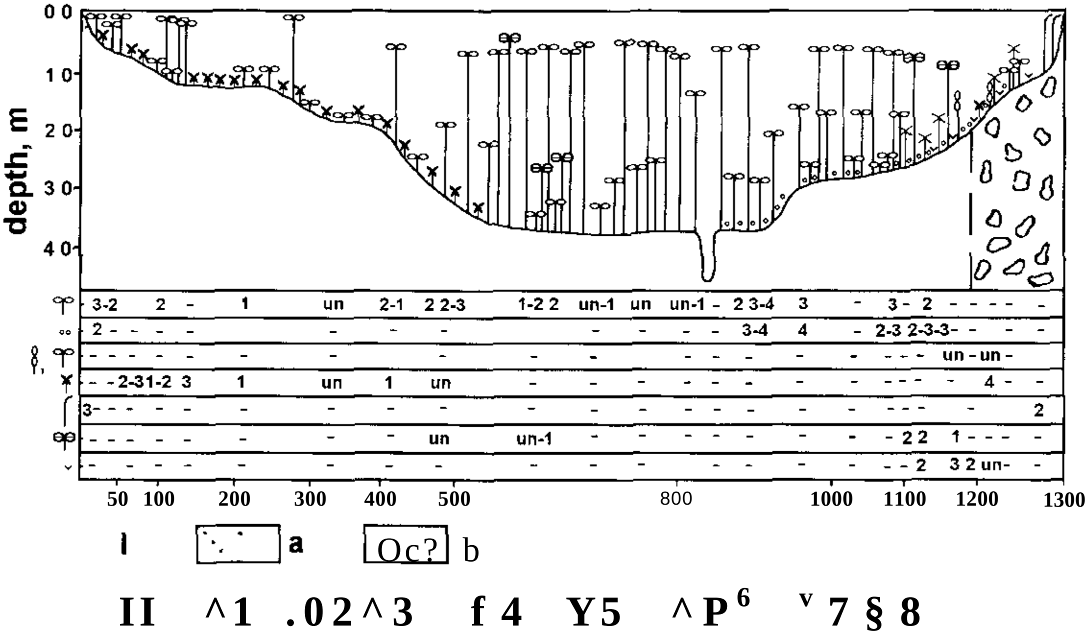


Fig 5 5 Zonation of bottom plants in Mukhor Gulf August 1972 After Pautova 1974
I - upper laver of soil (a-sand b-stones)
II - species (abundance of each indicate in balls in lower part of scheme) l - *Potamogeton perfohatus* L , 2 - *Lemna tnsuka* L , 3 - *Mynophyllum* sy?, 4 - *Pohgonum amphibutm* L , 5 - *Butomus sp* , 6 - *Potamogeton lucent* L , 7 - *Chara sp* , 8 - *Callitnche verna* L

chaetus (on strongly silted sands and on silts), *Limnodrilus satiricus, L palhdus* and *L pygmeus,* the molluscs *Benedictia hmnaeoides ongurensis, B maxima, Kobeltocochlea olchonensis, Baicahella nana, Korotnewia semenkewitschi, Korotnewia korotnewi, Pseudobaikaha jentteriana, P pulla tenuitosta, Godlewskia wrzesniowsku, Battalia carinata> B carinuto-costala, Megalovalvata pdigera pdigera* and genera of Pisidioidea, **the** gammands *Hyalellopes cannata, Crypturopus inflatus, Micruropus tahtroides, M glaber, M laevisculus, Poekilogammarus pictus, Cannogammarus cinnamomeus, Echiuropus rhodophthalmus,* and *Hyallelopsis carpenten*

The mollusc fauna is markedly poorer, as the sand becomes silted Strongly silted sands and silts predominate in the supra-abyssal zone at depths of 70-250 meters *in* central and northern MaJoye More. The richest community occurs on silts of the central part, where the biomass reaches 30 g m~^{2}. Nearer to the deeper part, benthic life becomes thinner, with the biomass falling to 14 g m~^{2}, and in the deepest part itself, at depths of more than 200 meters, to 8.5 g m~^{2}. Maloye More is inhabited by omul, gwyniad, black and white grayling, perch, pike and, more rarely, by roach, dace and other fluvio-lacustrine species, as well as numerous Cottoidei.

5.6. Selenga Shallows

The lower Selenga River breaks up into a series of gullets, forming a delta with an area more than 600 km^2. In the south, this delta borders on lstoksky Sor, in the north on Proval Gulf. The Selenga Shallows (avandelta of the Selenga River) show a smooth underwater relief, broken by rows of sandy elevations (levees), which may reach close to the water surface. The highest levee lies opposite the largest gullet, Srednyaya (Kharaus). Levees develop as a result of wave activity and drift of suspended material from the gullets. A slow increase in depth is typical of the avandelta. The 50-meter isobath, opposite to the gullet Srednyaya, is seven kilometers away from the shore (Lut, 1971).

High wind speeds during iceless periods distinguish the Selenga Shallows from other regions of Baikal (Shimaraev, 1964; Verbolov *et al.,* 1965). Warm waters in summer are typical. In July the difference between the surface temperature there and in deep-water parts of south Baikal are 5-6°C. The thermal balance of the Selenga region is close to that of Barguzin and Chivyrkui gulfs (Shimaraev, 1971).

The Selenga waters carry into Baikal 2.6 10^6 tonnes of suspended material and more than 4 10^6 tonnes of dissolved substances (Votintsev *et al.,* 1965). In pre-delta regions, the rate of sediment accumulation is about 0.52 cm annually (Mizandrontsev, 1971), much greater than in open Baikal (Votintsev *et al.,* 1965).

Due to turbidity and wave action, bottom vegetation is absent from the open littoral of the avandelta. This is the reason for the low content of organic carbon in its sandy sediments (Goldyrev *et al,* 1971).

The bottom fauna of the Selenga region differs dramatically from that of open Baikal, and contains a high percentage of Palaearctic species. According to Vereshchagm (1940b), the Selenga is a junction zone of two faunas. The Palaearctic species at a depth of 5-7 meters account for 24% of the total species, at a depth of 10-20 km this is 4%, but deeper than 200 meters, they are practically absent (Bazikalova, 1971). One of its peculiarities is the presence of local endemics, such as *Korotnewia korotnewi selengensis* and *Choanomphalus amauronius westerlundianus* among molluscs (Kozhov, 1962), and *Micruropus wahlii, Pallasea grubei aremcola, P. brandti flaviceps,* and *Poekilogrammarus longipes* in the Amphipoda (Bazikalova, 1971). In some groups, Bazikalova claims that hybrids between species and subspecies can be distinguished.

At depths of 80-100 meters (up to 200 meters), we can come across 'giant' forms of molluscs in the group *Benedictia fragilis* (the height of the shell reaches 5 cm or more), Amphipoda: *Garjajewia sarsi, Acanthogammarus grewingki* (length of more than 6 cm); and Turbellaria: *Rimacephalus arecepta arecepta* (9-10 *cm* long). In the Selenga region, species typical of sandy and silty sediments in open Baikal occur (Bazikalova, 1971).

In all biotopcs of the avandelta, Ohgochaeta (50-70% of total the biomass) and Amphipoda (20-30%) are predominant. The role of molluscs is modest (about 5%). Such figures are valid for depths of from five to 200 meters (Bekman, 1971).

Bekman & Mizandrontsev (1971) give the following characteristics for the distribution of zoobenthos in the Selenga Shallows. The impact of the Selenga River, the complex relief of the bottom of its avandelta, and the shallow and adjacent great depths of open Baikal account for a spatial nonuniformity of the Selenga region, in particular with regard to distribution of organic matter, conditions of burying, and decomposition of organic remains in the sediments. The average content of C_{org} in the surface layer of these sediments increases from coastal sands to coarse and fine alevntic silts, reaching a maximum in deep water clay and diatom silts (Knyazeva, 1954; Goldyrev *et al.,* 1971). The zoobenthos biomass increases from coastal sands to coarse alevrites, but later, gradually decreases on transiting to fine aleuritic and clay sediments (Table 5.24).

In a cross-section through the avandelta, aleuritic silts occur close to the Selenga delta, at a depth of six to eight meters. Away from the delta, coarse aleurites are replaced by fine ones. At a distance of 7 km from the coast, the section crosses the underwater elevation, where, at a depth of 25-30 meters, the sands reappear. They differ from pre-delta sands by a larger pelite fraction. On the gentle slope of the underwater elevation, aleuritic sediments are gradually replaced by clay silts.

The contents of C_{org} in solid-phase sediments in this section increase from pre-delta sands (0.19%) to coarse and fine alevritic silts (1.69-2.54%), then decrease on the sandy bottoms of the underwater elevation (0.73%), only to increase again (to 2.60-2.70%) in deepwater silts. Sediments at depths of seven to 20 meters and 55-130 meters contain practically an equal amount of C_{org} in the solid phase, but the concentration of decayed products of organic matter in the liquid phase is higher at lesser depths. This can be accounted for by a better availability of organic remains, buried in the pre-delta zone at great sediment accumulation rates, and is confirmed by a greater number of saprophytic micro-organisms (up to 50 I0^{3} cells g''' of sediment). Allochtonous macroscopic plant detritus occurs widely in the zone of aleuritic silts, with an average of 0.1-0.3% of dry weight, and not more than 2% in the upper 15 cm layer of sediment. Thus, it is not significant in the total amount of organic matter.

In some cases a similarity in the distribution of allochtonous detritus and the biomass of zoobenthos occurs, but not infrequently, accumulations of detritus are accompanied by a small zoobenthos biomass.

The discrepancy between content of C_{org} and zoobenthos biomass, and the absence of a quantitative linkage between allochtonous plant detritus and zoobenthos can probably be accounted for by the unequal values of organic matter in sediments at various depths. This circumstance is aggravated by a considerable decrease in the sediment accumulation rate with distance from the delta. Zoobenthos distribution in various transects of the Selenga Shallows and its dependence on sediment detritus is presented in Fig. 5.6.

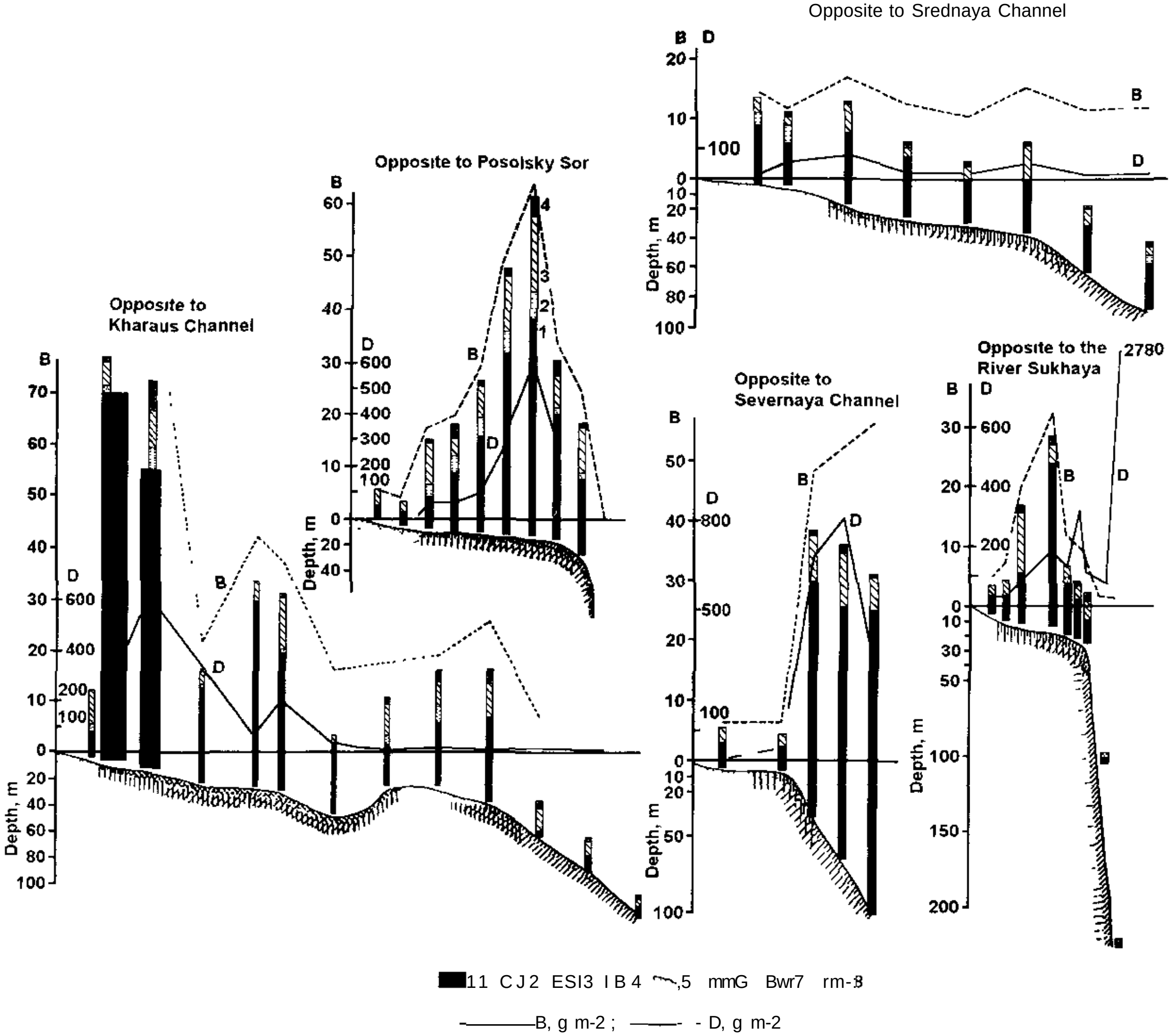
At high rates of sediment accumulation, organic detritus is buried in bottom deposits of the pre-delta in a slightly degradable state. In open Baikal, the rate of sedimentation is slow, but yet, most solid organic remains, settling to the bottom, become mineralized prior to burying. In deep-water sediments, only stable organic matter, which is slow to decompose, is buried. The percentage occurrence of zoobenthos, characterized by a different biomass, in the Selenga Shallows is shown in Fig. 5.7. Thus, allochtonous macroscopic detritus and dispersed organic matter of the sediments of the pre-delta zone must have a greater nutrient value than that in the external part of the shallows and in open Baikal. Circumstantial evidence for this is the slight decrease, in transiting from shallow water to deep-water sediment, in the content of organic matter in the liquid phase of these sediments, upon oxidation by permanganate in acid and neutral media (Table 5.25). Organic matter, buried at approximately equal depths in similar sediments, may differ by its quality and capacity for bacterial degradation. For example, in shallow water sands along the Selenga delta, the changes in the zoobenthos biomass are in agreement with fluctuations in concentration of the decayed products of organic matter in the liquid phase of sediment. The maximum biomass and highest *content* of ammonium nitrogen and organic matter in groundwater occur in the Kharaus mouth, where the amount of C_{org} is small, but absolute values of input and rate of burying are highest.

5.7. General conclusions

The distribution of the zoobenthos biomass in Baikal is following. The biomass is highest in zones showing a transition to true Baikalian conditions. These include, for instance, the northern half of the Mukhor Gulf (40 g m ^{2}), the bays of Maloye More (33 g m~^{2}), and the southern part of Chivyrkui Gulf (33 g m^{-2}). The biomass in sors and in bays with conditions close to those of eutrophic Siberian lakes is considerably lower, ranging from 2 to 10-15 g m~^{2}. The coastal belt of open Baikal is much richer in zoobenthos than the sors, especially in the littoral (25-30 g m~^{2}) and the

Table 5 24 Average values of C_{org} in solid-phase sediments, oxidizability of soil water and zoobenthos biomass (g m^{-2}) in different sediments of the Selenga region. After Bekman & Mizandrotsev, 1971

Depth m	*Types oj sediments*	*Average diameter of parti-cles. mm*	*Peine fraction*	*C_{org} % air'dry weight of sediments*	*Oxidiza-bilm of soil solutions, mg O_2 /"'*		*Zooben-thos biomass*
					acid	*neutral*	
0-5	Sands	0.14	6.6	0 73	8.0	4 8	10.9
5-20	Coarse alevntes	0 075	24.1	1.47	7.4	45	39 1
20-50	Fine alevntes	0 028	37 4	1.96	7.4	4.6	27 7
50	Clay and diatom silts	0 007	60 0	241	6.9	4.1	16 7



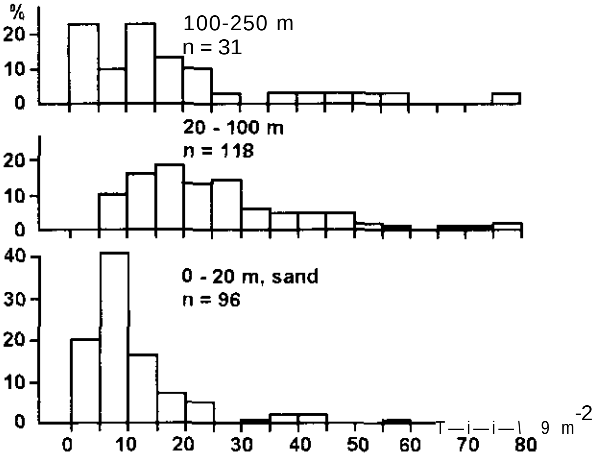


Fig 5 7 Occurence frequency (%) zoobenthos biomass *(g* m~^{2}), n the region of Selenga Shallows After Bekman, 1971
n - number of samples

the bottom-dwellers can be provided only by the bodies of large and small pelagic organisms sinking from the water column of the pelagic zone.

The average biomass of zoobenthos for the entire area of Baikal can be estimated at approximately 5-6 g m"^{2}.

It should be noted that the biomass of zoobenthos in Baikal remains, on the whole, at the same level throughout the year. Seasonal variations are insignificant. Seasonal variations resulting from consumption by fish have not been detected, although Cottoidei fish, graylings, gwynlads, sturgeons, and others, evidently feed on benthos around the year. Investigations conducted in Maloye More by Bekman (1959) showed that there, from spring until autumn, the total biomass of all benthic groups also changes little. In contrast, the zoobenthos of the sors and other lakes of the Baikal area have a biomass which varies with the season. Spring values are a half or third of autumn values and fall again in winter as a result of natural causes and consumption by fish.

There is a gap in our knowledge of the microbenthos in Lake Baikal. As far as we know, the microbenthos is fairly rich, varied and distinct in composition. It *contains* quite a few species of Cyclopoida, Harpacticoida, Cladocera, Rotifera and Nematodes. In the microbenthos of Maloye More bays, Vilisova (1959b) found 13 species of Copepoda, six species of Cladocera, *Hydra* and Ostracoda, and seven species of Rotifera. Even a cursory study of the microbenthos of Baikal conducted recently yielded many interesting results,

sublittoral (20-25 g m"^{2}), while extensive shallows, such as Maloye More, Barguzin Gulf, and Chivyrkui Gulf, are richer than the open regions of Baikal at corresponding depths.

The average zoobenthos biomass (without sponges) in the coastal belt of Baikal, down to a depth of 250 meters is estimated to be about 22 g m~^{2}. In the abyssal zone (deeper than 250-300 meters), the benthic biomass seems to be very low. Only in regions influenced by fluvial deposits does the biomass of the abyssal zone reach values comparable to that of the coastal belt, but far from the shores, in the main trough occupying up to 85% of total Baikal, the average biomass does not exceed 1.5-3 g m ^{2}. This is understandable, since food for

Table 5 25 Zoobenthos biomass, C_{org} (solid phase), and decay products of organic remains m soil water in the coastal (up to 5 meters) zone of the Selenga Shallows, sands. After Bekman & Mizandrontsev, 1971

	Kharait[1],	*Middle channel*	*North em channel*	*Shamanka*	*Poso Isk*	*Istok*
Biomass, g m ^{2}	25.7	12.0	"' 3	58	56	5.2
Neutral oxidizability, mg $0_2$1 '	8 1	60	5 1	59	2.6	2.8
N-NH_4 mg l"^{1}	1 33	0 36	0.45	0 29	0 05	0 15
C_{org}	0 19	0 35	0 46	-	-	0 29

←

Fig 5 6 Distribution of zoobenthos biomass (B) and piant detritus density (D) on different transects m the region of Selenga Shallows. After Bekman, 1971.

1 Oligochaeta, 2 - MoUusca, 3 - Amphipoda, 4 - others, 5 - sand, 6 - coarse aleurite, 7 - fine aleurite, 8 - clay silt.

such as elucidation of the role of microbenthos in the diet of fish, particularly fry, as well as of molluscs, gammarids and oligochaetes. An investigation of the animal and plant microbenthos is a priority task for the future.

It is interesting to compare the biomass of the zoobenthos of Baikal with that of other large basins, freshwater, brackish and marine. In 1935-1949 the zoobenthos biomass in the northern Caspian Sea ranged from 4.8 (1938) to 30.4 (1949) and 40.3 (1935) g nr^{2}, with molluscs (mostly Bivalvia) accounting for 4% to 36% (Birstein & Spassky, 1952). These values considerably exceed those for Baikal. But the biomass of the deep zone of the southern and central parts of the Caspian Sea is also low. In zoobenthos biomass, Baikal is much poorer than the Barents Sea, the Sea of Okhotsk and the Sea of Japan (Zenkevich, 1947, 1951). But the benthos of such large European lakes as Ladoga and Onezhskoe is evidently much poorer than that of Baikal, and Baikal is many times richer than Lake Balkhash, whose biomass, despite its shallowness, is valued at an insignificant 0.5-1.5 g nr^{2} (Burmakin, 1956).

That the biomass of zoobenthos in the coastal belt of open Baikal is higher than in the sors and in the eutrophic lakes of the Baikal area, does not mean that its annual production is also higher than in these waterbodies. Owing to lower temperatures, production in Baikal is slow, as is evident from a comparison of the biological processes in the same groups of animals in ordinary lakes and in Baikal. For instance, the development of caddisflies in Baikal can sometimes take as long as three years, whereas in the warm shallow lakes elsewhere in the Baikal area, it usually takes no more than one year. Most lacustrine molluscs also reach maturity a year or two earlier than Baikalians. Because of this, the P/B (production-biomass) ratio for the zoobenthos of Baikal is much lower than that of other lakes and sors.

Study of the productivity of the Baikahan zoobenthos were carried out by Bekman & Bazikalova (Bekman & Bazikalova, 1951; Bekman, 1954, 1959). Judging by the rate of growth and cycle of development of some widespread littoral species of gammarids, their potential production is high. For example, the P/B factor for the gammarid *Micruropus possolskii* approaches 3.4, the same as is obtained for the ordinary *Gammarus lacustris* in lakes of the Angara floodplain.

Chapter 6

Pelagic life

6.1. Seasonal and annual distribution of phytoplankton and zooplankton

The first plankton studies in Baikal were by Yasnitsky (1923, 1924, 1930; Yasnitsky & Skabichevsky, 1957), Meyer (1930), Visloukh (1924), Genkel (1925), Yashnov (1922), Skvortsov (1937; Skvortsov & Meyer, 1928), Skabichevsky (1929, 1935, 1954), and Zakhvatin (1932). The investigations of Yasnitsky (1930) were of special importance for a knowledge of annual and seasonal changes of the plankton in the area of Bolshiye Koty, in 1926 to 1928. Subsequently, extensive studies were undertaken by Kozhov and colleagues.

At the present time, open Baikal is known to have 170+ species of planktonic algae (Kozhova, 1956b, 1957, 1959a,b, 1987), several dozen of ciliates, up to 30 species of rotifers, and about 18 species of crustaceans (Amphipoda: 1; Calanoida: 5; Cyclopoida: 3; Harpacticoida: 1; Cladocera: 8).

By origin, the plankton can be divided into two main groups: Baikalian and European-Siberian. The latter is richer in species but restricted to shallow, enclosed gulfs, bays, and other sections of the littoral-sor region. Some of these European-Siberian species sporadically occur in open water, but few of them are permanent residents, although they may comprise endemic forms. Such are, for in-

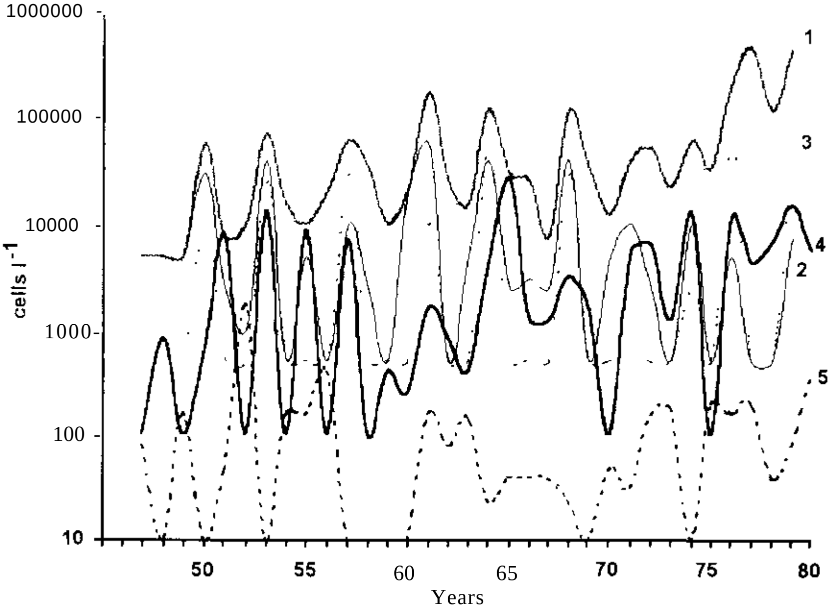


Fig. 6.1. Annual fluctuations in the number of cells of diatom algae in the open water of south Baikal (the Bolshiye Koty), in the 0-50 m layer (average). 1 - total numbers of phytoplankton; 2 - *Melosira baicalensis;* 3 - *Melosira islandica helvetica;* 4 - *Cyclotelhi minutu;* 5 - *Cyclotella baicalensis.* Data of the Research Institute of Biology.

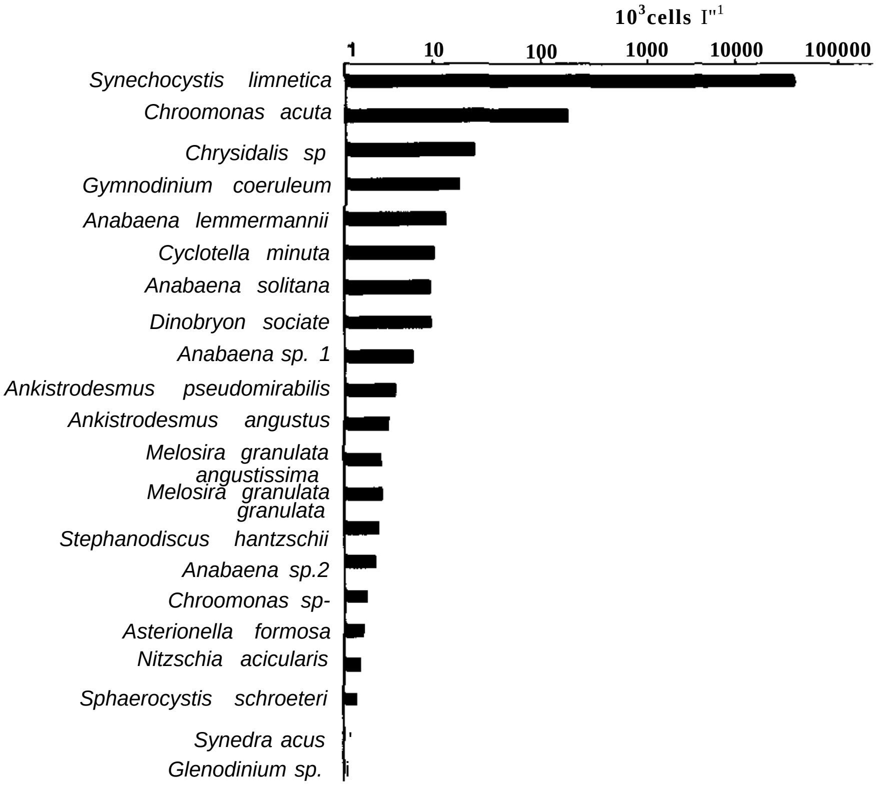


Fig 6 2 Concentration of algae (10^5 cells l^{-1}) in order of decreasing of number August-September 1987 Data of the Research Institute of Biology.

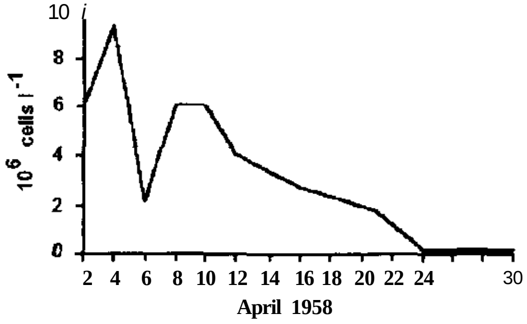


Fig 6 3 Fluctuations in the number of cells of "*Gymnodinium bmcalensis* + *G minutum* in April 1958, in the 0-1 m layer, 10 m from the shore After Kozhova, 1959a

stance, the rotifers *Kellicoltia longispina, Keratella quadrata, K. cochlearis* and *Filinia terminalis.*

The commonest European-Siberian species in *open* Baikal are the afgae *Aulacoseim islandica helvetica, Synedra ulna, S. acus, Dinobryon cylindricum alpina,* and the copepod *Cyclops kolensis.* The Baikalian group, which is characterized by profound endemism, is especially numerous in deep open water regions. Examples of these are the diatoms *Cyclotella baicalensis, C. minuta, Aulacoseim baicalensis,* the peridineans *Peridinium baica-lense,* species of *Gymnodinium,* the ciliates, the gammand *Macrohectopus branickii* and the copepod *Epischura baicalensis.*

Four zones of horizontal distribution of plankton (as well as of temperature) can be distinguished:

1. sections of the littoral-sor zone, characterized in the chapter on the distribution of benthos;
2. shallow regions adjoining the estuaries of large rivers;
3. gulfs, straits, bays and other shallow sections along the open fringe;
4. deep regions.

The first three zones comprise the littoral region, analogous to the *neritic* region of the sea, *in* contrast to the true deep-water region (Kozhov, 1957; Kozhova, 1957). In addition, Kozhova subdivides open Baikal into a shelf zone, adjacent to the shore,

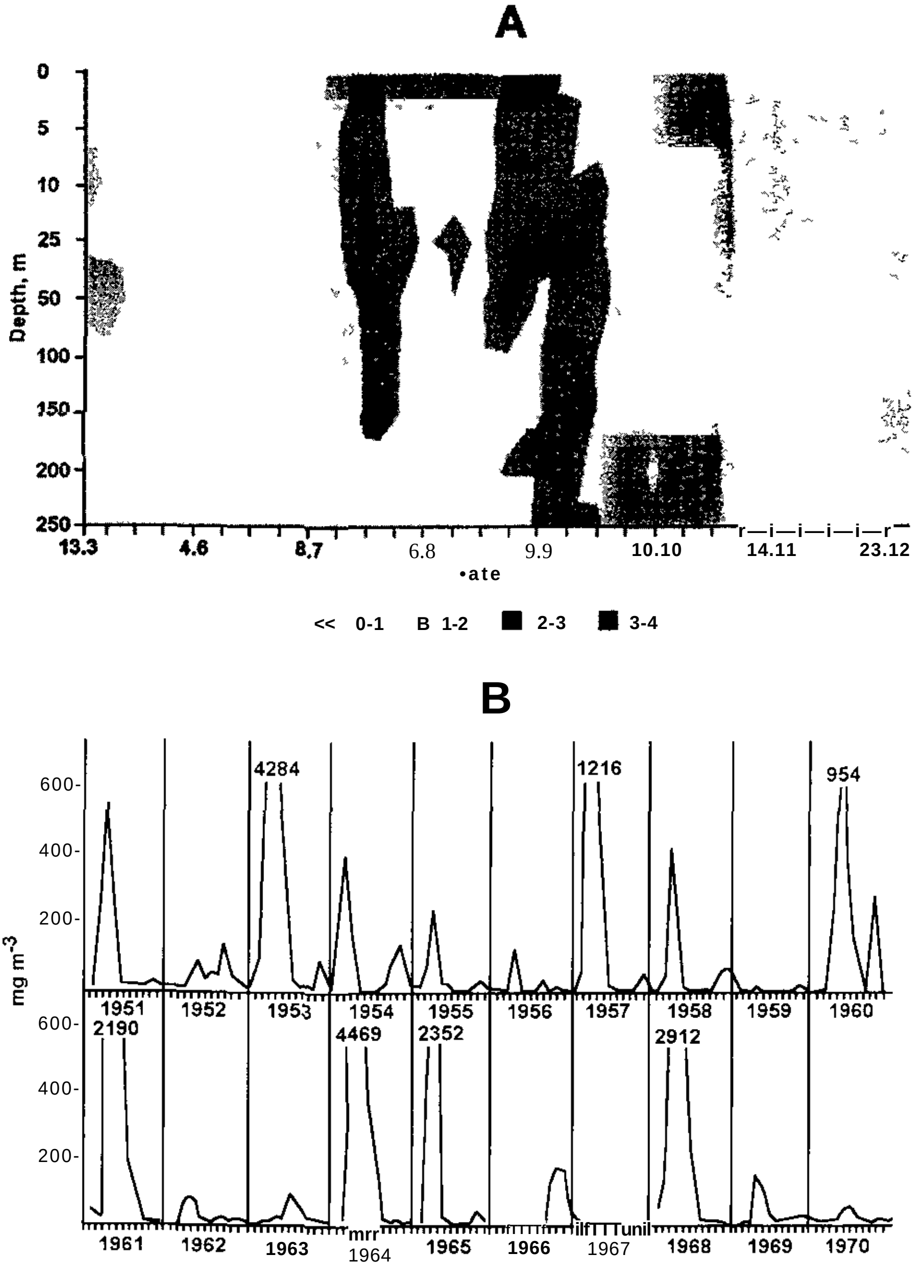


Fig 64 A seasonal changes of chlorophyll «d» (mg m ^ distribution 1996 After Izmesteva unpublished data B-seasonal and annual changes in the raw biomass of phyloplankton in the 0-50 m layer (average) Data of the Research Institute of Biology Years with extremely high biomass - «Melosira>i years South Baikal BoKhiye Koty

characterized by several specific features, and a deep-water zone

The vertical distribution of life in the water comprises the following zones (Kozhov, 1954, 1958)

1 The upper, trophogenic zone of intense photosynthetic activity, where most of the primary product is created and the bulk of plankton is concentrated for most of the year The lower limit of this zone changes in the course of spring and summer but does not descend beyond 25-50 m, although

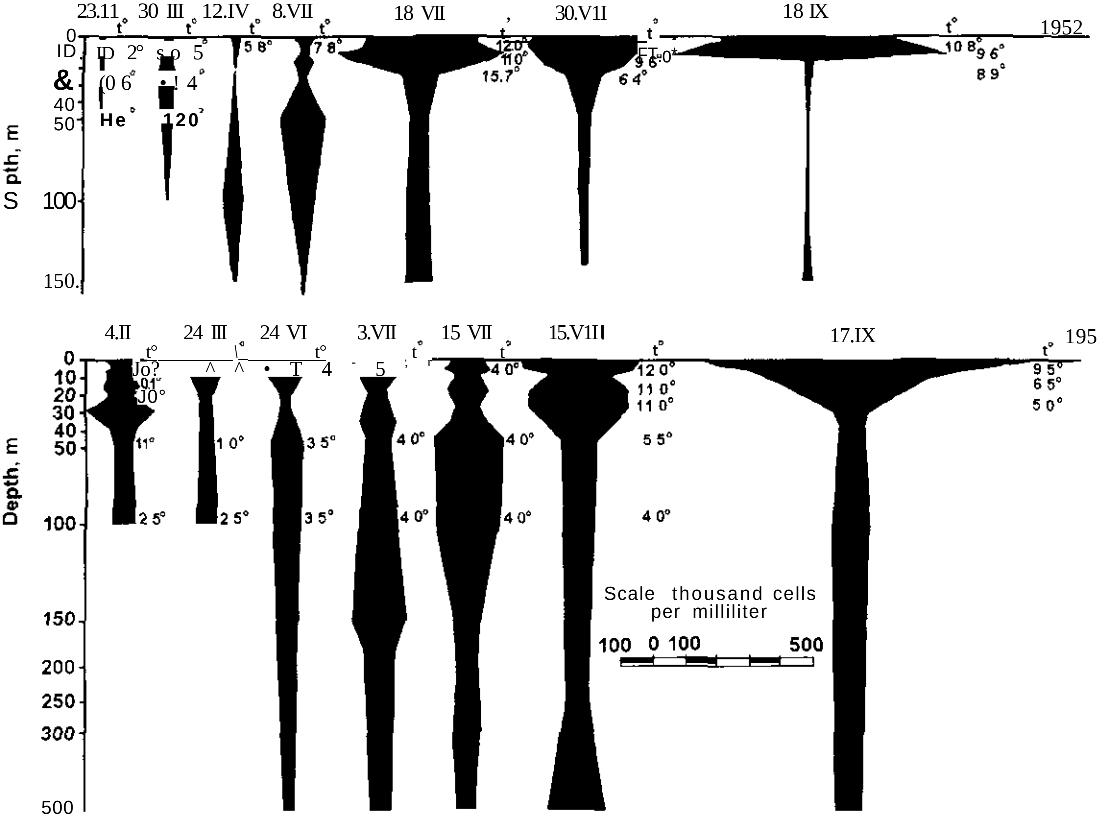


Fig 6 5 Seasonal changes in bacterioplankton and temperature in the open waters of south Baikal A - in 1952 (a Melosira - poor year); B - in 1957 (a Melosira - rich year) After Kozhova & Kazantseva, 1961

during homothermy, vegetative reproduction of algae takes place to a depth of at least 100 m.

2. The middle, or transitional zone, where, as a **rule,** *few* or no swarms of plankton are observed, except at near-bottom layers in shallow regions. The lower limit of this zone is situated at about 250 m.

3. The deep zone, which includes the entire water mass below 250-300 m. It is poor in living plankton

4. The near-bottom zone, where accumulations of living plankton, especially of *Macrohectopus bramckii,* are observed in winter and early spring.

Table 6.1 illustrates seasonal changes in the development of plankton in Baikal's open waters. Shown in Fig. 6.1-6.8 are seasonal and annual changes in numbers and biomass of the most important species and groups (Kozhov, 1955a,b). The role of different species of algae in the community of the phytoplankton significantly changes seasonly and annually. Relation of species according to data from 40 samples collected around the whole Baikal in late summer of 1987 demonstrates on the Fig. 6.2.

Biological spring in open Baikal begins early Not infrequently, vegetatively reproducing cells and colonies of *Aulacoseira baicalensis, A. islandica. helvetica, Cyclotella baicalensis,* and *Synedra ulna,* can be found in January-February under newly formed ice, still free from snow (Yasnitsky, 1930)

In March, the numerical density of algae increases considerably (Fig. 6.9); peridineans, especially species of *Gymnodinium,* appear and begin to multiply vigorously. In April, a bloom of algal life under the ice is observed; water transparency in the photosynthetic zone drops to 8-5 m, and the zone of mass occurrence of aigae extends to 30-40 m (Antipova & Kozhov, 1953; Kozhova, 1959a). In early spring under the ice, *Synedra acus, Nitzschia*

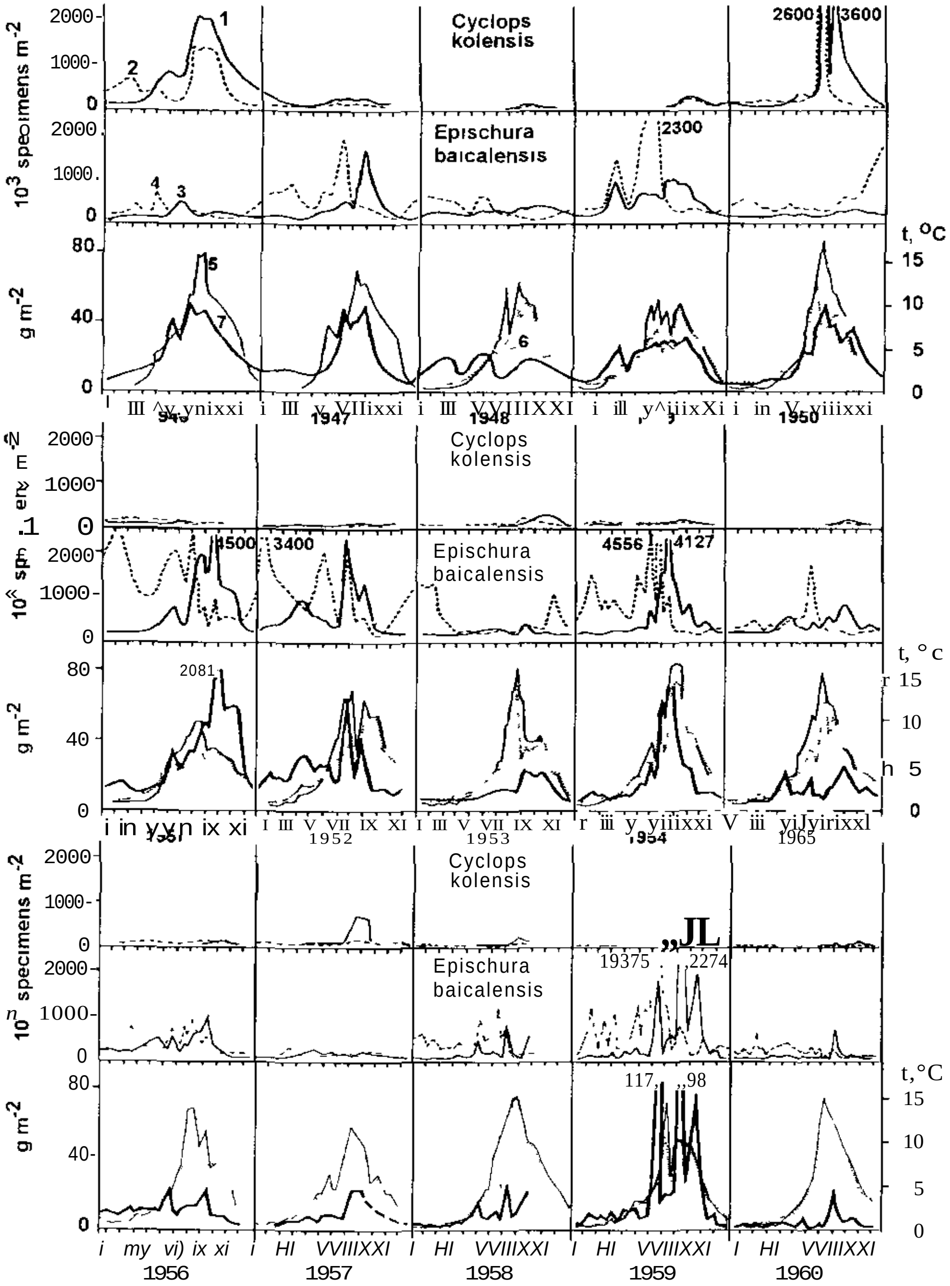


Fig 6 6 Seasonal and annual changes in mass species of zooplankton in the 0-250 layer in the open waters of iouth Baikal 1-4 - number of crustaceans in the 0-250 m layer in thousands under m 1- copepodits stages of *C\clops Kolensis. 2* - nauphi of the same species, 3 - copepodits stages of *Epischura baicalensis,* 4 - nauphi of the same species, 5 - temperature of the upper layer of water, 6 - temperature at a depth of 25 m, 7 - raw weight ot crustacean plankton m grams under m^2 in the 0-250 m layer. After Kozhov, 1963

acicularis, Peridinium baicalense, Dinobryon cylindricum, Stephanodiscus binderanus may become numerous. Chlorophyll " a" in the upper layers reaches 16 mg rrr^3 (Izmest'eva, 1983) (Fig. 6.10). Simultaneously with this, an increase of *Epischura baicalensis,* and of rotifers and ciliates, is observed.

Among rotifers, *Kellicottia longispina, Notholca grandis, N. intermedia,* the carnivorous *Synchaeta pachypoda,* as well as *Filinia terminalis* and *Kera-*

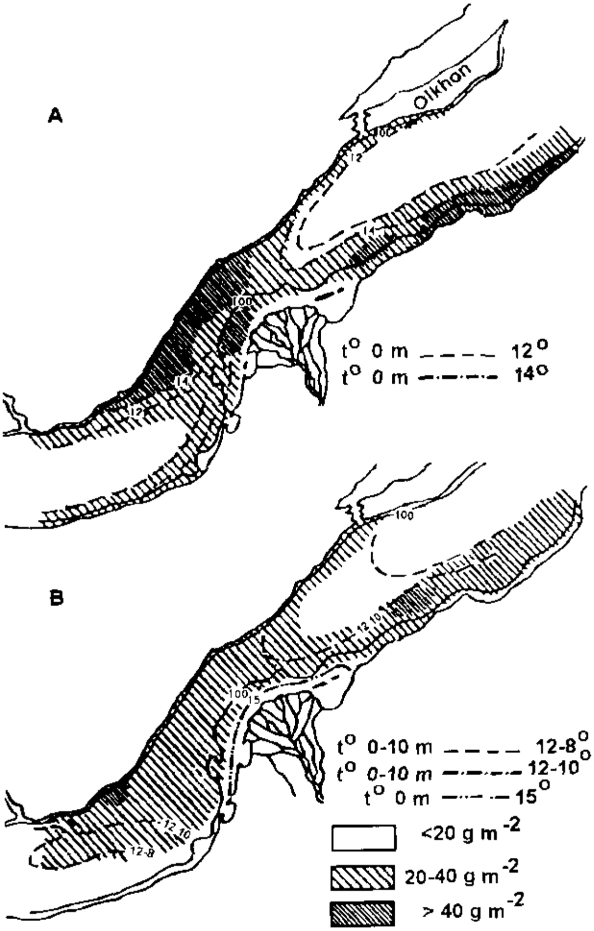


Fig 6 7. Distribution of temperature and crustacean plankton biomass in the 0-50 m layer in the middle part of Baikal A - in the second half of July and the beginning of August 1950, B - at the end of August 1952. After ICozhov, 1958

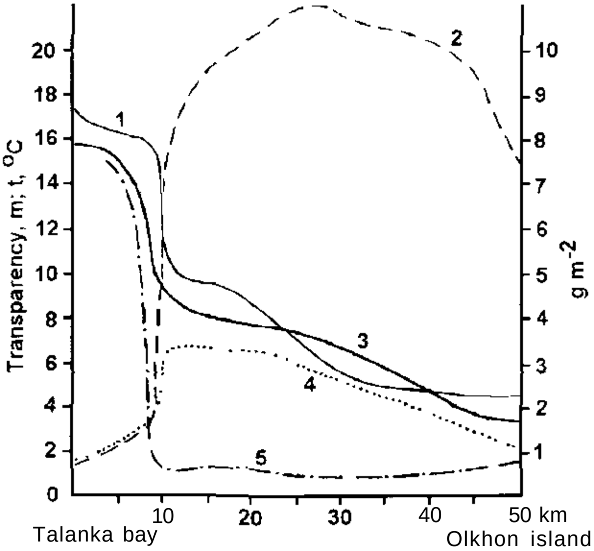


Fig 6 it Distribution of temperature and zooplankton in the Talanka Bay - Olkhon Island section on July 16, 1950 1 - water temperature, 2 - Sccchi disk transparency at daytime, 3 - total raw biomass of zooplankton m grams under m^2 in the 0- 50 m and down to the bottom m shallow water, 4 - biomass of *Epischura baicalensis,* 5 biomass of *C\clops kolensis.* After Kozhov, 1957.

tella spp., are especially conspicuous.

In winter and early spring, nauphi of *Epischura baicalensis* hatch, chiefly in deep layers. In early January they rise to the upper layers, where they accumulate, to comprise 50 to 80% of the total density. But throughout the ice period, adult crustaceans remain in deeper layers. The vertical distribution of adult *Epischura baicalensis,* including females with eggs, is shown in Fig. 6.11. In autumn and winter the amphipod *Macrohectopus branicku* also prefers deep and even near-bottom layers (Fig. 6.12).

In January and February the total zooplankton mass is insignificant Between-year values vary from 5, occasionally 10 g m~^{2} in the 0-250 m layer, to from 3.5 to 5 g rrr^2 in the 0-50 m layer.

In April, at the end of the ice period, the density and biomass of zooplankton increase chiefly due to growth of the winter generation of *Epischura baicalensis.* The melting of the ice is followed in May and June by the mass mortality of vernal algae, a growth of the microbial population (particularly in the 20-50 m layer), an increase in dissolved oxygen, and a re-charging of the upper layers with nutrients released from dying plankton rising from the deeper zones. Vernal forms now begin to be replaced by aestival ones.

In the transitional period (May-June), the vernal population of *Epischura baicalensis* gives rise, in deep water, to a second (aestival) generation of nauphi, whose number reaches a maximum in the upper layers in June.

The establishment of temperature stratification is followed by a differentiated distribution of plankton. The bulk of the aestival algae and zooplankton (with the exception *of Macrohectopus branickii)* is concentrated in the upper layers. The zooplankton biomass reaches its annual maximum in August-

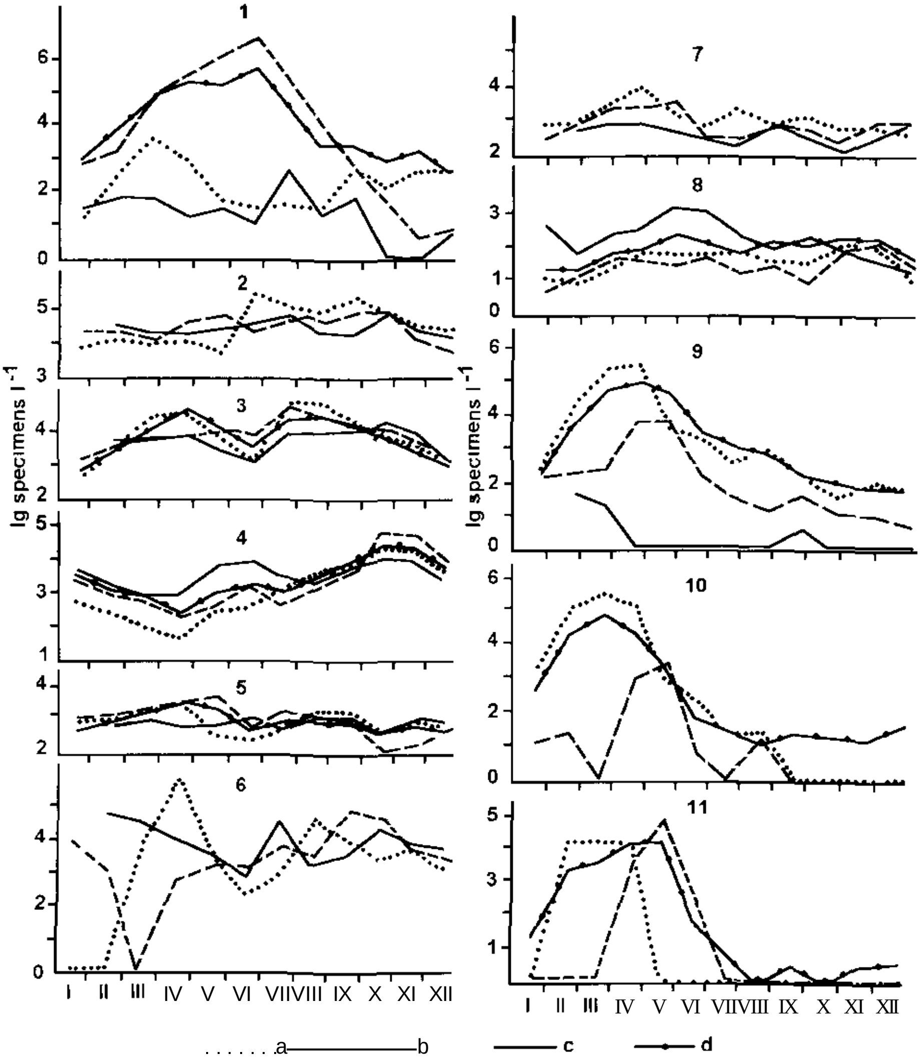


Fig 6 9. Dynamics of average-suspended number of algae (lg specimens 1^{-}') of various species, the 0-50 m layer South Baikal, Bolshiye Koly. 1979-1981

Background species. 1 - *Nitzschia aciculans* 2 - *Chroomonas acuta,* 3 - *Ankistrodesmus pseudomirabihs,* 4 - *Cvclotella minuia,* 5 *Gymnodimum coeruleum,* 6 - *Chrysidahs* sp , 7 - *Glenodimum* sp., 8 - *Cyclotella baicalensis*

Developing periodically. 9 - *Svnedra acus,* 10 *Melostra islandica,* 11 - *Stephanodiscus hinderanus*

a - 1979, b - 1980, c - 1981, d - average from 197<> to 1981. Data of the Research Institute of Biology

September. In the 0-50 m layer, it often reaches 40 to 50 g m^2 (0.8 to 1.0 g m~^{3}), and in peak-crop years, 70 to 100 g rrr^2 (1.4 to 2 g m"^{3}). *Epischura baicalensis* accounts for 80 to 90% of the open water biomass. The dynamics (monthly average number) of *Epischura baicalensis* and *Cyclops kolensis* in 1946-1970 are shown in Fig. 6.13. Statistical analysis has shown that in the 1970's and 1980's, the seasonal dynamics of *E. baicalensis* was less expressed than before and that the numbers of *C. kolensis* declined, although fluctuating markedly between years (Kozhova, 1982, 1983) (Fig. 6.14). The rotifers *Kellicottia longispina, Keratella quadrata,* and *Filinia terminalis* may form two, three or more maxima per annum (Fig. 6.15).

At extreme depths, the biomass of aestival phytoplankton is usually small, but m the littoral

Table 61 Biological seasons in Baikal s open waters After Kozhov 1963

	Spring		*Summer*		*Autumn*	*Winter*
Factors	Early spring (ice) period February-March	Late spring (transitional) period May-June	barly July-first 10 days of August	Late August September	October-November	December-lanuary
1	*2*	*3*	*4*	*5*	*6*	7
Seasonal average water t °						
0 m	07	25	100	125	*i)* J	20
20 m	08	*2* 8	70	90	58	2 2
Maximum t °						
0 m	1 5	**40**	150	150	90	3 6
20 m	1 0	**36**	100	100	80	3 6
Water circulation	Attenuated circulation	Intence vertical convection and wind-induced circulation	Wind-induced circulation Horizontal currents	Wind induced circulation Strong horizontal currents	Intense vertical thermal circulation Horizontal Currents	Attenuation of circulation at end of period
Compounds of biogenous elements	Decrease, annual minimum towards end of period	Increase, spring-summer maximum towards end of period	Decrease	Decrease summer minimum	Increase	Increase, winter maximum
Phytoplankton	Mass vegetative reproduction of diatoms and pendineans, annual maximum of biomass in abyssal regions	Beginning of dying off vernal forms and their subsidence High biomass decrease toward end of period	Mass dying-off of vernal forms Appearance of aestival forms	Mass development of aestival forms in open shallows	In some years autumnal Outburst Of diatoms but total biomass diminishes Sharply	Scant, annual minimum of biomass
Zooplankton	Mass outcrop of young *Epischura* of mass winter spring generation Reproduction of *Macrohectopus*	Period of growth of winter spring generation of *Epuchuia* Start of a new explosive reproduction by end of period Jncreasc in biomass	Mass outcrop of young *Epischura* ot summer generation Emergence of summer forms *Cyclops* Cladocera, *VoXicella etc* Annual maximum of biomass	Period of growth of summer generation of *Epischwa* Annual maximum of biomass at outset of period Decrease in biomass by end of period	Decrease in biomass Subsidence ot adult *Epischura*	Scant annual minimum of biomass

Table 6 1 Continued

1	*2*	*3*	*4*	*5*	*6*	*7*
Vertical distribution of zooplankton	Maximum density in upper layers (0-5 D m)	Dispersal in water mass down to 220-300 m with greater density in upper layers	Maximum density in upper layers. (0-50 m especially 0-25 m)	Maximum density in upper layers (0-50 m. especially 0-25 m)	Dispersal in water mass, descent to deep layers	Greater part in deep layers. Ascent by end of period
Intensity of diurnal vertical migrations of zooplankton	small	very small	great	great	small	very small
Plankton-eating fish	Omul hatchlings begin to migrate down at end of period Movement of omul mostly and *Collocomephorus* from wintering grounds to shores	Omul shoals converge in shallow fishing grounds Approach to *Cotiocomer phonis* to shores for spawning. Omul fry migrate down to Baikal	Movement of omul to open regions and extensive Feeding migrations in upper layers Mass outcrop of *Cottocomephorus* hatchlings and fry in shallows	Extensive feeding and spawning migrations of omul in upper layers Mass accumulations of *Cottocomephoms* fingerlings along shores	Start of movement to winter grounds in deep layers	Wintering of omul and *Cottocomephoru<i* at 200-300 m deeper. in near bottom layers close to shallows

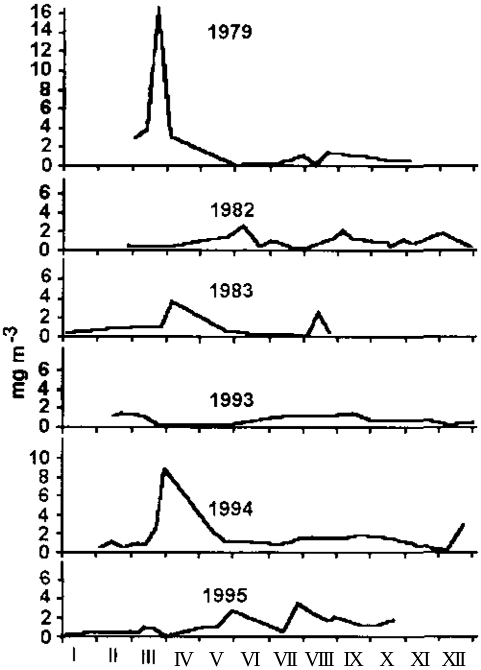


Fig 6 JO Seasonal changes of chlorophyll "a" concentration at the water surface South Baikal, Bolshiyc Koty After Izmest'eva, unpublished data

and in the belt of deep currents, especially after a prolonged period of calm, aestival algae often cause water blooms and their biomass may considerably exceed that of the vernal phytoplankton.

In gulfs, bays, and pre-estuarine areas, *Cyclops kolensis* reaches maximum development in August-September, residing, on the whole, in layers above those occupied by *Epischura baicalensis.*

In late July, August, and September an increase in the quantity of rotifers and ciliates in the open waters occurs. Especially abundant among the rotifers are endemic forms of *Keratella quadrata, K. cochlearis, Filinia terminalis,* and *Kellicoltia longispina.* Vorticellas are sometimes plentiful too. The main mass of the amphipod *Macrohectopus branichi* now lives at between 150 and 250 m, migrating to the surface during the night.

Despite its uniformity, the pelagic deep-water region is affected by strong horizontal currents and wind-induced water movements, which complicates the picture of the distribution of temperature and plankton. Areas of relatively warm water, driven there by wind from the shores, can be found in deep-water regions. After strong winds, plankton near the leeward shores is scarce, but more or less evenly dispersed in the 0-50 to 0-100 m layer. In such periods, plankton in warmer water in the middle of Baikal is often more abundant than near the shores.

In summer a correlation is observed between temperature and plankton biomass in the upper 10 meters in deep-water regions. The higher the temperature, the richer the plankton, and *vice versa* (Fig. 6.7). In August and early September, the sections with the greatest density of zooplankton show a temperature of 14-12°C at the surface, and 8°C at approximately 10 m (Fig. 6.7; Kozhov, 1957).

As already mentioned, the plankton of the littoral-sor zones (Vilisova, 1954, 1959a; Kozhov, 1957) consists of forms widespread in European-Siberian waters, to which Baikalian species are added only in the cold period of the year. The closer these sections are to the open waters of Baikal, the greater the part played by these Baikalians. In spring, before the ice breaks up, the algae *Aulacoseira haicalensis, Cyclotella baicalensis, Aulacoseira islandica helvetica,* and *Stephanodiscus binderanus* can be observed there. In the zooplankton, small numbers of *Epischura haicalensis, Cyclops kolensis* and Rotifera are found.

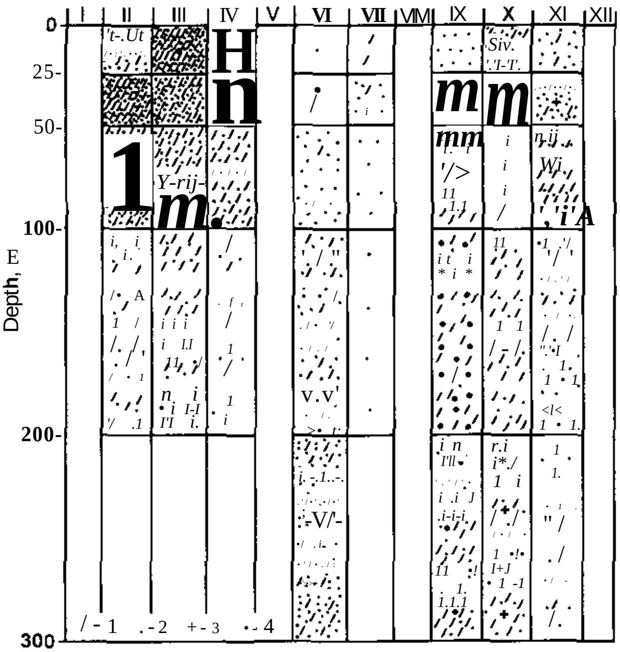


Fig 6 11 Vertical distribution of adult *Epischura* in pelagial testing ared South Baikal, Baikalsk. 1987 L - male;, (10 specimens m~^{3}), 2 - females with egg sacks (10 specimens m~^{3}); 3 - females without egg sacks and without spermatophore (10 specimens *m~^{J}),* 4 - females with spermatophore (10 specimens m–^{J}), blank - no sampling was done After Kozhova, unpublished data.

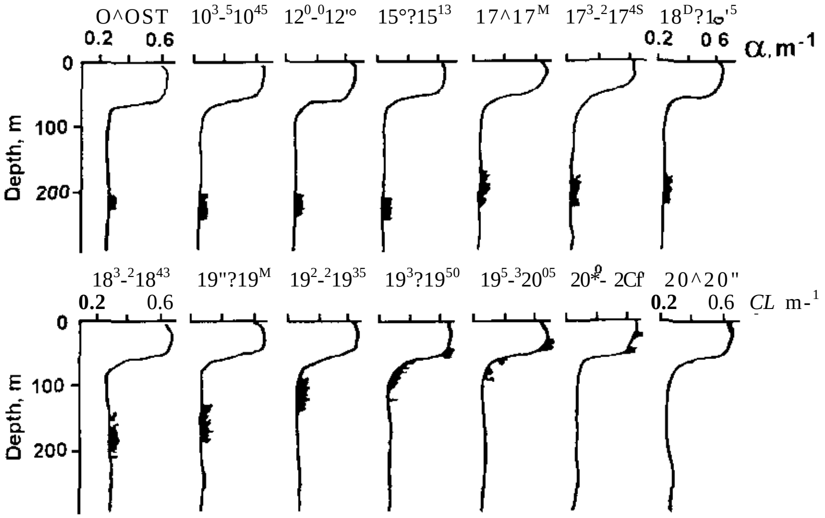


Fig 6 12 Vertical migration of zooplankton *{Macroheciopm bmmcku),* traced from the measurement of atienuation coefficient. South Baikal, ice station April 4 After Sherstyankin & Kaplin, 1973.

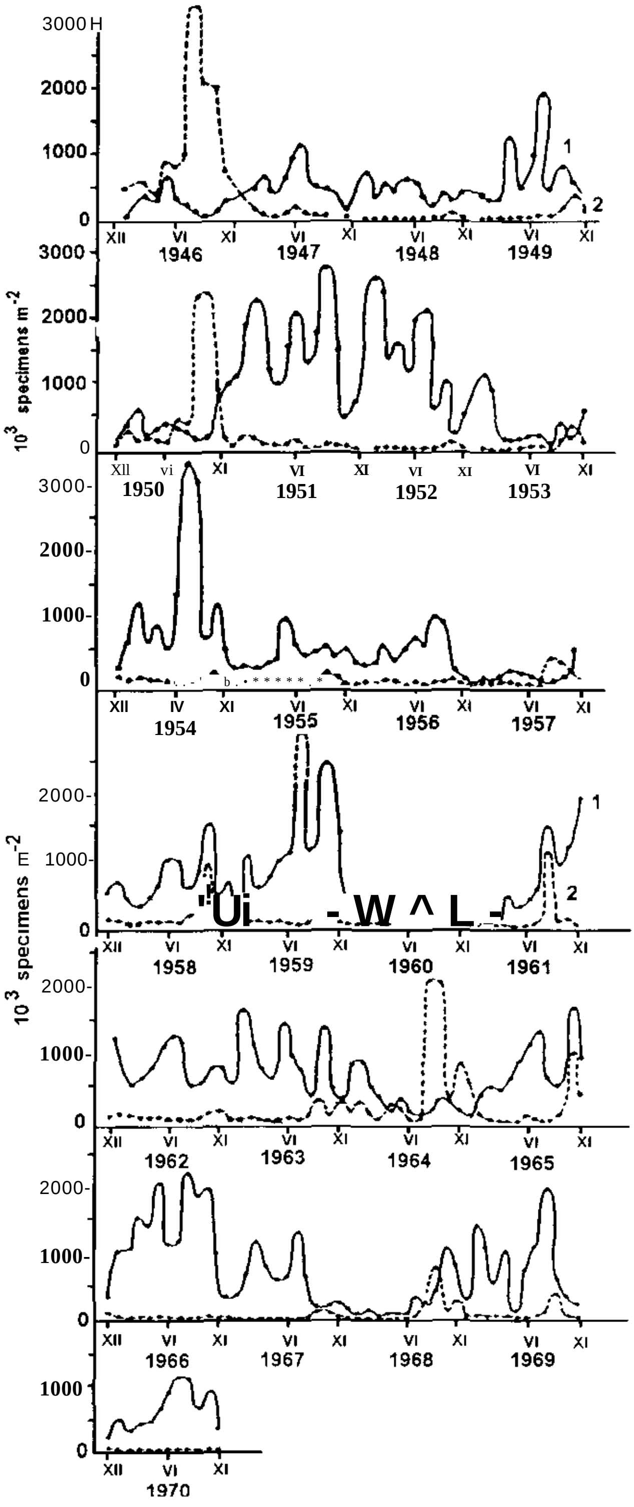


Fig 6 13 Seasonal dynamics of monthly average number of *Epischura baicalensis* (1) and *Cyclops kolensis* (2), the 0-25 m layer 1946-1970 Data of the Research Institute of Biology

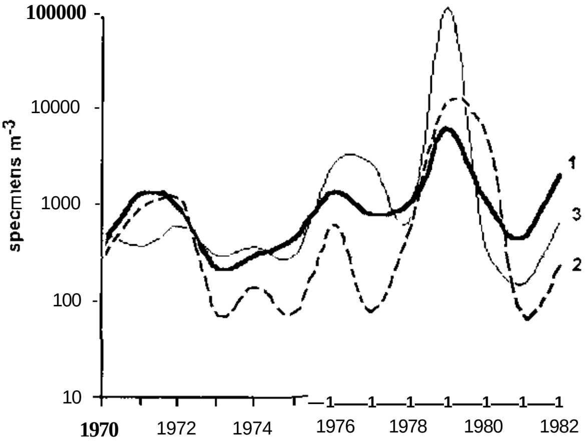


Fig 6 14 Number of *Cyclops kolensis,* the 0-50 m layer August-September 1 average for the whole Baikal, 2 - area of Bolshiye Koty, August, 3 - the same, September. Data of the Research Institute of Biology

But it is lacustrine species that predominate: *Eudiaptomus graciloides, Cyclops vicinius, Mesocyclops leuckarti, Chydorus sphaericus, Bosmina longirostris, Daphnia longispina,* the rotifers *Polyarthra dolychoptera, P. euryptera, Keratella cochlearis,* and *K. quadrata.* After the ice in these littoral shallows has melted, vernal Baikalian forms disappear. Gradually, with warming up, a typically lacustrine aestival plankton develops. Among algae, the predominant species are *Anabaena flos-aquae, Dinobryon cylindricum, Ceratium hirudinella, Asterionella gracillima,* and *A. formosa.* In the zooplankton, Cladocera, Cyclopoida, Rotifera and Ciliophora are abundantly represented.

In spring and summer the concentration of zooplankton in such littoral-sor waters can be high. The biomass of copepods and rotifers often reaches 3-5 g m^{-3}, providing plenty of food for the young of plankton-eating cyprinoids and related fish.

Extensive areas are taken up by pre-estuarine regions of the rivers Selenga, Upper Angara, Barguzin and Turka. These regions can be divided into an internal zone, with depths not exceeding 10-15 m, constantly under the influence of fluvial waters, and an external zone, influenced by both the internal part and the neighboring deep-water regions.

As noted above, the water in the sections directly bordering the river estuaries and deltas

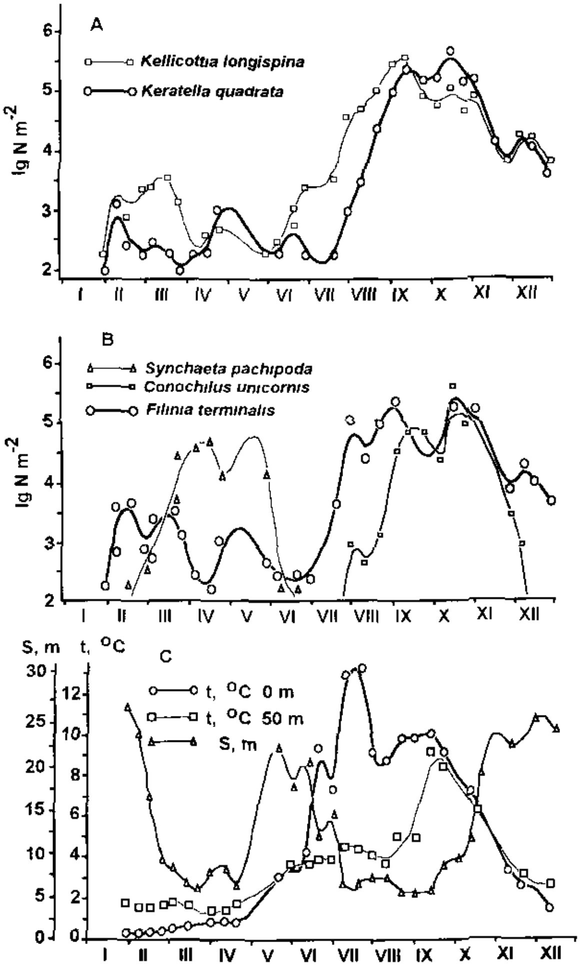


Fig 6 15 Number of the dominant species of Rotatoria (A, B) in the 0-500 m layer, temperature and water transparency (C). South Baikal, Bolshiye Koty 1979. Data of the Research Institute of Biology

warms up rapidly, and its temperature in spring is always 2-4°C above that of the adjacent open zone, causing an earlier blooming of the plankton. But at the same time, its development is adversely affected by a constant turbidity. Turbidity is particularly high near river deltas, from the shore to the 10-15 m isobath with a transparency of not more than 1-3 m. In the Selenga delta, turbid water stretches along the shores for almost 80 km in a belt of 1-2 to 6-8 km wide, depending on wind direction.

The plankton of these pre-estuarine regions is of mixed composition. Together with Baikalian species, it frequently contains lacustrine species carried in from sors and marginal lakes. But in spring it consists chiefly of the diatoms *Aulacoseira islandtca helvetica, A. haicalensis, Cyclotella baicalensis, Synedra ulna danica,* and *S. acus.* Characteristic diatoms are *Stephanodiscus binderanus, Aulacoseira itahca, A. granulata,* and *Nitzschia acicularis.* In spring, its zooplankton contains numerous *Cyclops kolensis* and rotifers.

In summer, blue-green algae bloom, among which *Anabaena fios-aquae, Aphanizomenon flos-aquae,* and *Gtoeotrichia echinulata,* but also *Ceratium hirundinella,* species of *Pediastrum, Asterionella, Dinobryon, Volvox,* and *Eudorina.* Among crustaceans, *Cyclops kolensis* usually predominates, and *Epischura baicalensis* plays only a secondary part. Considerable populations of *Eudiaptomus graciloides, Daphnia hyahna, Bosmina longirostris, Chydorus sphaericus, Mesocyclops leuckarti, Cyclops vicinus,* and many rotifers, appear.

The biomass of zooplankton in these internal pre-delta zones is insignificant, even in summer. It usually does not exceed 0.3-0.1 g m~\ although its concentration at the surface can reach 1-2 g m"^{3} during the night.

The external zone of the pre-estuarine regions (beyond the 10-15 m isobath) is characterized by greater transparency and lower temperatures.

In spring, its plankton is typically Baikalian, while in summer it becomes mixed, with forms brought in by currents from the pre-estuarine shallows. For instance, an abundant development of *Cyclops kolensis* occurs, and *Eudiaptomus graciloides, Daphma hyalina, Bosmina longirostris, Chydorus sphaericus,* and lacustrine species of rotifers appear there as well.

Winds and currents may carry this mixed plankton far into the adjoining deep-water regions. From the pre-delta region of the Selenga, it penetrates to the south-west, at least to the outflow of the Angara. In north Baikal, it is carried from the pre-estuarine regions of the Kichera and Upper Angara along the western shore, for dozens of kilometers, to Boguchan Bay and further south.

In warm and quiet weather, this aestival plankton can also develop in the neighboring deep-water regions (chiefly in the belt of warm currents, causing a water bloom and reducing transparency to 4-6 m). But such blooms are usually short-lived and end after the first storm.

Fluvial waters enrich Baikal with nutrients, which cause a summer bloom in pre-estuarine sections But of equal significance is the higher temperature in spring and summer, and the vicinity of the bottom, where resting stages of algae are preserved, rising rapidly to the photosynthetic zone in early spring

The zooplankton of the Selenga region was thoroughly studied in 1958-1968 (Mazepova & Afanasyeva, 1971) Its complex dynamics are due to an admixture of coastal-sor species, particularly in summer But the main biomass is due to the same species as in open Baikal During some years, *Epischura baicalensis* was even the main species here In the shallows, there was a more rapid growth of its juveniles and an earlier summer maximum than outside But later, a sharp decrease in number and biomass was observed, and the share of *E baicalensis* in the total biomass dropped to a few percent at some stations, while outside the shallows, its growth in the biomass continued Conversely, in the summer, the importance of Baikahan rotifers, *Cyclops kolensis* (1958, 1960-1961, 1962), and Cladocera showed an increase in the shallows, but was insignificant on the whole The average total zooplankton biomass in the Selenga Shallows was similar to that in south Baikal These observations do not substantiate those of Kozhov (1954)

The highest biomass of *E baicalensis, C\ clops kolensis* and Cladocera occurred at an average temperature of 6°C to 10-12°C in the 25 m water layer There was no correspondence between zooplankton biomass and average temperature of the water of the Selenga River

Near the delta of the Selenga, the zooplankton biomass is usually low, due to suspended material The input of such turbid waters during summer floods causes a depression in the growth of *E baicalensis* This influence of the Selenga River is detected far beyond the pre-estuarine areas During prolonged periods of calm, fluvial waters can reach the western coast The low biomass of zooplankton in the shallows may also be attributed to consumption by fish Neither Baikahan *nor* Palaearctic species find favorable conditions in the Selenga Shallows

The distinctive zooplankton distribution near the Selenga Shallows in late summer is demonstrated in Fig 6 16, while the distribution of zooplankton *in* open Baikal *is* shown *in* Fig 6 17

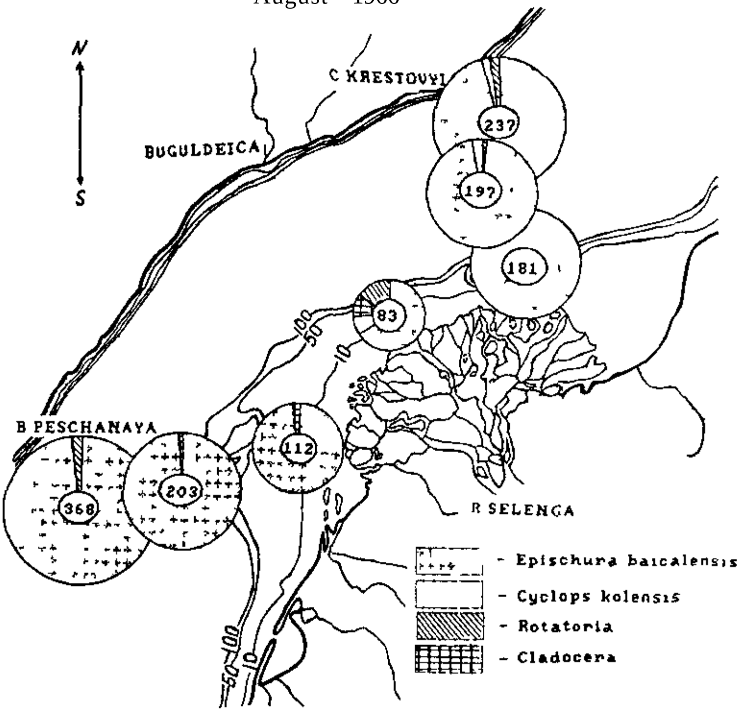
The plankton of large gulfs and other regions isolated from open waters also has certain peculiarities In early spring the phytoplankton of the gulfs is, roughly, of the same composition everywhere, with the diatoms *Aulacoseira baicalensis, A islandica helvetica, Stephanodiscus binderanus, Cvclotella baicalensis,* and *C minuta* being dominant and *Epischwa baicalensis, Cyclops kolensis, Keratella cochleans, K quadrata, Kelhcottia longispina* and *Svnchaeta pachvpoda* dominating the zooplankton Owing to the more rapid warming of the inner zones of such gulfs, copepodite stages of *Epischura baicalensis* and *Cyclops kolensis* occur there already in June, and the zooplankton biomass reaches, on average, 1 5-2 g m^{3} In the central and external section of the gulfs, plankton is still poorly developed in June, but towards the middle of July it reaches its maximum development in the central sections By this time, *Cvclops kolensis,* Cladocera, and lacustrine-sor forms of rotifers are predominant in the internal sections The maximum biomass of *Epischura baicalensis* follows the movement of the 10-12-14° isotherm at the surface, and the 8-10° isotherm at a depth of 10 meters (Fig 6 18) When the temperature exceeds this limit, *Epischura baicalensis* and other cold stenothermic Baikahan forms disappear

It should be stressed that, in the plankton of large gulfs such as Chivyrkui and Barguzin, *Cvclops kolensis* and the alga *Stephanodiscus binderanus,* for which such regions present a permanent habitat, are almost always dominant elements

In internal zones, especially of Chivyrkui Gulf, the composition of summer phytoplankton is diverse, and usual lake species dominate

Special attention should be paid to the plankton of the Maloye More (Vilisova, 1959a, Kozhova, 1959b) It stands out by its qualitative and quantitative abundance But in open regions, algae *are* richly represented by comparatively few forms *Stephanodiscus binderanus, Aulacoseira baicalensis, A islandica helvetica, Cyclotella baicalensis, C minuta, Asterionella formosa,* and such aestival forms as *Anabaena flos-aquae, Gloeotrichia echinulata, Epischura baicalensis, Cyclops kolensis, Keratella quadrata,* and *K cochlearis* are usually common in the zooplankton

August 1966



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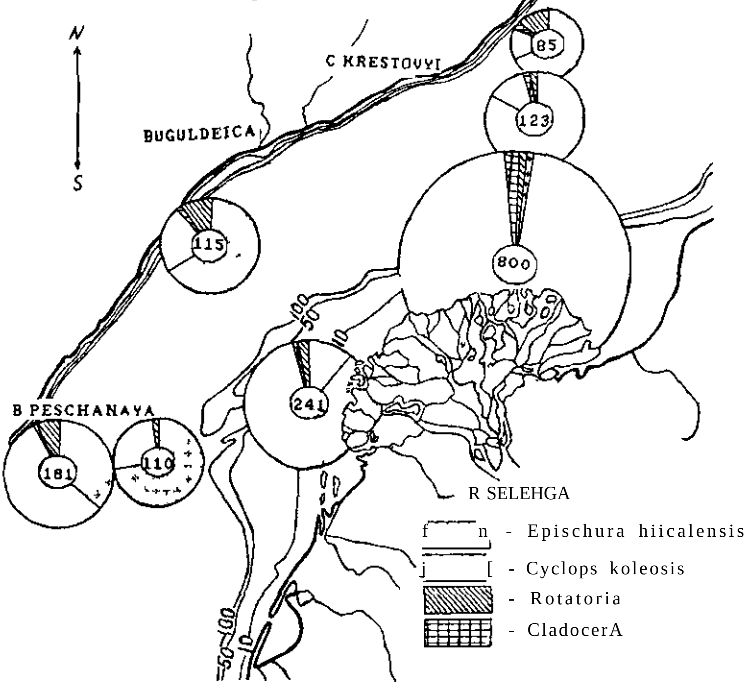


Fig 6 16 Structure of zooplankton in the upper layer of water Sclenga Shallows The area of circles corresponds to biomass (mg m^{3}) in the centre of the circle Data of the Research Institute of Biology

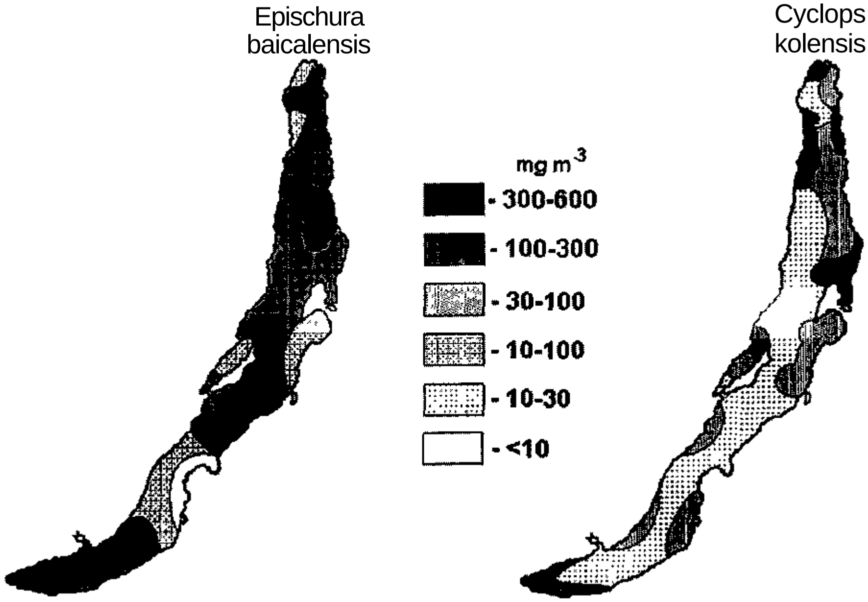


Fig. 6 37. Biomass (mg m^{-3}) *of Epischura baicalensis* and *Cyclops kolensis* in Baikal, the 0-25 m layer, August-September 1990. Data of the Research Institute of Biology.

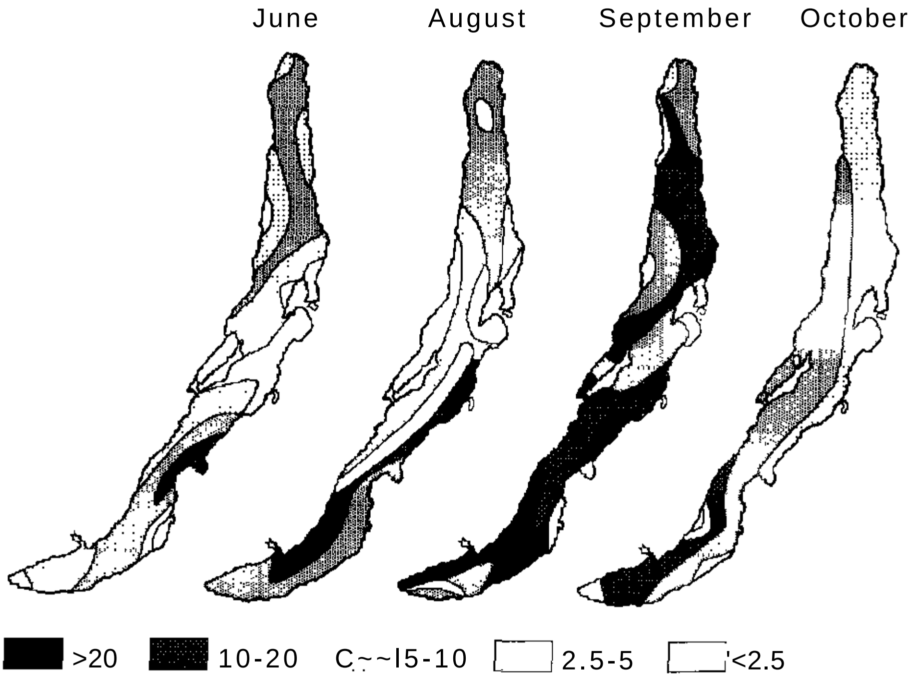


Fig. 6.18. Distribution of *Epischura baicalensis* biomass in Baikal (g m^{-2}), the 0-50 m layer, 1965. After Afanasyeva, 1983.

In winter, the snow cover on the ice of the Maloye More is usually thin, as winds often blow it off. Therefore in January the daytime light intensity *under the* ice is fairly high. This explains the unusually early development of algae there. In 1952, *for* example, a mass development of *Stephanodiscus binderanus* in the Maloye More was observed in February. Other Baikalian algae also develop there early. Nauplii of *Epischura* appear *en masse* under the ice in January-February, reaching maturity soon after the melt. In the south of the Maloye More, the development of the summer generation of *Epischura baicalensis* begins in May, and in late June, its biomass may reach its annual maximum. In the center of the Maloye More, the annual maximum of the zooplankton biomass is observed from the second half of July until August, and in the northern part, in August and September. As in the gulfs, this maximum, resulting chiefly from the development of *Epischura baicalensis,* shifts from the internal to external shallows, moving with a temperature of 12-14°C at the surface, and 8-10°C at a depth of 10 m.

Figs. 6.1-6.6 show changes in the quality and biomass of the most important species and groups of plankton in open Baikal in different years. Especially extensive fluctuations are observed in the phytoplankton (Antipova & Kozhov, 1953), mainly due to the diatom *Aulacoseira baicalensis* and, partially, to *A. islandica helvetica,* and in the shallows, *Stephanodiscus binderanus.*

After 1941, exceptionally high crops of *A. baicalensis* were recorded in 1943, 1946, 1950, 1953, 1957, and 1960 (Fig. 6.1).

In 1961, accumulations of *A. baicalensis* and *A. hlandica helvetica* were recorded in south Baikal only. To the north of the Selenga Shallows these diatoms were rare.

In *Aulacoseira* -rich years, the gross biomass of diatoms reaches an average of 4-6 g m$\sim^3$ in March-April (0-25 m layer). In years of poor development of *Aulacoseira.* the maximum biomass of vernal phytoplankton does not exceed a few hundred mg m$\sim^3$. In such years, *Cyclotella baicalensis* and sometimes *Synedra* predominate in the open waters in spring, and the peridinean *Gymnodinium* in early spring.

The peridineans of the genus *Gymnodinium* annually appear in open waters, chiefly in the uppermost layer of water under the ice, but their numerical density varies widely between years. In high-crop years, their biomass may reach 0.5-1 g m$\sim^3$ in the 0-50 meter layer. In the 0-10 m layer, even denser concentrations can be observed.

In good years for *Aulacoseira* species, their development spreads either over the whole of Baikal, or over its south and middle parts. In 1950, *A. baicalensis* densely populated the southern and middle parts of the lake but was much less abundant in the north, although even there it predominated over other algae. In 1960 the picture, on the whole, repeated itself. In poor years, *A. baicalensis* is either absent or develops extremely poorly in all parts of the lake, yielding predominance to other vernal algae, such as *Cyclotella baicalensis* and species of *Synedra* and *Gymnodinium.* It is only in extensive shallows such as the Selenga delta, the south part of the Maloye More, and others, that fluctuations in the crop of *Aulacoseira* species, *A. baicalensis* included, are less pronounced than in deep-water regions.

The biomass of aestival algae and the area occupied by them also vary widely with years, even in the shallows. In deep-water regions, aestival algae appear in considerable amounts only in the immediate vicinity of shallows or in the belt of deep currents, and even there, not every year.

Mass development of phytoplankton, first detected in the 1950s, was later observed for other algae in the pelagic (Kozhova, 1987): Bacillanophyta *{Synedra acus, Nitzschia acicularis, Achnantkes minutissima),* and Chrysophyta *(Dinobryon cyhndricum).*

From the 1970's to the 1990's, no very high biomasses of *Aulacoseira baicalensis* and *A. islandica helvetica* were observed, even though they were present and, sometimes, abundant. Mass development of *Stephanodiscus binderanus* was not observed either. Long-term observations (1940-1990) of phytoplankton succession show that it is less expressed in a change of the biomass, than in a change in algal numbers. In other words, the number of large algae declines, but the number of small species increases.

During the last 15 years, phytoplankton counts were accompanied by determinations of chlorophyll "a", using the SCOR-UNESCO (1966) method and a submerged fluorimeter (Figs. 6.11, 6.19-6.21).

The biomass of zooplankton and its qualitative composition also differ from year to year, but the amplitude of its annual fluctuation in the biomass is much less than in the phytoplankton (Fig. 6.22).

To understand the inter-annual variability in the

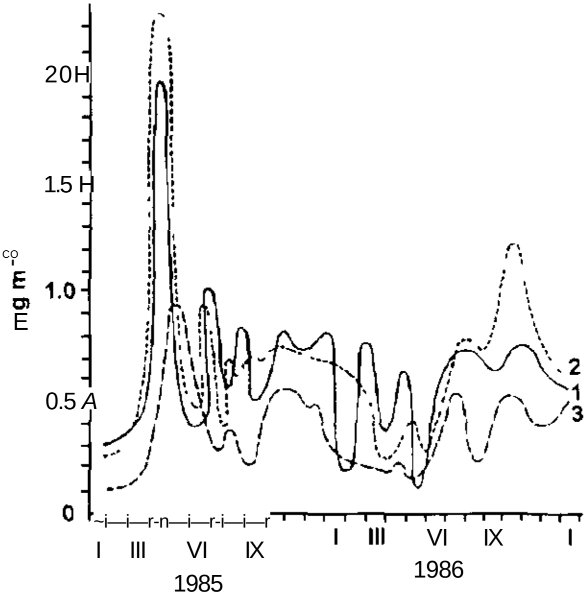


Fig 6 19 Seasonal changes of chlorophyll "a" concentration South Baikal. Baikalsk Data of the Research Institute of Biology

Shelf testing area *I - 0 m, 2 - 10* rn, *3-25* rn

pelagial, the comparative data obtained by Smirnov and others (Fig 6 23) are of interest All hypotheses regarding the problem of fluctuation of plankton crops are of a preliminary nature Only a comprehensive study across successive years will help to elucidate the causes of plankton crop fluctuations

With regard to zooplankton, we can distinguish regions of 1 high aestival biomass reached in August (c 40 g m~^{2}), or c 1 g m"^{3} in the 0-50 meter layer, 2 medium biomass (20-40 *g m~^{2})*, or 0 4-0.8 g m~^{3}, and 3 low biomass (less than 20 g ITT^{2}), or 0 4 g nr^{3}

Regions of high biomass (c 400 kg ha^{-1}), even in zooplankton-nch years, do not cover more than one-fifth to one-tenth of the area of Baikal, whereas regions with a medium biomass may occupy up to half the total area of the lake

In low-crop years, regions with a high and medium *biomass of zooplankton are chiefly shallows,* gulfs, bays, etc , but even there the biomass rarely exceeds 20-30 g m"^{2}

The first determinations of phytoplankton production in Baikal were carried out by Votintsev (1948b, 1952a,b, 1953a,b,c, 1955, 1956, 1961) and by Samanna (1960), using the 0$_2$ method, and by Kuznetsov (1955), using the C^{14} method

An interesting feature of Baikal is the discrepancy between biomass maxima and values of primary production in an annual cycle and between years (Glazunov & Kozhova, 1966) The highest values of production, found during the summer-autumn period, do not correspond to biomass maxima in the ice-cover period One explanation for this phenomenon may be found in inadequate counting of nanoplankton organisms, and in algae decomposed at fixation Another cause may be the weak sensitivity of the O, method to oligotrophic Baikal However, a comparison of data of the 0$_2$ and C^{14} methods revealed that the C'^{4} method gave results similar to those obtained by the 0$_2$ method

The highest values of primary production were recorded in the ice-free period (Fig 6 22) The curve of values for production differed not only from phytoplankton biomass, but also from chlorophyll "a" content

The annua) values of *primary* production (by C^{14}) in 1966 were- 42, in 1978 39, in 1979 124, and in 1980 28 g C nr^{2} As can be seen, 1979 was three to four times more productive than the other years The annual value of primary production determined by the 0$_2$ method is about 100 g C m~^{2} (Votintsev *et al*, 1975)

Zooplankton production in Baikal depends chiefly on *Epischura baicalensis,* and, in the shallows, on *Cvclops kolensis* and Cladocera The production of the amphipod *Macrohectopus* is much smaller than that of the copepod plankton There are no data on the production of smaller zooplankton, such as rotifers and cihates A rough estimate of total crustacean production (natural dying-off excluded) is obtained by doubling its maximum aestival biomass For high-crop years, this leads to an annual production of 1-1 4 g m~^{3} for the 0-50 m layer (50-70 g m"^{2} per hectare), and 1,600,000 tons of gross biomass for the whole lake In low-crop years, production ranges from one-half to one-third of the above The annual production suggested *above is probably an underestimate*

Recently, Afanasyeva (1983) estimated *Epischura baicalensis* production at 124 6 g nr^{2}, using a 'physiological' method The yearly average biomass was 0 256 10^{6} t and the P/B coefficient ~ 15 Including deep layers, the production value

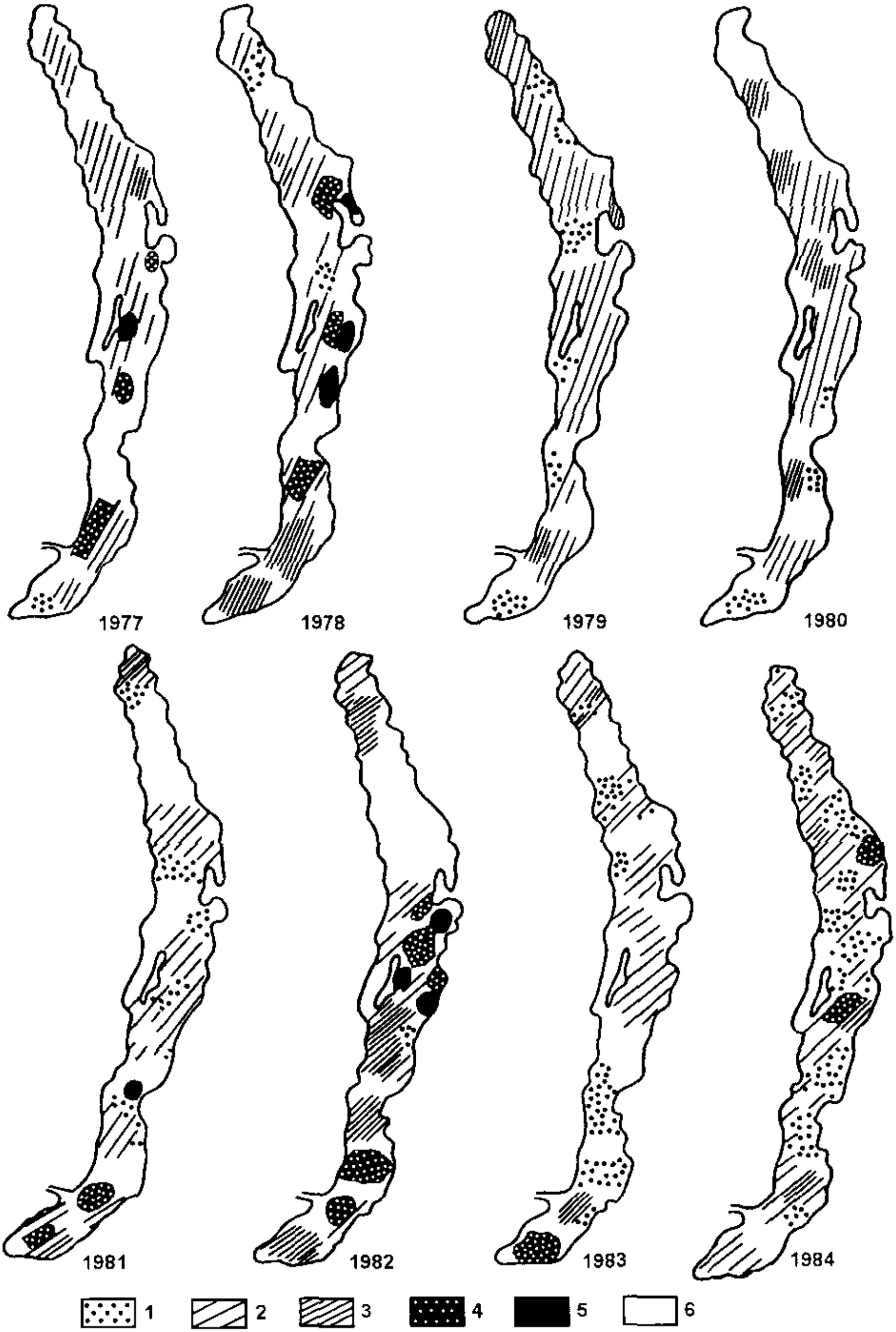


Fig 6 20 Distribution of chlorophyll "a" concentration at the water surface in the pelagial of Baikal Data of the Research Institute of Biology
\ - cMoroptytt "a" <05m%m^3, 2 -0 51-10, J - I 01-1 5.4-1 51-20, 5 - > 2 01 iftg mr\ & - irodaU.

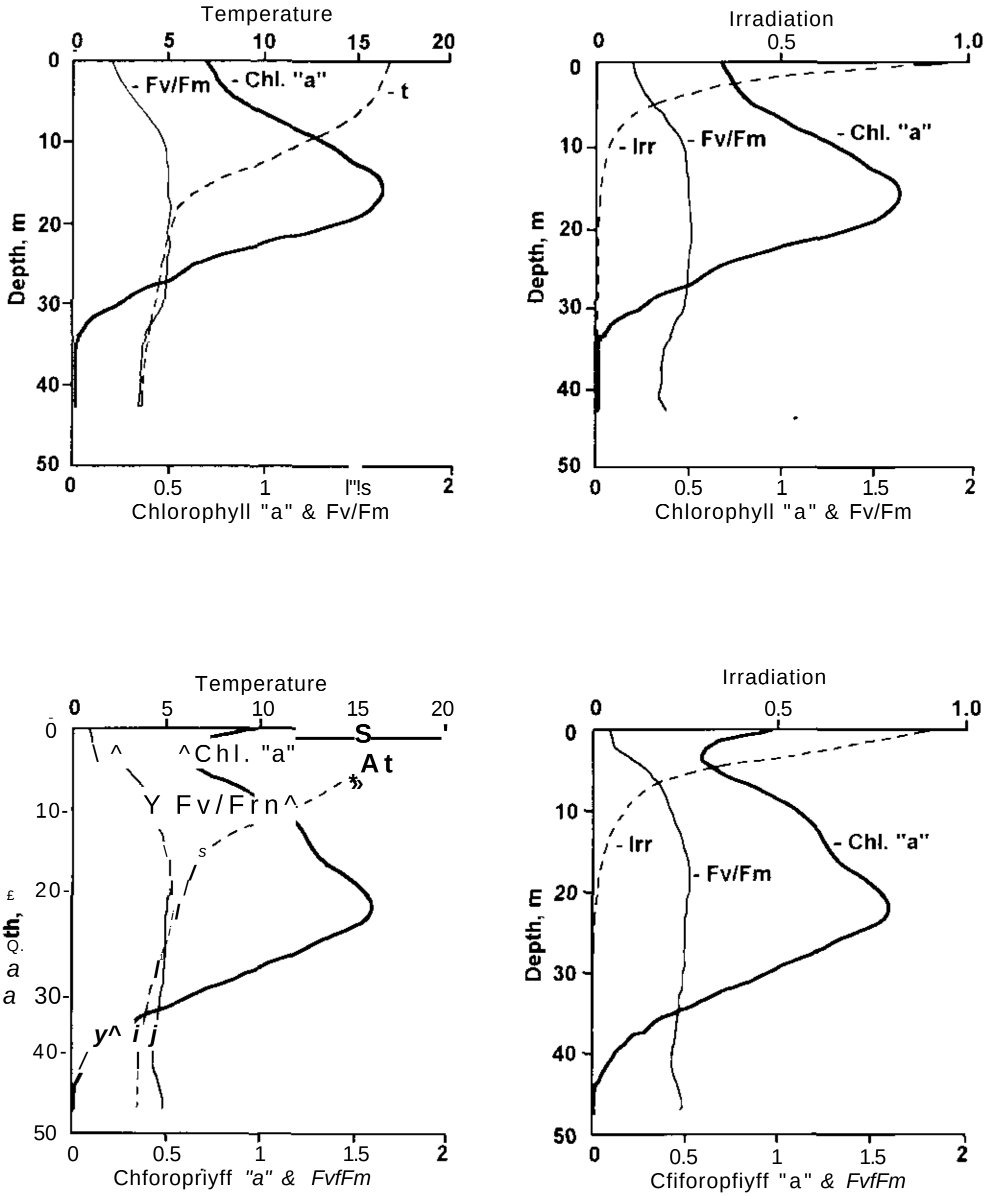


Fig 6 21. Examples of vertical distribution of chlorophyll "a" (mg m ^{3}). photosynthetic activity (Fv/Fm, relative units), temperature (°C) and solar radiation (relative units) South Baikal July 1993 After Izmcst'eva & Kuznetsov, 1993.

throughout Baikal might increase to 7 10^{6} t of fresh weight.

6.2. Bacterioplankton and bacterioneuston

The bacterial plankton of Baikal has been studied by Yasmtsky *et al.* (1927), Kuznetsov (1951, 1957), Rodina (1954), Kozhova (1953), Kozhova & Kazantseva (1961), and Romanova (1958). These studies revealed two maxima in the development of bacterial populations: a vernal (April) and an aestival (August-September) one, which coincide with the maxima of the algae (Fig. 6.5). In April 1954 (Fig. 6.5), the number of bacteria in the 0-25 m layer of south Baikal, which is especially

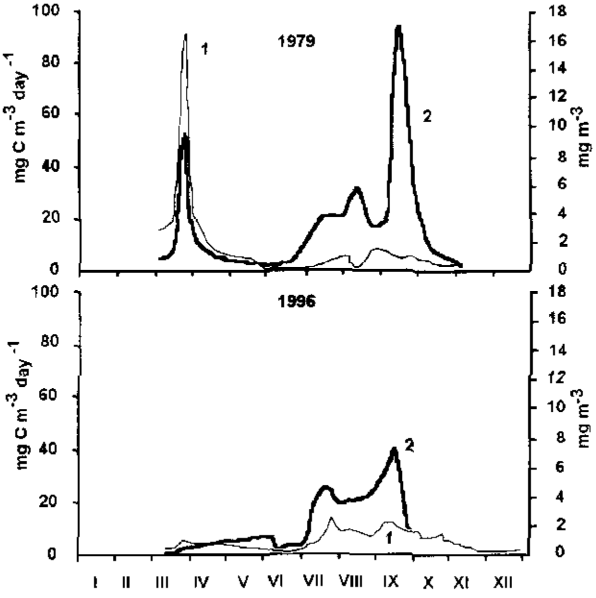


Fig 6 22 Examples of seasonal changes of chlorophyll "a" and primary production in the surface water layer South Baikal, Bolshiye Koty

1- chlorophyll "a" (mg m"^{3}), 2 - primary production (mgC m"^{3} day^{-1}} Data of the Research Institute of Biology

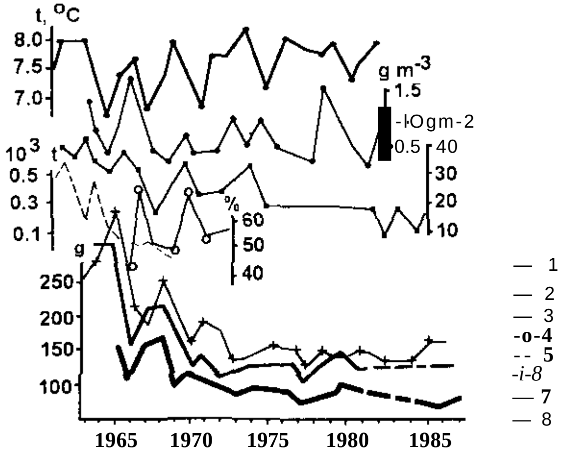


Fig 6 23 Interannual fluctuations of the main parameters of the lake Baikal ecosystem

I - temperature of water surface, 2 - phytoplankton biomass in the layer 0-25 m in spring, 3 - zooplankton biomass in the layer 0 - 250 m in September, 4 - catchment of yellowfin sculpm, 5 - related number of *Comephorus dybovsku;* 6 - biomass of North Baikal omul population; 7 - biomass of Selenga omul population; 8 - biomass of Posolskaya omul population After Smirnov *e! al,* in^1 Atlas of Baikal, 1993

densely populated, ranged between 139,000 and 335,000 cells ml"^{1}. In August of the same year, the number of bacteria in the upper layers reached 800,000 to 1,000,000 cells ml"^{1} The lowest density was observed in June. The 0-25 m layer is thus particularly rich. Below 100 m, bacterial numbers become insignificant.

Recently, the dynamics of the bactenoplankton was investigated by Maximova & Maximov (1989). Seasonal changes in the total number of bacterial plankton are shown in Fig. 6.24. The share of colony-forming units (CFU) on fish-pepton agar (1:10) in the total number of bacteria is rather insignificant. Seasonal and vertical distribution of CFU is presented in Figs. 6.25-6.26.

The first studies on the identification of some physiotogicaf groups of bacteria, participating in nitrogen turnover, appeared in 1935 (Nechayeva & Salimovskaya-Rodina, 1935). A more detailed study was made by Romanova (1959, 1961). In Baikal, bacteria contribute to all processes of nitrogen turnover, ammomfication, nitrification (I-II phases), nitrogen fixation and denitnfication.

In the littoral, the number of ammonifiers and of aerobic and anaerobic nitrogen fixers increases in

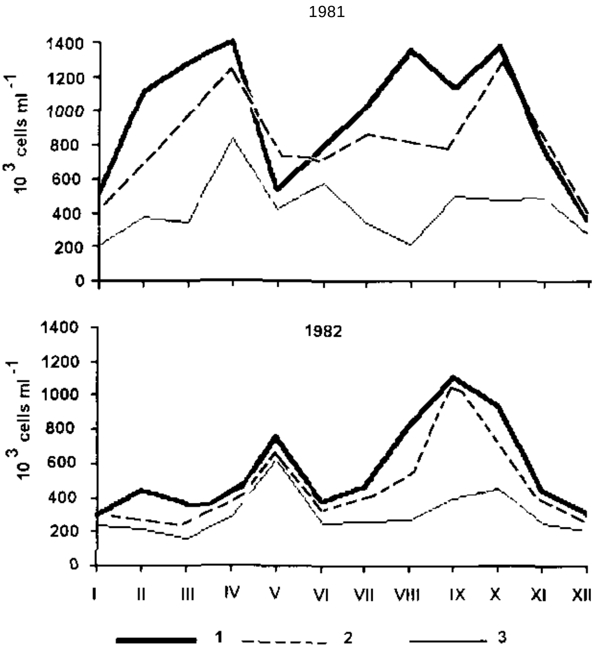


Fig 6 24 Seasonal fluctuations of the total number of bacteria in the pelagic part of south Baikal Water layers I - 0—10 m, 2 - 10-50 m, 3 - 50-70 m After Maximova & Maximov, 1989.

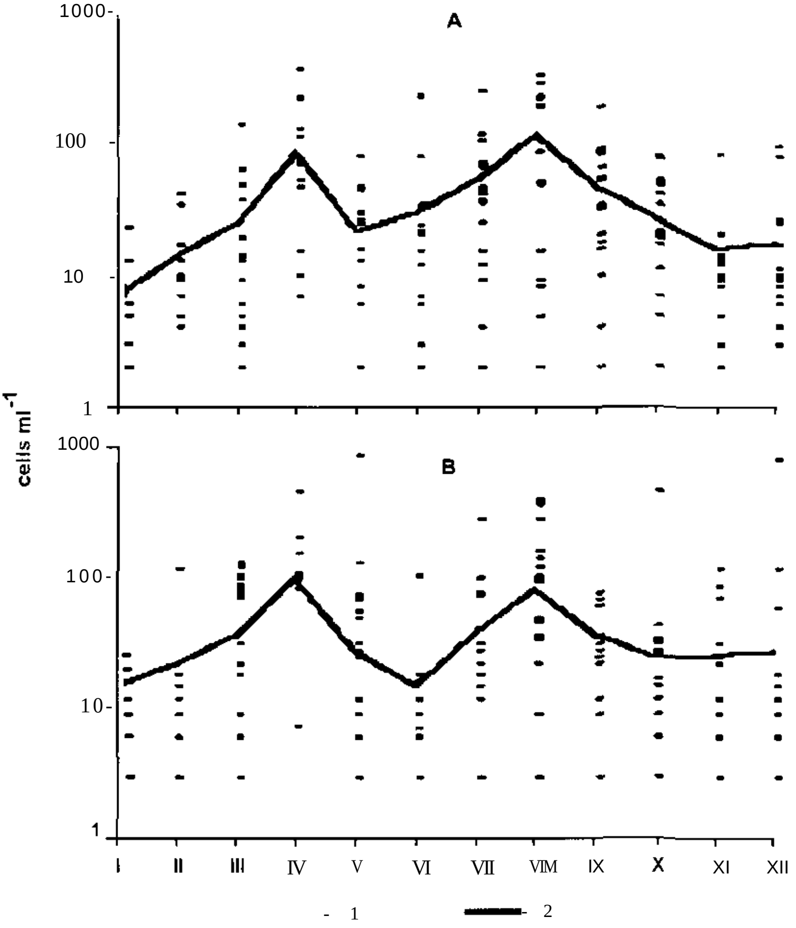


Fig 6 25 Seasonal dynamics of colony forming units m the upper layers of pelagic (A) and littoral (B) zone of Baikal 1 - data for 1970-1985, 2 - average After Maximova & Maximov, 1989

summer; the number of nitrifying bacteria increases in spring and autumn. Demtrifiers develop intensively in spring, only to decline in summer and autumn. In the pelagial, the number of ammonifiers increases significantly from spring to summer, reaching a maximum in August-September (Romanova, 1959; Mladova, 1971).

Ammonifying bacteria develop best in waters rich in phytoplankton and nutrients, down to 50 m (Verkhozina & Semenchenko, 1982) (Fig. 6.27). Their number do not exceed 50 10^3 cells l$^{"1}$ in summer, and in October 200 10^3 cells I$^{"1}$. The amount of nitrite-oxidizing bacteria reaches 150 cells l$^{"1}$. The maximum amount of ammonifiers occurs in October, of anaerobic nitrogen-fixers (200 cells 1'") in August. Aerobic nitrogen-fixers have been detected in small quantities (from 1 to 10 10^3 cells I$^{"1}$)-

Correlations between the number of bacteria and temperature of the pelagial have not been established.

With regard to time and space, nitrogen cyclers are distributed unevenly. The number of ammonifiers ranges from 1 to 100 10^3 cells 1 ' horizontally (Fig. 6.28) and vertically (Fig. 6.29). Maximum population densities of aerobic nitrogen fixers, and of nitrite- and nitrate-oxidizing bacteria are shown in Fig. 6.30. The amount of demtrifiers in the pelagial reaches 50 cells l$^{"1}$, with a frequency of occurrence of from 0 to 18% of the total investigated samples (Verkhozina, 1985).

Part of the bacterial flora is associated with detri-

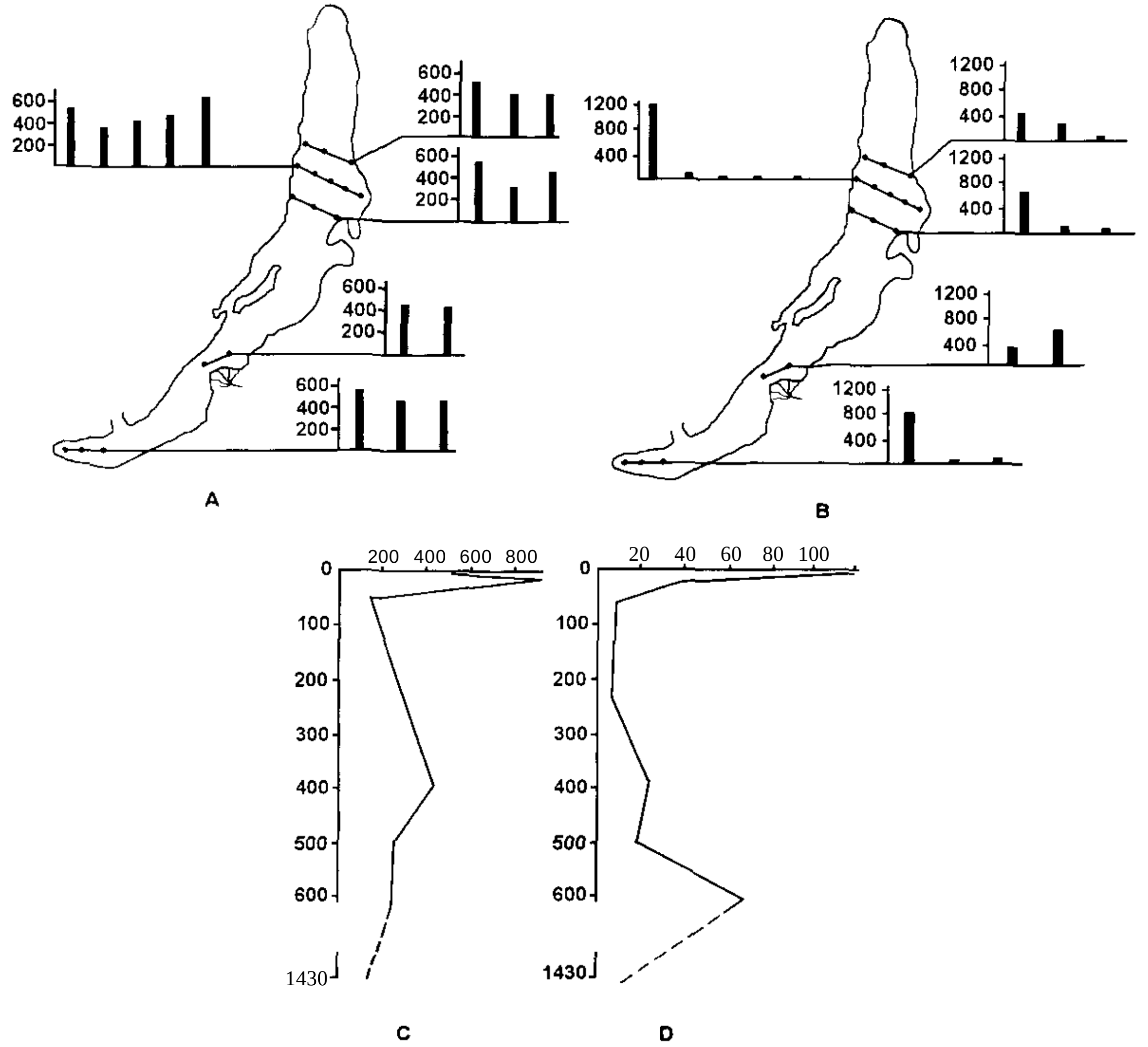


Fig 6 26 Horizontal (A, B) and \ertical (C, D) distribution of bacterioplankton in Baikal in late summer. A, C - total number of bacteria (10^1 cells ml"^{1}), B, D - number ot colony forming units on fish-pepton agar I 10 (cells ml ') After Shimarae\a, 1994

tus and forms microcolonies (Spiglazov, 1977, 1983, 1984). Yasmtsky (1930) was the first to report on such colonies in Baikal.

All bacterioplankton elements reach their maximum in the photic layer and decrease with depth.

Microcolonies often take the shape of monolayer plates, with dimensions of from 2-3 to 10 urn, occasionally 100-200 urn. The mix of individual bacteria with bacterial microcolonies leads to a considerable dimensional and spatial heterogeneity (Spiglazov, 1983). The change of individual bacteria, bacterial colonies and detrital-bacterial associations with depth is, in general, identical.

The larger the number of bacteria in a colony, the fewer the colonies present. The share of bacteria! microcolonies reaches 10-39% (on average 25%) of the total bacterial biomass. The lake contains 1,3-4.5 g m^{-2} of bacteria in microcolonies, and 0.8-2.7g m"^{2} of bacteria on detritus, *i.e.*, the aggregated bacteria calculated for the whole lake amounts to many thousands of tonnes. This is an enormous food supply for consumers (Spiglazov, 1981, 1983, 1984).

As stated, most bacteria are observed within the

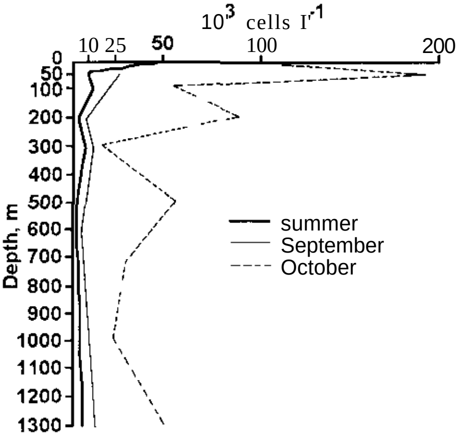


Fig 6 27 Vertical distribution of ammonifying bacteria in the pelagial of Baikal After Verkhozina & Semenclienko, 1982.

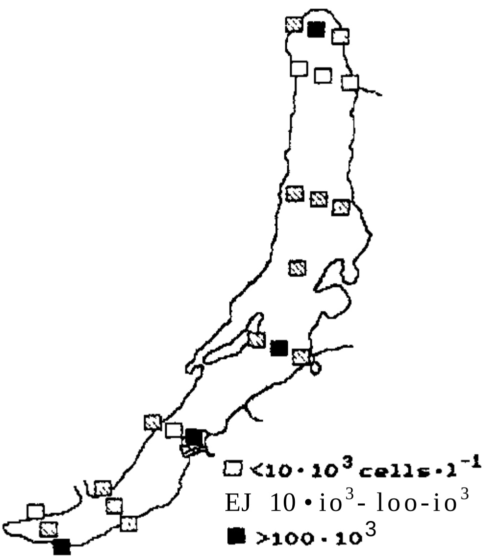


Fig 6 28 Horizontal distribution of ammonifying bacteria (cells 1 ') in the pelagial of Baikal at the water surface June 1978 After Verkhozina & Semenclienko. 1982

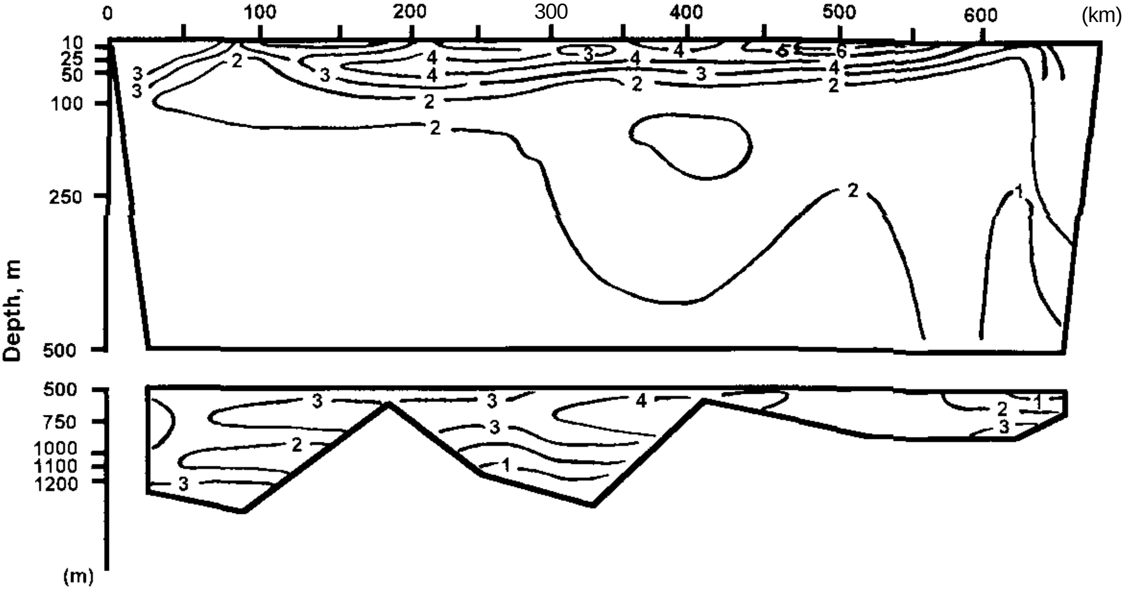


Fig 6 29 Izohnes of the number of ammonifying bacteria across longitudinal lake Baikal June 1978 Levels 1-2, 2-5, *3-8.* 4-11; 5-20, *6-30.* 7-40, *8-55; 9-80;* 10-100 10^3 *celh* J"1 After Verkhozina & Semenclienko, 1982

limits of the trophogenic layer (0-50 m). They decrease at a depth of 100-250 m ('the layer of dispersion' of Kozhov, 1962) and are lowest in 'the layer of subsidence', including the deep-water zone (more than 250 m). Such a distribution is explained by the fact that the *0-50 m* layer contains the highest phytoplankton density (Kozhova, 1956b), the products of metabolism and postmortal decomposition of which serve as food for bacteria.

The bacterioneuston was studied by Nikitin (1985). One of the primary reasons for distinguishing the bacterioneuston as an independent

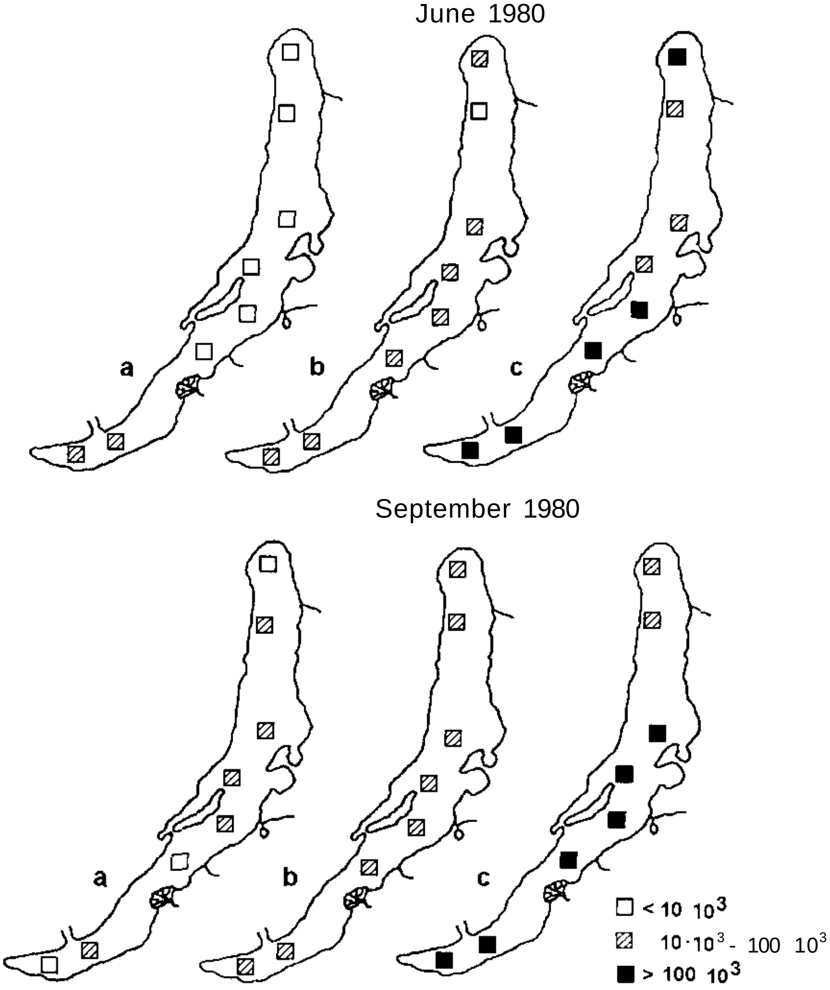


Fig 6 30 Distribution of maximum number in water column of nitrogen-fixers (a), nitrito- (b) and nitrato-oxidazing bacteria (c) (cells l^{-1}) the pelagial of Baikal After Verkhozina, 1985

biocenosis was the higher density of microbial populations and biomass in the surface microhorizon of the lake.

At the 'water-air' interface of Lake Baikal, abundant bacterial populations develop, whose density exceeds that of the water column by two to four orders of magnitude.

In south Baikal, average values of the numbers and biomass of neuston bacteria ranged within comparatively small limits. The accumulation coefficient (K), or ratio of the microflora in the surface film and in subsurface waters in the south trough, reached K=880. In this region of the lake, an increased density of bactenoplankton (more than 10^6 cells ml^{-1}) was traced down to 50 m. In the middle trough, lower concentrations of bacterioneuston and bacterioplankton occur. The average accumulation coefficient of bacterioneuston in that region was K=694. The highest concentration of bacteria was found in the presurface layer of north Baikal. There, the accumulation coefficient of bacterioneuston reached K=953. The vertical distribution of number and biomass of bacteria was the same as in other troughs, but sizeable concentrations of bacteria there reached a depth of 100 m. It should be noted that the richer the microflora in the water mass, the higher the number of neustonic bacteria.

The ratio of CFU micro-organisms to total bactena was 0 01 to 0 001% and changed vertically and spatially A considerable increase (by two to four orders of magnitude) of the CFU of bactenoneuston over bactenoplankton has been established The average number of SFU bacteria in neuston was 12 37-105 30 10^3 cells ml \ compared with 0 01-2 70 10^3 cells ml ' in bactenoplankton Accumulation coefficients of the SFU microflora of the bactenoneuston were similar in value in different troughs of the lake K=841 (south Baikal), K=936 (middle Baikal), and K-732 (north Baikal) Vertically, the density of SFU micro-organisms was more uneven than their total number Increased concentrations of SFU bacteria in the middle and south troughs were conditioned by an uneven distribution of dissolved organic matter in the lake

The qualitative composition of the microflora revealed the genera *Pseudomonas, Luctococcus, Bacillus, Bacterium, Chromobacterium,* and *Mycobacterium* Many fungi of the genera *Pemcdhum, Aspergillus Mucor Alternaria Cladosporium,* and *Stemphhum* were also found In the neuston and underlying water, representatives of *Pseudomonas* were dominant (52 and 59%, respectively) In the neuston, the genus *Micrococcus* was frequent (41%) In the air, representatives of *Micrococcus* and *Mycobacterium* (44% each) were common A comparison of species composition of neuston and surface water bacteria showed that some species occurred **only** in **the** neuston *(Ps scissa M flavus, M roseus, Bac megaterium),* others in water *(Ps sinousa, Ps epstenu, B album, Chr aqwtile),* while still others occurred both in the neuston and in water *(Ps fluorescens, Ps hquida, Ps hqifaciens M citreus)* The number of species common to both environments was 29% The microflora of the air contained 18 species of the genera *Micrococcus, Mycobacterium andBacillus* On comparing the species composition of the air and the surface film *of the lake, some* 'common' *species (22%)* were found *(M roseus, M citreus, M cremoides, Bac megaterium)* A relationship between the bacterial populations in the air and 'water-air' interface is evident The majority of organisms, isolated from the boundary zone, were pigmented (67-100%), while with depth the number of pigmented bacteria decreased markedly An increased content of pigmented forms in the 'water-air' interface could be an adaptation of the bactenoneuston to the presence of ultraviolet light A comparative study of the biochemical activity of cultures of bactenoneuston and bactenoplankton showed that proteolysis of gelatine was carried out by almost all (93%) the neuston cultures, by 74% of the bactenoplankton, and by more than half the cultures of precipitated aerial microflora The majority of strains, peptonizing lactic protein, occurred in the surface microhonzon All neuston cultures fermented saccharose and hydrolyzed starch, and the majority of strains utilized mineral nitrogen (85%) All cultures of bactenoneuston were highly oxidizing, and the majority degraded protein (82%), fats (93%) and were active producers of aminoacids (100%)

The bactenoneuston of Lake Baikal is thus a microbiocenosis with polyfermentation properties, capable of playing a significant role in decomposing many organic compounds

The bactenoneuston has been studied according to Romanenko & Kuznetsov (1974) Electron-microscopy revealed a considerable morphological diversity Together with conventional bactenal forms, *Caulobacter* cells were detected Filamentous cells with prostheca at the end, filamentous with fimbnas, coiled intonngs, budding bacteria, and micro-organisms of other distinctive shapes, were discovered

The highest density of bacteria in the surface film was observed at coastal stations, attributable to cyclonic macrocirculation inside each trough of the lake An impact of river flow on the density of micro-organisms of the neuston manifested itself in the pre-estuary regions of such rivers as the Upper Angara, Barguzin and Selenga In these regions, the number of bacteria increased by one order of magnitude

Analysis of the spatial distribution of micro-organisms in the presurface microhonzon showed *that maximum concentrations of bacteria occur* m impact zones of the lake It is generally accepted that CFU bacteria should be considered as one of the most indicative groups of micro-organisms, reacting to input of allochthonous organic matter Using that index, three 'patches' of pollution have been singled out south Baikal in the region of Baikalsk town, the River Selenga delta, and north Baikal, in the region of the Baikal-Aimur railway

In spring, the quantity of micro-organisms in the bactenoneuston increases from March to June, from 2 0 to 21 7 10^3 cells ml ', and in bactenoplankton from 0 01 to 0 17 10^3 cells ml ' In summer (July-August), a slight decrease in the number of CFU bacteria occurs, to 8 4-14 3 10^3 cells ml ' At the end of summer, a marked increase in density is characteristic from August to September (30 5-40 2 10^3 cells ml ') In Autumn (October-November), a drastic decrease in micro-organisms in the surface film (to 16-18) and in subjacent water layers (to 0 02-0 04 10^3 cells ml ') occurs In winter, the number of CFU bacteria reaches its minimum

Between the years 1976 and 1979, the highest concentration of neustonic micro-organisms was seen m 1977, the lowest in 1978

6.3. **Trophic relationships, interspecific contacts and vertical migrations of pelagic species**

The need for food and feeding relationships plays an important role in the biology of species The mam links in the pelagial *of* Baikal *are* algae (producers), the crustacean *Epischura baicalemis* and the young of the amphipod *Matrohectopus bramcku* (the chief consumers of phytoplankton) Among the fish, the omul, *Cottocomephorus* and *Comephorus* species, are the chief consumers of zooplankton The seal, finally, feeds upon pelagic fish Moreover, bacteria participate in the processes of disintegration of dying organisms and serve as food for the small filter-feeders of the zooplankton (Kozhov, 1954, Potakuye\, 1954, 1956)

Seasonal changes in temperature and plankton strongly influence the horizontal and vertical migrations of pelagic fish

The feeding period of planktivorous fish lasts all year around, but is least intensive in winter In late autumn (November-December), when temperature of the upper layers drops to 4-5°C, the omul, *Cottocomephorus* and *Comephorus,* descends to deeper layers Shoals overwinter near the shallows which serve as spring convergence grounds, at a depth of 150 to 300 m In winter, *Comephorus* are often found together with the omul, and in deep-water regions they may descend to still deeper layers

Their shoreward migration begins in March In April-May, the *Cottocomephorus* comes close to the shores to spawn The passage of the omul towards the shores during ice cover chiefly takes place *m* the near-bottom layers In June, shoals *of* omul converge on the shores, making beach-seine and gill-net fishing possible

Deep-water regions with poorly developed nearshore shallows are avoided by the omul in spring and the first half of summer In general, it is an inshore fish in the broad sense of the word It prefers regions not deeper than 200-300 m, where it occurs throughout the year, leaving them (partially) only in August-September

As of mid-July, the omul rises to the upper waters, spreading to open shallows where a rich crustacean plankton occurs at this time Thus, towards midsummer, the omul's feeding grounds expand to the regions of maximum density the crustacean plankton

The fry of *Cottocomephorus grewingki* hatch in the second half of July and at the beginning of August, and accumulate in vast numbers along the shores, feeding vigorously on the littoral plankton The omul, too, appears near the shores, attracted by this fry Adult *Cottocomephorus* feed on planktonic crustaceans, but also consume their own fry until it spreads over extensive areas of the littoral

The period between late July and early September is one of formation of adult omul spawning shoals, which migrate in the open waters, in the direction of the pre-estuarme regions of their spawning rivers After returning from these rivers in autumn, the shoals move towards the sites of spring convergence

Fig 6 31 is a simplified picture of the trophic relationships between the most important components of the community of the open water

Many years of study of seasonal and diurnal migrations *of* the plankton suggest that the intensity, amplitude, period and timing of the migrations of migrating species are controlled by food Direct contacts during migrations occur when a grazer finds algae, a predator meets prey or, conversely, a prey finds shelter Among abiotic conditions, light and temperature are of particular importance But since these factors are subject to a seasonal and diurnal rhythm, periodicity and rhythm become incorporated into the vertical migrations and gradually turn into essential physiological reactions, to which periodical changes in environmental factors

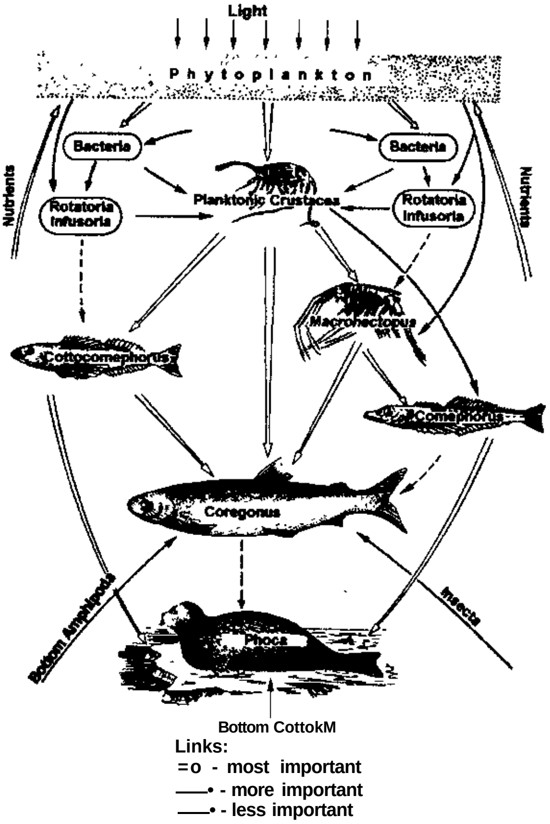


Fig. 6.31. Main food relationships in the mass of water of open Baikal. After Kozhov. 1962.

become of less importance (Kozhov, 1947, 1959; Nikolaev, 1950; Manteifel, 1959, 1961).

This is illustrated hereafter by the vertical migration of some important species of Baikalian plankton in different thermal, light and biotic conditions.

January-February: first half of the ice cover

In January, an ice cover forms over the lake but snow is usually blown off by the wind. As a result, the free passage of sunlight is possible through the transparent ice. (Table 6.2 provides data on the area of Bolshiye Koty, south Baikal, during ice cover).

As already noted, in January-February the reproduction of vernal peridineans and diatoms begins. They concentrate in the 0-10 m layer, and reach a maximum density under the ice. In zooplankton, *Epischura baicalensis* nauplii concentrate in the photosynthetic zone (Fig. 6.32). Rotifers and ciliates are also found there.

In January-February, consumers of this crustacean plankton are absent from the upper layer. The omul and *Cottocomephorus* still overwinter at about 150-300 m.

According to Smirnov (1983), the Selenga region shows maximum concentrations of omul at the upper boundary layer of the mesothermic maximum over the slope. Here, young and average-aged groups of the Selenga population feed on zooplankton; average-aged groups of the North-baikalian and Barguzinskaya populations have a mixed diet. In the layer of the mesothermic maximum in deep-water sections, adults of the Selenga population feed on *Macrohectopus* and young *Comephorus.* Under the ice, the omul of the Posolskaya population dwell in the region of underwater slopes (mesothermic maximum) and lower, at depths of 150-400 m, feeding on bottom gammarids, and on *Macrohectopus,* which occur down to the bottom.

60 to 80% of the migrating *Epischura baicalensis* and *Cyclops kolensis* (in percentage of their total numerical density in the 0-50 m layer) nauplii constantly remains in the 0-10 m layer, and in the 0-5 m layer if there is snow cover on the ice. In the second half of the day, they form swarms under the ice (Mazepova, 1952b); at night their concentration diminishes. Not more than 15 to 20% take part in these periodic accumulations under the ice (in the 0-2 m layer). Their average amplitude of diurnal migration does not exceed ten meters.

The copepodites of *Epischura baicalensis* are situated slightly below the nauplii. A partial rise to the 0-2 m layer is observed after midday, at about 3 p.m., approximately two hours before sunset. Large concentrations remain there until 8-9 p.m., after which they disperse slightly. At about 8 a.m. (before sunrise), a new short-lived concentration is observed in the upper two-meter layer. About 20-25% of the total number of crustaceans take part in this vertical migration of 10-15 m in amplitude.

In January-February, rotifers are scattered in the 0-30 m layer, and their diurnal migration is insignificant. The amphipod *Macrohectopus branickii* also accomplishes vertical diurnal migrations in January-February, but this is almost impossible to ascertain with ordinary sampling nets. It prefers to live between 150 and 200 m.

No defined vertical diurnal movements (in Janu-

Table 6 2 Important factors dunrig ice cover, I 5 km from the shore over a depth of about 1000 meters in the area of Bolshiye Koty (1955-1956). After Kozhov„ 1963

Factors	*Middle of January*	*Middle of February*	*Middle of March*	*Pint 10 days of April*	*Last 10 days of April*
Ice thickness in cm	20-40	50-80	80-110	80-60	60-40
Snow thickness in cm	Insignificant	Insignificant	5-10	Snow fused with ice	Snow fused with ice
Sunrise at observation point *)	About 9'00	About 8 00	About 7.00	6 30	About 6 00
Sunset	About 17 00	About 18 00	18 30	19 10	19.30
Day length	8 h	About 11h	13h 40m	14h 20m	**15h**
Photopenod (light mtcnsivity > 1 lux)	9 h 40 m	About 11h	13h 40m	14h 20m	**15h**
Maximum light intensity on ice at noon (x 1,000 lux)	12	17	35-44	55	**58**
Secchi disc transparency (meters)	20-30	15-25	7-8	8-14	**10-12**
Water t °					
0 m	0.1	**0.1**	0 3	0 8-1 0	**1.4**
5 m	0 3	0.3	0 5-0 8	1 0-1 4	**1.4**
20 m	0.4	0.4	0 8	1 0	**1.2**
50 m	1 3	**1.0**	1.3	I 2-1 3	**I** 2
250 m	3 4	3.6	3.6	3 6	3 3
Layer of maximum concentration of algae	0-2=0-5	0-2=0-5	0-2=0-5	0-2=0-5	0-2=0-5

*) Clouds or fog sometimes prevented the timing of sunrise and sunset accurate within mmutes

ary-February) have been observed among *Cottocomephorus* and *Comephorus.*

March-April: second half of ice cover

In March, the temperature of the 0-50 m layer changes little. But beginning with mid-April, the layers up to 5-10 m, with the exception of the ice surface, are warmed to 1-1.4°C and a relative homothermy is established in the upper 50 m layer

The ice cover reaches a thickness of 80-120 cm in March, and begins to thin in mid-April, but snow cover then increases to 5-10 cm. In April, the snow begins to thaw and fuses with the ice. This reduces light penetration considerably, although the days are lengthening and the light intensity above the ice is increasing.

In March-April the vernal peridineans and diatoms continue to develop and their density in the photosynthetic zone becomes greater (Figs. 6.1-6.4). The greatest concentration of algae is observed in the uppermost 2 m.

Among *Epischura baicalensis,* late nauplii and copepodites of the winter generation predominate in March-April. In March, a maximum density of these crustaceans is observed around the clock in the 10-25 = 10-50 m layer, *i.e.,* somewhat deeper than in February, coinciding with the extension of the algae (Fig. 6.32).

Increased concentrations of *Epischura baicalensis* in the 0-2 m layer are also observed after midday. They rise to the surface, right up to the ice, chiefly from the 2-10 m layer, whereas their concentration in the 15-25 m layer remains almost unchanged. Not more than 10 to 15% of the total

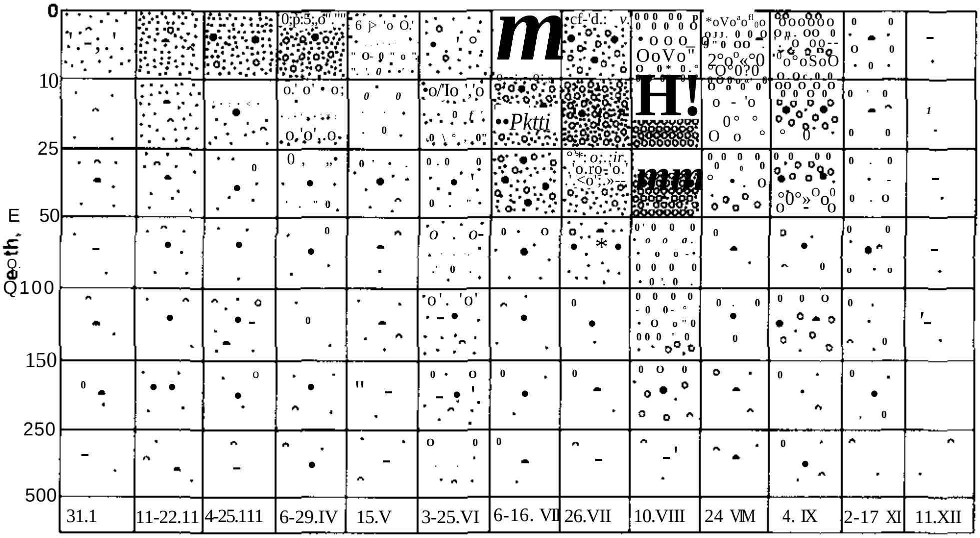


Fig 6 32 Vertical distribution of *Epischura baitalensis* m the mass of water of open Baikal at daytime in 1954 Symbols the same as in Fig 6 33 After Ko7ho\, 1963

number of nauphi and a still lower percentage of copepodites take part in these migrations. About half the total number of the latter keep in the 50 m layer around the clock, with a weak tendency towards upward migration during the lighter part of the day. Most adult females remain at about 150-200 m or deeper. No distinct migrations have been detected among them.

The concentration of *Cyclops kolensis* under the ice changes with light intensity (Fig. 6.33). If there is snow on the ice, they accumulate under the ice in daytime and scatter to deeper layers at night Under patches of transparent ice, free from snow, their number drops sharply in daytime and increases towards midnight (Mazepova, 1957).

An increase in vertical migration of *Epischura baicalensis* occurs at the very end of the ice cover, in April. A considerable part of the winter generation now matures, which results in a greater demand for food. The bulk of crustaceans of all age groups remains in the 15-50 m layer, day and night. After midday, up to 20% of the total number of nauphi rise to the 0-2 = 0-5 m layer. Increased concentrations of copepodites in the 0-2 m layer are observed during the day, and also in the evening and morning.

The bulk of *Macrohectopus branickii* remains in the 150-250 m layers. In March-April, their vertical migration to the upper layers seems to intensify somewhat. In the 0-50 m layers, their young appear in the night, forming swarms in the 0-10 m layer.

Rotifers remain, as before, in a more or less dispersed state between 0 and 30 m, with a certain increase in concentration in the upper 5 m. During the day, their concentration in the 0-2 m layer is somewhat increased.

Among fish, adult *Cottocomephorus* rise from the depths and, at the end of the ice period, they move towards the shores for spawning. The omul shifts slowly from its winter sites to the shores of shallows, but this movement primarily proceeds along the near-bottom layers. Its feeding during its approach to the shores is low.

May-June: transitional period

The ice melt brings about abrupt changes in life in the pelagial, such as an intense warming up, a sharp increase in convection and wind-induced mixing, and a higher and deeper illumination of the upper layers. In May the temperature in the 0-50 m layer ranges between about 2 and 3°C. But around June 20th-25th, a homothermy at 3.5-3.8°C sets in in south Baikal.

In this period, a sharp divide can be seen between spring and summer in the ecology of the plankton. As soon as the temperature in the superfi-

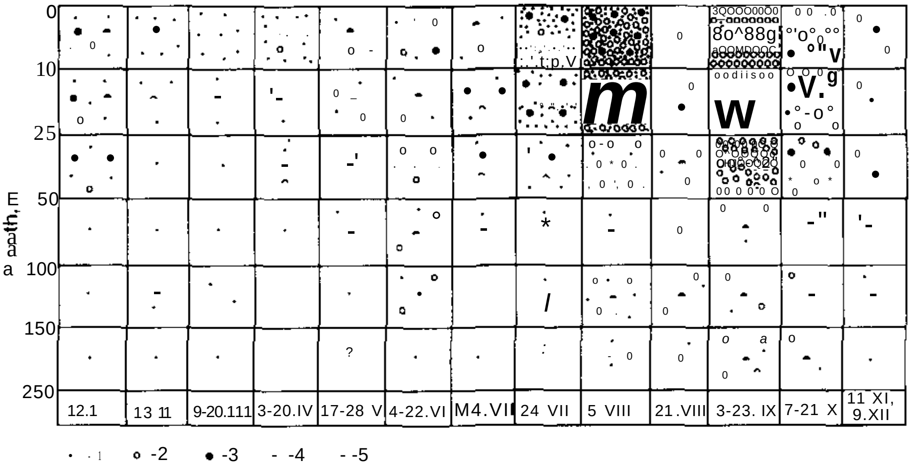


Fig 6 33 Vertical distribution of *Cyclop*, kolensis* in the mass of water of open Baikal at daytime in 1950, 1 - nauplu, 2 - copepodits. 3 - adults Each sign corresponds to 1.000 specimens per m^3. on the average, in the layer of water studied; 4 - copepodits and 5 - adults in amount less than 500 per m^1 After Kozhov, 1963 There was a strong north-western storm on August 19 and 20

cial layer exceeds 4-5^{c}C, vernal algae sink to the deep layers and disperse. This descent proceeds slowly, and even in July concentrations of dying-off *Aulacoseira* still occur at a depth of 200-300 m (Fig. 6.34).

Zooplankton *{Epischura baicalensis,* rotifera, cihates) also sinks in May-June. More than half their total number now occur below the *50* m isobath. Adults and older copepodites of *Epischura baicalensis* actively descend, following the subsiding algae. They feed on them and on the bacteria accompanying the algal decay. This part of the zooplankton does not participate in diurnal vertical migration.

Adult females of *Epischura baicalensis* in these deep layers feed intensely and produce a new, vernai-aestival generation.

The largest concentration of copepodites of *Epischura* is observed, day and night, in the 10-50 m layer, although a few specimens also reside in the 2-5 m layer. No more than 25% of the total number in the 0-50 m layer (12% of the number in the 0-250 m layer) seem to take part in an upward movement. After a certain dispersal at midnight, an insignificant, barely detectable increase in concentration is observed in the 0-2 m layer during the morning hours.

In June, in conditions of complete spring homothermy (at least on June 25th-26th, 1956), the share of nauplh migrating upward is rather insignificant, not exceeding 3-5% of their total numbers in the 0-250 m layer. Over 24 hours, the crustaceans are more or less evenly distributed in the water mass, but mostly in the 5-25 m zone, where up to 40-50% of their total number occurs. Only a slight increase in concentration in the 0-2 m layer takes place in the evening (6-8 p.m.), at midnight, and early in the morning (5-6 a.m.)

The diurnal vertical migration of rotifers and of *Macrohectopus branickii* in May-June is also weak. June is the period of the mass approach of the omul *(Coregonus autumnalis migratorius)* to the shores of the shallows (Fig. 6.35). Summer begins earlier here, and zooplankton develops faster. The summer type of vertical migration, which will be dealt with below, also starts earlier here. Thick shoals of omul move along the shores of shallows in search of plankton-rich water.

Summer: second half of July, August, September

Characteristic of summer are a high light intensity, relatively high temperatures of the upper water layer, direct thermal stratification, discontinuation of *convection* mixing, and intense horizontal currents with emergence of hypolimnetic waters at the surface, especially after north-westerly gales and storms.

At the end of July the temperature in the upper

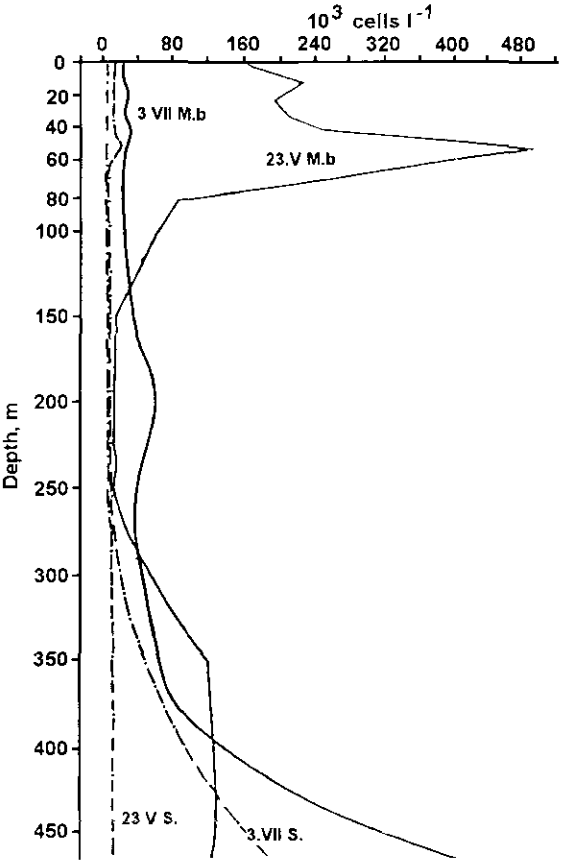


Fig 6 34 Vertical distribution of *Autocoseua (tyelosua) baicalensis* (M B) and species of the genus *Synedra* (S) in May and July of 1950, when *Meloura* was abundance South Baikal. Bolshiye Koty After Kozhov, 1963

layers of open lake water (0-5 m) reaches 8-10°C. An abrupt temperature drop often occurs at about 5-8 m *(e.g.,* from 10° to 6-5°C), while at a depth of 50 m the temperature remains at 4-4.5°C. In August the temperature of the surface zone, even in deep-water regions, reaches 12-13°C, and in some years even 15-16°C. At approximately 10 m, it is still 8-10°C. In September the upper layers begin to cool, whereas the deep layers continue to warm up. Towards the end of summer, light intensity in the upper layers gradually decreases and visibility becomes restricted, from 20-30 m (in June) to 6-10 m (in August-September)

In July, the slow descent of vernal algae in deep-water regions continues. Their place on top is taken by aestival, mostly blue-green algae. They concentrate in the heated upper layers (0-5 m). They decrease with depth, but are still fairly common in the 10-20 m zone. Appreciable numbers of descending diatoms are also found in deeper layers, down to 150 m or more (Fig. 6.34). Bacteria in the open water are also plentiful at this time, especially in the 10-25 m zone. In August their maximum density extends from 0-50 m (Fig. 6.5).

In *Epischura baicalemis,* July is the month of the highest density of nauplii of the summer generation. In summer, these grow rapidly and need large amounts of food, Nauplii and copepodites are at a maximum (up to 50-60% of the total) at 10-25 m. At about 5 p.m., they begin to rise, reaching a peak in the 0-2 m layer in the evening (7-9 p.m.) and early in the morning (about 4 a.m.). In the darkest period of the night, their concentration in the uppermost layer diminishes. Up to 20-25% of the nauplii and up to 40-70% of the copepodites take part in these migrations. Sizeable concentrations of crustaceans *are* maintained in the 0-2 m layer until 4-5 a.m., *i e,* for about seven to eight hours.

In August and September the zone of mass occurrence of nauplii and copepodites is still at 0-15 = 0-25 m. The rise of nauplii to the upper layers begins at sunset (approximately 7 p.m.), and of copepodites at 5-6 p.m., *i.e.,* an hour and a half before sunset. Towards 9-10 p.m., two or three hours after sunset, the concentration of crustaceans in the 0-2 m layer reaches a maximum of hundreds of thousands of specimens per m^3 (up to 80% of their total number), and increased densities persist in the 0-2 m layer throughout the night (Figs. 6.36-6.37)

On overcast and foggy days, these migrations are less pronounced than on clear days.

At dawn, the copepodites and nauplii leave the upper layer and, towards 8-9 a.m., disperse in the watermass. During daytime, no more than 2-5% is found in the upper 0-2 m.

During the summers of Cyclops-rich years, *Cyclops kolensis* permanently resides above *Epischura* (Fig. 6.38). Similar to the latter, *C. kolensis* has intense diurnal migrations, moving up in the evening and down in the morning. A certain midnight descent in the upper 2 m is also observed, with a regaining of density before dawn.

Among rotifers, a distinct diurnal migration in

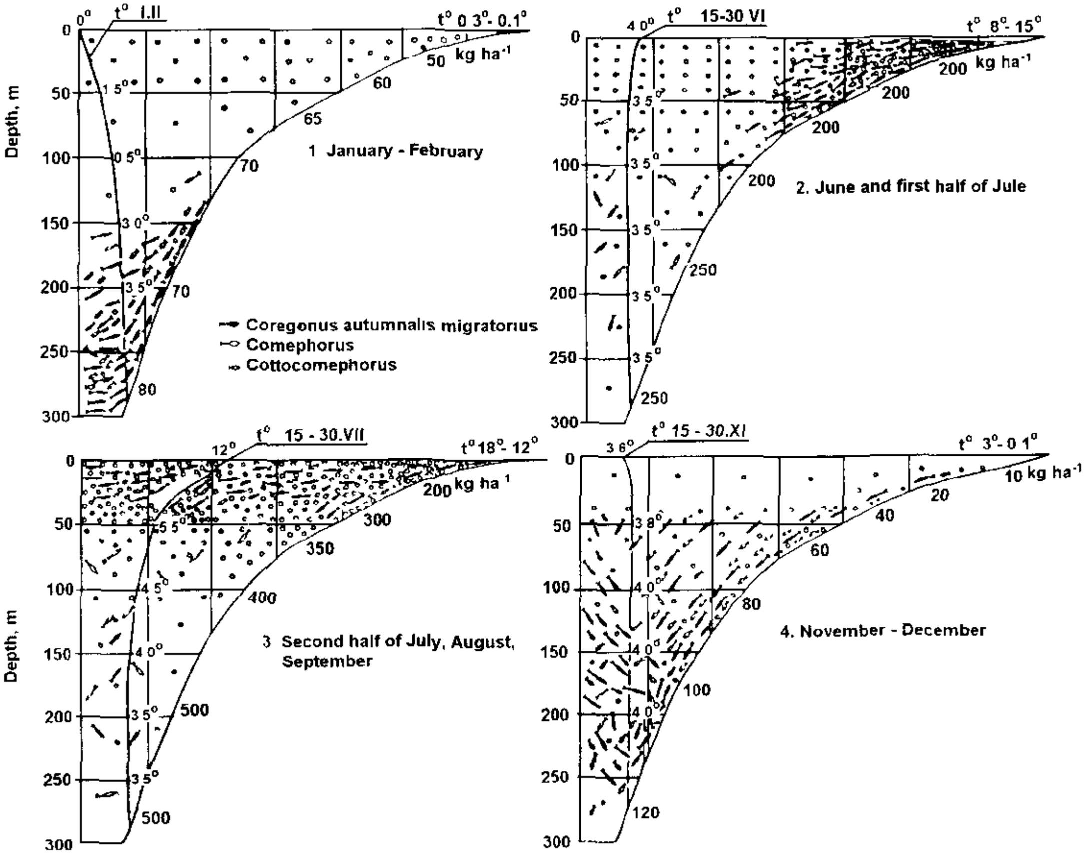


Fig. 6 35 Seasonal changes in the vertical distribution of water temperature, zooplankton and pelagic fish in lake Baikal. One circle denotes 10 kg ha"' of crustacean plankton in the 0-250 m layer After Kozhov, 1958

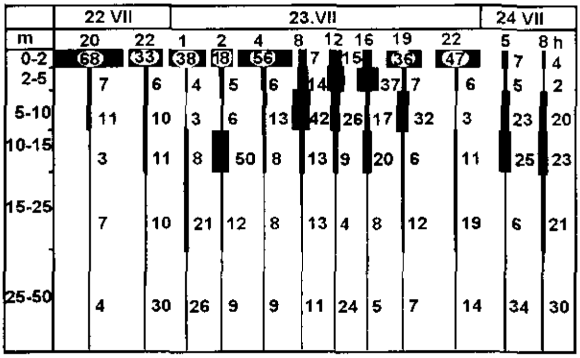


Fig 6 36 Vertical distribution of copepodit stages of *Epischura baicalensis m* the course of My 22-24,]955, *in* the open waters of Baikal in per cent of their total number in the 0-50 m layer The areas of shaded sections are proportional to this value After Kozhov, 1959.

summer is observed in *Filima longiseta* and *Notholca longispina.* At night, they concentrate in the 0-2 = 0-5 m layer and during the daytime, at 5-25 m.

The summer vertical migrations of *Macrohectopus bramckii* are fairly intense too. In the first half of the night, swarms in the surface layers are so thick that they are visible to the naked eye. Yet, not less than 50-60% of the total number of *Macrohectopus bramckii* in a zone of between 0 and 500 m participates in these upward movements.

Summer is also the period of mass consumption of crustacean plankton by plankton-eating omul and *Cottocomephorus. Epischura baicalensis* is also preyed upon by *Macrohectopus* and the young of *Comephorus,* while *Macrohectopus bramckii* and the young of *Cottocomephorus* are themselves eaten by the omul and adult Cottoidei.

From mid-July until October, horizontal feeding

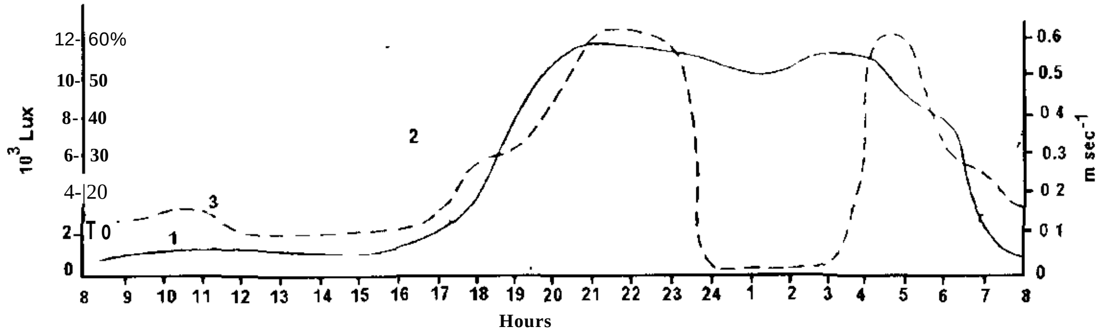


Fig 6 37 Diumal changes of 1 - number copepodit stages of *Epischura* in the 0-50 m layer in per cent of their total number, 2 - illumination m 1,000 luxes above the water surface; 3 - speed of the movement of the young omul in m sec ^{1} August 1960 After Kozhov, 1963.

migrations of the omul and pelagic Cottoidei occur in the upper warm, life-rich waters (Fig. 6.35). The routes of these migrations coincide with increased concentrations of crustacean plankton. In July, mass hatching of *Cottocomephorus* takes place. Vast schools of fry first move along the shores and then penetrate more open regions, consuming tremendous amounts of zooplankton. In summer the sections of Baikal where pelagic fish feed for extended periods of time are practically clear of crustacean plankton. Thus, the highest intensity of vertical migration in the prey of pelagic fish coincides with the feeding migrations and highest feeding rates of the latter.

In July-August, the migration of different species towards different habitats occurs. The Selenga omul leave slope regions and disperse in open Baikal, feeding on zooplankton, *Macrohectopus branickii* and the young of golomyanka-bullhead fish. The Posolsky omul, dispersing within the slope zone, occur at lower and at intermediate depths (50-150 meters). The North-baikahan and Barguzinskaya population omul proceed to feed in the coastal-pelagic zone (Smirnov, 1974; Smirnov & Shumilov, 1974). The main food of the Posolsky omul is *Macrohectopus branickii;* that of the North-baikalian and Barguzinskaya population bottom gammarids, and that of the fry of bullheads zooplankton and *Macrohectopus branickii* (Smirnov & Ustuzhanina-Gurova, 1969). In July-August, sexually mature Selenga and Posolskaya population omul migrate to the coastal zone, and to their river spawning grounds.

In autumn, maximum concentrations of omul are observed in pre-bottom waters, near the boundary between cooled coastal waters and warmer water masses of deep-water Baikal. There, dense accumulations of *Macrohectopus branickii* and of bullhead fry are also found (Koryakov, 1964; Smirnov, 1974, 1983; Bekman & Afanasyeva, 1977).

Summing up, the following conclusions can be reached:

During ice cover, the development of phytoplankton and an increase in the number of its grazers *(Epischura baicalensis,* some rotifers and infusorians) proceed simultaneously, and contact between them occurs throughout the photosynthetic zone. But the greatest phytoplankton density *is* found immediately under the ice layer, as is that of their consumers, the copepods and rotifers, but only for a short time after midday, when twilight sets in under the ice. At the low prevalent temperature, almost homogeneous across the whole 0-50 m layer, periodic upward movements of crustaceans are inconspicuous. Their predators, the fish, then winter at depths of 150-250 m and feed little.

In the transitory period (May-June), after the ice melts, a dispersal of phyto- and zooplankton takes place to depths of 100-150 m. Most copepods, rotifers and infusorians then scatter in the watermass, and the intensity of their vertical diurnal migration is extremely low (Fig. 6.40). At that time, fish mainly keep to near-bottom layers of water near shallows and feed inactively on plankton. The intensity of migrations rises in summer, when up to 70-80% of the total plankton becomes involved. This increase is simultaneous with an increase in water temperature and in stratification, whereas transparency drops noticeably compared with May-June (Fig. 6.40).

The greatest density *of* algae *is* now *observed in* the 0-5 m zone. There, contact between phyto- and

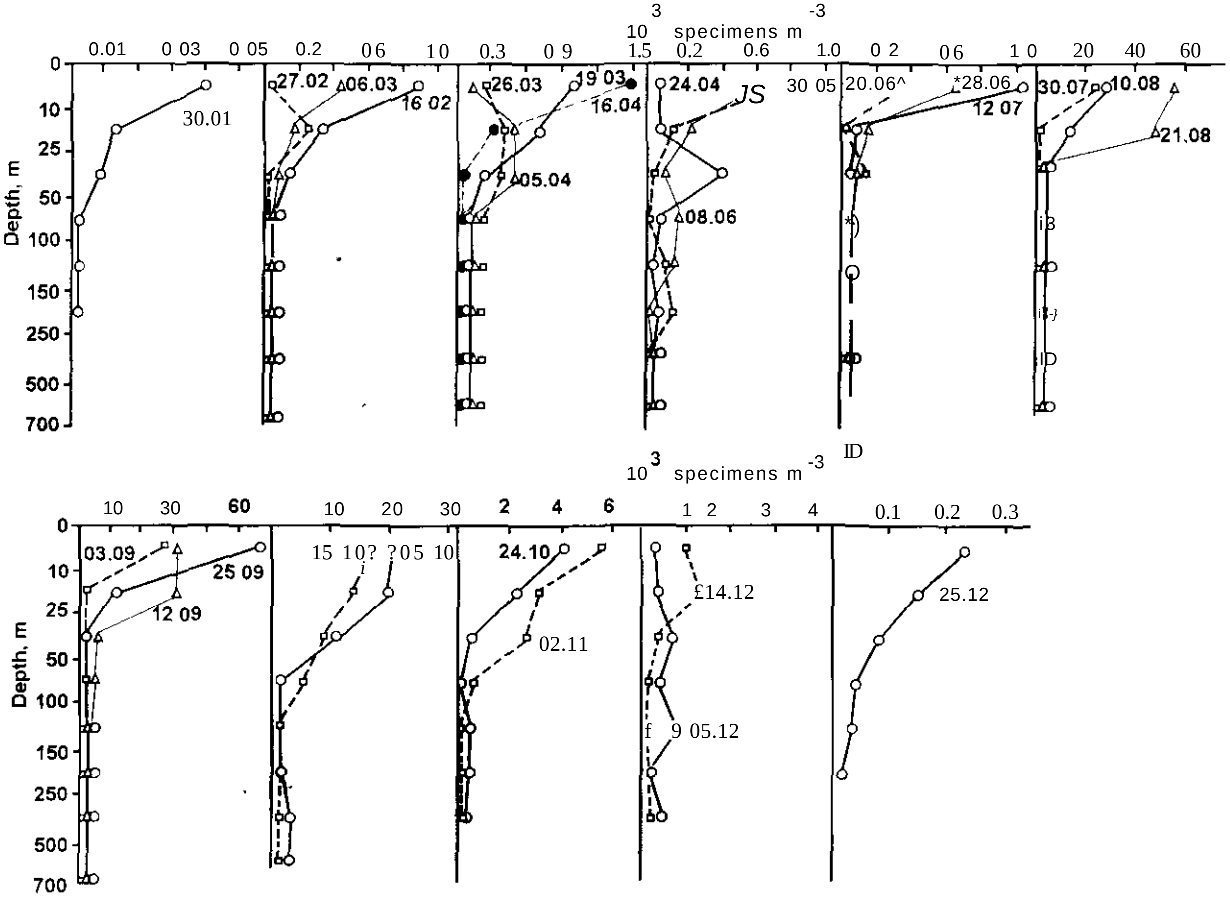


Fig 6 38 Vertical distribution of *Cyclops kolensis* South Baikal, Bobhiye Koty 1979 Data of the Research Institute of Biology Figures - dates of sampling

zooplankton mainly occurs in the evening, before sunset.

The diurnal vertical migrations of zooplankton described above strongly influence the diurnal rhythm of plankton-eating fish. Such changes in feeding and swimming activity in the course of 24 hours are particularly clearly defined in the summer period (July-September), and have been observed in natural and artificial conditions (round tanks in which the behavior of young omul can be followed during all seasons of the year) (Fig. 6.37).

At low temperatures (1 to 3°C in winter), the *activity* of the fish in the tank is as low as in the nature. They eat little even when offered abundant live zooplankton. When the temperature rises (in summer), their need for food increases sharply. They search for and catch food visually. Older omuls filter plankton-rich water through their gills, but even in this case, eyesight remains an indispensable aid. Blinded fish cannot catch food in sufficient amounts and sooner or later will starve to death. The highest feeding activity of omul in tanks occurs in summer, as in natural conditions, from 6 to 9 p.m., when the light intensity on the water surface drops below *1500-1000* lux. When complete darkness sets in, feeding activity drops abruptly. It increases somewhat at sunset but remains low throughout the day. This rhythm of feeding activity of the fish coincides with a rhythm in the speed and nature of their movements (Fig. 6.37).

In the daytime, the fish take shelter in shaded sections of the tank and move only a little. At twilight they gather in a shoal and swim rapidly (0.6 m

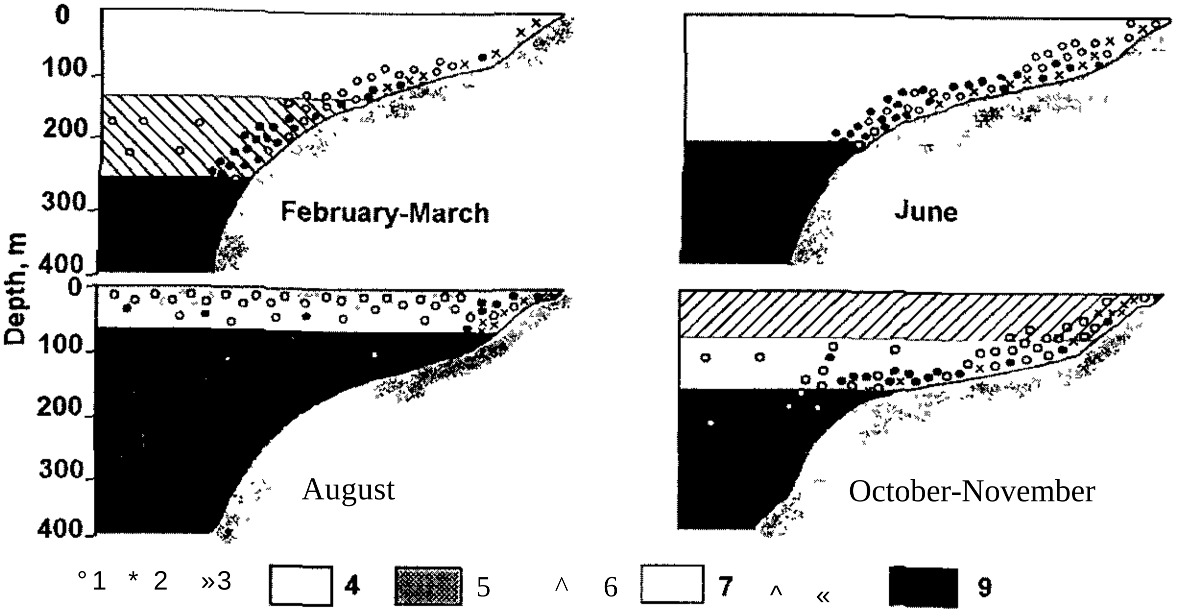


fig 6 ,?9 Seasonal distribution of omul in the region of Selenga delta 1 - pelagic omul, 2 - coastal-pelagic omul, 3 - deepwater omul, 4 - cold upper layer, 5 - warm upper layer. 6 - mesothermic maximum. 7 - the layer of temperature jump, 8 - the layer of summer warming, 9 - the deep water waters After Smirnov, in. Atlas of Baikal. 1993

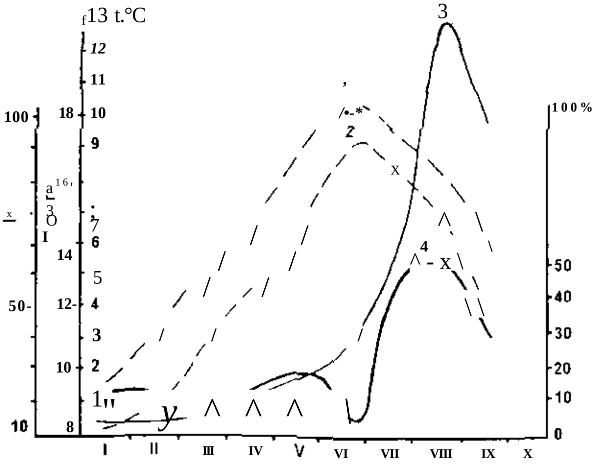


Fig 6 40 Seasonal changes in water temperature, illumination and the intensity of diurnal vertical migrations of copepodit stages of *Epischura baicalensis* in open Baikal, as observed in 1955 and 1956 1 - duration of light period in hours (light intensity more than 1 lux above the water at the point of observation), 2 - maximum light intensity in 1,000 luxes above the water at midday, 3 - average water temperature in the 0-20 m layer, 4 - intensity of migrations of *Epischura batcalenus* (migrating species in per cent of their total number in the 0-50 m layer) After Kozhov, 1959

sec^{-1} or more) along the walls of the tank, always counter-clockwise. *In deep darkness, the shoal* breaks up, and the movements of the fish become slow and random. At dawn, rapid movement of the shoal is resumed for some time.but before sunrise it decreases markedly. All these changes within a 24-hour cycle are in phase with the diurnal vertical migration of the crustaceans. In the daytime, the crustaceans are scattered in the water, and a search for them does not justify the expenditure of energy. In the darkest period they are not visible, although they amass thickly in the surface layer. The conditions for hunting are favorable only in the period of poor (twilight) illumination in the upper layer, where the crustaceans accumulate densely in the evening.

On the basis of these observations, the following explanation of the origin of the phenomena of diurnal changes in the behavior of animals, inter-connected by the food-chain was proposed by Kozhov (1947, 1955a,b, 1960). The main feeding ground of grazing crustaceans lies in the photosynthetic zone, with the highest concentration of algae being in the uppermost layer (0-5 *m* in Baikal). But this layer is brightly lit and, in the presence of carnivores that hunt visually, prey would be in danger of extinction there. This danger is neutralized by the development of a periodical change in habitat. During the daytime, when they are visible to enemies, zooplankton descends and disperses.

In the darkness, when they are less visible, they ascend to their grazing grounds in the upper layer, but do not remain there for longer than six to eight hours (in summer) These rhythms have acquired the force of instinct, but are controlled by abiotic factors such as light and temperature.

The tendency of zooplankton to remain in conditions of twilight or complete darkness throughout 24 hours is not absolute. In some periods of the year, the majority of crustaceans remain in the 'survival zone' day and night and do not migrate. Even in summer, the period of intense migrations, a certain number remains in deep water. Evidently an important impulse to migrate (or not) is provided by the physiological condition of the animal, *(e.g.*, its fat index), while genetic factors (the result of natural selection in the past) must also be important.

Chapter 7
Economic Use and Anthropogenic Pressure

7.1. Industry influence

The growth of the anthropogenic influence on Lake Baikal was slower than in other regions of Russia. Several stages can be distinguished in the economic activity around Baikal:

1. Restricted economic use: forest cutting for pasture, impact of forest fires, traditional agriculture, fishery.
2. Increase of economic use after the construction of the Irkutsk Hydropower dam on the Angara River. This period began in 1956. The ensuing rise in water level played a major negative role, which resulted in a restructuring of the coastline, particularly in shallow regions of the lake, changes in coastal biocoenoses, and a change in the breeding grounds of *Cottocomephorus grewingki.*
3. Intensive economic activity, beginning with the construction of the Baikalsk Pulp and Paper Plant (BPPP) in 1966. This stage is characterized by intensive use of mineral fertilizers, transportation, log rafting, growth of settlements along the shores, development of tourism, increase in coal usage (construction of heat and power stations), and construction of the Baikal-Amur railway. The pollution of the Selenga River increased due to the impact of waste water from the Selenginsk Pulp and Paper Plant. This plant is located 60 km from the mouth of the Selenga, and came into operation in 1974; its volume of waste water is 40,000 m^3 day"^{1}.

Hence, a need for monitoring, control, analysis and prognosis of the state of the ecosystems in the region has arisen. The Research Institute of Biology attached to Irkutsk State University, the Institutes of the Academy of Sciences and of the State Committee for Hydrometeorology and Environmental Control and other scientific and industrial organizations have become involved in this problem.

Table 7 1 Concentration of oil products m the water of south Baikal in spring, mg I'" After Izrael *et al*, 1985

Year	*Concentration*	*Year*	*Concentration*
1971	0.05±0.02	1976	0 21±0 07
1972	0.75±0.39	1977	0 *28±Q* 02
1973	0.20±0.10	1978	0 34±0 11
1974	0 10±0 10	1979	0.14±0.09
1975	0 18±0.23		

The large area of the lake basin belonging to the Buryat Republic, Chita and Irkutsk regions, and Mongolia, are the major source of anthropogenic influence. The main volume of pollutants comes into the lake with the waters of tributaries. During the last 40 years the capital investments in Buryatia increased 22-fold, the population three-fold, and the area of arable land two-fold (Borzhonov, 1985). Forest cutting (0.4% of the basin per year), and ploughing lead to increased washout of soil. Votintsev (1978) believes that the high mineralization of the tributaries of the lake originated during the last 150-200 years, by forest cutting and land ploughing. This input of minerals affects the content of some ions in the water mass. The input of anthropogenic organic matter in the lake is, at present, about 5% of the natural input.

Input of toxic substances is the most direct kind of anthropogenic influence. Oil products, phenolic compounds and heavy metals are the main pollutants by amount and toxicity.

Oil products (Table 7.1) are preserved in the lake for a long time due to its low temperatures. These are dangerous for the lake as they create a film on the surface. Input of oil products in low

Table 7 2 Share (%) of various sources in the total input of oil products and phenols in Baikal After Dombrovsky *et al*, 1983

Source of pollution	*Oil products*	*Phenols*
River inflow	92	79
Input from the atmosphere	-	19
Input from the coast	0 2	1
Region of Baikal-Amur railway	4 8	–
Water transport	3 0	

Table 7 3 Input of heavy metals and microelements in Baikal with atmospheric precipitations, kg km$^{'1}$ y^{1} After Vetrov *et al*, 1983

Element	*South Baikal*	*Middle Baikal*	*North Baikal*
Al	16	68	-
Sc	0 09	0 055	0 04
Cr	0 7	1.3	1
Mn	2 5	3 7	-
Fe	193	35 8	74
Co	0 1	0 02	0 03
Cu	0.45	0 55	-
Zn	2 5	0 6	1 1
Se	0 01	0 0052	-
Br	0 1	0 3	0.15
Rb	0 4	0 08	0 18
Mo	0 04	0 07	-
Sb	0 06	0 016	0 03
Ba	4 8	1 6	2 4
Ce	0 4	0 07	0 18
Hg	0 06	0 06	-
Pb	1 0	1 2	-
U	0 08	0 03	0 24

concentrations results in the development of bacteria. The number of hydrocarbon-oxidizing bacteria in the water can reach up to 100 cells ml '.

Phenolic compounds, washing into the lake with industrial and municipal waste water, also present a real danger to the ecosystem. Water quality control agencies still only determine the content of evaporating phenolic compounds in the water, while soluble diphenols (resorcine, hydrochinone and pyrocatechol) are more toxic (Beim, 1985). Phenol-oxidizing bacteria, now widespread around Baikal, provide evidence *of* the presence of phenolic compounds formed during phytoplankton dying-off (Goman, 1985). The share of various sources of oils and phenols is presented in Table 7.2.

Input of heavy metal ions is another danger to *the* ecosystem, due *to* their conservatism and bioaccumulation. They are carried away by the Angara River (0.25% per year) or sink to the bottom, where they become incorporated in bottom sediments. In the latter case, they return to the lake with the dead bodies of hydrobionts There they are converted into metal-organic compounds, more toxic than ions.

The data presented in Table 7.3 testify to the amounts and ways of penetration of heavy metals into Baikal. Significant contributions from the air are worthy of attention. They are derived from particles suspended in the air, coming from territories beyond the boundaries of the basin. The input with waste water from BPPP is low when compared with that from tributaries and the air.

Input of biogenic elements is yet another important external influence. Most of these are derived from agricultural waste water (wash-off from fertilized lands, waste from livestock-breeding farms) and domestic waste. Each inhabitant of the Baikal region produces 2.18 g of phosphorus and 10.8 g of nitrogen per day. Another important source of nitrogen is atmospheric precipitation.

Briefly characterizing the regions of anthropogenic influence on Lake Baikal, we come to the following conclusions (Kozhova, 1982, 1983; Matveev and Anikanova, 1985). The main source of pollution in Baikal is the River Selenga, where increased contents of mineral compounds, suspended matter, oil products, phenols, and heavy metals have been recorded. There is also an increase of pollution in the traditionally pure north Baikal, due to the development of industry in the regions of the Baikal-Amur railway (Nizhneangarsk, Severobaikalsk), and destruction of the soil cover.

The Baikalsk Pulp and Paper Plant is located in the southern town of Baikalsk on the east coast of Baikal. The Trans-Siberian railway and Siberian highway also run through the town, which has a population of 16 thousand. The plant produces sulphate-bleached celluloses for chemical treatment: cord cellulose (80,000 tons per year), viscose cellulose (80,000 tons per year), packing paper (120,000 tons per year), and turpentine (120,000 tons per year). The volume of timber processed is 1,380,000 m^3 per year. The total area of major and subsidiary facilities of the plant covers 473,000

Table 7 4 Input of substances (t y ') with waste waters from Baikalsk Pulp and Paper Plant into Baikal After Anikanova *et at,* 1985

Minerals	(49 7 ± 1 0) 10^3
Organic matter	(5.6± 0 1) • 10^3
Suspended substances	672 ± 32
Volatile phenols	1 6 ± 0 05
Sulphur-organic substances	12.3 ± 0 7

Table 7 5 Discharge of pollutants into the atmosphere from industry (10^{J} t y"^{1}) Data from various sources

Sources	*Solid substances (dust)*	*Sulphurous gas*
BPPP	15-28 4	6 5-7 0
Angarsk	**115.1**	153 6
Irkutsk	**15.5**	162
Shelehov	**19.9**	4 0
Usolye-Sibirskoye	**36.3**	143
Cherein ho vo	**134**	7 3
Sum without Baikalsk PPP	200	200
Contribution of Baikalsk PPP. %	14	3

m^2, including its own heat and power plant with a turbogenerator capacity of 105 MegaWatt, an electric and thermal capacity of 990 GCal h"^{1}, and a water purification station with a volume of 250,000 m^3 day^{-1}. Residuals of the production: purified waste water is 240,000 m^3, of the sludge-lignin-silt 550 t day"^{1}, and further, bark 79,100 t year"^{1}, and ash 113,000 t year"^{1}.

The input of substances with waste water from BPPP is shown in Table 7.4

Baikal is also polluted by contaminated substances from the atmosphere. A large amount comes from the north-west, from cities located along the Angara valley (Table 7.5).

The impact of industrial centers in Buryatia is essential (the Selenga river). A comparison of the anthropogenic pollution sources of Baikal is shown in Table 7.6.

A comparison of the input of waste water substances from the Baikalsk PPP, with their balance, is presented in Tables 7.7 and 7.8.

The rate of decomposition of some pollutants compared with that of phytoplankton under conditions close to Baikalian is shown in Table 7.9.

Kozhov began investigations on the influence of waste water from BPPP on the communities in Baikal even before its start in 1961 Evaluation of the pelagial showed that water transparency (Fig. 7.1), temperature and chlorophyll "a" concentrations (Fig. 7.2) were not affected by waste water. However, changes in the plankton and benthos communities were recorded at the point of waste water discharge. In the direct proximity of the point of entry of these effluents, a decline in the number of some planktonic species of algae, an increased mortality of *Epischura baicalensis* and *Macrochectopus branickii*, and an appearance of invertebrates typical of purification waters were

Table 7 6 Comparative characteristics of anthropogenic substances (10^3 t y"^{1}), coming into Baikal Data from various institutions, 1986

Substances	*Irku tsk-A nga rsk Complex, input to atmosphere*	*Timber-rafting*	*The Selenga river*	*Other affluents*	*Sum*	*Baikalsk Pulp and Paper Plant*	
						PWW	*4 ID*
Sum of minerals including	30	–	414	55 4	449 4	46	14
chlorine-ion	-	-	14	5 4	26 7	7 3(8)	
natrium sulphates	25	-	200	50	312	26(28)	11
Sum organic (including phenols)	5	**140**		20	152	4.5(6)	3
Suspended (dust)	200	-	1800	160	1,960 7	0 7	15-28

Note PWW purified waste water, AID aero-industrial discharges According the Baikalsk Pulp and Paper Plant, the discharge of mineral substances is 145 t d', or 52,955 t y^1 Between brackets data from other institutions

Table 7 7 Balance of the sum of dissolved mineral substances (10^6 t y ') according to various authors

Input	
With affluents	7-8
With precipitation	0 1
From Baikalsk Pulp & Paper Plant:	
Into the atmosphere	0 0005
With industrial purified waste water	0 05-0 122
Consumed by organisms and buried in bottom sediments	1 9
Carried away with the Angara river	6-7
Remaining in Baikal	1 378
Amount of dissolved mineral substances in Baikal	2162-2360

Input with precipitation according to Votmtsev *et a!* (1975)

observed. The number of bacteria growing on fish-peptone agar, putrifiers, and cellulose decomposers, was much higher than in the background regions. The influence of waste water on bottom communities, both plants (Fig. 7.3), and invertebrate (Figs. 7.4,7.5,7.6) was particularly marked. Annual changes in the zoobenthos biomass are presented in Table 7.10.

The area of bottom, where the zoobenthos composition is dramatically changed (polluted and strongly polluted soils) is shown in Fig. 7.7.

The sensitivity of Baikahan biota, including endemics, to waste water from the Baikalsk PPP has been determined experimentally (Table 7.11).

Table 7 8 Mass balance of Lake Baikal (10^3 t y ') According to data from the Limnological Institute SB RAS

Substance	*Occurs in Baikal, 10^3 t*	*Entering Baikal in rivers*	*Entering Baikal in precipitation*	*Outflow in Angara River*	*Remains in Baikal*	*Coma from Baikalsk Pulp & Paper Plant*
Nitrogen,						
organic	1035	23.8	–	**9.9**	**13.9**	–
mineral	–	123	–	**8.0**	**4.3**	–
nitrate	–	22 8	5.5	**18.3**	**10.0**	–
Phosphorus						
organic	552	4 2	–	1.2	**3.0**	–
mineral	–	1 3	–	**1.1**	0.2	–
phosphate	3 5	0 4	1.6	2.4	—	–
Chlorine-ion	13800	74.4	–	**44.1**	**30.3**	7-8
Sulphate-ion	119600	373-552	–	255-306	231	26-28

Algae consumption sulphur - 116-140, chlorine - 56-460 10^1 t y ^{1}

Table 7 9 Companson of decomposition rates of some substances in Lake Baikal

Substance	*Day*	*Degree of decay*	*t, °C*	*Author*
Labile fraction OM* of Pendinea	30	Complete	4 25	Tarasova, 1982
The same, Diatoms *(Synedra)*	60	Complete	4 25	..
Hard-decomposing OM* of phytoplankton	360	80%	4 25	"
Organic sulphides, dimethyl-disulphide	7	80%	**10**	Sudakova, 1982
Same	20	90%	6 7	„
Methylmercaptan, H_2S	3	Concentration begins to decrease	—	"

*OM organic matter

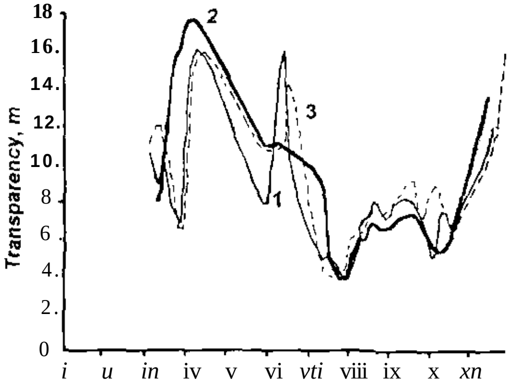


Fig. 7.1. Seasonal dynamics of water transparency (m). South Baikal. Baikalsk. 1991.

1 - shelf testing area I, 2 - pelagial testing area III; 3 - shelf testing area V, near discharge of waste waters of BPPC. Data of the Research Institute of Biology.

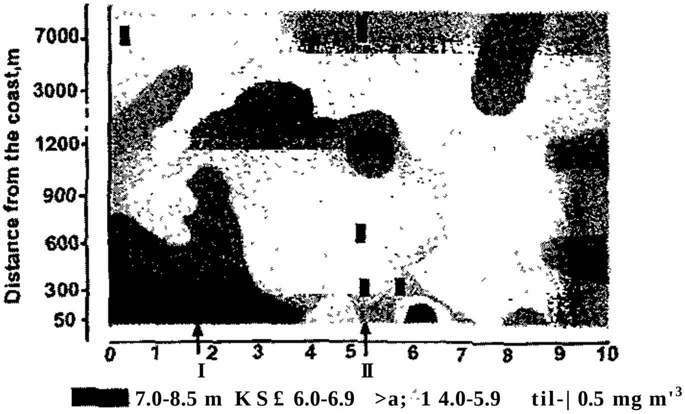


Fig. 7.2. Water transparency (m, Secchi disk) and chlorophyll "a" concentration (mg m^{-3}). South Baikal, Baikalsk. 1988.

I (2 km) - discharge of conditionally-pure waters; II (5 km) - discharge of industrial purified waste water from the Baikalsk Pulp and Paper; III - chlorophyll "a" concentration. Data of the Research Institute of Biology.

Thus, at present Lake Baikal is affected by the following anthropogenic influences: regulation of the water level by the hydropower station; fishing and hunting; input of chemical substances with the waters of tributaries; atmospheric precipitation, coastline erosion, and industrial waste water.

The last impact is most essential and manifests itself in the form of locally (*e.g.,* the Selenga Shallows, regions of BPPP) increased concentrations of alien substances, or a global (*e.g.,* water mineralization, sulphate concentration) increase of substances normal for Baikal. The main pollutants of the lake are a general mineralization (in particular, sulphates), nontoxic allochtonous organic matter, nutrients, toxic substances (phenolic compounds), oil products, and metal ions.

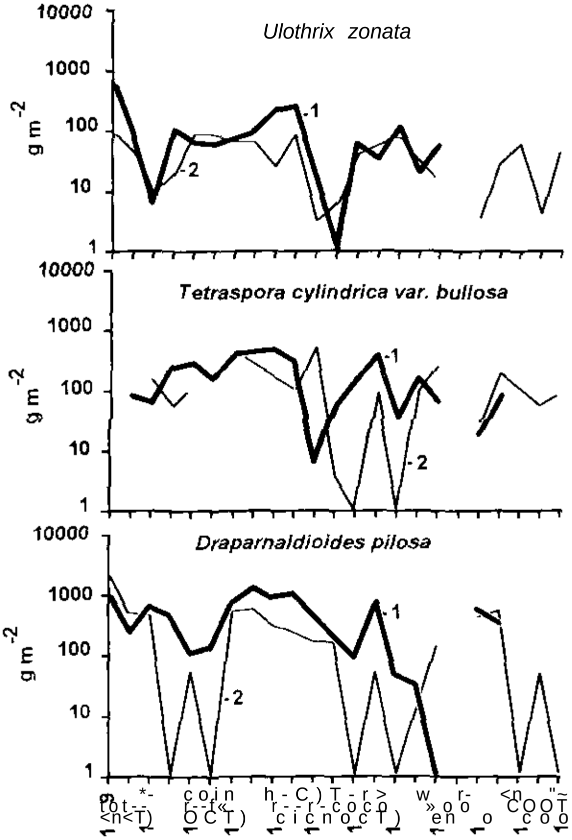


Fig. *7.3* Interannual dynamics of phytomass of bottom plants in the region of discharge of waste waters from the Baikalsk Pulp and Paper Plant.

1 - control, 2 - place of discharge of waste waters from BPPC. Data of the Research Institute of Biology .

Analyzing the ways of entry of effluents into the lake in relation to their significance, we can arrange them in the following sequence; river waters (Selenga, Upper Angara and Barguzin), atmospheric precipitation, region of the Baikal-Amur railway, region of the BPPP.

The strongest long-term influence is perhaps the increased mineralization of tributary waters due to forest cutting and agriculture.

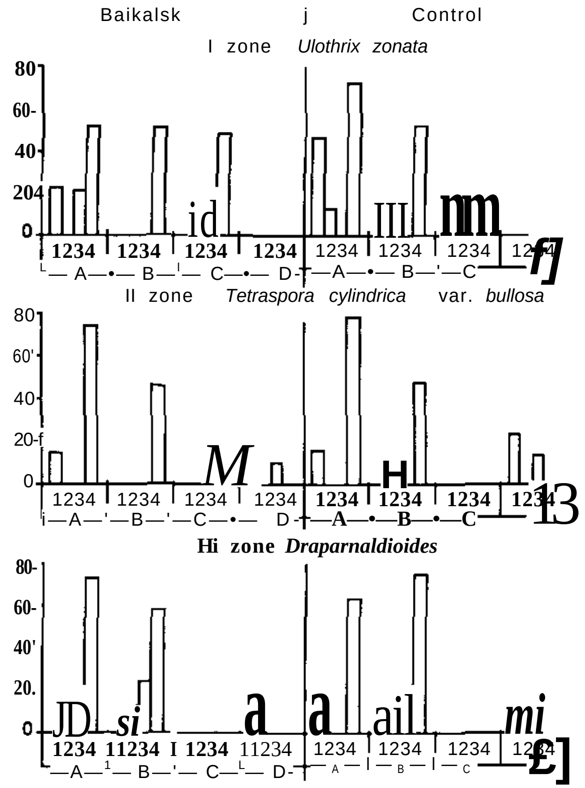
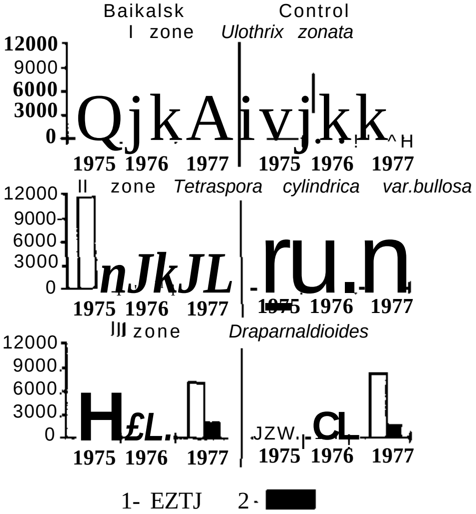


Fig 7 4 Indices of the structure of *Chironomidae* taxocene in the area of the discharge of industrial purified waste waters *from* the Baikalsk Pulp and Paper Plan: *and the control* sections Data of the Research Institute of Biology.

Indices of the structure are calculated as the square root of the product from occurrence frequency (%) and density 1 - 1975, 2 - 1976, 3 - 1977, 4 - 1978, A - *Orthocladim gr ohvaceus,* B - *Orthocladiiis decoratus,* C - *Pagastia onentahs,* D — *Potthastia longimana.*



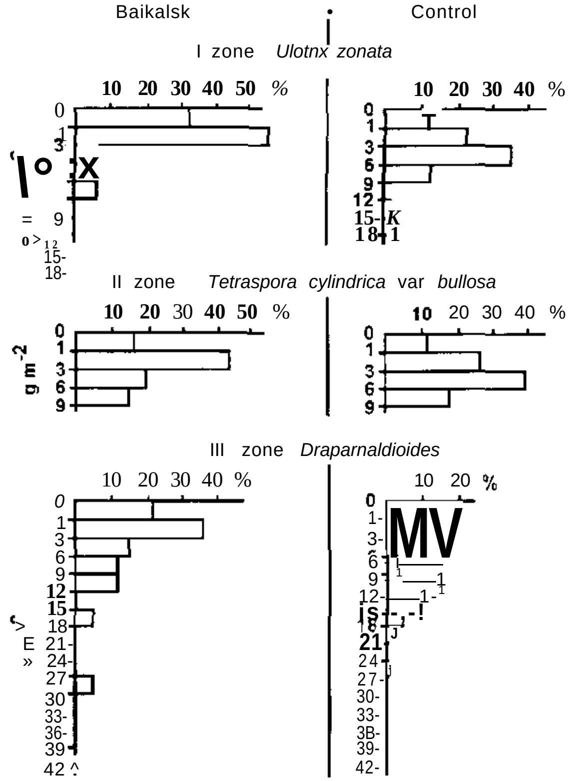


Fig 7 6 Occurrence frequency (%) of macrozoobenthos biomass (g m^{-2}) in various plant belts in the area of discharge of industrial purified waste waters from the Baikalsk Pulp and Paper Plant *and in* the control sections 1975-1977. Data of the Research Institute of Biology

7.2. Fish and seal

The number of omul *(Coregonus autuminahs migratorius)* - the main commercial species of fish - fluctuates dramatically This instability of omul catches is seen in the commercial fisheries records of Baikal. The yearly average catch was about 35-0^3 centners for the period from 1900 to 1968, ranging from 8-10-10^3 centners in 1905-1912 and 1965-1968, to 90 10^3 centners in 1937-1943 (Table 7.12). But in the 19th century, the extent of

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←
Fig 7 5 Number of zoobenthos (specimens m^2) in the region of discharge of waste waters from the Baikalsk Pulp and Paper Plant (Baikalsk) and on the control sections (Control) in various plant zones Data of the Research Institute ot Biology

Vertically - number, horizontally - years

1 - number of the total zoobenthos, 2 - number of *Chironomidae.*

Table 7 10 Biomass of zoobenthos (g/m ^{2}) on soft soils in the period of open water, South Baikal, Utulik-Murmo Data of the Research Institute of Biology

In the 5-20 meter zone

Year	/				2				3				4			
	TB	*Ol*	6	*M*	*TB*	*Ol*	G	W	*TB*	*Ol*	G	W	*TB*	**o/**	G	A/
	22 8	8 0	08	13 5												
1966	23 4	9 8	1 9	11 2												
1968-1971	53 4	122	5 0	32 9	53 6	184	2 8	31 2	60 0	20 8	2 9	35 8	5 1	1 1	3 0	0 8
1972-1976	31 0	13 0	2 8	140	196	7 6	2 0	94	21 6	11 2	34	54	13 2	7 7	1 6	32
1979	50 2	62	I *9*	42 0	20 5	2 2	05	178	20 8	4 5	46	11 6				
1980	-	-	-	-	33 5	1 9	06	20 8	109	07	08	94				
1981	*30 3*	*24*	*29*	25 0	20 9	4 5	03	160	43 6	If 3	I 0	30 9				

In the 20 50 meter zone

Yeai	/				2				J				4			
	TB	*Ol*	*G*	*M*	*TB*	*Ol*	G	*M*	**rs**	*Ol*	G	*M*	*TB*	0/	G	*M*
1963-1965	28 0	140	22	3 4												
1966	100	2 5	1 3	22												
1968-1971	164	8 7	3 0	42	182	109	24	3 7	22 2	146	3 2	40	5 8	1 3	2 9	09
1972-1976	145	8 8	4 7	1 3	129	6 2	3 2	2 8	12 1	8 2	1 4	2 2	72	3 7	I 7	1 6
1979	106	5 6	2 6	1 3	106	54	07	44	11 6	8 7	1 8	0 8				
1980	5 5	2 3	1 2	1 9	12 3	3 5	1 4	74	11 6	5 2	09	29				
1981	14 1	45	3 2	3 4	196	94	63	3 8	17 5	9 5	3 3	46	69 4	07	0	68 6

In the 50-120 meter zone

Yeai	;				2				3				4			
	TB	*Ol*	*G*	*M*	*TB*	*Ol*	G	M	*TB*	*Ol*	*G*	*M*	*TB*	0/	*G*	¥
1965	15 3	13 5	1 8	0												
1966	15 9	12 6	28	05												
1968-1971	23 2	167	0 05	63	19 7	15 3	3 2	04	14 3	106	3 5	0	5 6	08	48	0
1972-1976	20 6	173	3 2	0 1	11 1	7 2	3 6	02	69	5 9	1 0	0	5 2	03	48	0 1
!979	11 6	100	1 5	0 1	48	3 6	07	03	7 5	63	1 2	0	6 7	4 8	1 9	0
1980	106	9 6	09	0	10 1	5 0	5 0	0 1	17 8	10 7	1 6	3 9	0 3	02	0 06	0
1981	7 8	6 1	09	0 8	70	4 9	09	1 2	4 8	3 8	1 0	0	0	0	0	0

In the 120-310 meter zone

Year	/				2				?				4			
	TB	*Ol*	*G*	*M*	*TB*	0/	*G*	*M*	*TB*	*Ol*	G	*M*	*TB*	0/	*G*	*M*
1966	150	12 5	*2 5*	0												
1968-1971	-	-	-	-	5 9	*1 2*	4 7	-								
1972-J976	-	-	-	-	11 0	*W0*	09	*0*	3 9	3 8	0 1	*0*	*03*	0	02	0
1979	146	12 7	1 8	0	7 9	*2 1*	5 8	0	11 3	11 3	0	0	34	28	06	0
1980	96	9 6	001	0	24	1 8	0 6	0					0 04	0	0 04	0
1981	103	100	0 3	0	93	62	3 0	0 1					0	0	0	0

1-4 types of bottom deposits (1 control, 2-4 region of industrial purified waste water from the Baikalsk Pulp and Paper Plant 2 visually clean, 3 polluted, 4 stronglv polluted), T B total biomass, Ol Oligochaeta, G Gammandae, M Mollusta, 0 animals absent - no data Blank columns type of soil mentioned was absent

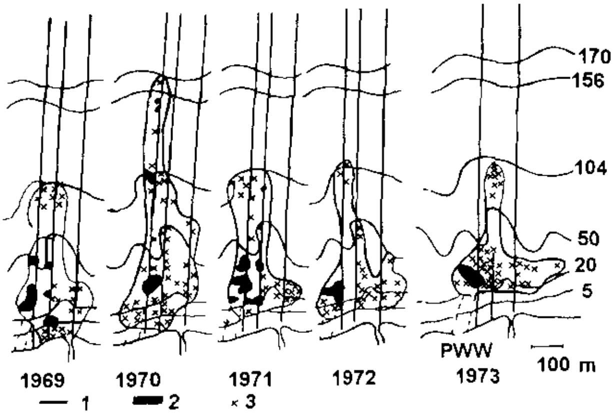

Fig 7 7 The scheme of a spot of polluted bottom sediments in the area of discharge of industrial purified waste waters from the Baikalsk Pulp and Paper After Kozhova, 1983

1 - total area of polluted bottom sediments, 2 - area covered by suspended authropogenic substances, 3 - sediments have a specific smell

Table 7 1! Vital dilution of industrial purified waste water from the Baikalsk Pulp and Paper Plant

Species	*Dilution*	*Author*
Melosira baicalemis	4-6 times	Votintsev *et al*, 1975
Epischura baitulensis	50-100 times	Kondratyeva, 1983
Cyclops kolensis	1-6 times	
Chydorm sphaencus	2-10 times	
Thymallus urctičus baicalensis	5 times	Nazarova *et at*, 1981

catch fluctuations was also 80 10^3 centners: from 6-10 10^3 in 1888-1891 to 87 10^3 in 1840 (Sollertinsky, 1929).

The water volume and level regime of Baikal and its tributaries play a significant role in the population size of the omul (Kozhov, 1947). Smirnov (1977) found a highly positive correlation between the size of the Selega population and the volume of Selenga flow in the year preceding the drive of their larvae from their spawning grounds (*r* = 0.79). The same is true of the North-baikalian population and the volume of the Upper Angara flow in May-August in the year their fry drive into the lake (r = 0.61), and of the Posolskaya population and the level in Baikal in the year of the larval drive (r = 0.88).

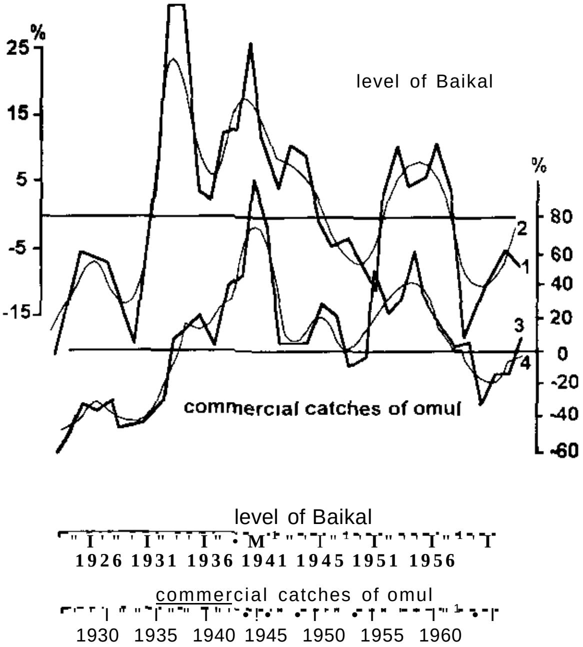

Fig 7 S Long-term variations of level of Baikal and commercial catches of omul (deviations from the average during 1923-1962). After Smrrnov, in Atlas of Baikal, 1993

1, 3 - annual values, 2, 4 - averaged from 4 years

A close positive correlation is also observed between the level of Baikal and omul catches, (for the period of 1923-1961, *r* = 0.72). The commercial omul catches increase three to five years after each maximum lake level (Fig. 7.8). The main fishery regions are the Maioye More, the Selenga, and the Upper Angara shallows, where the omul concentrates for feeding (the Maioye More) and before spawning (Tables 7,13, 7.14).

The commercial omul catches in the regions of fattening are considerably affected by the peculiarities of seasonal warming of the lake waters. The smaller the pelagial warming in the summer of the previous year, the greater the quantity of omul migrating into shallower regions for feeding during the next year, as can be seen from the inverse relationship between the average water temperature during August-November of one year and the average catch of omul in June of the next year (the Maioye More) (Fig. 7.9). The later the warming of the coastal waters begins, the longer the omul stays in the shallow regions, and the larger the commercial catches during summer in the regions of fattening *(r* = 0.76) (Fig. 7.10).

The relationships observed can be used to lm-

Table 7 12 Some fishery statistics Baikal fish After Tyutrina, 1988

Species	*Region*	*Year*	*Catch (!()' tj*	*Biomass* $(10^J\ t)$	*Number of specimens* $(I0^6)$	*Source of information*
Acipenser baen stenorhynchus		1983	0 47			Baikalrybvod
		1985	0 02			
		1986	0.04			
Thymallus arcticus brevipmms		1981	20 3			„
		1982	63.8			
		1983	34.3			
		1984	149			
		1985	6 J			
		1986	16.7			
		1987	20.7			
Coregonus lavaretus		1938-1960	0 77 (0 23-1 89)			Skryabin, 1969
		early 1980s		3 0-3 5	0 6	Mamontov, 1977
		1981	0.66			Baikalrybvod
		1982	0 53			
		1983	15 6			
		1984	44.3			
		1985	25.9			
		1986	10.6			
		1987	5.72			
		last years	0 53-44 3			
		1984	3.50	0 2		Norenko, 1984
Sor fish		1977-1978	7.30	20-22		Mamontov, 1977 Moskalenko *et al*, 1978
Comephorus dybowskii baicalensis	all lake	1975		62.0±11.0	$28.0\ 10^3 \pm 3\ 4\ 10^3$	Stankov, 1971
	„	1975		118.0±19.5	$13.2\ 10^3 \pm 2.5\ 10^3$	
	„	1977-1978		150 0		Mamontov, 1977 Moskalenko *et al*, 1978
Coregonus autumnalis migratorius	„	1966-1968			2.04	Norenko, 1984
	„	1970-1982	0.9-1 2		4.75	
	Upper Angara	1969			0 679	Afanasyev *et al*, 1984
		1973			3.718	
	bottom	1973		0 165	9 15	Smirnov, 1977
	coastal			0.613	30.1	
	pelagial			0 763	39 5	
	all lake	1977		**2.261**	127.7	Smirnov, 1983
	Upper Angara	1977			3.5	Afanasyev *et al*, 1984
		1982			1.3	
	all lake	1977	8 0	40.0		Mamontov, 1977 Moskalenko *et al* , 1978
		1978	7 3	30.0		

Table 7 13 The share of different populations of omul (%) in the Selenga River (according to data from SibrybNIIproekt)

Year	*Populations*			*Total*
	Selenga	*North-baikahan*	*Posolska\a*	*Ht of specimens*
1981	90 80	3 10	6 10	*2* 56
1982	87 20	3 90	8 90	2 90
1983	98 20	0 33	1 65	3 72
1984	97 09	0 74	1 57	3 44
1985	97 59	1 12	1 29	1 80
1986	95 16	0 52	4 32	1 20
1987	84 00	2 38	13 65	0 85

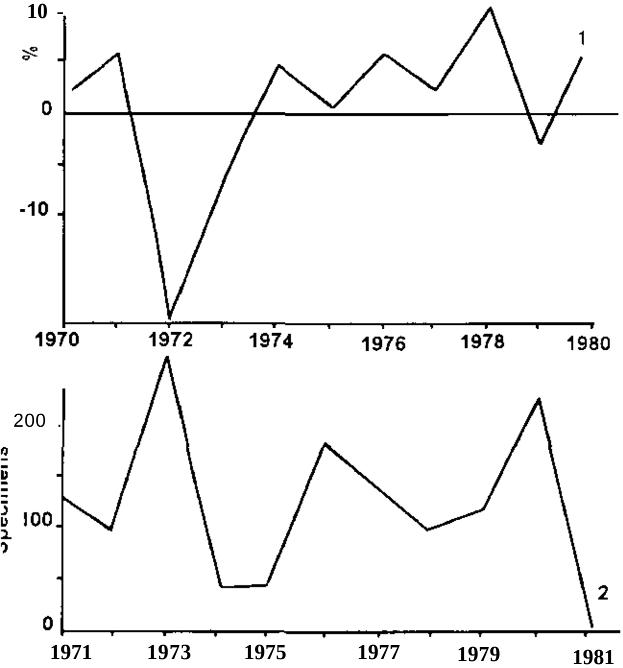

Fig 7 9 Interannual variations of intensity of the warming up of Baikal surface in VIII XI month and numbers of omul in the Maloye More strait m spring next year

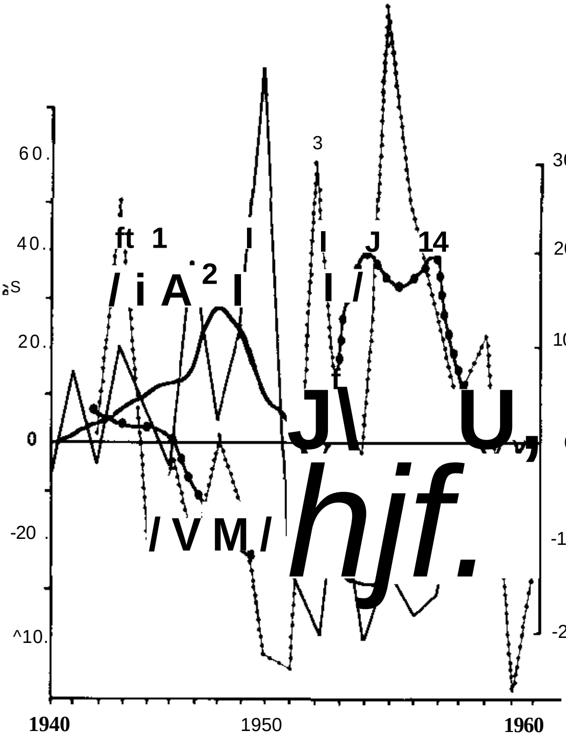

Fig 7 10 Long-term changes of water surface temperature in May (the Peschanaya Bay) and summer commercial catches of omul in the regions of fattening (deviations, % from the average longtcrm during 1940-1960)

1 - annual temperature values. *2 - temperature* values averaged for 5 years, 3 - annual values of commercial omul catches, 4 - commercial omul catches averaged for 5 years After Smirnov. unpublished data

←

1 - temperature of the lake surface according to meteostation data in the Peschanaya bay in **VIII-XI** (deviations from the average during 1970-1980), 2 - omul catch using 300 m order of gillnets with mesh size 14-40 mm for one cast After Smirnov, unpublished data

Table 7 14 Average age (years) of omul catches in Baikal (according to data from SibrybNIIproekt)

Years	*Populations*					
	Selenga		*North-baikahan*		*Posohkaxa*	
	Age	*Number 10* specimens*	*Age*	*Number 10^3 specimens*	*Age*	*Number 10^s specimens*
1982	7 83±0 48	390 4	6 43±0 16	3296 0	10 68±0 21	511 0
1983	7 51±0 18	3306 6	5 92±0 15	4121 0	I0 69±0 22	2218 0
1984	7 62±0 16	2624 4	6 08±0 16	4793 8	10 70±0 21	200 0
1985	7 45±0 22	3283 6	5 96±0 17	3853 3	10 15±0 20	6197
1986	7 53±0 16	3986 1	5 79±0 17	4457 4	9 32±0 18	223 3
1987	7 20±0 20	4652 8	5 65±0 19	5893 5	10 24±0 22	151 6

Table 7 15 Results of autumn-spring investigations of omul spawning places in the River Selenga between 1984 and 1985 Data from Baikalrybovod

Sampling sties	*Total eggs. exem m'²*		*Live eggs, exem m²*		*Dead eggs, %*		*Survival of live eggs in % of the total roe, spawned in autumn*
	Autumn	*Spring*	*Autumn*	*Spring*	*Autumn*	*Spring*	
Novoselengmsk	0	0	0	0	0	0	0
Gansunno	0	0	0	0	0	0	0
Omulevka	0	0	0	0	0	0	0
Ulan-Ude	1.0	-	0	-	100	0	-
Oshurkovo	0.5	-	0	-	100	-	-
Tataurovo	199 0	-	190.0	-	4	-	-
Ilyinka	634 0	566 9	6(75	104 5	3	82	16
Selenginsk PPP	502 0	458 6	496 2	413 1	1	10	82
Kabansk	190	-	14.6	-	23	-	-
Fofdnovo	-	2 5	-	0 4	-	86	-
Kolcsovo	239 0	182 4	213 0	87.6	11	52	37
Mursino	26.0	17 3	17 3	102	33	41	39

Note. - no record. Survival of eggs calculated by B K Pa\lov from data given in the table

prove fishery management, prognosis and planning for the entire area of Baikal, and for specific regions of commercial fishing.

Pollution of spawning places, particularly in the Selenga River, decreases the numbers of omul.

It is believed that the intensification of fisheries in the 1940s and 1950s, as well as a decline in the quality of spawning grounds, resulted in a depression of omul numbers. These slowly began to increase after a ban on commercial fishing in 1969, but still have not reached their previous values. This can partially be explained by poaching and sport fishing. In future, sport fishing, provided the necessary recommendations are observed, may become the only acceptable type of omul fishing. Results of autumn-spring investigations of omul spawning grounds in the River Selenga in 1984-1985 are shown in Table 7.15.

Due to poaching, the number of other species of commercial fish *(Coregonus lavaretus* and *Thymallus arcticus baicalensis)* decreased dramatically at the beginning of the 1960s.

Particular attention was drawn to the high mortality of the seal, *Phoca sibirica,* in 1987 (Grachev (ed.), 1992). An earlier ban on shooting caused it to concentrate in its habitats. Stress became a factor regulating its numbers, and created favorable conditions for disease. Specialists came to the conclusion that a morbitlivirus infection was present (Grachev *et al,* 1989). Due to this, Pastukhov (1993) estimates that about 6.5 10^3 seals out of a total of 70 10^3 died during autumn-winter. It was also established that the Baikalian morbilhvirus is closely related to the one which causes disease in Northern European seals (Osterhaus, 1988). Symptoms of the disease are paralysis of the hind flappers, and abundant epiphora.

Variations in the numbers of, and in the intensity of hunting, the Baikalian seal can be summarized as follows: in the second half of the 19th century the annual harvest was about 2 10^3 individuals. Since the beginning of the 20th century, the annual number of individuals shot has increased to 5680 (yearly average for 1931-1936). The maximum harvest reached was 6468 seals per year (Ivanov, 1938).

7.3. Biological pollution

Biological pollution by invasive species presents a new type of danger for the lake. The main one of these 'biological pollutants' is *Elodea canadensis* Michx., which invaded the lake in the mid-1970s

(Kozhova & Izhboldina, 1993). Its dispersal in the lake is shown in Fig. 7.11, and the role it plays in the bottom communities, in Table 7.16.

An essential role in the biocoenoses of the River Selenga delta is now played by *Percottus glehni*. This was first observed at the beginning of the 1980s. It spawns in the second half of June, and its number of eggs can reach 5350 (Skryabin, 1988). This fish serves as a significant source of food for predatory waterfowl.

Peled *(Coregonus peled)* was first recorded in Posolsky Sor in 1987 (Tyutrina, 1988). Its possible source of appearance is the fish-breeding plant, located in the sor. If the spread of the peled is successful in the lake, it may become the main competitor of the Baikalian omul *{Coregonus autumnalis migratonus).*

The number of common carp earlier acclimatized in the lake (introduced artificially in 1944 from the Amur River) and other fish inhabiting the coastal zone and sors also increased during the 1960s, due to a rise in water level. At the same time, the number of endemic fish decreased (Table 7.17).

During the last two decades, Pronin (1982) identified several dozens of parasitic invertebrates, not observed previously. These, too, may have invaded the lake by anthropogenic means.

Changes in microbiological indices are convincing evidence of the pollution of the lake. Thus, *Escherichia coli* was discovered near settlements and along ship courses.

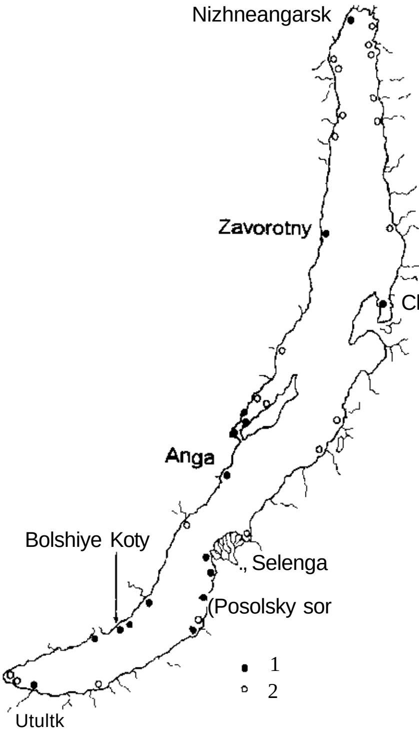

Fig ^{7}*II* Scheme *of Elodea canadensis* distribution in Baikal

1 - points of discover, 2 - points, free of *E canadensis* After Kozhova & *izhbojdina,)992*

1.4. The state of the coasts, and protected territories

The economic development of the Baikalian region has proved unfavorable for the state of the Baikal

Table 7 16 Area occupied and phytomass of *Elodea canadensis* in different sites of Baikal After Kozhova & Izhboldina, 1993

Month, year	*Area, (ha)*	*Phylomass, (t)*			*Areas with phytomass densitv (gm') per cent*			*Average phyto-mass density (gtn^2)*		
		Fresh	*Dry*	C *org*	*0 1-10*	*10-100*	*100-1000*	*Fresh*	*Dry*	C *org.*
In Posolsky Sor										
June, 1984	1064	166	28	10	35	65	-	15	*2*	0
September, 1984	1064	425	68	24	45	43	12	40	7	2
In Olkhonskiye Vorota and Maloye More straits										
June, 1984	963	2840	474	J 72	*32*	47	15	294	*49*	18
August, 1985	1261	3795	634	230	29	56	10	*300*	*50*	18
August, 1986	1189	3344	558	202	30	35	26	281	47	17

Table 7 17 Fish introduced into Baikal After Fish and Fisheries..., 1958, Karasev, 1974

Species	*Region of origin*	*Region of settling (initial years)*	*Year and place of appearance in Baikal*
1 *Parasilurus asotus* (L)	Amur basin	Ivano-Arakhlciskye lakes, 1938	40-th
2 *Cvprinus carpio haematopteris* (Temm et Schleg)	Amur basin	Ivano-Arakhleiskye, Eravno-Harginskye, Gusino-Ubykunskyc lakes, 1934-1976	Posolsky Sor, Proval Bay, Selenga Shallows 40-th
3 *Coregomis albula* (L)	Ural	Era\ no-Hargmskye, Gusmo-Ubukmskye lakes, 1954-1963	Selenga region 1971-1973
4 *Coregonus peled* (Gmelm)		Shuchye Lake (the Selenga basin) 1968-1970	Selenga region 1971-1973
5 *Percottus glehm* (Dyb.)	Amur basin	Gusmoye Lake	Selenga Shallows 1970
6 *Abramis brama* (L)	Ubmskoye Lake (Barabinskoye Lake)	Gusinoye Lake 1954	Selenga delta 1989-1992 Proval Bay

coast. The highest anthropogenic pressure is observed in south Baikal, where two-thirds of the population of its basin is concentrated. Moreover, this region is affected by atmospheric pollutants from businesses in the cities of Irkutsk, Angarsk, Usolye-Sibirskoe and Shelekhov, located in the Angara River valley (Table 7.18)

The forests of north Baikal (except for the region of the Baikal-Amur railway: about 30 km of coastline) retain their natural state, with its inherent characteristics. But in the middle and south parts, the natural state has become superimposed by anthropogenic pressure.

Among the reasons *for* the deteriorating state *of* the forests, one of the most important is the impact of atmospheric pollutants which affect 6% of the surface area of the forest. Forest vermin affect only 0.12%. Damage caused by fires does not exceed an area of 0.3%.

The directions of anthropogenic pressure and of the natural succession of the dark-coniferous forests of south Baikal, most subject to anthropogenic pressure, coincide. The natural process of replacement of fir forests *(Abies sibinca)* by polydominant cedar forests *(Pinus sibirica)* with an admixture of spruce *(Picia obovata)* and fir-tree *(Abies sibirica)* is proceeding at an increased rate.

Table 7 IS Slate of the forests along the coasts of middle and south Baikal (%) After Pavlov, 1995

Region	*State afforests*			
	slight l\ decaved	*badh decayed*	*dry ing*	*dead*
Middle Baikal				
East coast	3.0	0.3	0.1	1.5
West coast	7.4	0.8	–	3.0
South Baikal				
East coast	5 4	0 5	0 1	0.2
West coast	0 8	0.4	–	–
South coastline	5 0	0 1	–	–

These changes in the natural environment of the coasts of Baikal provided strong impetus for the development of protected areas.

Three scientific reserves (zapovedniki), and two national parks can be found on the coasts of Baikal. The oldest is the Barguzin Reserve, situated on the east coast of the northern part of Baikal, occupying the western slopes of the Barguzin Range. Its boundaries include 45 km of coastline and 3 km of water frontage. Its territory extends deep into the mountains, from 30 km in the south to 60 km in the north. Its total area is 263.2 10^3 ha. The reserve was created in 1917 to protect the sable {*Martes zibellina* L.). At present it is designated as a Biosphere Reserve.

On the south coast we find the Baikalian Reserve, established in 1970 to preserve a natural complex in the Khamar-Daban Range, which is famous for its large number of endemic and relict plants. Along the coast, its territory stretches for 49 km, and it penetrates some 45 km into the mountains. Its total area is 165.7 $I0^3$ ha. In 1993, the Baikalsk Reserve was given the status of a Biosphere Reserve.

The Baikalian-Lena Reserve is located on the west coast of the central zone of Baikal. It stretches over a distance of 90 km along the coast (together with a 3-km water band), and penetrates deep into the mountains: up to 60 km. Its total area is 659.5 10^3 ha. The aim of this reserve is to protect the natural ecosystems of the upper reaches of the Lena River and of the west coast of Baikal.

Pribaikalsky National Park is located along the western coast of south and middle Baikal. Along the coast, the park stretches for a distance of 335 km (including Olkhon Island), and it penetrates deep into the mountains (from 5 to 25 km).

On the east coast, centrally located, is Zabaikalsky National Park. This covers 75 km of coastline (including Svyatoi Nos Peninsula and Ushkany Islands), and extends up to 25 km into the mountains.

Many plants growing on the coasts of Baikal can be found in lists of rare and disappearing species. For example, 96 species of the 1800 species of higher plants of the flora of Irkutsk region are included in these lists.

Conclusion

M M Kozhov in his conclusion to the book written at the beginning of the 60s, spoke of "gaps" in the system of knowledge on Baikal dealing with the origin and evolution of its fauna and flora, factors of abiotic nature, peculiarities of distribution and functioning separate ecosystem elements (parameters), biogeocenotic links and general productivity of the lake He advanced tasks for future studies of Baikal as an ecosystem

As is seen from the present edition of the book many of these tasks have been solved Though, as we all understand, science is ever-lasting and with appearance of new techniques in research studies of each problem can be continued making us more knowledgeable about the lake Of major importance is the concept that Baikal is an ecosystem which is characterised by a great variety of species differing in time and place of origin, evolution rate, numbers and its temporal dynamics and by its stability to the impact of external factors of environment All these factors define a complicated and exclusive biogeocenotic structure of the lake

While studying Baikal there appeared new theoretical concepts and methodology of ecological research, which have enriched different branches of knowledge about nature In particular, they were used to make prognoses of hydrobiological regime of reservoirs on the River Angara, of changes in the state of lakes in Eastern Siberia and Central Asia under the impact of natural climatic and anthropogenic factors The data obtained were a basis for making prognoses of the state of Baikal proper, for proposals to minimise negative anthropogenic pressure on the lake

A very important role in the analysis of these problems was played by regime long-term monitoring of planktonic and benthic communities in south Baikal on the Baikahan Biological station (Bolshiye Koty) and in the region of Baikalsk town, where in 1966 the Baikahan Pulp and Paper Plant was built These observations started by M M Kozhov, are continuing now Their results provided reasons for development of a number of normative- legal acts - *A Baikal Pi election Law* - and documents declaring Baikal a World Heritage Site We hope that Baikal - treasure chest of diverse flora and fauna and pure water- will be saved for our descendants

Finally, we must remember the words of M M Kozhov that Baikal is a natural laboratory of knowledge and "Baikal should be protected in all its pristine magnificent beauty with crystal clear waters, majestic mountain taiga, decorating the shores of the Great Lake, with its unique fauna and flora We all need such Baikal now and there will be greater need in it for generations to come[1]' (Kozhov, 1972)

O M Kozhova,
L R Izmesfeva

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Subject index

Appendix

List of planktonic algae species. Compiled by O.M. Kozhova & G.I. Kobanova

Modem systematics of algae, as is known, is characterized by diverse systems differing from each other even at the highest taxonomic levels Besides, application of electron microscopy, most new biochemical, physiological, genetic data allowed to discover many new taxonomic characteristics. This resulted in new changes in previous taxonomic combinations, in the description of new species.

While making up the list of planktonic algae in Lake Baikal, we, if possible, took into consideration modem approaches to lower plant classification. The basis for it was the algae system of the Ukrainian school (Algae, 1989) except Chrysophyta and Bacillariophyta. The Chrysophyta system was extended according to Starmach (1968) and Hindak *et al.* (1975). The Bacillariophyta system is presented with regard for the data obtained using electron microscopy methods (Simonsen, 1979; Diatom algae of the USSR, 1992; Flower, 1993; Gcnkal & Popovskaya, 1987 and others).

The list contains algae of open Baikal. Besides, it contains colourless Flagellata studied only in living material. Colourless Flagellata in Baikal were studied by Zhukov (1975) also. The first extended list of the baikalian algae was made up by Meyer (1930)

To identiflcate taxa we used keys (Gollerbakh *et al*, 1953; Kondratyeva, 1968; Kondratyeva, Kovalenko, Prihodkova, 1984; Kiselyov, 1954; Matvienko, 1965, Zabelina *et al.*, 1951; Topachcvsky & Oksyuk 1960; Korschikov, 1953; Dedusenko-Schegoleva & Matvienko, 1959; Andrceva, 1975; Moshkova, 1979; Palamar-Mordvintseva, 1984, 1986; Tsarenko, 1990) and new papers.

	Species and subspecies	Endemic or not	Typical of		Biococnolic role in the open Baikal
			open Baikal	coastal-sor zone & internal parts of bays	
Procaryoia					
Divisio	Cyanophyta				
Class	Chroococcophyceae				
Oido	Chrooeoccales Gcitl				
Family	Synechococcaceae				
Genus	Synechocystis Sauv				
	Synechocystis limnetica Popovsk.	+	+	+	m
Genus	Synechococcus Näg				
	Synechococcus elongatus Nag	–			
	Synechococcus sp (Synechocystis sp ")	?	+	+	m
Genus	Dactylococcopsis Hansg				
	Dactylococcopsis fasciculans Lernm	–			s
	D rhaphidioid.es Hansg f falciformis Pnnt7	–		+	s
Genus	Cyanarcus Pasch				
	Cyanarcus hamiformis Pasch 71	–	+	+	us
Family	Mensmopediaceae Elenk				
Genus	Mensmopedia (Mcyen) Elenk emend-				
	Mensmopedia tenuissima Lemm.	–		+	s
Family	Microcystidaccac Elenk				
Genus	Microcystis (Kutz) Elenk				
	M Kirchn flos-aquae (Wittr)	–		+	s

Continuation of list of PLANKTONIC ALGAE species

	Species and subspecies	Endemic or not	Typical of		Biocoenotic role in the open Baikal
			open Baikal	coastal-sor zone & internal parts of bays	
	M wesenbergu Komarek (= Coelosphaenum dubium Grun)	–		+	s
	M puiverea (Wood) Forti emend Elenk	–		+	s
	M puiverea f incerta (Lemm) Elenk	–		+	s
	Microcystis sp	?		+	s
Genus	Aphanothece (Nag) Elenk emend				
	Aphanothece clathrata W et G S West	–		+	
	A clathrata f brcvis (Bachm) Elenk	–		+	
Genus	Cyanodictvot; Pasch				
	Cyanodictyon sp	?	+	+	m
Family	Gloeocapsaceae Elenk et Hollerb				
Genus	Gloeocapsa (Kut?) Hollerb emend				
	Glococapsa magma f opaca (Nag) Hollerb	–		+	s
	G kuet2ingiana Nag	–			s
	G limnetica (Lemm) Hollcrb	–		+	s
	G minor (Kutz) Hollerb	–			s
Family	Coelosphaenaceae Elenk				
Genus	Coelosphaenum (Nag) Elenk				
	C kuetzrngianum Nag	–		+	
Family	Gomphosphaenaceae Elenk				
Genus	Gomphosphaerid Kut7				
	Gomphosphaena lat-ustris Chod	–		+	s
	G lacustns f compacts (Lemm) Elenk	–		+	s
Family	Woronichiniaceae Elenk				
Genus	Woronichima Flenk				
	Woromchinia sp	?		+	s
Class	Hormogoniophvceae				
Ordo	Oscillatonales (Flenk) Starmach em Kondrat				
Family	Oscillatonaceat (Kirchn) Elenk				
Genus	Oscillatona Vauch ex Gom				
	Oscillatona ornata f planctomca Flenk	–		+	s
Genus	Romena Koczwara				
	Romena sp	?			s
Genus	Lvngbya C Agardh ex Gom				
	Lyngbya limnetica Lemm	–		+	s
Ordo	Nostocalcs (Geitl) Elenk				
Family	Anabaenaceae Elenk				
Genus	Anabaena Bory ex Born & Fl				
	A spiroides Klcb	–		+	s
	A scheremetievi Elenk	–		+	s
	A flos-aquae Breb ex Born & Fl	–		+	s
	A lemmcrmdnnu p Richt	–	+	+	m
	Anabaena sp	?		+	s
Family	Aphanizomenonaccae Elenk				
Genus	Aphamzomenon Morr				
	Aphamzomenon flos-aquae (L) Ralfs	–		+	s
Family	Rivulanaceae (Menegh) Elenk				
	Rivulana (Roth) Ag emend *Thur*				
	Rivulana planctomca Elenk	–		+	s
Genus	Gloeotnchia J Ag ex Born &. Fl				
	Gloeotruhia echinulata (J S Smith) P Richt	–		+	s

Continuation of list of PLANICTONIC ALGAE species

	Species and subspecies	Endemic or not	Typical of		Biocoeriotic role in the open Baikal
			open Baikal	coastal-sor zone & internal parts of bays	
Eucaryota					
Divisio	Dmophyta (Dinophyceae, Pyrrhophyta, Pyrrhophycophyta, Pendineae)				
Class	Dinophyceae				
Ordo	Gymnodmiales				
Family	Gymnodiniaceae (Bergh) Sehiitt, 1896				
Genus	Gymnodinium Stein, 1888 emend Kofoid et Swezy, 1921				
	Gymnodinium baicalense Antip '	+	+	+	m
	G baicalense var minor Antip ^	+	+	+	m
	G coeruleum Antip [3]	–	+	+	us
Ordo	Pendmiales				
Family	Pendimaceae Ehr, 1838				
Genus	Glenodimum Ehr				
	Glenodimum sp. (large)	9	+	+	us
	Glenodimum sp (small)	7	+	+	us
Genus	Pendinium Ehr, 1830				
	P. aciculiferum f merme Wolosz	—		+	s
	P baicalense Kiss et Zwetkow	+	+	+	us
	Pendinium sp	9			5
Genus	Ceratium Schrank, 1793				
	Ceratium hirundinella (O F M) Bergh	–		+	s
Divisio	Cryptophyta (Cryptophycophyta, Crvptophyccac)				
Class	Cryptophyceae				
Ordo	Cryptomonadales				
Family	Cryptomonadaceae Ehrenberg, 1838				
Genus	Cryptomona^ Ehrenberg, 1838				
	C gracilis Skuja	–	+	+	us
	C reflexa Marsson	-			s
	C ovata Ehr	–			s
	Cryptomonas sp	?			s
Genus	Chroomonas Hansgirg, 1885				
	Chr acuta Uterm	–	+	+	m
	Chroomonas sp	i	+	+	m
Divisio	Chrysophyta (Chrysophycophyta, Chrysophyceae)				
Genus	Chromulma Cienk				
	Chromuhna sp	•'	+	+	us
Genus	Chrysidahs Schiller				
	Chrysidahs sp	?	+	+	m
Genus	Chrysococcus Klebs				
	Chrysococcus spp	?	+	+	us
Genus	Kephynon Pasch				
	Kephynon spirale (Lack) Conr.	-			s
	K momliferum (Schmid) Bourelly	–			s
Genus	Pscudokeph> non Pasch				
	P schillen (Schiller) Conrad	-			s
Genus	Mallomonas Perty				
	M vannigcra Asmund	-	+	+	us
	M alpina (Pascher et RuTtn) Asmund et Kristiansen	–		+	s
	M tonsurata E. Teiling	–	+	+	us
	Mallomonas spp	?		+	s

Continuation of list of PLANKTONIC ALGAE species

	Species and subspecies	Endemic or not	Typical of		Biocoenotic role in the open Baikal
			open Bdikdl	coastal-sor zone & internal parts of bays	
Genus	Uroglena Ehr				
	U volvox Ehr	–		+	
	Uroglena sp (= Uroglenopsis sp)	?	+	+	us
Genus	Dinobrvon Ehr				
	Dinobrvon cvlindncum lmh	–	+	+	us
	D cvlindncum \ar palustre lmh	–	+	+	us
	D cylmdncum \ar alpinum (lmh) Bachm	–	+	+	us
	D souale Ehr	–	+	+	*us*
	D socialc \ar stipitatum (Stein) Lemm	–	+	+	us
	D bavancum lmh	–		+	s
	D di\ergens lmh	–		+	s
Genus	Svnura Ehr				
	S uwella (Ehr) Korsch	–		+	s
Genus	Ochromonas Wys				
	Ochromonas sp	?			s
Genus	Heterochromonas Pasch				
	HeterochromondS sp	?			s
Genus	Pseudopcdinella Carter				
	Pseudopedinclla sp	?	+	+	us
Genus	Chrvsosphaera Pasch				
	Chrvsosphaera mclosirde (K Mever) Bourelly {= Fpichrysis melosirae K Meyer)	+	+	+	us
Genus	Chrysosphaerella Laut				
	C ccwadu BoureJly	–			
	C baicalensis Popo\sk[4]	+	+	+	us
Flagellata	colourless				
Genus	Monosigd Kent				
	M ovata S Kent	–		+	
	M \anans Skuja	–		+	
Genus	Astrosiga Kent				
	A radiata Zachanas	–		+	
Genus	Spacroecd Lautcrborn				
	S \ohox Lauterborn	–		+	
Genus	Bodo Stein				
	B saltans Ehr	–		+	
	B minimus Klebs	–		+	
Genus	Bicocca (J Clark) Stein				
	B lacustns J Clark	–		+	
Divisio	Bacillanophyta (Diatomeae)				
Class	Centrophvceae				
Ordo	Thalassiosiralcs Glezer ct Mdkr				
Famılv	Thalassiosiraceae Lebour emend Hasle				
Genus	Thalassiosird CI[5]				
	Thalassiosira pseudonana Hasle et Heimdal	–			
	T guillardu Hasle	–			
Famıly	Stcphdnodiscaceae Cilezcr Makar				
Genus	Stephanodiscus Ehr				
	Stephanodiscus hantzschn Grun	–		+	s
	Hakansson et Stoermer				
	(= S tenuis Hust S tenuis subsp				
	rddjolana Skdbitsch)	–		+	
	S skabitschevskyi Popovsk	–		+	s
	S binderanus (Kutz) Kneger				

Continuation of list of PLANKTONIC ALGAE species

	Species and subspecies	Endemic or not	Typical of		Biocoenotic role in the open Baikal
			open Baikal	coastal-sor zone & internal parts of bays	
	var baicalensis Popovsk et Genkal[6]	+	+	+	us
	S lnvisitatos Hohn et Hellerman	–			
	S makarovae Genkal	-		+	
	S trrporus Genkal et Kuzmin	–			
	S minutulus (Kutz) Cleve et Moller (= S astraea var minufula (Kutz) Grun , S rotula var minutulus (Kutz) Ross et Sims, S perforatus Genkal et Kuzmin S minutula (Kutz) Round)	-		+	s
	S inconspicuus Makarova et Pomazkina[7]				
Genus	Cyclostephanos Round				
	Cyclostephanos dubius (Fncke) Round	-		+	
	C costatus var sibincus (Skabitsch) Lupik (= Stephanodiscus dubius subsp sibinca Skabitsch , Cyclostephanos sibinca (Skabitsch) Genkal et Popovsk)				
Genus	Cyclotella Kutz				
	Cyclotella baicalensis (K Meyer) Skv	+	+	+	us
	C *ornata (Skw)* Flowed (= C baicalensis *t* minor Skv K Meyer, C baicalensis fo ornata Skv ,				
	C minuta (Skv) Ant (some forms)	+	+	+	us
	C minuta (Skv) Antip"	+	+	+	us
	C pseudostelligera Hust	-		+	
	C sibinca Skabitsch	-			
Ordo	Melosirales Crawford				
Family	Melosiraceae Kutz				
Genus	Melosira Ag				
	Melosira vanans Ag	-		+	s
Ordo	Aulacoseirales Crawford				
Family	Aulacosciraceae (Moiss) Crawford				
Genus	Aulacoseira Thw				
	Aulacoseira baicalensis (K Meyer) Sim (= Melosira baicalensis (K Meyer) Wisl , M islandica var baicalensis K Meyer)	+	+	+	s,m
	A distans (Ehr) Sim (= M distans (Ehr) Kutz)	-			s
	A hrata var alpigena (Grun) Haworth (= A distans var alpigena (Grun) Simonsen M distans var alpigena Grun)	-		s	
	A granulata (Ehr) Simonsen (= M granulata (hhr) Ralfs)	-		+	s
	A granulata var angustissima (O Mull) Sim (= M granulata var angustissima (O Mull) Hust)	-		+	s
	A islandica ssp helvetica (O Mull) Sim (= M islandica ssp helvetica O Muil)[10]	–	+	+	m
	A italica (Kutz) Sim (= M italica (Ehr) Kutz)	-		+	s

Continuation of list of PLANKTONIC ALGAE species

	Species and subspecies	Endemic or not	Typical of		Biocoenotic role in the open Baikal
			open Baikal	coastal-sor zone & internal parts of bays	
Ordo	Rhizosolemales Siha				
Family	Rhizosolemaceae Dc Tom				
Genus	Urosolerua Round et Crawford				
	Urosolenia longiseta (Zach) Round et Crawford (= Rhizosolenia longiseta Zachanas)	–		+	s
	U enensis (H L Smith) Round et Crawford (= R enensis H L Sm)	–			s
Ordo	Chaetocerotales Round et Crawford				
Family	Acanthocerataceae Craw ford				
Genus	Acanthoceros Honigmann				
	A magdeburgense Honigmann (= Attheya zachanassn G Bran)	–			s
Class	Pennatophyceae				
Ordo	Araphales				
Family	Tabellanaceae Kutz				
Genus	Tabcllana Ehr				
	Tabellana fenestrata (Lyngb) Kutz	–		+	s
Family	Fragilanaccae (Kutz) D T				
Genus	*Diatoma Bory*				
	Diatoma elongata Ag	–		+	s
	D vulgare Bory	–		+	s
Genus	Ceratoneis Ehr				
	Ceratoneis arcus (Ehr) Kutz	–		+	s
Genus	Astenonella Hass				
	Astenonella formosa Hass	–	+	+	us
	A gracillima (Hantzsch) Heib	–		+	s
Genus	Fragilana Lyngb				
	Fragilana crotonensis Kitt	–	+	+	s
	F capucina Desm	–		+	us
Genus	Syncdra Ehr				
	Synedra vauchenae Kutz	–		+	s
	S ulna (Nitzsch) Ehr	–	+	+	us
	S ulna var damca (Kutz) Grun	–	+	+	us
	S acus Kutz	–	+	+	us
	S acus var radians Kutz	–	+	+	m
	S acus var angusrissima Grun	–		+	
	S actinastroides Lemm	–		+	s
Ordo	Monoraphales				
Family	Achnanthaceae (Kutz) Grun				
Genus	Achnanthes Bory				
	A minutissima (Kutz) Grun erw Cleve"	–		+	
Ordo	Aulonoraphales				
Family	Nitzschiaceae Hass				
Genus	Nitzschia Hass				
	N aciculans (Kutz) W Sm	–	+	+	m
	Nitzschia sp	?		+	s
Family	Sunrellaceae Kutz				
Genus	Cymatopleura W Sm				
	Cymatopleura solea var apiculata (W Sm) Ralfs	–		+	s
Divisio	Chlorophyta (Chlorophycophyta, Chlorophyceae, Chlorobionta, Vindiplantae)				

Continuation of list of PLANKTONIC ALGAE species

	Species and subspecies	Endemic or not	Typical of		Biocoenotic role in the open Baikal
			open Baikal	coastal-sor zone & internal parts of bays	
Class	Chlorophyceae (Euchlorophyceae)				
Ordo	Volvocales (Phytomonadina, Phytomonadinea, Volvophvceae. Volvocineae)				
Subordo	Chlamydomonadinede (Chlamydomonadales)				
Family	Chlamydomonadaceae				
Genus	Chlamydomonas Agassiz				
	Chlamydomonas sp	?		+	s
Subordo	Volvocineae {Volvocales)				
Family	Volvocaceae				
Genus	Gonmm O Mull, 1973				
	G pectorale OF Muller, 1773	–		+	s
Genus	Pandorma Bory 1824				
	Pandorma morum (O F Mull) Bory	–		+	s
Genus	Eudonna Ehr , 1831				
	Eudonna elegans Ehr	–		+	s
Ordo	Chlorococcales				
	Marchand Orth Mut 1895				
Family	Characiaceae (Nageli) Wille 1884				
Subfamily	Schraedenoideae				
Genus	Ankyra Fott, 1957				
	Ankyra sp (= Lambertia sp)				s
Genus	Schroedena Lemm em Korsch\koff, 1953				
	Schroedena setigera (Schrod) Lemm	–		+	s
	S robusta Korschik	–		+	s
Family	Hydrodictyaceae (S F Gray) Durmortier, 1880				
Genus	Pediastrum Meyen 1829 (= Staundmm Corda, Monactinium Corda, Tetrasoma Corda, Asterodictyon Ehrenberg)				
	P duplex Meyen	–		+	s
	P boryanum (Turp) Menegh	–		+	s
	P tetras (Ehrb) Ralfs	–		+	s
	P kawraiskyi Schmidle	–		+	s
Family	Micractmiaceac (Brunnthabcr) GM Smith, 1950				
Genus	Golenkimopsis KorschikofT, 1953				
	Golenkiniopsis parvula (Woronich) Korshik	–			s
Family	Botryococcaceae Wiile, 1909				
Subfamily	Dictyosphaenoideae				
Genus	Dictyosphaenum Nageli, 1849				
	Dictyosphaenum pulchellum Wood	–		+	s
	D ehrenberg i an urn Nag	–		+	s
Genus	Pseudodictyosphaenum Hmdak				
	Pseudodictyosphaenum mmusculum Hmdak, 1988[12]	–	+	+	us
Subfamily	Botryococcoideae				
Genus	Botryococcus Kutzing, 1849				
	Botryococcus braunn Kutz	–			s
Family	Radiococcaceae Fott ex Komarek, 1979				
Subfamily	Radiococcoideae				
Genus	Coenochlons Korschikoff 1953				
	Coenochlons polycocca (Korschik) Hindak 1984 (= Spaerocystis				

Continuation of list of PLANKTONIC ALGAE species

	Species and subspecies	Endemic or not	Typical of		Biocoenotic role in the open Baikal
			open Baikal	coastal-sor zone & internal parts of bays	
	polycocca Korschik, Sphacrocystis schroeten Chod)	–	+	+	us
Family	Chlorellaceae Brunnthaler, 1915				
Subfamily	Chlorelloideae				
Genus	Chlorella Beijennck, 1890				
	Chlorella minutissima Fott et Novako\a	–	+	+	us
	C vulgaris Beijer	–		+	s
	C mucosa Korschik	–		+	s
Subfamily	Tetracdronoideae				
Genus	Tetraedron Kutz				
	Tetraedron minimum (A Br) Hansg	–		+	s
Family	Oocystaceae Bohl				
Subfamily	Lagerheimioideae				
Genus	Lagerheimia Chodat, 1895				
	Lagerheimia genevensis Chod	–		+	s
Genus	Excentrosphaera G T Moore, 1901				
	Excentrosphaera vindis G T Moore	–			s
Subfamily	Oocystoideac				
Genus	Oocystis Nag ex A Braun, 1855				
	O pelagica Lemm	–		+	s
	O pusilla Hansg	–			s
	O parva W et W	–			s
	O submanna Lagerh	–			s
	O lacustns Chodat	–	+	+	us
	Oocysts sp	?			s
Family	Selenastraceae (Blachm et Tansl) Fntsch, 1927				
Genus	Monoraphidium Kom-Legn , 1969°				
	Monoraphidium contortum (Thur) Komar -Legner (= Ankistrodesmus angustus Bern)	–	+	+	us
	M griffithn (Berkeley) Komar -Legner (= Ankistrodesmus aciculans (A Br) Korschik)	–		+	s
	M mmutum (Nag) Komar-Legner (= Ankistrodesmus mmutissimus Korschik)	–			s
	M pseudomirjbile (Korsch) Hmdak et Zagorenko, 1992 (= Ankistrodesmus pseudoinirabilis Korschik)	–	+	+	m
Genus	Kirchnenella Schmidle, 1893				
	Kirchnertella lunans (Kirchn) Moeb	–			s
Genus	Quadngula Printz, 1915				
	Quadngula pfitzen (Schrod) G M Smit (= Ankistrodesmus pfitzen (Schrod) G S West)	–			
	Quadngula korschikoffii Komarek (= Ankistrodesmus clostenoides (Printz) Korschik)	–	+	+	us
Genus	Ankistrodesmus Corda, 1838				
	A falcatus (Corda) Ralfs	–			

Continuation ot list of PLANKTONIC ALGAE species

	Species and subspecies	Endemic or not	Typical of		Biocoenotic role in the open Baikal
			open Baikal	coastal-sor zone & internal parts of bays	
Famıly	Coelastraceae Wille. 1909				
Genus	Coelastrum Nägeli, 1849				
	Coelastrum sp	?			s
Genus	Actinastrum Lagerheim. 1X82				
	Aetinastrum hantzsehn var subtile Woloszynska (= Actinastrum hantzsehn var gracile Roll sensu Korsch)	–		+	s
Famıly	Scenedesmaceae Oltmanns, 1904				
Subfamıly	Crucigenioideae				
Genus	Tetrachlorella Korschikoff, 1939				
	Tetrachlorella sp.	?			s
Genus	Willea Schmidle, 1900				
	Willea irregularis (Wille) Schmidle (= Crucigenia irregularis Wille)	–		+	s
Genus	Crucigenia Morren, 1830				
	Crucigenia tetrapedia (Kirchn) W et G S West	–			s
Genus	Cruciginiella Gaillion, 1900				
	Crucigeniella rectangulans (Nageli) Komarek (= Crucigenia rectangulans (Nag) Gay)	–			s
Genus	Tetrastrum Chodat, 1895				
	Tetrastrum triangulate {Chod) Komarek (= T glabrum (Roll.) Ahlstr et Tiff)	–			s
	T komareku Hindak	–			s
	T elegans Playfair	–			s
Subfamıly	Sccnedesmoideae				
Genus	Didymocystis Korschikoff, 1953				
	Didymocystis mconspicua Korschik (?)	–			s
Genus	Scenedesmus Meyen, 1829				
	Sccncdesmus obhquus (Turp) Kutz. (S bijugatus Kutz.)	–		+	s
	S acuminatus (Lagerh.) Chod.	–		+	s
	S quadncauda (Turp) Breb.	–		+	s
Ordo	Ulotnchales Bohhn				
Subordo	Ulotnchineac				
Famıly	Ulotnchaceae Kutz				
Genus	Binucleana Wittr				
	Binucleana lauterbormi (Schmidle) Pr-Lavr	–			s
Genus	Koliella Hindak, 1964 (= Raphidonema Lagerh p.p., Ankistrodesmus Corda p p , Raphidium Kutz p p.)				
	K longiseta (Vischer) Hind	–			s
	K longiseta f variabilis Nygaard[14]	–	+	+	m
	Koliella sp.	?			s
Genus	Elakotothnx Wille, 1898				
	Elakotothnx genevensis (Reverd) Hindak, 1962 (= E. lacustns Korschik.)	–			us
	E gelatinosa Wille	–			s
Class	Conjugatophyceae (Zygnematophyceae)				
Ordo	Desmidiales				

Continuation of list of PLANKTONIC ALGAE species

	Species and subspecies	Endemic or not	Typical of		Biocoenotic role in the open Baikal
			open Baikal	coastal-sor zone & internal parts of bays	
Family	Clostenaceae				
Genus	Clostenum Nitzsch ex Raifs				
	Clostenum monihferum (Bory) Ehr ex Raits	–		+	s
	Clostenum sp	?			s
Family	Desmidiaceae				
Genus	Staurastrum Meyen ex Ralfs				
	S paradoxum Meyen ex Ralfs	–			s
	Staurastrum sp	?		+	s
Genus	Cosmanum Corda, 1835 ex Ralfs				
	Cosmanum sp	?		+	s

Comments m - most significant, us - usual, s - insignificant Blanks in columns 3, 4 - controversial or insufficient data In brackets synonyms are given

Notes

1 In phytoplankton samples we observed only solitary cells, similar m form and size to C *hamifotrtiis* (Kondratyeva *et al* 1984, 164, Fig 44) and did not find two-four cellular colonies typical of the genus Some cells were spiral-shaped Probably, they are large bacteria

2 Colonies are mucoid, shapeless, cells are ball-shaped Colonial mucus is colourless, homogeneous, soft Cells are without gaseous vacuoles, pale bluegrcen, their diameter is 0 8-1 0 mkm In colonies cells are arranged in loose straight or wavy striae In a stria cells close in pairs rare single arranged more or less uniformly In preservation samples colonies come to the surface and join in mucoid, colourless strands visible by eye Species planktomc, free-living Attains mass development m August, numbers 10-100 10^6 cell 1 ' Species morphology is in good agreement with Cyanobactena

3 These species were described by Antipova (1955)

4 The species was described in 1971 (Popovskaya, 1971)

5 The list of species of this genus are given according Genkal & Popovskaya (1987)

6 In literature on phytoplankton in Lake Baikal this alga was referred to as *S binderanus* (Kutz) Kneg (= *Meloura bindeiana* Kutz)

7 The species was described in 1992 (Makarova & Pomazkma, 1992)

8 The species was described in 1993 (Flower, 1993)

9 *C baicalensis* f *mmuta* as an independent species was described by Antipova (1956b) Genkal & Popovskaya (1990) extended the diagnosis of this species and included f *ornata* and morpha *minor* into it

10 It is shown (Kozhova & Kobanova, 1995) that the ultrastructure of vegetative valves of the pelagic population *A islcindica* differs significantly from that of valves of the coastal-sor population described b> Genkal & Popovskaya (1991) Taxonomic characters of the pelagic population are considerably beyond the limits of a species diagnosis The pelagic population deserves an independent taxonomic status at least at a level of a form or even of a species

11 It was found m large amounts under ice in March, 1992 (Kozhova & Kobanova, 1994)

12 The species is discovered in lakes and ponds of Slovakia and Bohemia in lakes in Austria (Hindak, 1988) Inhabits Lake Khubsugul (Hindak & Zagorenko, 1992) For Baikal it is mentioned for the first time Vegetates in mass in July, August

13 Systematic position of species of the genus *Monoraphxdium* is established according Komarkova Legnerova (1969) and Hindak & Zagorenko (1992)

14 The alga was first described by Nigaard G (1977) from the lakes of Denmark In Lake Baikal the alga was described in 1982 (Zagorenko & Kobanova, 1982) Recently we have found one more taxon - f *tenuis* Nigaard (Nigaard 1977)

List of BOTTOM ALGAE species. Compiled by L.A. Izhboldina

	Species and subspecies	Endemic or not	Open Baikal	Coastal-sor zone & bays	Distribution outside of Baikal	Depth, m	Bottom
Divisio	Cyanophyta						
Class	Chrootoccophyceac						
Family	Microcystidaceae						
Genus	Microcystis						
	Microcystis sp	–	Regions of the big rivers inlet	+	–	1 6-102	Silted sand, silt
	M ichthyoblabe Kutz	–	WB	–	Palaearctic, India	18-25	Silt with detritus
	Aphanothece stagnina (Spreng) B Peters et Gaitl emend	–	–	+	Palaearctic, India	2-13	Silted sand, silt
Class	Hormogoneae						
Family	Nostocaceae						
Genus	Sphaeronostoc						
	Sphaeronostoc kihlmann (Lemm) Elenk	–	WB	+	Palaearctic, Greenland	3	Silted sand
	S pruniforme (Aq) Elenk	–	MB, M More	+	Palaearctic	1 5 20	Silted sand, silt
	S zetterstedtn (Aresch) Elenk	–	WB, M More	–	Palaearctic	3 5-24	Stones, silted sand
	S coeruleum (Lyngb) Elenk	–	–	+	Palaearctic	3-4	Silt
	Stratonostoc linckia (Roth) Elenk f Jmckia	–	–	+	Palaearctic	–	Silted sand, silt
	S linckia t mulare (Kutz) Elenk	–		+	Palaearctic		
	S verrucosum (Vauch) **Elenk** f verrucosum	–	All	+	Palaearctic	0 8-35	Stones, sand, silted sand
	S commune (Vauch | Elenk f sphaencum (Vauch) Elenk	–	Ushkany Islands M More	+	Palaearctic	3-5	Silted sand
Family	Scytonemataceae						
Genus	Tolypothrix						
	Tolypothrix distorta (Fl Dan) Kutz f distorta	–	All	+	Holarctic, North India	1 5-5 to 25	Stones
	T distorta f pemcillata (Ag) Kossinsk	–	MB, NB	+	Holarctic, North India	1 2-9	Stones
	T helicophila Lemm	–	SB			1 25	Stones
	T limbata Thur	–	All	+	Cosmopolitan	2-5	Stones
	T tenuis Kutz t polymorpha (Lemm) Kossinsk	–	–	+	Palaearctic		
Family	Rivulanceac						
Genus	Calothrix						
	Calothnx braunn Born et Flah f braunn	–	SB	–	Palaearctic, India, EAGL	2 15	Stones
	C kawraiskn Schmiedle	–	–	+	Palaearctic		On underwater subjects

Continuation oflist of BOTTOM ALGAE species

	Species and subspecies	Endemic or not	Open Baikal	Coastal-sor zone & bays	Distribution outside of Baikal	Depth m	Bottom
	C panetina (Nag) Thur f panetina	–	All	–	Palaearctic	2-10	Stones
	C stcllans Born et Flah	–	–	+			
	C kossinskajae V Poljansk	–	NB	–	Palaearctic	0 8-7	Stones
	Cdlorhnx sp	–	AN	–	Palaearctic	1 5<S	Stones
Genus	Gloeotnchia						
	Gloeotrichia pisum (Ag) Thur	–	Regions of the big; rivers inlet	+	Holarctic	2-100	Silted sand, silt
Ordo	Oscillatonales						
Family	Oscillatonaceae						
Genus	Oscillatona						
	Oscillatona amoena (K.utz) Gom	–	Alt	–	Palaearctic, India	0 5-10	Stones
	O lacustns (Kleb) Geitl	–		+	Palaearctic, India	-	In brushwood of higher aquatic plants
	O sancta (Kutz) Gom	–	M More	–	Palaearctic, India EAGL	–	
	O splendida Grev	–	SB	–	Holarctic, EAGL	–	
	O tenuis Aq	–	NB	+	Holarctic, EAGL	5	Silted sand
	Oscillatona sp 1	–	NB SB	–	–	02-10	Stones
	Oscillatona sp 2	–	*\U*	–	–	0 5-30	Stones among thalloms of green algae
	O formosa Bory *ex Gom*	–	SB, Ushkany Islands	–	Palaearctic EAGL	-	-
	O hmosa Gom	–	–	+	Palaearctic EAGL	-	-
Genus	Phormidium						
	Phonnidium jmindatiim Kutz ex Gom	–	WB	–	Palaearctic, EAGL	2 18	Stones
	Ph papyraceum Gom	–	SB	–	Palaearctic, EAGL	-	-
	Ph purpurasceus {Kutz) Gom	–	Olkhon Island	–	Palaearctic, India	-	-
	Ph ambiguum Gom	–	–	+	Palaearctic India, EAGL	1 5	Stones
	Ph crouann Gom	–	NB	–	Cosmopolitan	3-5	Stones
	Ph uncinatum (Ag) Gom	–	MB NB	–	Cosmopolitan	2-23	Stones pebbles sand
	Ph conum Kut7 ex Gom	–	NB western shore	–	Palaearctic EAGL	2 5	Silted sand chara s algae
Genus	Lyngbya						
	Lyngbya aestuani Liebm ex Gom	–	All western shores	–	Palaearctic EAGL	15-25	Silted sand
	L major Menegh	–	MB western shore, M More	–	Palaearctic	10-20	Silted sand

Continuation of list of BOTTOM ALGAE species

	Species and subspecies	Endemic or not	Open Baikal	Coastal-sor zone & bays	Distribution outside of Baikal	Depth, m	Bottom
Family	Schizothrichaceae						
Genus	Schi70thrix						
	Schizothrix sp	–	AH	–	–	1-10	Stones, among thalloms of other algae
Genus	Microcoleus						
	Microcoleus subtorulosus (Breb) Gom	–	NB western shore	–	Palaearctic	–	
	M. baicalensis Ischb.	+	All	+	–	8-89	Silted sand, silt, silt with detritus
DiviSio	Chrysophyta						
Class	Chrysocapsmeae						
Ordo	Chrysocapsales						
Family	Chrysocapsaceae						
Genus	Tetrasporopsii,						
	Tetrasporopsis reticulata C Meyer	+	All	–	–	1-15	Stones, on chara'b algae and higher aquatic plants
Ordo	Hydrurales						
Family	Hydmraceae						
Genus	Hydrurus						
	Ffydrurus foetidus Kirchn	–	SB in regions of the big nvevs inlet	–	Cosmopolitan	0.5-1	Stones
Divisio	BacillarJophyta						
Class	Pennata?						
Ordo	Raphinales						
Family	Naviculaceae						
Genus	Didymosphema						
	Didymo^phenia gemtnata (Lyngb j M Schmidt.	–	Ail	–	Cosmpolitan	0.3-5	Stones
	D, dentata (Dorogostaisky) Skv	+	All	–	–	0 3-5	Stones
Genus	Gornphonema						
	Gomphonema quadnpunc*tatum* (Oestr.) Wisl var baicalensc Skv	–	All		Palaearctic	[5 S	Stones
DlMSlO	Chlorophyta						
Class	Chlorophyceae						
Ordo	Tetrasporales						
Family	Tetrasporaceae						
Genus	Tetraspora						
	Tetraspora lubnca (Roth) Ag.	–	MB	–	Palaearctic	1-2	Stones
	T cyhndrica (Wahienb) Ag var, bullosa C. Meyer	+	AH	–	–	1-10	Stones
Class	Ulotiicliophyceae						
Ordo	Ulotnchales						

Continuation of list of BOTTOM ALGAE species

	Species and subspecies	Endemic or not	Open Baikal	Coastal sor zone & bays	Distribution outside *of* Baikal	Depth, m	Bottom
Famıly	Ulotnchaceae						
Genus	Ulothnx						
	Ulothnx zonata (Web et Mohr) Kutz	-	All	–	Cosmopolitan	0-4	Stones
	U tenuissima Kutz	-	All	–	Palaearctic	1-1 5	Stones
Famıly	Chactophoracca						
Genus	Stigeoclonium						
	StigeocIonium tenue (Ag) Kutz	-	SB		Cosmopolitan	0 5-2	Stones
Genus	Draparnaldia						
	Draparnaldia plumosa (Vauch) Aq	-	-	+	Cosmopolitan	-	–
	D glornerata (Vauch) Ag	-	-	Inlet of mer B Koty	Cosmopolitan	1 5	Stones
Genus	Myxonemopsis	+					
	Myxonemopsis crassimembranaceae C Meyer	+	WB, Ushkany Islands	–	–	2 5-10	Stones
Genus	lreksokonia	+					
	Ireksokonia formosa C Meyer	+	All	–	–	2 5-15	Stones, thalloms of chara s algae
Genus	Draparnaldioides	+					
	D simplex C Meyer et Skabitsch	+	*Ml*	–	–	2 5-15	Stones, rocks, thalloms of chara's algae
	D simplex f tnfurca C Meyer	+	M More	Chivyrkui Gulf	-	2 5 5	Stones, thalloms of chara's al gae
	D simplex f pentafurca C Meyer	+	MB	–	–	*2* 5-5	Stones
	D goroschankinu C Meyer et Skabitsch	+	All	–	–	2 5-15	Stones
	D goroschankinu f plumosa C Meyer	~	NB, SB. M More	–	–	2 5-5	Stones
	D arenana C Meyer et Skabitsch	+	All	–	–	3-7	Stones
	D arenana *f* plumosa C Meyer	+	M More	–	–	4-7	Stones
	D arnoldn C Meyer et Skabitsch	+	All	–	–	1 5-10	Stones, rock
	D pumila C Meyer et Skabitsch	+	All	–	–	1-3	Stones
	D pilosa C Meyer et Skabitsch	+	All	–	–	1 5-5	Stones
	D vilosa C Meyer et Skabitsch	+	Ml	–	–	1 5-3 5	Stones on the sand
	D haicalensis C Meyer et Skabitsch	+	SB, MB along western shore, east shore of Ushkany Islands	–	–	1 5-6 0 to 15	Stones, rock

Continuation of list of BOTTOM ALGAE species

	Species and subspecies	Endemic or not	Open Baikal	Coastal-sor zone & bays	Distribution outside of Baikal	Depth, m	Bottom
	D lubnca C Meyer et Skabitsch	+	All	–	–	1 5-5	Stones
Class	Siphonocladophyceac						
Ordo	Cladophorales						
Famıly	Cladophoraceae						
Genus	Gemmiphora	+					
	Gemmiphora compacta Skabitsch	+	All	–	-	1 5-12 0	Cracks of *'Mz* stoves
Genus	Cladophora						
	Cladophora glomerata (L) K.utz var glomerata	–	A!!	–	Cosmopolitan	1-5	Stones
	C glomerata var crassior (Ag) Hoek	–	SB	–	Cosmopolitan	3	Stones
	C fracta (Mull ex Vahl) Kutz var fracta	–	–	+	Cosmopolitan	25-15 to 30	Silted sand, brushwood of chara's algae
	C floccosa C Meyer var floccosa	–	All	+	Khubsugul	2 5-35	Stones, silted sand
	C floccosa C Meyer var irregularis Skabitsch	–	All	+	Khubsugul	1 5-40	Stones, silted sand
	C compacta (C Me>ei) C Meyer	+	All	–	–	1 0-20 to 70	Stones, rock
	C pulvinata (C Meyer) C Meyer	+	All	–	–	1 5-50	Coarse-grained sand, pebbles in ihe sand
	C globulus C Meyer	+	MB NB	+	-	10	Silted sand, stones
	C meyen Skabitsch	+	All	Chivyrkui Gulf	–	3-67	Coarse-grained sand, silted sand
	C meyen Skabitsch var gracihor (C Meyer) Hollerb	+	All	+	–	2-30	Silted sand
	C kursanovn Skabitsch	+	All	+	–	1 5-60	Stones, coarse-grained silted sand
	C kusnetzown C Meyer	+	M More	+	-	3-25	Silted sand, silt
	C aegagropila (L) Rabcnh	–	–	+	-	3-60	Silt, silted sand
Genus	Chaetomorpha						
	Chaetomorpha baicalensis C Meyer	+	SB. MB, western shore M More, Ushkany Islands	–	–	1 5-16	Silted sand
	Ch moniliformis Skabitsch	+	MB, NB	–	–	6-35	Stones, sand

Continuation of list of BOTTOM ALGAE species

	Species and subspecies	Endemic or not	Open Baikal	Coastal-sor zone & bays	Distribution outside of Baikal	Depth, m	Bottom
	Ch curta Skabitsch	+	All	NB	–	15-116	Coarse sand, pebbles, gravel, silted sand
	Ch sohtana Skabitsch	–	All	NB	Khubsugul	10-60	Silted sand, pebbles, gravel
Genus	Chaetocladiella						
	Chaetocladiclla pumila (C Meyer) C Meyer et Skabitsch	+	All western shore, Ushkany Islands, Svyatoi Nos Pennunsula	–	–	1-7 to 23	Stones
	Ch microscopica (C Meyer) C Meyer et Skabitsch	+	All	NB	–	12-40	Silted sand, coarse sand
	Ch litorahs Skabitsch	+	SB	–	–	0 5-0 75	Stones
Genus	Rhizoclomum						
	Rhizoclomum sp	–	-	+	–	1 5-38	Silted sand, chara's algae
Divisio	Charophyta						
Class	Charophyceae						
Ordo	Charales						
Family	Nitellaceae						
Genus	Nitella						
	Nitella flexilis (L) Ag var flexilis	-	SB western shore	–	Cosmopolitan	3 20	Silted sand, silt
	Nitella opaca (Bruz) Ag	–	SB	–	Cosmopolitan		
	Nitella sp	-	All western shore	+	–		
Family	Characeae						
Genus	Chara						
	Chara fragifera Duneu	-	M More	NB	Palaearctic	1 5-16	Silted sand
	Chara sp	-	—	+		1 5-3	Silted sand, silt, fine sand
Divisio	Rhodophyta						
Class	Flondeophyceae						
Ordo	Nemahales						
Family	Batrachospermaceae						
Genus	Batrachospermum						
	Batrachospermum mohmforme Roth	–	-	+	Cosmopolitan	I 5-2 0	
	B vagum (Roth) Ag	–	-	+	–	–	

Comment SB - south Baikal, NB - north Baikal, MB - middle Baikal, WB - western shore of Baikal, EAGL - East African Graet Lakes

Remark only 3 species of bottom diatoms are cited here, the list is expected to be much more extensive

List of HIGHER WATER PLANTS species. Compiled by M.G. Azovsky

	Species and subspecies	Frequency	Distribution	Depth	BiococnotiL role
Mosses					
Famil}	Amblystcgiaceae				
	Calliergon giganteum (Schimp) Kindb	r	Holarctic	Shallow	Assectator
	Hydroamblystegium tenax (Hedw) Jenn	r	Holarctic	Shallow	Assectator
	Lcptodictium npanum (Hedu) Warnst	r	Cosmopolitan	Shallow	Assectator
	Scorpidium scorpioides {Hedw '.) Limp	r	Holarctic	Shallow	Assectator
Family	Fontinalaceae				
	Fontmahs antipvretica Hedw	r	Cosmopolitan	Shallow	Assectator
	F mtida Lmdb et Am	r	Cosmopolitan	Up to 50 m	Assectator
Family	Ricciateae				
	Ricciocarpus natans (L) Corda	very r	Cosmopolitan	Drifts on the water surface	Assectator
Ferns					
Famiiv	Isoetaceae				
	lsoetes echmospora Duneu	\cty *i*	Eurosib\re an	Shallow	Assectator
Family	Spargamaceae				
	Spargamum gramineum Georgi	us	Euroasian	Shallow	Assectator
Flowering plants					
Family	Potamogetonaceae				
	Potamogcton alpinus Balb ssp tenuitohus (Raf) Hulten	r	Asia North America	Shallow	Assectator
	P berchtoldn Fieb	r	Holarctic	Shallow	Assectator
	P crispus L	r	Holarctic	Shallow	Assectator
	P compressus L	us	Holarctic	Shallow	Assectator
	P filiformis Pcrs	r	Holarctic	Shallow	Assectator
	P fnesii Rupr	r	Holarctic	Shallow	Assectator
	P gramineus L	us	Holarctic	Shallow	Dominant
	P lucens L	r	North Africa	Up to 5 m	Dominant
	P mddckianus A Benn	r	East Asia	Up to 6 m	Assectator
	P natans L	r	Holarctic	Shallow	Assectator
	P obtusifohus Mert et Koch	r	Holarctic	Shallow	Assectator
	P pectinatus L	us	Cosmopolitan	Up to 15 m	Dominant
	P periohatus L	us	Cosmopolitan	Up to 7 m	Dominant
	P praelongus Wulf	r	Holarctic	Up to 4 m	Assectator
	P pusillus L	r	Holarctic	Shallow	Assectator
	P vaginatus Turcz	us	Holarctic	Up to 4 m	Dominant
Family	Zanmchelliaceae				
	Zanmchellia palustns L	r	Cosmopolitan	Shallow	Assectator
Family	Najadaceac				
	Caulinia flexihs Willd	r	Holarctic	Shallow	Assectator
	Najas manna L	very r	Cosmopolitan	Shallow	Assectator
Family	Ahsmataceae				
	Sdgittana natans Pall	r	Euroasian	Shallow	Assectator
Family	Butomdceae				
	Butomus umbellatus L	r	Euroasian	Up to 4 m	Assectator
Farm ly	Hydrochantai-eae				
	Elodea canadensis Michx	us	Cosmopolitan	Up to 1 ^ m	Dominant
Famiiv	Lemnaceae				
	Lemna minor L	r	Cosmopolitan	Drifts on the water surface	Assectator

Continuation of list of HIGHER WATER PLANTS species

	Species and subspecies	Frequency	Spread	Depth	Biocoenotic role
	L tnsulca L	us	Cosmopolitan	up to 30 m	Dominant
	Spirodela polyrrhiza (L.) Schleiden	us	Cosmopolitan	Drifts on the water surface	Sporadic
Famıly	*Polygonaceae*				
	Polygonum amphibium L.	us	Holarctic	Shallow	Dominant
Famıly	Nymphaeaceae				
	Nymphaea tetragona Georgi	-t	Holarctic	Shallow	Assectator
	Nuphar pumila (Timm) DC	-1	Euroasian	Shallow	Assectator
Famıly	Ceratophyllaceae				
	Ceratophyllum demersum L	*I*	Holarctic	Up to 6 m	Dominant
Famıly	Ranunculaceae				
	Batrachium *circwatum* (Sith) Spach	*us*	Euroasian	Up to 4 m	*Codommant*
	B. tnchophyllum (Chaix) Bossche	us	Holarctic	Up to 15 m	Dominant
	Ranunculus reptans L.	r	Holarctic	Shallow	Assectator
Famıly	Brassicaceae				
	Subulana aquatica L	very r	Holarctic	Shallow	Sporadic
Famıly	Crassulaceae				
	Tillaea aquatica L	very r	Holarctica	Shallow	Sporadic
Famıly	Callitnchaceae				
	Callitnche hermaphroditica L	r	Holarctica	Shallow	Assectator
	C verna L.	r	Cosmopolitan	Shallow	Assectator
Famıly	Elatinaceae				
	Elatine hydropiper L	very r	Eurosibirean	Shallow	Sporadic
Famıly	Haloragaceae				
	Mynophyllum spicatum L	us	Cosmopolitan	Up to 11 m	Dominant
	M. verticillatum L	r	Cosmopolitan	Up to 4 m	Assectator
Famıly	Hippundaceae				
	Hippuns vulgaris L.	r	Holarctic	Shallow	Assectator
Famıly	Menyanthaceae				
	Nymphoides peltata (S.G Gmel.) O. Kuntze	r	Euroasian	Shallow	Dominant
Famıly	Lentibulanaceae				
	Utnculana intermedia Hayne	r	Holarctic	Shallow	Sporadic
	U. minor L	r	Holarctic	Shallow	Sporadic
	U vulgaris L	r	Holarctic	Shallow	Assectator

Comment[1] t - tare, us - usual.

List of SPONGIA species. Compiled b> S.M. Efremova

	Species and subspecies	Endemic or not	Open Baikal	Coastal-sor zone & bays	Depth, m	Bottom	Forms and colours of colonies
Family	Lubomirskudae Rezvoi, 1936						
Genus	Lubomirskia Dyb 1880						
	Lubomirskia baicalensis (Pallas, 1776)	+	+	–	1-50	Rocks, rocks-sand	At depths from 1 to 6 m forms bark-like overgrown colonies At depths from 3 to 50m the shape of colonies is branchy, comb-shaped, fan-shaped Colour-bngh-green, emerald
	L fusifera Soukatschoff, 1895	+	+	–	4-50	Rocks, rocks-sand	In contrast to L baicalensis, L fusifera at great depths does not form branchy colonies Colour-green
	L abietma (Swarczewsky, 1901)	+	+	–	20-60	Rocks-sand	Bark-like colonies Colour-green
Genus	Baicaiospongia Annandale, 1914						
	Baicalospongia bacillifera (Dybowsky, 1880)	+	+	–	2-530	Rocks, silt with stones	Bark-like and massive colonies, often tuben-form Colour-green
	B uxtamwtdAa (Dybowsky, 1&SQ>	+	+	–	1-900	Rocks. silt with stones gidvel	Back-Like CaLam:- from green to brownish
Genus	Swanschewskia Makuschok, 1927						Bark like colonies, forming papilhform out-growth resembling "caps"with osculum at the apex Colour-whitish or cream
	Swartschewskia papyracea (Dybowsky, 1880)	+	+	–	1-80	Rocks	

List of TURBELLARIA species. Compiled after Porfierieva, 1977; Porfierieffl & Timoshkin, 1989a,b; Timoshkin, 1985; 1986; 1990

	Species and subspecies	Endemic or not	Open Baikal	Coas-tal-sor zone & bays	Distribution outside of Baikal	Depth in m	Bottom
Ordo	Maerostomida						
Family	Macrostomidao						
Genus	Macrostomum						
	Macrostomum aunculatiim Nassonov, 1935	+	SB, MB	–	–	2-5	Stones, overgrowing algae
Ordo	Lecithoepithehata						
Family	Prorhynchidae						
Genus	Prorhynchus M Schultze, 1851						
	Prorhynchus stagnahs stagnalis M Schultze, 1851	–					
	P baicalensis Tim, 1990	+					
Genus	Gcoccntrophora do Man, 1876						
	G. mtersticialis Tim , 1984	+	All	–	-		Sand, interstitial
	G olgae Tim, 1990	+	SB			10	Stones
	G. incognita Tim et Sabr , 1984	+	SB	–	-	7	Stones
	G wasiliew Tim , 1990	+	SB	–	-	5	Stones
	G wagini Tim , 1984	+	MB, NB	–	-	5-120	Sand
	G porfinevae Tim et Sabr 1984	+	All	–		0 3-50	Stones
	G levanidorum Tim., 1984	+	MB, NB	–	-	2-50	Stones
	G gigas Tim , 1984	+	NB	–	-	10-25	Stones
	G sphyrocephala de Man, 1876	–	–	–	Mountain rivers of South Pnbaikalye		
Ordo	Prolccilhophora						
Family	Protomonotrcsidac						
Subfam	Bafcar'arcTrnae	+					
Genus	Baicalarctia Friedman, 1926	+					
	Baicalarctia gulo Friedman, 1926	+	MB, SB	–	–	25-1300	S\U with detritus
Genus	Fnedmamella Tim et Sab, 1985	+					
	Fricdmaniclla rufula Tim. et Sab, 1985	+	MB	–	–	50-100	Silty sand with detritus
	F alba Tim et Sab, 1985	+	SB, MB	–	–	3-4	Stones with overgrowing
	F minima Tim et Sab , 1985	+	SB	–	–	3 5	Stones with overgrowing
Ordo	Seriata						
Subordo	Tncladida						

Continuation of list of TURBELLARIA species

	Species and subspecies	Endemic or not	Open Baikal	Coas- tal- sor zone & bays	Distribution outside of Baikal	Depth in m	Bottom
Family	Dendrocoehdae						
Genus	Archicotylus Korotncff, 1912	+					
	Archicotylus decoioratus Kor., 1912	+	SB, MB M More	–	Angara	2-18	Stones
	A. elogatus Kor., 1912	+	SB, MB	+	Angara	7-17	Sand, silted sand
	A. stnngulatus Kor, 1912	+	SB	–	Angara	2-8	Stones
	A junca Kor., 19J2	+	SB	–	–	4-120	Rock, *stones,* silted sand, Sill
	A. rubzovi Porf, 1977	+	SB	–	–	3-20	Stones
	A parvipunctatus Kor, 1912	+	All	–	-	2-20	Stones
	A planus (H Sab, 1913)	+	All	+	—	4-70	Silted sand, silt
Genus	Armilla Livanov, 1961	+					
	Armilla livanovi (H Sab, 1913)	+	All	–	–	1-42	Stones
	A pardalina (Grube, 1872)	+	SB	–	–	10-150	Stones, pebbles, silted pebbles
Genus	Papilloplana Kenk, 1974	+					
	Papilloplana leucocephala (II Sab, 1903)	+	All	–	Angara	2-25 (525)	Stones, rocks
	P gnsea (H Sab, 1903)	+	MB., NB	–	Angara?	6-40	Stones, rocks
	P zebra (Grube, 1872)	+	MB	+	Angara"	I 8-2, 21	Stones, silt sand
Genus	Hyperbulbina Livanov et Porfineva, 1962	+					
	Hyperbulbina bifasciata {H Sab, 1903)	+	SB, MB	–	–	1 5-50	Stones, silt
	H grubei (H Sab, 1903)	+	All	–	—	2-300	Stones, sand. Silt
	H dybovskyi (H Sab., 1903)	+	NB, MB	–	-	14-70	Sand, silt
	H bekmanae Porf, 1977	+	SB	–	-	400-600	Sand with silt
	H nana Porf, 1977	+	SB	–	-	60	Sand
Genus	Alaoplana Kenk, 1974	+					
	Alaopiana sublanceolata (Liv. et Porf., 1964)	+	SB, M. More	-	Angara	I -400	Stones, silt
	A lanccolata (Grube, |&72)	+	SB	+	—	5-65	Silt with detritus and algae
Genus	Hypcrpapillina Porf, 1973	+					

Continuation of list of TURBELLARIA species

	Species and subspecies	Endemic or *not*	Open Baikal	Coas-*tal*-sor zone & bays	Distribution *outside* of Baikal	Depth in m	Bottom
	HyperpapiJIma graffi *(H* Sab. 1903)	+	SB, MB M More	+	_?	J5-23{	Silt
	H. ocellata (Kor, 1912)	+	M More Ushkany Islands	+	–	1-14 (110)	Stones
Genus	Bdellocephala Dc Man, 1875						
	Bdcllocephala angarensis angarensis (Gerstf, 1858)	+	All?	+	Angara, Yenisei	1 5-2 (20)	Stones
	B angarensis olivacea (Kor, 1912)	+	SB, MB	+	-	1 5-2	Stones
	B a. melanocmerea (Kor, 1912)	+	Chivyrkui	+	-	1 5-2	Stones
	B a bathyalis Tim ct Porf, 1989	+	SB	-	-	610-770	Silted sand
	B. baikalcnsis baikalensis (H Sab, 1903)	+	All	-	-	[-70	Stones
	B b subniger			-	Angara		
Genus	Rimaccphalus H. Sab, 1901	+					
	Rimacephalus pulvinar (Grube, 1872)	+	All	+	–	8-100 (795)	Stones, silt
	R. arecepta arecepta Porf, 1969	+	SB	+	-	50-286 (877)	Silt
	R a depigmentata Por et Tim, !9KI	+	MB	-	-	570-610	
Genus	Baikaloplana Berg, 1925						
	Baikaloplana valida valida (Kor., 1912)	+	SB, MB	-	-	250-600 (40)	Silted sand, silt, rocks
	B valida bathybia I im. et Porf, 1989	+	MB	-	-	800-1300	Silted sand
Genus	Baikalocotylus Porf, 1977	+					
	Baikdloeorylus limnosus Porf, 1977	+	MB, MB, M. lvlore	-	-	3-30	Sand wrth pebbles, stones
Genus	Atria Porf, 1970	+					
	Atria kozhowi Porf., 1970	+	SB, MB	-	-	2, 5-360	Stones, silted sand, silt
Genus	Sorocchs Grube, 1872	+					
	Sorocehs nigrofasciata (Grube, 1872)	+	All	-	-	1-200	Sand, stones
	S hepatizon (Grube. 1872)	+	AH	+	—	20-525	Silts, sill with sand or stones
Genus	Protocotylus Kor, 1908	+					
	Protocotylus flavus flavus Kor, 1908	+	SB	+	-	6-1125	Silt with sand
	P fabissorum Tim, et Por, 1989	+	M vlore	–	–	800-1300	

Continuation of list of TURBELLARIA species

	Species and subspecies	Endemic or not	Open Baikal	Coas-tal-sor zone & bays	Distribution outside of Baikal	Depth in m	Bottom
	P fungiforms (H Sab., 1903)	+	SB, MB, M More	–	-	10-625	Silts with sand
	P magnus (Kor, 1912)	+	MB, M. More	–	-	1150	Silt
Genus	Baikalobia Kenk, 1930	+ -					
	Baikalobia guttata (Gerstf., 1858)	+ -	All	+	Angara, its reservoirs. Yenisei	0-20 (70)	Stones
	B copulatnx (Kor, 1912)	+ -	All	+	Angara, its reservoirs, Him	1.5-5 (25)	Stones
	B vanegata (Kor, 1912)	+	All	–	-	0-5 (20)	Stones
	B raddei (H. Sab, 1912)	–	–	–	Angara	0-1	Stones
Ordo	Neorhabdocoela						
Subordo	Typhloplanoidd						
Family	Typhloplamdae						
Genus	Mesostoma Ehrenberg, 1835						
	Mcsostoma vivipara Tim, 1985? (need to be investigated)	+	NB	–	–		Coastal plants
Genus	Castrada O Schmidt, 186!						
	Castrada baicalensis Nas, 1935	+	SB	–	–	?	?
Subordo	Dalyelloida						
Family	Provorticidae						
Genus	Baicalellia Nassonov, 1930						
	Baicalcllia baicali baicali Nas, 1930	+	MB	–	–		Coastal plants
	B b fasciata	+	MB	–	–		Coastal plants
	B b bicornis	+	MB	–	–		Coastal plants
	B albicaudata Nas, 1930	+	SB	–	–	1-3	Stones
	B nigrofasciata Nas., 1930	+	SB	–	–		Coastal plants
	B petlucida pellucida Nas , 1930	+	SB, MB	–	–	2-21	Stones
	B. p coerulea Nas, 1930	+	SB, MB	–	–	2-21	Stones
	Bp.nigra Nas, 1930	+	SB, MB	–	–	2-21	Stones
	B ocellata Nas, 1930	+	SB	–	–	5-60	Stones, sand
Subordo	Katyptorhynchia						
Family	Koinocystididae						
Genus	Dyplosyphon Evdonin, 1977						
	Dyplosyphon baicalcnsis (Rubzov, 1929)	+	All		–	12-80	Stones with

Continuation of list of TURBELLARIA species

	Species and subspecies	Endemic or not	Open Baikal	Coastal-sor zone & bays	Distribution outside of Baikal	Depth in m	Bottom
							overgrowing, sand
	D livanovi Tim , 1986	+	SB		–	2-3	Stones with overgrowing
	D tetrastylus Tim , 1986	+	SB		-	2-3	Stones with overgrowing
	D beckmanac Tim , 1986	+	SB, MB		-	2-3	Stones, with overgrowing
	D macrorhynchus Tim, 1986	+	MB		–	100	Silt, sand
	D ninae Tim, 1986	+	NB		–	25	Detritus
	D microstylus Tim , 1986	+	NB		-	25	Detritus
Family	Polycystididae						
Genus	Opisthocystis Sekera, 1912						
	Opisthocystis angarensis (Sibir , 1929)	–	All	+	Angara	0 5-20	Stones
	O sdbussovi Tim , 1986	+	SB, MB	–	–	3-40	Stones with overgrowing, sand with detritus
	O curvistylus Tim , 1986	+	SB, MB	-	-	0 3-3	Stones
	O pcdistylus Tim , 1986	+	NB	-	-	28	Sand with stones
	O abbyssalis Tim, 1986	+	MB	-	-	690-720	Silt
	O canottus Tim, 1986	+	NB	–	–	100	Coarse sand, rock", rarely stones
Genus	Gyratnx Ehrenberg, 1831						
	Gyratnx hermaphroditus Ehrenberg, 1831	–	All	–	–	1-30	Stones

Comment SB - south Baikal, NB - north Baikal, MB - middle Baikal, M More Maloye More

List of NEMATODA species. Compiled by S.Ya. Tsalolikhin & A.V. Shoshin

	Species and subspecies	Endemic or not	Open Baikal	Coastal-sor zone & bays	Distribution outside of Baikal	Habitat	Bottom
Class	Nematoda						
Ordo	Enoplida						
Family	Tobnlidae						
Genus	Tobnlus						
	T bckmanae Tsalohcbm, 1975	+	+	–	-	SA, A	Silt
	T amabihs Tsalolichin, 1974	+	+	–	+	L	Sand
	T incognitus Tsalolichin, 1972	+	+	–	-	L	Sand
	T latcns Tsalolichin, 1974	+	+	–	-	L	On sponges
	T macramphis Tsalolichin, 1977	+	+	–	-	A	Silt
	T undophylus Shoshin, 1988	+	+	–	-	L	Sand
Genus	Futobrilus						
	E anguiculus {Tsalolichin, 1977)	+	+	–	+	SL, SA, A	Silt
	E selengaensis (Tsalolichin, 1977)	+	+	–	+	L, !SL	Sand
	E fortis (Tsalolichin, 1972)	+	+	–	-	L, !3L	Sand
	E affectiosus Shoshin, 1988	+	+	–	-	L	Sand
	E assimulatus Shoshin, 1988	+	+	–	—	L	Sand
	E differtus Shoshin, 1988	+	+	–	-	L	Sand
	E prodigiosus Shoshin, 1988	+	+	–	-	L	Sand
	E peregrmator Tsalolichin, 1983	+	+	+	+	L	Sand
Genus	Paratnlobus						
	P grandipapilloides Micoletzky, 1922	–	+	–	+	L	Sand
	P expugnator (TsaloliLhin, 1976)	+	+	+	–	L, iiL, SA., A	Silt
	P brcvis (Tsalolichin, 1976)	+	+	–	-	SL, SA, A	Silt
Genus	Quasibnlus						
	Q nannostomus Tsalolichin, 1976	+	+	–	-	SA, A	Silt
Genus	Lamuama						
	L onentalis Tsalolichin, 1976	+	+	–	-	A	Silt
Genus	Kunkania						
	K. sibinca Tsalolichin, 1976	+	+	–	–	A	Silt
	K tsalolichim, Shoshin, 1991	+	+	–	-	L	Sand
Genus	Mesotobnlus						
	M ultimus (Tsalolichin, 1977)	+	+	+	–	L	Sand
	M dehcatus Shoshin, 1988	+	+	–	–	L	Sand
Genus	Asperotobnlus						
	A asper Shoshin, 1991	+	+	–	–	L	Sand
Family	Tnpylidac						
Genus	Tnpjla						
	T d>bowskyi Tsalolichin, 1976	+	+	–	+	A	Silt
	T fihpje\i (Althen, 1972)	—	+	–	+	L	Sand
Ordo	Mononchida						
Family	Mononchidae						
Genus	Mononchus						
	M niddensis Skwarra, 1921	–	+	–	+	L	Sand
Genus	Tcctonchus						
	T absconditus Tsalolichin, 1974	–	+	–	+	L	On sponges
	T chingishan Tsalolichin, 1975	+	+	–	–	L, SL, SA., A	Silt
	T machairodus Tsalolichin, 1975	+	+	–	–	A	Silt
	T kirjanovae Tsalolichin, 1975	+	+	+	–	SL, SA, A	Silt
Ordo	Dorylaimida						
Family	Prodorylaimidae						
Genus	Prodoryldimus						
	P kralli Tsalolichin, 1975	+	+	+	–	SL, SA, A	Silt
	P eliavdi Tsalolichin, 1977	+	+	–	–	A	Silt
	P kukuy Tsalolichin, 1977	+	+	–	–	L	Sand

Continuation of list of NEMATODA species

	Species and subspecies	Endemic or not	Open Baikal	Coastal-sor zone & bays	Distribution outside of Baikal	Habitat	Bottom
Family	Dorylamidae						
Genus	Mesodorylaimus						
	M jankowskyi Tsalohchin, 1977	+	+	–	–	**L**	**Sand**
Genus	Dorylamus						
	D stagnahs Dujardin, 1845	-	-	+	+	**L**	**Sand**
Family	Qudsianematidae						
Genus	Eudorylaimus						
	E spongiophylus Batalova, 1983	+	+	–	–	L	On sponges
Family	Ironidae						
Genus	Ironus						
	I tenuicaudatus de Man, 1886	-	-	+	+	**L**	**Sand**
Ordo	Monhystenda						
Family	Monhystendae						
Genus	Monhystera						
	M paludicola de Man, 1881	-	+	–	+	**L**	**Sand**
Ordo	Chromadonda						
Family	Ethmolaimidae						
Genus	Ethmolaimus						
	E pratensis de Man, 1880	-	+	–	+	**L**	**Sand**
Ordo	Araeolaimida						
Family	Axonolaimidae						
Genus	Domorganus						
	Dacutus (Tsalohchin, 1977)	+	+	–	–	**L**	**Sand**
Ordo	Rhabditida						
Family	Diplogastendae						
Genus	Koernena						
	K bajcalensis *(Tsalohchin,* 1972)	+	+	–	–	**L**	**Sand**
	Kiupaia Shoshm, 1989	+	+	–	–	**L**	**Sand**
	Kpantolaba Shoshin, 1989	+	+	–	–	**L**	**Sand**
	Kmordax Shoshin. 1989	+	+	–	–	**L**	**Sand**
	Kregia Shoshin, 1989	+	+	–	–	**L**	**Sand**
Family	Diplogasteroididae						
Genus	Goffartia						
	G praepilata Shoshin, 1989	+	+	–	–	**L**	**Sand**

Comment L - Littoral, SL - Sublittoral, SA - Supra-abyssal, A - Abyssal

List of NEMATODA, MERMITIDAE species. Compiled by M.Yu. Bekman

	Species and subspecies	Endemic or not	Open Baikal	Distribution outside of Baikal	Depth, m	Bottom	Host
Genus	Abathyniermis Rubzov, 1971	–					
	Abathymermis brevicauda Rubz, 1976	+	SB	–	1-20	Rock	Unknown
	A parvula Rubz , 1976	+	SB	-	68	Silt	
Genus	Baikalomermis Rubz, 1976*	7					
	Bdikdlomermis acroporosa Rubz, 1976	+	SB	–	72	Silt	
	B okunevae Rubz, 1976	+	SB	-	30-370	Silt	
	B pusilJa Rubz, 1976	+	SB	-	30-90	*Slit*	
Genus	Gammaromermis Rubz, Bekman, 1979	+					
	Gammaroinermis baicalensis Rubz, Bekm, 1979*	+	SB	–	29-32	Silt	Amphipoda
	G cannogammari (Rubz, 1976)*	+	SB	-	28	Silt	Amphipoda
	G longicaudata Rubz, Bekm, 1979	+	SB	-	20-56	Silt, sand	Amphipoda
Genus	Gastromermis Micoletzky, 1923	–		–			
	Gastromermis acutipapillata Rubz, 1976	+	SB	–	30		
	Gaunta Rubz, 1976	+	SB	-		Silt	
	Ginflata Rubz, 1976	+	SB	-	47	Silted sand	
	G isolaterajis Rubz, 1976	+	SB	-	*3*	Rock	
	G terminahstoma Rubz, 1976	+	SB	-	16 108	Silted sand	
	G transiens Rubz, 1976	+	SB	-	350	Silt	
Genus	Hydromermis Corti, 1902	–					
	Hydromermis orbicaudata Rubz, 1976	+	SB	-	350, 360		
Genus	Lanceimermis Artyukhovsky, 1969	–					
	Lanceimermis baicalensis Rubz, 1976	+	SB	-	0 5-0 8	Rock	
Genus	Limnomermis Daday, 1911	–					
	Limnomermis acuticapitis Rubz, 1976	+	SB	–	50		
	L bekmaniae Rubz, 1976	+	SB	-	230, 240	Silt	
	L psychrophila Rubz, 1976	+	NB	-	400	Silt	
Genus	Mesomermis Daday, 1911	–					
	Mesomermis crenamphidis Rubz, 1976	+	SB	–			
	M latifasciata Rubz, 1976	+	NB	-	300	Silt	
	Mlitoralis Rubz, 1976	+	SB	-	0 3	Rock	
	M membranacea Rubz, 1976	+	SB	-	*34-300*	Silt	
	M oxyacantha Rubz, 1976	+	NB	-	300	Silt	
	M ventralis, Rubz, 1976	+	SB	-	34-59	Silt	
Genus	Paramermis Linstow, 1898	–					
	Paramermis antica Rubz, 1976	+	SB	-	90	Silt	
Genus	Spiculimermis Artjukhovsky, 1963	–					
	Spiculimermis acaudata Rubz, 1976	+	SB	–	20	Silted sand	
	S baicalensis Rubz 1976	+	**SB**	–			

Note "First placed into genus Lanceimermis (Rubtsov, Bekman, 1979)

Comment SB - south Baikal, NB - north Baikal

List of ROTATORIA species. Compiled by N.G. Sheveleva & G.I. Pomazkova

	Species and subspecies	Endemic or not	Open Baikal	Coastal sor zone & bays	Bio-coenotic role	Distribution outside of Baikal	Ecological characteristics	Habitat	Temperature diapason and/or optimum
Subclass	Eurotatona								
Ordo	Ploimida								
Family	Brachionidae								
Genus	Notholca Gosse								
	Notholca acuminata (Ehrb)	–	+	+	Nn	Cosmopolitan	P	PZ	
	N acuminata extensa (Olofs)	–	–	+	F	Holarctic	P	PZ	
	N bdicalensis Jasch	+	+	–	F		PB	L	
	N beta Kut	+	+	+	F		PB	L	
	N gaigalasi *Kut*	+	+	–	F		PB	L	
	N grandis Voron	+	+	+	D		P	PZ	1-5°C
	N intermedia Voron	+	+	+	Sd		P, Pm	PZ	1-5°C
	N jasmtskn Tikhom	+	+	+	F		PB	L	
	N kozhovi Vas et **Kut**	+	+	+	F		PB, Pm	L	
	N labis Gosse	–	–	+	F	**Cosmopolitan**	P	PZ	
	N labis hmnetica Lev	–	–	+	F	**Cosmopolitan**	P	PZ	
	N lapponica Rutt -Kol	–	–	–	F		Pm	PZ	
	N lamellifera lamellifera Vas et Kut	+	+	+	F		PB	L	
	N lamellifera determinata Vas et Kut	+	+	–	F		PB	L	
	N lamellifera jaschnovi Kut	+	+	+	F		PB	L	
	N lyrata Tikh	+	–	+	F		PB	L	
	N olehonensis olehonensis Tikh	+	+	+	F		PB	L	
	N olehonensis dcviata Vas et Kut	+	+	–	F		PB	L	
	N orbiculdta Kut	+	–	+	F		PB	L	
	N rectospina Kut	+	+	+	F		PB, Pm	L, Pm	
	N squamula (Mult)	–	+	+	Nn	Cosmopolitan	P	PZ	
	N squamula fngida Jasch	–	–	+	F	Norfh-West of Europe	P	PZ	
	N tnarthrotdes Scor	–	+	+	F	The same and USA	PB	L	
	N foliacea (Ehrb)	–	–	+	F	Cosmopolitan	P	PZ	
Genus	Keratclla Bory de St Vincent								
	Keratella cochleans (Gosse)	–	+	+	Sd	Cosmopolitan	P, Pm	PZ, Pm	
	K cochleans bdicalensis Gaig	–	+	+	Sd		P	PZ	12-15°C
	K cochleans *tccla* (Gosse)	–	–	+		In warm waters	P Pm	PZ Pm	
	K cochleans hispidd (Laut)	–	–	+	F	Cosmopolitan	P	PZ	
	K cochleans macracantha (Laut)	–	–	+	F	Cosmopolitan	P	PZ	
	K irregularis (Laut)	–	–	+	F	Cosmopolitan	P	PZ	
	K hiemalis Carl	–	–	+	F	Palacarctic	P	PZ	
	K quadrata (Mull)	–	+	+	D	Cosmopolitan	P, Pm	PZ, Pm	
	K quddrata baicalcnsis Gaig	–	+	+	D		P	PZ	

Continuation of list of ROTATORIA species

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	K quadrata frenzeli (Eckst)	–	+	+	F	Palaearctic	P	PZ	
	K valga (Ehrb)	–	+	+	F	Cosmopolitan	P	PZ	
Genus	Kelhcottia Ablstrom								
	Kellicottia longispina (Kell)	–	+	+	D	Cosmopolitan	P, Pm	PZ, Pm	12-15°C
Genus	Brachionus Pallas								
	Brachionus angulans Gosse	–	–	+	Nn	Cosmopolitan	P	PZ	
	B angulans bidens Plate	–	–	+	F	Cosmopolitan	P	PZ	
	B bennini Leiss	–	–	+	F	Cosmopolitan	P	PZ	
	B calyciflorus Pall	–	-	+	F	Cosmopolitan	P	PZ	
	B calyciflorus anuraciformis Brehm	-	–	+	F	Cosmopolitan	P	PZ	
	B calyciflorus dorcas Gosse	-	–	+	F	Cosmopolitan	P	PZ	
	B calyciflorus spinosus Wierz	-	–	+	F	Cosmopolitan	P	PZ	
	B diversicorms (Dad)	–	-	+	F	Old World	P	PZ	
	B leydign Cohn	–	–	+	F	Western Europe, China, India, USA, New Zealand	P	PZ	
	B leydign quadratus Rouss	–	–	+	F	Central European regions of Russia, Caucasus, Australia	P	PZ	
	B leydign tridentatus *Zern*	–	–	+	F	From Pnbaltic to Ukraine, Ural, Ob, Far East	P		
	B quadndentatus Herm	-	–	+	F	Cosmopolitan	P		
	B quadndentatus brevispinus Ehrb	-	–	+	F	Cosmopolitan	P		
	B quadndentatus melheni Barr et Dad	-	–	+	F	Cosmopolitan	P		
	B quadndentatus ancylognathus Schm	-	–	+	F	Cosmopolitan	P		
	B quadndentatus cluniorbiculans Scor	-	–	+	F	Cosmopolitan	P		
	B urceus (Linn)	–	+	-	F	Cosmopolitan	P	L	
	B urceus sencus Rouss	–	+	+	F	Cosmopolitan	P	L	
	B plicatilis Mull	-	–	+	F	Cosmopolitan	P	L	
Genus	Anuraeopsis Lauterborn								
	Anuraeopsis fissa (Gosse)	-	–	+	F	Cosmopolitan	P, Pm	PZ, Pm	
Genus	Platyias Hairing								
	Platyias polyacanthus (Ehrb)	–	–	+	F	Palaearctic	P	PZ	
	P quadncornis (Ehrb)	-	–	+	F	Cosmopolitan	PI	L	
Famıly	NotomiTidtidae								
Genus	Notommata Ehrenberg								
	Notommata pachyura (Gosse)	-	–	+	F	Cosmopolitan	PI	L	
Genus	Cephalodella Bory de St Vincent								
	Cephalodella catellina (Mull)	–	-	+	F	Cosmopolitan	PB, Pm	Pm	

Continuation of list of ROTATORIA species

	Species and subspecies	Endemic or not	Open Baikal	Coastal sor zone & bays	Bio-coc-JlOtlC role	Distribution outside *of* Baikal	Ecological cha-racteri-stics	Habitat	Temperature diapason and/or optimum
	C aunculata (Mull)	–	+	-		Cosmopolitan	Pm	Pm	
	C eudelicata Wulf	–	+	-		Germany	Pm	Pm	
	C eva (Gosse)	–	+	-	F	Cosmopolitan	PI, PB	L	
	C gibba (Ehrb)	–	+	+	F	Cosmopolitan	PI, PB, Pm	L	
	C. gibba microdactyla Koch -Alt.	–	+	—	F	Germany, oligo-trophy lakes	PB	L	
	C globata (Gosse)	–	+	-	F	Holarctic	PB	L	
	C gracilis (Ehrb)	–	+	-	F	Cosmopolitan	Pm	Pm	
	C hcina Wulf	–	+	-	F	Germany	Pm	Pm	
	C hmosa Wulf	–	+	-	F	Palaearctic	Pm	Pm	
	C megaloccphala (Glass)	–	+	-	F	Cosmopolitan	Pm	Pm	
	C poitera Myers	-	–	+	F	Sweden, USA	L		
	C stenroosi Wulf.	–	+	+	F	Germany, Finland	PB	L	
	C. sterea (Gosse)	–	+	-		Cosmopolitan	Pm	Pm	
	C. stngosa Myers	–	4-	-		Holarctic	Pm	Pm	
	C. tenuior (Gosse)	–	+	-		Cosmopolitan	Pm	Pm	
	C ventnpes (Dix.-Nutt.)	–	+	-	F	Cosmopolitan	Pm, PB	Pm, L	
	C vittata Kut	4-	+	-	F	Germany	PB	L	
	C volvocicola (Zaw)	-	–	+	F	Holarctic	Pa	In Vol vox	
Genus	Enteroplea Ehrenberg								
	Enteroplea lacustns Ehrb.	-	–	+	F	Cosmopolitan	PI	L	
Genus	Resticula Hairing et Myers								
	Resticula nyssa Harr et Myers	–	+	-	F	Cosmopolitan	PB	L	
Family	Tnchocercidae								
Genus	Trichocerca Lamarck								
Subgenus	Trichocerca Lamarck								
	Trichocerca capucina (Wierz. et Zach)	–	+	+	Nn	Cosmopolitan	P, PI	PZ, L	
	T.cylmdnca (Imh j	–	–	+	F	*Cosmopolitan*	P, *PI*	PZ, L	
	T.longiseta (Sch)	–	–	+	F	Cosmopolitan	PI, PB	L	
	Tpusilla (Laut)	–	–	+	F	Cosmopolitan	PI, P	L, PZ	
	T rattus carmata (Ehrb.)	–	–	+	F	Cosmopolitan	PI	L	
	T muliierinis (Kell.)	–	–	+	F	Jakutia, USA	P	PZ	
	T.stylata (Gosse)	–	–	+	F	Cosmopolitan	P	PZ	
Subgenus	Diurella Bory dc St Vincent								
	T.(Diurella) intermedia (Stcn.)	–	+	-		Cosmopolitan	PI, PB	L	
	T (D.) rousseleti (Voigt)	–	–	+	F	Palaearctic	P	PZ	
	T (D.) simihs (Wierz)	–	–	+	F	Cosmopolitan	Pm	L	
	T,(D) taurocephala (Hauer)	–	+	-	F	Holarctic	PI, PB	L	
	T (D.) cavia (Gosse)	–	+	-		Cosmopolitan	Pm	Pm	
	T (D,) brachyura (Gosse)	–	+	-	F	Cosmopolitan	Pm	Pm	

Continuation of list of ROTATORIA species

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	T (D.) tigns (Müll)	–	+	–	F	Cosmopolitan	PI	L	
	T (D.) vassiljevae Kut.	+	+	–	F		PB	L	
	T (D.) weben (Jenn)	-	+	–	F	Cosmopolitan	PB	L	
Family	Gastropodidae								
Genus	Gastropus Imhof								
	Gastropus styhfer Imh	-	+	+	Nn	Palaearctic	P, Pm	PZ, Pm	
Genus	Ascomorpha Perry								
	Ascomorpha ecaudis Perty	-	+	+	F	Palaearctic	P	PZ	
Family	Synchaetidae								
Genus	Synchacta Ehrenberg								
	Synchaeta cecilia Rouss	-	–	+		Holarctic	P	PZ	
	S grandis Zach	-	+	+	Sd	Holarctic	P, Pm	PZ, Pm	
	S. kitina Rouss	-	+	+	Nn	Holarctic	P, Pm	PZ, Pm, L	
	S oblonga Ehrb	-	–	+	F	Cosmopolitan	P	PZ	
	S. pachypoda Jasch	+	+	+	D		P	PZ	1-5°C
	S pachypoida Kut. et Vas	+	+	+	Sd		P	PZ, L	1-5°C
	S pectinata Ehrb	-	+	+	Nn	Cosmopolitan	P	PZ	
	S prominula Kut et Vas.	+	+	+	Nn		P	L	
	S rufina Kut. et Vas	+	+	+	Nn		P	L	
	S. stylata Wierz	-	+	+	Sd	Cosmopolitan	P	PZ	12-15°C
Genus	Polyarthra Ehrenberg								
	Polyarthra euryptera Wierz.	-	–	+	Nn	Holarctic	P	PZ	
	P longiremis Carl.	-	–	+	F	Cosmopolitan	P	PZ	
	P.dolichoptera Idels	-	+	+	Nn	Cosmopolitan	P	PZ, Pm	
	P luminosa Kut	-	–	+	F	Russia, Poland	P	PZ	
	P.major Burckh	-	–	+	F	Cosmopolitan	P	PZ	
	P remata Skor.	-	–	+	F	Cosmopolitan	P	PZ	
	P vulgaris Carl.	-	–	+	F	Cosmopolitan	P	PZ	
Genus	Ploesoma Herrick								
	Ploesoma truncatum (Lev)	-	–	+	F	Palaearctic	P	PZ	
Genus	Bipalpus Wierzejski et Zacharias								
	Bipalpus hudsoni (Imh)	-	+	+	Nn	Palaearctic	P	PZ	
Family	Dicranophondae								
Genus	Encentrum Ehrenberg								
Subgenus	Encentrum Ehrenberg								
	Encentrum impletum sp.n.	+	+	–			Pm	Pm	
	E. parvum Don.	-	+	–		Palaearctic	B	L	
	E putonus Wulf	-	+	+		Palaearctic	B, Pm	L, Pm	
	E. sutor Wisz	-	+	–		Poland, Czechoslovakia	Pm	Pm	

Continuation of list of ROTATORIA species

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Subgenus	Parencentrum Wiszniewski								
	F (Parencentrum) plicatum (Eyf)	–	+		F	Palaearctic	B	L	
	E (P) umbonatum Kut	+	+	-					
Genus	Dicranophorus Nitzsch								
	Dicranophorus facihs Kut	+	+	–	F	Palaearctic	B	L	
	D leptodon Wisz	-	+	+	F	Palaearctic	B	L	
	D longidactylum Fad	-	+	+	F	Palaearctic	B	L	
	D lutkeni (Berg)	-	+	-	F	Cosmopolitan	B, Pm	Pm, L	
	D npanus Kut	+	+	-	F		B	L	
	D hercules Wisz	-	+	-		Palaearctic	Pm	Pm	
	D robustus Harr et Myers	-	+	-		Cosmopolitan	PB, Pm	Pm, L	
	D saevus Hdrr et Myers	-	+	-		USA, Sweden	Pm	Pm	
Genus	Wierzejskiella Wiszniewski								
	Wicrzejskiella sabulosa (Wisz)	–	+	–		Poland, Germany	Pm	Pm	
	Wvelox (Wisz)	–	+			Russia, Sweden, Poland, Romania, USA	Pm	Pm	
Genus	Inflanta Kutikova , gen n	+							
	Inflanta pomazkovae Kut	+	+	–	F		B	L	
Genus	Albertia Dujardin								
	Albertia woronkowi Zenk	+					Pa	In oligochaeta intestine	
Family	Asplanchmdae								
Genus	Asplanchna Gosse								
	Asplanchna herncki Gucrne	–	+	+	Nn	Cosmopolitan	P	PZ	
	A pnodonta Gosse	–	+	+	Sd	Cosmopolitan	P	PZ	
	A pnodonta helvetica Imh	–	+	+		Cosmopolitan	P	PZ	
	A sjeboldi (Leyd)	–	+	+	Nn	Cosmopolitan	P	PZ	
Family	Lecmidae								
Genus	Lccane Nitzsch								
Subgenus	Lecane Nitzsch								
	Lecane luna Mull	–	–	+	F	Cosmopolitan	P	PZ	
	L flexilis (Gosse)	–	+	+	F	Cosmopolitan	PI	L	
	L inennis (Bryce)	–	+	+	F	Cosmopolitan	PB, B	L	
	L ungulata (Gosse)	–	–	+	F	Cosmopolitan	PI	L	
Subgenus	Monostyla Ehrcnberg								
	L (Monostyla) aspersa Kut et Ar	+	+	+			PB, Pm	Pm	
	L (M) cornuta (Mull)	–	–	+	F	Cosmopolitan	PI	L	
	L (M) decipiens (Murr)	–	+	–	F	Cosmopolitan	PI, B	*L*	
	L(M) lunam(Ehrb)	–	+	+	F	Cosmopolitan	P	PZ	
	L (M) pennaki sp nov	+	+	–			Pm	Pm	

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	L(M) pyriformis (Dad)	–	+	+	**F**	Cosmopolitan	PI	L	
Family	Proahdae								
Genus	Proales Gosse								
	Proales globulifera (Hauer)	–	+	–		Germany, Poland, Austria	**B, PB**	L	
	P halophik Rem	–	+	–		Palaearctic	PB, Pm, &	L	
	P theodora (Gosse)	–	+	–	**F**	Palaearctic	B, PB	L	
Genus	Bryceeld Remane								
	Bryceela tcnclla (Bryce)	–	+	–		Palaearctic	Pm	Pm	
Family	Epiphanidae								
Genus	Epiphanes Ehrenberg								
	Epiphanes brachionus (Ehrb)	–	+	–		Cosmopolitan	**PB**	L	
Family	Trichotrndae								
Genus	Trichoma Bory de St Vincent								
	Trichoma curta (Scor)	–	+	+		Palaearctic	PI	L	
	T pocillum (Mull)	–	–	+		Cosmopolitan	PI	L	
	T tetractis (Ehrb)	–	–	+		Cosmopolitan	PI	L	
	T tetractis caudata (Lucks)	–	+	–		Cosmopolitan	PI	L	
	T truncata (Whit)	–	–	+	F	Cosmopolitan	PI	L	
Family	Mytilimdae								
Genus	Mytilma Bory dc St Vincent								
	Mytihna mutica (Perty)	–	–	+	F	Palaearctic	PI	L	
	M mucronata (Mull)	–	–	+	F	Cosmopolitan	PI	L	
	M videns (Lev)	–	–	+	F	Palaearctic	PI	L	
Family	Colurellidae								
Genus	Colurella Bory de St Vincent								
	Colurclla colurus (Ehrb)	–	+	+		Cosmopolitan	B, Pm	L, Pm	
	C colurus compressd Lucks	–	+	–		Cosmopolitan	Pm	**Pm**	
	C gastracantha Hauer	–	+	–		Palaearctic	Pm	**Pm**	
	C grandiuscula Kut et Ar	+	+	–			B, Pm	L, Pm	
	C gcophila Donn	–	+	–		Russia, Furope	Pm	Pm	
	C adriatica Ehrb	–	+	–		Cosmopolitan	Pm	Pm	
	C hindenburgi Stein	–				Cosmopolitan New Zealand	Pm	Pm	
	C obtusa (Gosse)	–	+	+		Cosmopolitan	PI, Pm	L, Pm	
	C uncinata (Mull)	–	+	+	**F**	Cosmopolitan	PI, Pm	L, Pm	
Genus	Lepadelld Bory de St Vincent								
Subgenus	Lepadella Bory dc St Vincent								
	Lepadelld ovabs (Mull)	–	–	+	**F**	Cosmopolitan	PI Pm	L, Pm	
	L acuminata (Ehrb)	–	+	–	**F**	Cosmopolitan	PI, Pm	L, Pm	

Continuation of list of ROTATORIA species

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	L patella (Mull)	–	4-	+	F	Cosmopolitan	PI, Pm	L, Pm	
	L patella oblonga (Ehrb.)	—	-	4-		Cosmopolitan	PI, B	L	
Famıly	huchlanidae								
Genus	Euchlanis Erenberg								
	Euchlanis deflexa Gosse	–	–	+	F	Cosmopolitan	PI, P	L, PZ	
	E dilatata Ehrb	–	4-	+	Nn	Cosmopolitan	P, Pm	PZ, Pm	
	E dilatata unisetata Leyd.	-	–	+	F	Palaearctie+Australia	PI	L	
	E lucksiana Hauer	-	–	+	F	Cosmopolitan	P	PZ	
	E incisa Carl	-	–	+	F	Cosmopolitan	P	L	
	E ligulata Kut et Vas	+	+	4-	F		PB, B, Pm	L, Pm	
	E lyra Huds	-	–	+	F	Cosmopolitan	PI	L	
	E. pynformis Gosse	-	–	+	F	Cosmopolitan	PI	L	
	E tnquetra Ehrb	-	–	+	F	Cosmopolitan	PI	L	
Ordo	Monimotrochida								
Family	Floscularndae								
Genus	Flosculana Cuvier								
	Flosculana sp	–	–	+					
Family	Conochilidae								
Genus	Conochilus Erenberg								
	Conochilus unicornis Rouss	–	+	4-	D, Sd	Cosmopolitan	P	PZ	Summer
	C hippocrepis (Schr)	–	–	+	Nn	Cosmopolitan	P	PZ	Summer
Genus	Conochiloides Hlava								
	Conochiloides coenobasis Scor	–	–	4-	F	Cosmopolitan	P	PZ	
Family	Testudinellidae								
Genus	Testudiiieiia Bory dc St Vincent								
	Testudinella patina (Herm)	–	–	4-	Nn	Cosmopolitan	P	PZ	
Genus	Pompholyx Gosse								
	Pompholyx complanata Gosse	–	–	+	F	Cosmopolitan	P	PZ	
Family	Fihnidae								
Genus	Fihnia Bory dc St Vincent								
	Fihnia terminalis (Plate)	–	+	4-	D, Sd	Cosmopolitan	P	PZ	)2-15°C
	F longiseta (Ehrb)	–	–	4-	Nn	Cosmopolitan	P	PZ	
Ordo	Pacdotrochida								
Family	Collothecidae								
Genus	Collotheca Harring								
	Collotheca murabilis (Huds)	–	4-	+	D, Sd	Cosmopolitan	P, Pm	PZ, Pm	Summer
	C. pelagica (Rouss)	–	+	+		Cosmopolitan	P	PZ	Summer
	C ornata natans (Tschug.)	–	4-	-		Cosmopolitan	P	PZ	
	Collotheca sp.	–	4-	-	Nn		P	PZ, L	Spring

Continuation of list of ROTATORIA species

	Species and subspecies	bndemic *or not*	Open Baikal	Coastal *sor zonr* & bays	Bio-coe-notic role	Distribution ou tiide of Baikal	Ecologi-cal cha-racteri-stics	Habitat	Temperature diapason and/or optimum
Ordo	Bdelloida								
Family	Philodimdae								
Genus	Philodina (Erenberg) em Bryce								
	Philodma vorax (Jans)	–	–	+	F	Cosmopolitan	PI	L	
Genus	Rotana Scopoli								
	Rotaria rotatoria (Pall.)	–	+	–		Cosmopolitan		L	

Comment P - planktonic; B - benthos, PB - plankto-benthos; Pm - psammonic, Pa - parasitic; PI - among the plants, Pz - pelagic zone, L - littoral; Pm - psammal; D - *dominant; Sd - subdommant;* Nn - not numerous; F - *few.*

List of OLIGOCHAETA species. Compiled by L.N. Snimshikova & T.V. Akinshina

	Species and subspecies	Endemic or not	Open Baikal	Coastal-sor zone & bays	Distribution outside of Baikal	Depth, m	Bottom
Class	Chtellata						
Subclass	Aphanoneura						
Ordo	Aeolosomatida						
Family	Aeolosomatidae Beddard, 1895						
Genus	Aeolosoma hhrenberg, 1828						
	Acolosoma aremcola Semernoy, 1987 nom nnd	+	MB	–	–	0-1	Sand
	A singulare Semernoy, 1982	+	All	–	–	1-200	Sand, silted sand, silt
Subclass	Oligochaeta						
Supraordo	Naidomorpha						
Ordo	Tubificida Timm, 1987						
Family	Naididac Benham, 1890						
Subfamily	Naidinae Lastočkin, 1921						
Genus	Stylana Lamarck, 1816						
	Stylana fossulans Lcidy. 1852	–	MB	–	Asia, North America	! 5	Sand
	S lacustns (Linnaeus, 1767)	–	MB	+	Holarctic, **India**	2-27	Sand
Genus	Ripistes Dujardin, 1842						
	Ripistes parasita (Schmidt, 1847)	–	–	+	Palaearctic	2 5	Algae, sdt with detritus
Genus	Vejdovskyella Michaelsen, 1903						
	Vejdovskyella dilucida Snimschikova, 1982	+	NB	–	–	50	Silted sand
	V intermedia (Brctschcr, 1896)	-	SB	–	Palaearctic	15	Stones, algae
	V intermedia sublitorale Semernoy, 1987, nom nud	+	M More	–	–	120	
	V intermedia schizodentata Semernoy, 1982	+	SB, M More	-	-		All types
	Vejdovskyella sp. [Gavnlov, 1950]	+	SB	–		0-1	Sand, algae
Genus	Slavina Vejdovsky, 1883						
	Slavina appendiculata (Udekem, 1855)	-	MB	–	Cosmopolitan	0 5	Sand
Genus	Dero Oken, 1845						
	Dcro obtusa Udekem, 1855	–	SB	–	All over the world exept Australia	7-27	Stones, sand
Genus	Nais Muller, 1773						
	Nais abissahs Semernoy, 1984	+	NB	–	–	700	Silt
	N baicalensis Sokolskaja, 1962	+	All	–	*Angara*	0, 2-25	Stones, *algae,* silled **sand**
	N barbata Muller, 1773	–	MB	+	Palaearctic	1 5-15	Stones, algae, sand
	N bekmanae Sokolskaja, 1962	–	SB, NB, M More	+	Angara, Khubsugul	0 2-20	Rock, stones, alga
	N. communis Piguet, 1906	–	SB	+	All over the world exept Australia	4-18	Rock, stones, algae, **sand**

Continuation of list of OLIGOCHAETA species

	Species and subspecies	Endemic or not	Open Baikal	Coastal-sor zone & bays	Distribution outside of Baikal	Depth, m	Bottom
	N. elinguis Midler, 1773	–	–	+	Cosmopolitan		
	N. koshovi Sokolskaja, 1962	+	SB, NB, M More	+	Angara	2-93	Stones, algae, silted sand, silt
	N pardalis Piguet	-	SB	–	Holarctic, South America	2 5	Stones
	N pseudobtusa Piguet, 1906	–	SB, NB	–	Holarctic	4-50	Stones, algae, sand, silt
	N similis Semernoy, 1984	+	SB, M. More	–	–	1.5-27	Stones, algae, sand, silt
	N simplex Piguet, 1906	–	–	+	Holarctic, Africa	1-8	Stones, silted sand
	N. tatijanae Semernoy, 1984	+	SB, M. More	–	–	0.3-30	Stones, sand, silted sand
	N. tygnna Isossimoff, 1962	+	SB, NB, M More	–	–	0.5-20	All types
	N variabilis Piguet, 1906	-	SB, NB, M More	+	All over the world exept Australia	1-55	All types
	Nais sp [Cercpanov et al , 1977]		–	+			
	Nais sp [Noskova, 1963]		MB, M More	–			
Genus	Neonais Sokolskaja, 1962						
	Neonais clegans Sokolskaja, 1962	+	SB, NB	+	-	2-20	Stones, sand, silted sand
Genus	Specana Sperber, 1939						
	Specana josinae (Vejdovsky, 1883)	–	–	+	Holarctic, Africa	1.5-3	Sand, silted sand
Genus	Uncmais Levinsen, 1884						
	L/ncmais mmoi Sokolskaja, 1962	+	**SB, NB**	+	Angara	I 5-70	Stones, aigae, silted sand
	U uncinata (Oersted, 1842)	–	**MB, NB**	+	Holarctic	1-55	All types
	Uncinais sp. [Noskova, 1963]	+	–	+		0 9	Sand
Subfamily	Chactogastrmae Lastockin, 1921						
Genus	Amphichaeta Tanber, 1879						
	Amphichaeta magna Sokolskaja, 1962	+	SB, NB, M. More	+	Angara	1 5-25	Sand
	A propinqua Semernoy 1987 nom nud	+	M More	–	–		
	A. rostnfera Akinschma, 1984	+	SB	–	Angara	**3 5-6**	Stones, algae, silted sand
	A. ('> sannio Kallstenius, 1862 [Gavnlov, 1950]	–	SB	–	Europe		Sand
Genus	Chaetogaster Baer, 1827						
	Chaetogaster cannibalus Semernoy, 1985	+	M More	–	–	10-25	Stones, algae, sand
	Ch. crocodilus Semernoy, 1985	+	M More	–	–	0.5-5	Stones, algae
	Ch. diaphanus (Gruithuisen, 1926)	–	M More	+	Holarctic, Africa	1.5-20	Sand

Continuation of list of OLIGOCHAETA species

	Species and subspecies	Endemic or not	Open Baikal	Coastal-sor zone & bays	Distribution outside of Baikal	Depth, m	Bottom
	Ch. diaphanus litoralis Semernoy, 1985	+	SB, M More	–	–	1.5-120	Stones, algae, sand
	Ch. dissetosus Semernoy, 1985	+	M More	-	-	10-25	Stones, sand, sand with detntus
	Ch gavnlovi Semernoy, 1985	+	M More	-	-	3	Stones, algae
	Ch. grandisetosus Semernoy, 1985	+	M. More	-	-	5-20	Stones, algae, sand
	Ch. ignotus Semernoy, 1985	+	M. More	-	-	25-50	Sand with detritus, silt
	Ch intermedius Akinschma, J 984	+	SB, M. More	-	-	2-25	Sand, sand with algae
	Ch multisetosus Semernoy, 1985	+	M. More	-	-	0-0 5	
	Ch paucus Semernoy, 1985	+	M More	-	-	0 5-50	Stones, algae, sand, silted sand
	Chaetogaster sp. (? diastrophus) [Gavnlov, 1950]	+	SB	–	-	1 5	Sand
Famıly	Tubificidae Vejdovsky, 1884						
Subfamıly	Rhyacodnlmae Hrabě, 1963						
Genus	Rhyacodnlus Brescher, 1901						
	Rhyacodrulus coccmeus (Vejdovsky, 1875)	–	MB, NB, M Vlore	+	Holarccic, Australia	1-200	Sand, silted sand, silt
	Rh coccineus inaequalis Michaelsen, 1905	+	MB	+	-	2.5-232	Stones, sand, silt, silted sand
	Rh coccineus selengaensis Noskova, 1967 nom. nud	+	MB	+	-	8-124	Silted sand, silt
	Rh. isossimovi Čckanovskaja, 1975	+	All	–	–	2-1610	Sand, silted sand, silt
	Rh. korotneffi (Michaelsen, 1905)	+	All	+	Angara, Yenisei	1.4-267	All types
	Rh korjakovi Semernoy, 1987 nom nud	+	M. More	–	–	22	
	Rh multispinus multispinus Michaelsen, 1905	+	All	–	Angara	2 5-125	Stones, sand, silted sand
	Rh multispinus multiovatus Burow, 1936	+	All	–	Angara	2-50	Stones, sand, silted sand, silt
	Rh propus Semernoy, 1987 nom. nud	+	M. More	–	–	78-140	
	Rh sibincus Semernoy, 1971	–	NB	+	Siberia	1-196	Sand, silt
	Rh. sokolskajae Semernoy, 1971	–		+	Siberia	3 5	Silt
	Rh. stephensoni Černosvilov, 1942	–	SB	–	Tibet	2 5-185	Silt, sand, silted sand
	Rh subtilis Semernoy, 1987 nom nud	+	M More	–	–	20	
Genus	Hrabeus Semernoy, 1987						
	Hrabeus magnus Semernoy, 1987 nom nud	+	M More	–	–	20	
	II. tortus Semernoy, 1987 nom nud	+	M More	–	–	20	
Genus	Pararhyacodnlus Snimschikova, 1986						
	Pararhyacodnlus aspersus Snimschikova, 1986	+	SB, NB	–	–	2-20	Stones, sand
Genus	Svetlovia Čckanovskaja, 1975						
	Svetlovia golyschkinae Snimschikova, 1985	+	NB	–	–	53	Silt with detritus
	S maculata Čekanovskaja, 1975	+	SB, NB	–	–	15-680	Sand, silted .sand, silt with detritus
	S majusculata Snimschikova, 1985	+	NB	–	–	2-360	Silt, silt with detritus
Genus	Rhyacodnloides Čckanovskaja, 1975						

Continuation of list of OLIGOCHAETA species

	Species and subspecies	Endemic or not	Open Baikal	Coastal-sor zone & bays	Distribution outside of Baikal	Depth, m	*Bottom*
	Rhyacodnloides abyssalis Čekanovskaja, 1975	+	SB, NB	–	-	5 1610	Sand, silted sand, silt
	Rh abyssalis irexoconensis Snimschikova, 1985	+	SB, NB	–	—	10-20	Stones, sand
Subfamıly	Tubificinae Eisen, 1879						
Genus	Tubifex Lamarck, 1816						
	Tubifex bazikalovae bazikalovae Čekanovskaja, 1975	+	SB, NB	–	-	5-1300	All types
	T bazikalovae aliquantulus Snimschikova, 1985	+	NB	–	-	10-200	Silt, silt with detritus
	T bazikalovae crassiseptus Semernoy, 1982	+	SB, NB	–	–	4-200	Sand, silted sand, silt
	T bazikalovae grandis Snimschikova, 1987	+	NB	–	-	20 50	*Sthed sand, bilt with detritus*
	T excavatus (Hrabě, 1982)	+	NB	–	-	25	Silted sand
	T eximius (Semernoy, 1982)	+	NB, MB	–	-	2 205	Sand silt, silt with detritus
	T pemcraspedifer Semernoy, 1982	+	-	+	-	0 8	Silted sand, silt with detritus
	T taediosus Čekanovskaja, 1975	+	All	–	-	600-1460	Silt
	T tubifex (Muller, 1773)	—	SB	+	Cosmopolitan	1 5-2 5 (to 100)	Silt with detritus, algae
	Tubifex sp [Snimschikova, 1987]		NB	–		5-220	Silted sand, silt with detritus
	Tubifex sp [Snimschikova, 1989]		–	+		1	Silted sand
Genus	Tasscrkidnlus Holmquist, 1985						
	Tasserkidnlus acapillatus (Finogenova, 1972) C?=Tubifcx kesslen variabilis Semernoy, 1982,'?=Limnodrilus infundibuliferus Isossimoff, 1972)	–	All	+	Caspian Sea, Angara	2-260	All types
	T baicalensis (Semernoy, 1982)	+	AH	+	–	5-360	All types
	T mirandus (Snimschikova, 1982)	+	NB	–	-	2 5-20	Stones, sand
	T C?=Tubificoides) propnus Semernoy, 1987 n comb	+	M Ivlore	–	–	40	
Genus	Tenendnlus Holmquist, 1985						
	Teneridnlus hubsugulensis (Semernoy, et Akinschina, 1980) n comb	–	MB, NB, M Ivlore	–	Khubsugul	0-220	Sand, silt, silt with detritus
	T minutus (Cekanovskaja, J 975) n comb	+	NB, MB	–	–	2-360	Silt, silted sand, silt **with** detritus
	T necopinatus (Snimschikova, 1985) n comb	+	NB	–	–	15-50	Silted sand, silt
Genus	Spirosperma Eisen, 1879						
	Spirospemid ferox Eisen, 1879	–	–	+	Hoiarctic	1 5	Silt with detritus
Genus	Embolocephalus Randolph, 1892						
	Embolocephalus velutinus (Grube, 1879)	–	M More	+	Holarctic	5-20	
Genus	Baikalodnlus Holmquist, 1978						
	Baikalodnlus bekmanae (Snimschikova, 1984)	+	NB	–	–	5-20	Sand, **silted** sand

Continuation of list of OLIGOCHAETA species

	Species and subspecies	Endemic or not	Open Baikal	Coastal-sor zone & bays	Distribution outside of Baikal	Depth, m	Bottom
	B bifidus Smnwchikova, 1989	+	MB	-	-	18	Silted sand, sand
	B crassus Snimschikova, 1989	+	MB, NB	–	-	13 50	Sand, silted sand
	B cnstatus (Snimschikova, 1982)	+	NB	-	-	5-500	Sand, silted sand, silt
	B digitatus Holmquist, 1979	+	NB, SB	–	—	5-200	Sand, silted sand silt with detritus
	B discolor discolor (Snimschikova, 1984)	+	NB, MB	–	-	5-360	Silt, silt with detritus
	B discolor acinacifer Snimschikova, 1989	+	MB	–	-	100-500	Silted sand, sand
	B discolor brcvipectinatus Snimschikova, 1989	+	MB	–	-	43	Silt
	B exihs (Snimschikova, 1982)	+	All	–	—	5-500	Sand, silt, silt with detritus
	B talcatus (Snimschikova, 1982)	+	NB	-	-	18	Silted sand
	B mflatus (Michaelsen, 1901)	+	All	+	-	1-300	Stone;*, sand, silted sand
	B intermedius Snimschikova 1991	+	MB	–	—	240	Sand
	B kozhovi (Hrabě, 1965)	+	SB	–	–	3 5-6	
	B malevici (Čekanovskaja, 1975)	+	All	-	-	2-1450	All types
	B medianus Snimschikova 1991	+	MB	–	-	*18*	Silted sand
	B multicrystallifer Snimschikova, 1989	+	MB, NB	-	-	50-120	Sand, silt
	B paradoxus (Snimschikova, 1984)	+	All	–	–	5-250	Sand, silt, silt with detritus
	B panlis (Semernoy, 1987) nom nud	+	M More	–	-	40	
	B phreodnloides. (Michaclsen, 1905) n comb.	+	SB, NB, M More	-	—	2-18	Stones, sand, silted sand
	B scaphoideus Snimschikova, 1989	+	MB	–	-	18	Silt and sand with detritus
	B solitanus (Snimschikova, 1982)	+	NB	–	-	10	Silted sand
	B undatus Snimschikova, 1989	+	MB	–	-	8	Silted sand
	B werestschagim (Michaelsen, 1933)	+	MB, NB, M More	+	-	3-1410	Silted sand, silt
Genus	Habcr Holmquist. 1978						
	Haber vetus (Semernoy, 1982) n comb	+	All	+	-	3-500	All types
Genus	Limnodnlus Claparĕde, 1862						
	Limnodnlus hoffmcisten Claparĕde, 1862	–	MB	–	Cosmopolitan		
	L profundicola (Verrill, 1871)	–	–	+	Holarctic	1 8	Silted sand
Genus	Isochaetides Hrabĕ, 1965						
	Isochaetides adenodicystis Semcrnoy, 1982	+	All	+	–	2-360	Silted sand, sand, silt with detritus
	I arenanus (Michaclsen, 1926)	+	All	-	Angara	1-260	Sand, silted sand, silt with detritus
	J are/jarjus maecmalis (Michaclsen ct Werestschagin, 1930)	+	MB	+	–	15-209	Silted sand, silt
	I baicalensis (Michaclsen, 1901)	+	All	+	–	1 5-304	Sand, silted sand, silt with detritus

Continuation of **list** of OLIGOCHAETA species

	Species and subspecies	Endemic or not	Open Baikal	Coastal-sor zone & bays	Distribution outside of Baikal	Depth, m	Bottom
	I baicalcnsis selcngaensis (Noskova, 1967)	+	MB	+	–	4-59	
	I michaelsem (Lastočkin, 1936)	–	–	+	Palaearctic	0 5	Stones, sand
	I werestschagini Akinshina et Snimschikova 1991	+	SB	–	–	30	Silt
	Isochaetides sp [Čcrcpanov ct al, 1977]	+	-	+	–		
	Isochaetides sp nov 1 [Snimschikova, 1987]	+	NB	–	–	2-108	Sand, silted sand, silt
	Isochaetides sp nov 2 [Snimschikova, 1987]	+	NB	–	–	5-100	Stones, sand, silted sand
	Isochaetides sp no\ 3 [Snimschikova, 1987]	+	NB	–	–	200	Silt with detritus
	Isochaetides sp nov 4 [Snimschikova, 1987]	+	NB	–	–	2 5-200	Sand, silted sand, silt with detritus
	Isochaetides sp I [Snimschikova, 1989]	+	–	+	–	I 2-1 8	Silted sand
	Isochaetides sp 2 [Snimschikova, 1989]	+	–	+	–	1 2-1 8	Silted sand
Genus	Psammoryctides Hrabč, 1964						
	Psammoryctidcs albicola (Michaelsen, 1907)	–	MB	–	Palaearctic		
	Psammoryctides sp [Semernoy, 1987]	+	M More	+	–	6-70	
	Psammoryctides sp [Snimschikova, 1987]	+	NB	–	–	10-180	Stones, **sand, silt with** detritus
Genus	Potamothrix Vejdovsky et Mrazek, 1902						
	Potamothrix moldaviensis Vejdovsky et Mrazek, 1902	–	MB	+	Holarctic	10	
Genus	Ilyodnlus Eisen, 1879						
	Ilyodnlus sp [Snimschikova, 1989]			+		0 15	Sand
Genus	Lycodnlus Grube, 1873						
	Lycodnlus dybowskn Grube, 1873	+	All	+	–	I 232	Sand, silt, silted sand
	<y Tubipenifer tendens Semernoy, 1982)						
	L grubei Michaelsen, 1905	+	All	–	–	1 50	Sand, silt, silt with detritus
	L mtens (Semernoy, 1982) n comb	+	NB **M More**	–	–	4-200	Sand, silt, silt with detritus
	Lycodnlus sp [Snimschikova, 1987]	+	**NB**			10-105	Sand, silted sand, silt
Gcnus	Lycodntides Hrabě, 1982						
	Lycodnhdes schizoehaetus (Michaelsen, 1903)	+	**All**	+	Angara, Yenisei	1 5-360	All types
Subfamıly	Aulodnlinac Hrabč, 1967						
Genus	Lymphdchaeta Snimschikova, 1982						
	Lymphachacta pinnigera Snimschikova, 1982	+	NB	–	–	50-70	Silted sand
Famıly	Propappidae Coates, 1982						
Gcnus	Propappus Michaelsen, 1905						
	Propappus glandulor>us Michaelsen, 1905	+	All	–	–	2-200	Stones, sand, silt
	P volki Michaelsen, 1915	–	AH	+	**Palaearctic**	0 3-200	AH types
Famıly	Enchytraeidae Vejdovsky, 1879						
Genus	Manonina Michaelsen, 1889						
	Manonina aliger (Michaelsen, 1930)	+	SB	+	–	1 2-275	**Sand,** silt, silt **with detritus**
Genus	Mesenchytraeus Eisen, 1878						

Continuation of list of OLIGOCHAETA species

	Species and subspecies	Endemic or not	Open Baikal	Coastal-sor zone & bays	Distribution outside of Baikal	Depth., m	Bottom
	Mesenchytraeus bungei Michaelsen, 1901	+	All	–	-	0-50	Stones, sand, silted sand
Genus	Enchytraeus Henle, 1837						
	Enchytraeus sp [Cerepanov et al, 1977]			+		0-2 5	
Supraordo	Lumbricomorpha						
Ordo	Lumbnculida, Timm, 1987						
Famıly	Lumbnculidae Vejdovsky, 1884						
Genus	Lumbnculus Grube, 1884						
	Lumbnculus vanegatus (Muller, 1774)	–	–	+	Holarctic	0-2 5	Silt
	Lumbnculus sp [Cerepanov et al , 1977]			+			
Genus	Lamprodnrus iVfrcrraefsen, *190!*						
	Lamprodrilus achaetus achaetus Isossimoff, 1962	-	All	+	Karelia	2-500	Sand, silted sand, silt
	L achaetus hemiachaelus Snimschikova, 1987	+	SB, MB	+	-	1 4-260	Sand silt, silt with detritus
	L ammophagus Michaelsen, 1905	+	NB	–	-	2-50	Sand, silted sand, silt
	L bythius Michaelsen, 1905	+	M More	–	-	90-1131	Silt
	L bulbosus Isossimoff, 1962	+	MB., NB, M More	–	–	5-504	Sand, silted sand, silt
	L decathecus Michaelsen, 1901	+	NB	–	-	21-46	Sand, silt
	L dithecus Michaelsen, 1901	+	NB	–	-	9-150	Stones, sand, silted sand
	L dybowskn Michaelsen, 1905	+				192-503	Silt
	L glandulosus Michaelsen, 1905	+	All	+	-	2-148	All types
	L mflatus Michaelsen, 1905	+	MB., NB	–	-	65-1073	Silt
	L isoporus Michaelsen, 1901	–	NB, M More	+	North Europe	5-55	Stones, sand silt with detritus
	L isossimovi Sememoy, m litt	+					
	L melanotus Isossimoff, 1962	+	NB	–	–	1 5 70	Stones, sand
	L nigrescens Michaelsen, 1903	+	All	+	-	2-120	Stones, sand, silt
	L novikovae Hrabě, 1982	+	SB	–	-	41	Silt with detritus
	L pallidus Michaelsen, 1905	+	M More	–	-	3-1073	Silt, silted sand
	L polytoreutus Michaelsen, 1901	+	SB	–	-	6 88	Stones, sand
	L pygmaeus pygmaeus Michaelsen, 1901	+	All	+	-	5-260	All types
	L pygmaeus oligosetosus Isossimoff, 1962	+				20 40	Sand
	L pygmaeus sulcatus Isossimoff, 1962	+				36	Sand
	L satynscus Michaelsen, 1901	+	M More	–	-	21-200	Silt
	L semenkewichi Michaelsen, 1901	+	–			6-11	Stones, sand
	L stigmatias Michaelsen, 1901	+	MB	+	-	6-107	Sand, silted sand, silt
	L tetrathecus Michaelsen, 1901	+	NB	–	-	2-360	Sand, silted sand, silt
	L wagncn wagnen Michaelsen, 1901	+	All	+	Angara	2 620	All types
	L wagnen longus Isossimoff, 1962	+	MB, NB, M More	+	–	14-882	Sand, silted sand, silt with detritus

Continuation of list of OLIGOCHAETA species

	Species and subspecies	Endemic or not	Open Baikal	Coastal-sor zone & bays	Distribution outside of Baikal	Depth, m	Bottom
Genus	Teleuscolex Michaelsen, 1901						
	Telcuscolex baicalensis (Grube, 1973)	+	SB, NB. M More	-	–	5-1197	Sand, silted sand, silt
	T. glaber Hrabě, 1982	+	SB	-	–	7-14	Silted sand
	T grubei Michaelsen, 1901	+				2-190	All types
	T korotneffi korotneffi Michaelsen, 1901	+	MB, NB, M More	+	–	2.5-304	All types
	T korotneffi gracilis Michaelsen, 1901	+	All	+	–	2.5-82	Stones, sand, silted sand
	Teleuscolex sp [Noskova, 1963]	+	-	+		2 5	Silted sand
Genus	Agnodnlus Michaelsen, 1905						
	Agnodnlus vcrmivorus Michaelsen, 1905	+	NB, M. More	-	–	20-58	Sand
Genus	Stylodnlus Claparède, 1862						
	Stylodnlus asiaticus (Michaelsen, 1901)	+	All	+	–	5-405	Sand, silted sand, silt
	S čerepanovi Semernoy, 1982	+	All	+	–	1-260	Stones, sand, silted sand
	S. crassus crassus Isossimoff, 1962	+	All	+	–	2-400	Stones, sand, silt with detritus
	S crassus crassior Isossimoff, 1962	+	MB	–	–	24-128	Stones, silt
	S. gracilis Semernoy, 1987 nom nud	+	M More	-	–	100	
	S mirandus (Hrabě, 1982)	+	SB	-	–	41-60	Silted sand
	S mirus (Čekanovskaja, 1956)	+	SB, NB	-	Yenisei	10-175	Sand, silted sand
	S. opisthoannulatus (Isossimoff, 1962)	+	All	+	Yenisei	2-860	All types
	S parvus (Hrabě et Černosvitov, 1927)	–	NB, M More	-	Europe	10-360	All types
Genus	Rhynchelmis Hoffmcistcr, 1843						
	Rhynchelmis brachycephala brachycephala Michaelsen, 1901	+	All	–	–	3-1680	Sand, silted sand
	Rh brachycephala tentaculata Isossimoff, 1962	+	SB, NB	–	–	20-900	Silted sand, silt with detritus
	Rh dissimilis Semernoy, 1987 nom. nud	+	M More	–	–	10-48	
	Rh minimans Semernoy, 1987 nom nud	+	M More	–	–	20	
	Rh spermatochaera Semernoy, 1982	+	NB, M More	–	–	5-500	All types
	Rh. tetratheca Michaelsen, 1920	-	NB	–	North Europe	10	Stones, sand, silted sand
Genus	Pseudorhynchelmis Hrabě, 1982						
	Pseudorhynchelmis olehonensis (Burow et Kozhov, 1932)	+	All	+	–	1-430	Stones, sand, silted sand, silt
Genus	Pseudolycodrilus Hrabě, 1982						
	Pseudolycodrilus parvus (Michaclscn, 1905)	+	SB, MB, M. More	+	–	1-304	Sand, silted sand
Genus	Styloscolex Michaelsen, 1901						
	Styloscolex asymmetncus Isossimoff, 1962	+	SB, MB, M. More	+	Angara	1-250	Sand, silted sand, silt
	S baicalensis Michaelsen, 1901	+	All	–	–	1-150	Sand, silted sand, silt

Continuation of list of OLIGOCHAETA species

	Species and subspecies	Endemic or not	Open Baikal	Coastal-sor zone $, bays	Distribution outside of Baikal	**Depth,** m	**Bottom**
	S chonoidalis Isossimoff, 1962	+	MB, NB	+		2-205	Sand, silted sand, silt with detritus
	S. kolmakovi Burow, 1931	-	NB	-	China	2-430	Sand, **silt**
	S solzamcus Hrabě, 1982	+	SB	-	-	3-60	
	S. swarczewskn Burow, 193]	+	M More	-	-	18-35	Sand
	S tetrathecus Burow, 1931	–	NB, M More	–	China	1-200	All types
Ordo	Ilaplotaxida Timm, 1987						
Family	Haplotaxidae Stephenson, 1930						
Genus	Haplotaxis Hoffmcister, 1843						
	Haplotaxis gordioides (Hartmann, 1821)	-	All	-	Holarctic	5-270	Sand, silted sand, silt
	H. ascandoides (Michaelsen, 1905)	–	SB, MB, M More	-	Telczkoye Lake	1-1130	Rock, sand, silt

Comment. SB - south Baikal, NB - north Baikal, MB - middle Baikal, M More - Maloye More.

List of HIRUDINEA species. Compiled by L.N. Snimshikova

	Species and subspecies	Endemic or not	Open Baikal	Coastal-sor zone & bays	Distribution outside of Baikal	Depth, m	Host
Subclass	Hirudiniones Epst, 1987						
Ordo	Rhynchobdellea Blanchard, 1894						
Family	Glossiphonndae Vaillant, 1890						
Subfamily	Giossiphoniinae Autrum, 1936						
Genus	Protoclepsis Livanov, 1902						
	Protoclepsis tessulata (OF Muller J774) (Syn Clepsina molhssima Grube)	–	–	+	Europe, North Asia		Birds
	Protoclepsis maculosa (Rathke, 1862)	–	–	+	Palaearctic		Birds
Genus	Hemiclepsis Veydowsky, 1884						
	Hemiclepsis marginata (OF Mulier, 1774)	–	All	+	Palaearctic		Fish, Amphibia
Genus	Glossiphonia Johnson, 1816						
Subgenus	Glossiphonia s str Lukin, 1976						
	Glossiphonia (Glossiphonia) complanata (L , 1758)	–	–	+	Holarctic		Molluscs, annelids, larvae of insecta
Subgenus	Alboglossiphonia Lukin, 1976						
	Glossiphonia (Alboglossiphonia) heteroclita (L , 1761)	–	–	+	Holarctic		Molluscs, annelids, larvae of insecta
Genus	Helobdella Blanchard, 1876						
	Helobdella stagnalis (L , 1758)	–	–	+			Olrgochaeta, molluscs, larvae of insecta
Subfam	Toncmae Lukin et Epstein, 1960						
Genus	Paratonx s str Lukin of Epstein, 1960						
	Paratonx baicalensis (Stschegolew, 1922)	+	All	+	–	27	Cottidae-fish
Genus	Baicaloclepsis Lukin ct Epstein, 1959	+					
	Baicaloclepsis echinulata (Grube, 1871)	+	All	–	–	6-635	9
	Baicaloclepsis grubei Lukin et Epstein, 1959	+	All	–	–	5 5-90	Salmonidae-fish
Family	Piscicolidae Johston, 1865						
Genus	Baicalobdella Dogicl, 1957						
	Baicalobdella torquata (Grube, 1871)	+	All	–	Angara	3-20 (80 130)	Amphipoda, Cottidae-fish
	B cottidarum (Dogiel et Bogolepova , 1957)	+	All	–	–	to 20	Cottocomephorus grewingki

Continuation of list of HIRUDINEA species

	Species and subspecies	Endemic or not	Open Baikal	Coastal-sor zone & bays	Distribution outside of Baikal	Depth, m	Host
	B truncata (Grube, 1872)	+	All	+	Angara	10-(1100)	Eulimnogammarus verrucosus Fish, Amphipoda
	B zelenskiji (Fmogenova et Snimschikova , 1991	+	NB	–	–	25-100	Fish''
Genus	Piscicola Blainville, 1818						
	Piscicola geometra (L , 1761) (Syn Baicalobdella hvanowi Dog et Bog, 1949, Piscicola multistnata Dog et Bog, 1957)	–	All	+	Palaearctic		Fish
Genus	Acipenserobdella Epst, 1969						
	Acipenserobdella volgensis (Zykoff, 1903)	–	–	+	Volga, Angara		Acipenser baen
Genus	Cystobranchus Diesing, 1859						
	Cystobranchus mammiltatus (Malm, 1863)	–	–	+	Palaearctic		Lota lota
Subclass	Archihirudinea Lukin, 1956						
Ordo	Acanthobdellea Livanow, 1905						
Family	Acanthobbellidae Livanow, 1905						
Genus	Acanthobdella Grube, 1851						
	Acanthobdella peledma Grube, 1851	–	–	+	Palaearctic		Salmo, Coregonus
Ordo	Arhynchobdellea Blanchard, 1894						
Family	Hirudinidae Whitman, 1886						
Subfamily	Hirudininae Blanchard, 1892						
Genus	Haemopis So\igny, 1822						
	Haemopis sanguisuga (L, 1758)	–	–	+	Palaearctic		Fish, Oligochaeta, molluscs, larvae of insecta

List of OSTRACODA species. Compiled by G.F. Mazepova

	Species and subspecies	Endemic or not	Open Baikal	Coastal-sor zone & bays	Biocoe-notic role	Depth, m	Bottom
Ordo	Podocopida						
Superfamily	Cypndoidea						
Famıly	Candonidae						
Subfamıly	Cdndoninae						
Genus	Candona						
	Candona unguiculata Br, 1930	+	All	-	us	5-100	Sand, silted sand
	C directa Br, 1947	+	All	Mukhor Gulf	us	5 100	Sand, silted sand
	C sensibilis sensibilis Br, 1947	+	All		us	210-1560	Silt
	C sensibilis profunda Maz , 1990	+	All, exept SB & M More	-	us	400-900	Silted sand, silt
	C semilunaris semilunaris, Br 1930	+	SB	-	very r	4 5-9 0	Sand and pebbles
	C semilunaris *digmtosa Ma7* , 1990	+	AH	-	*us*	200-1600	Silt
	C inequivalvis Sars, 1898, baicalensis Br, 1930	+	All	-	m	1-30	Sand
	C humilis Br, 1947 (C depessa Br, 1939)	+	MB, SB, M IVI ore	Barguzin Gulf	r	17-45	Soft soils
	C intcrsita Br nom n Maz , 1990 (C intermedia Br , 1947)	+	NB, M More	-	r	3 5-12	Sand and pebble
	C obtusa Br, 1947, nom n (C sp Br, 1930)	+	-	Selenga Shallows	very r	209	Grey silt
	C rupestns rupestris Br, 1947	+	All	+	us	5 20	Stones
	C rupestns dissona Maz, 1990	+	All	+	us	5-20	Stones
	C fossiliformis Maz, 1970	+	All	-	r	8-600	Silted sand, gravel
	C memoranda Maz, 1990	+	NB, SB	-	r	20-114	Silted sand, gravel
	C dybowskn Maz, 1990	+	All	-	us	2-50	Stones
	C godlewsku Maz, 1984	+	All	-	us	2 20	Stones
	C larvaeformis Br, 1947 (only larvae)	+	SB			! 5	Stones
	C larvaeformisoida larvaeformisoida Maz, 1990	+	All	-	us	2-10	Stones
	C larvaeformisoida minuta Maz, 1990	+	All	-	US	2-10	Stones
	C amanda Maz, 1982	+	All	-	r	0-10	Stones
	C longula Maz, 1985	+	Ushkany Islands	-	r	1 5	Stones
	C lamakini Maz, 1990	+	MB	-	r	20 480	Stones, sands
	C gracilenta Maz, 1990	+	All	-	r	210-1380	Silt
	C rara Maz, 1990	+	M 1vlore	-	r	8-16	All types
	C longiformis Maz, 1990	+	All	-	r	300-1400	Silt
	C limosa Maz, 1990	+	All	-	r	400-1400	Silt
	C iwanovi Maz , 1984	+	NB	-	very r	50	Silted sand

Continuation of list of OSTRACODA species

Species and subspecies	Endemic or not	Open Baikal	Coastal-sor zone & bays	Biocoenotic role	**Depth,** m	**Bottom**
C walukam Maz , 1984	+	NB	-	r	50-90	Silted sand with detritus
C gnzea Maz , 1982	+	All	Chivyrkui & Mukhor gulfs	us	1-50	Silted sand, silt
C muriformis Maz, 1984	+	All	-	us	10-20	Stones sand
C unimoda Maz, 1982	+	All	-	r	5-50	Stones sand
C arenosa Maz, 1982	+	All	-	r	1 25	Sand
C orbiculata Maz, 1990	+	M More	-	r	2-16	Sand, silted sand
C birsteini Maz, 1990	4-	MB	-	r	100-1600	Silt with admixtures
C spicata Maz, 1982	+	All	Chivyrkui Gulf	us	5-100	All types
C prava Maz , 1984	+	All	-	r	1 20	Stones
C digitata Maz, 1990	+	SB, M **More**	-	r	1-20	All types
C limpida Maz, 1984	+	All	Chivyrkui Gulf	r	0-25	Sands, stones
C modesta Maz, 1984	+	SB, M **More**	-	r	1-10	Stones
C deltoides Maz, 1990	+	M More	-	r	1-5	Sands with plants
C uschunica Maz	+	MB	-	r	I 5 50	Stones sand
C korjakovi Maz, 1982	+	M More	-	very r	1-10	Sand
C wasilievae nom n Maz , **1990** (C demissa Maz, 1984)	+	All	-	us	1 5-25	Sand, stones
C flava Maz. 1984	+	Ushkany Islands	—	r	1 5-10	Stones
C virgata Maz, 1985	+	All	-	us	1-25	Stones, sand
C picta Maz 1990	+	All	-	us	0-25	Stones, sand
C fluctigera Maz, 1990	+	M More	—	r	20	Silted sand with algae
C dryshenkoi Maz, 1990	+	All	Mukhor Gulf	us	5-100	Sand
C msulans Maz, 1990	+	Ushkany Islands	-	r	1-10	Sands
C stankovici Maz, 1990	+	NB	Selenga Shallows	us	300-860 (11-20)	Silts
C procera Maz, 1982	+	All	-	r	1-10	Stones, sands
C smaidae Maz, 1990		NB, MB M More	—	r	1 10	Stones, sands
C microdorsoconcava Maz, 1984	+	NB, MB M More	—	r	1-25	Sand;>
C Candida (O F Muller, 1785)	-	-	+	r	0 8-4 5	Silt
C sp cf C Candida var humilis Ekman, 1914 (>), juv	—	—	+	us	05 8	Silt

Continuation of list of OSTRACODA species

	Species and subspecies	Fndemic or not	Open Baikal	Coastal-sor zone & bays	Biocoe-notic role	Depth, m	Bottom
	C lepncvac Br, 1947	-	-	+	us	0 1-10	Silt, silted sand
	C hyalina Bret Rob, 1870 (C (Eucandona) hyalina Sywula. 1974)	—	-	Mukhor Gulf	r		
	C weltnen Hartw., 1898	—	—	Severobaikalsky Sor	r		Silt
	C levanden-balatonica	"	—	+	us	0 6-6	Silt
	C. holzkampfi Hartw , 1990 (C (Eucandona holzkampfi Sywula, 1900)	–	–	Severn baikalsky Sor Selenga channels	r	2-5	Silt
	C caudata Kaufm , 1900 (C (Eucandona) caudala Sywula, 1974)	–	–	Selenga channels	very r	1	Silt with detritus
	C sarsi Hartw, 1899 (Typhlocypns sarsi Sywula, 1974)	-	-	Scverobaikalsky Sor	very r		Silt
	C parallela G W Mull , 1900 (Typhlocypris parallela Sywula, 1974)	-	-	Selenga channels	very r		Silt
	C sp	?	NB	-	r	10-440	All types
Genus	Pseudocandona						
	Pscudocandona tuberculata tuberculata Br , 1947	+	All	Chivyrkui Gulf	m	1-25	Stones, sand
	P tuberculata distorts Maz, 1990	+	AH	-	u.s	1-20	Stones
	P tuberculata huluguneica Maz , 1990	+	M More, NB West coast		r	5-50	All types
	P parvispinosa Br, 1947	+	All, e\cept M More, Ushkany Islands	–	r	0-20	Sands
	P bispinosa (Br , 1930)	+	All	Mukhor Gulf	us	1 5-20	Sands
	P werestschagini (Br, 1930)	+	All	Mukhor Gulf	us	5-100	All types
	P. setosa selosa Br, 1947	+	All	Chivyrkui Gulf	us	0-100	All types
	P setosa abissahs Maz, 1990	+	All		us	210-1320	Silts
	P. alta Br, 1947	+	All	-	us	1-25	Stones
	P saxatilis Br, 1947	+	All	-	r	1-10	Stones
	P gajewskajae (Br, 1947) Carbonnel, 1969						

Continuation o1` list of OSTRACODA species

	Species and subspecies	Endemic or not	Open Baikal	toastal-sor zone & bays	Biocoe-notic role	Depth, m	Bottom
	(Alalocandona Carbonnel)	+	All	–	us	1-10	Stones, sand
	P glauci Maz, 1990	+	All	-	us	5 20	Stones
	P grumifera Maz , 1984	+	All	-	us	5-20	Sands
	P corniculdta Maz, 1984	+	All	-	r	5 200	Sands
	P bazicalovac Maz, 1990	+	All	-	r	5-100	All types
	P artuta Maz, 1984	+	MB	-	r	300-1360	Silts
	P ceralina Maz , 1982	+	NB, MB	Chivyrkui Gulf	us	5 50	Silted sand, sand with detritus
	P herbigrada Maz, 1982	+	All			2-25	Solid soils
	P renalis Maz , 1982	+	All	–	m	5-10	Sands
	P capitata Maz , 1982	+	All	Mukhor Gulf Severobaikalsky Sor	us	1-50	All types
	P valosa Maz , 1982	+	NB	-	us	5-100	Rock, stones
	P scita Maz, 1982	+	All	—	r	20	Silted sand with detritus
	P complexiva Maz, 1985	+	Ushkany Islands	—	r	10-110	Sands, silted sands with clay
	P valosiformis Maz, 1990	+	_".	-	r	1-10	Stones
	P pseudosetosa Maz, 1990	+	All	-	r	0-100	Soft soils
	P academica Maz, 1982	4	All	-	r	1-20	Stones
	P malomonca Maz, 1982	+	M More, NB	-	r	I 5-15	Stones with sponges
	P onduoltoryensis Maz , 1984	+	Ushkany Islands	-	r	1 5-10	Stones
	P lukmi Maz, 1985	+	NB, SB	-	r	5-100	All types
	P olchonica Maz, 1990	+	MB	-	r	*50-300*	Silted *sands*
Genus	Baicalocandona						
	Baicalocandona dorsoconcava dorsoconcava (Br , 1947 maz)	+	All	Mukhor Gulf	us	1-50	Silted sands
	B dorsoconcava applicata Maz , 1976	+	All		r	5-10	Sands
	B dorsoconcava flmtima Maz, 1976	+	All	-	r	0 50	Silled sands
	B dorsoconcava insulans Maz, 1990	+	Ushkany Islands	-	r	3-20	Stones
	B ambagiosa Maz, 1976	+			very r	0-50	Sands
	B ushkani Maz , 1984	+	Ushkany Islands	—	r	1 5 20	Stones
	B bivia Maz , 1976	+	All	Mukhor Gulf	us	5 100	All types

Continuation of list of OSTRACODA species

	Species and subspecies	Endemic or not	Open Baikal	Coastal-sor zone & bays	Biocoenotic role	Depth, m	Bottom
	B bronsteini Maz., 1976	+	All	Chivyrkuj & Mukhor gulfs	us	5-100	Soft soils
	B. profunda Maz, 1976	+	All	-	us	50-1335	Silted sands, silts
	B borutskn Maz, 1985	+	Ushkany Islands	—	r	1.5-10	Stones
	B. aspiranti Ma?., 1984	+	All	-	r	1-50	Stones
	B. zenkevichi Maz., 1976	+	All	-	r	*20-100*	All types
	B navitarum Maz, 1976	+	SB	-	r	20-40	Sand
	B sp(Maz., 1990)	+	MB	—	very r	410	Sand
Subfamily	Cyclocypridinae						
Genus	Cypna						
	Cypna ophtalmica (Jur , 1820)	-	-	Selenga channels	r	1 2-2	Silt with detritus
Genus	Cyclocypns						
	Cyclocypns ovum (Jur, 1820)	—	—	+		0.3-5 0	Sand, silt
Family	Uyocypndidae						
Genus	Ilyocypns						
	Ilyocypns sp.	–	–	+		0.8-1.5	
Family	Cypndidae						
Subfamily	Cypndopsinae						
Genus	Cypridopsis						
	Cypndopsis vidua (O.T Miiller, 1776)	–	–	Avandelta of Selenga		0.5-1.0	Silted sand
Subfamily	Dolerocypndinac						
Genus	Dolerocypris						
	Dolerocypris fasciata (OF Miiller, 1776)	–	–	+	r		Silt
Superfamily	Cytheroidea						
Family	Cythendeidae						
Genus	Cythenssa						
	Cythenssa dubitabilis Br., 1947	+	All	Mukhor Gulf	m	1-20	Sands
	C. scrnovi sernovi Br, 1930	+	All	–	m	100-tlOO	Sands, silts
	C. sernovi ovata Br, 1947	+	All	–	r	2-100	Sands
	C sernovi insularis Maz, 1990	+	Ushkany Islands	–	r	20	Sand
	C interposita interposita Br, 1947	+	All	Mukhor Gulf	us	5-150	Exept silts
	C. interposita ushkani Maz, 1990	+	Ushkany Islands	–	r	20	Sand
	C truncata Br., 1930	+	All	–	m	5-100	Sands
	C. fuscata Br, 1947	+	All	–	m	5-100	Sands

Continuation of hst of OSTRACODA species

Species and subspecies	Endemic or not	Open Baikal	Coastal sor zone & bays	Biocoe-notic role	Depth, m	Bottom
C simstrodentdtd Br , 1930	+	All	–	m	5-1400	Silted sand, silt
C parallela Br, 1947	4	All	-	us	1 5-70	Sands
C lata Br, 1930	+	All	-	us	1 5-100	Soft soils
C pterygota Br, 1947	+	All	-	us	10-300	All types
C tubcrculata tubercuUta Br, 1930	+	All	-	m	1-1620	All types
C tuberculdtd dmsoptera, Maz, 1990	+	All	-	us	10 50	All types
C tnangulata Br, 1947	t-	All	-	us	20-300	Sands, sdts
C cythenformis Br, 1947	+	M More	Selenga region	r	10-100	Sands
C elongata elongata Br, [947	+	All	-"-, MuJchoi t.ulf	m	2 100	All types
C elongata ssorensis Maz, 1990	+		Posolsky & Istoksky sors	us	I 3	Silted sand
C golyschkinae Maz, 1990	+	All	-	us	1-50	All types
C burchani Maz, 1990	+	All	-	us	50-260	All types
C placida Mdz , 1990	+	Ushkany Islands	–	r	20	Stones
C glomerata Maz, 1990	+	All	–	r	20-1300	Silted sands, silts
C *plena MAZ* , *i* 985	+	M More, NB	–	*r*	10-25	Sands
C obrutshevi Mdz , 1990	+	All	–	r	1 50	Sands, stones
C florensovi Maz , 1990	+	All	–	r	1-50	Sands, stones
C attenuata attenuata Maz, 1984	+	All	–	r	I 5-50	Stones
C attenuata minor Maz, 1990	+	Ushkany Islands	–	r	20	Silted sand
C latirecta Maz , 1985	+	NB, SB	–	r	50-100	Soft soils
C latiundata Ma/ , 1985	+	NB	–	r	50-100	All types
C donquixotei Maz, 1990	+	Ushkany Islands	–	r	5-10	Stones with sponges
C neobaicalensis Maz, 1984	+	All	–	us	2-50	Stones, sand
C compta Maz , 1990	+	All	–	us	50 100	Soft soils
C mirabilis Br, 1947	+	NB	–	very r	65	Sand with silt
C puschkarevi Maz, 1990	+	NB, MB	–	us	50-100	All types
C verrucosa Maz , 1990	+	Ushkany Islands, NB	–	r	5-20	Sand, stones
C uvaeformis Maz, 1990	+	NB, M More	–	r	10-50	Stones, sands
<L penndtd Maz, 1990	+	NB, MB, M More	–	r	10-100	Stones
C sinistra Mjz, *1984*	+	NB, M *More*	–	*r*	*110-900*	*Silts*, siited sands
C dextima Maz, 1984	+	NB, M More	–	r	10 100	Silt, silted sand
C calva Maz, 1990	+	NB, MB	–	r	10-20	All types

Continuation of hst of OSTRACODA species

	Species and subspecies	Endemic or not	Open Baikal	Coastal-sor zone & bays	Biocoe-notic role	Depth, m	Bottom
	C crepera crepera Ma7 , 1990	+	Ushkany Islands	-	very r	10	Stones
	C crepera angustimarginata Maz	+	-"-	-	very r	10	Stones
	C crepera magna Maz , 1984	+	"	-	very r	10	Stones
	C multipora Maz, 1984	4-	NB, MB, M More	Selenga Shallows	r	10-50	Sand, silted sand
	C parva pana Maz, 1984	+	All	-	r	20-100	All types
	C parva *confmts Maz, 1990*	4-	Ushkany Islands	"	very r	20	Sand
	C bisetosa Maz, 1984	+	SB	-	very r	3 5-5 0	Stones with sponges
	C derupta Maz , 1984	+	SB, MB	Selenga Shallows	us	5-20	Sand
	C exceisa Maz , 1990	+	SB, M More	-	*us*	3 5-20	All types
	C excelsitorniis Maz, 1990	+	Ushkany Islands	"	very r	20	Sand
	C microext.ulpla Maz, 1984	4-	NB, M More	-	r	50-460	All types
	C nana Maz , 1984	+	MB	-	r	270-300	Silt
	C tenella Ma^ , 1984	4-	All	-		5-100	Soft soils
	C cymbulata Maz, 1984	+	Ushkany Islands	—	r	50	Concretions
	C pusilla Maz, 1985	+	All	–	very r	5-300	Soft soils
	C lacustns lauistns Sars, 1862	–	–	+ ?	very r		
	C lacustns baicalensis Br, 1930, 1947	–		4-	us	1-50	Sands, silted sands with detritus
Family	Limnocythendae						
Genus	Limnocytherc						
	Limnocythere mopmata (Baird, 1850}	-	-	+	us		Silted sands with plants
	L sanctipatncn Brady ct Rob, 1869	-	-	+	r		Silt with detritus
	L baicalensis Martens et Mazepova, 1992	4-	—	+	r	2 5-5	Sand with macrophytes

Comment SB - south Baikal, NB - north Baikal, MB - middle Baikal, M More - Maloye More, us - usual, r - rare, m - mass

List of CYCLOPOIDA species. Compiled by G.F. Mazepova

	Species and subspecies	Endemic or not	Open Baikal	Coastal-sor zone & bays	Biocoenotic role	Depth, m	Bottom	Ecological characteristic
Subfamily	Cyclopinae							
Genus	Acanthocyclops							
	Acanthocyclops rupestns rupestns Maz , 1950	+	All	–	m	20-max	All types	Nben
	A rupestns sigmfer Maz , 1978 (A. sigmfer Maz., 1952)	+	All	–	us	5-50	Sand, stones	
	A. tahevi (Maz., 1970) (Diacyclops lanuidoides tahevi Mazepova, comb. nov Monchenko, 1974)	+	All	–	us	400-max.	Silt	Nben
	A profundus profundus Maz, 1980	+	All	–	us	20-max	Sand, silt	
	A. profundus tomilovi Maz, 1978	+	All	+?	us	5-50	Sand, silt	
	A notabihs Maz, 1950	+	All	-	r	5-50	Sand	
	A. similis Flossner, 1984	+	-	Selenga Shallows	r	20	Soft silt	
	A spongicola Maz., 1962	+	NB,SB.M.More	–	us	1-100	On sponges	
	A. arenosus Maz , 1950	+	SB,M.More	-	r	1-15	Sand	
	A intermedius Maz., 1952	+	SB.NB.M More	-	r	1-15	Stones	
	A jasmtskn (Maz., 1950) (Diacyclops languidoides jasmtskn, (Mazepova) comb.nov , Monchenko, 1974)	+	All	-	r	1-20	Sand	
	A. macolotaema Maz. 1950	+	SB.NB	–	SB,us	1-50	Stones	
	A. elegans (Maz., 1962) (Diacyclops languidoides elegans (Mazepova) comb nov. Monchenko, 1974)	+	All	–	us	10-400	All types	Nben
	A konstantim (Maz, 1962) (Diacyclops languioides konstantim (Mazepova) (comb.nov), Monchenko, 1974)	+	All	–	m	1-400	Stones, Sand, silt	
	A galbinus (Maz., 1962) (Diacyclops languioides moravicus Sterba, 1956, Monchenko, 1974)	+	SB	–	us	1-100	Stones	
	A. versutus Maz., 1950	+	All	–	r	5-100	Soft soils	
	A improcerus (Maz., 1950) (Diacyclops languidoides improcerus (Mazepova) (comb.nov), Monchenko, 1974)	+	All	–	us	0-50	Stones, sands	
	A bicuspidatus (Claus, 1857) (Diacyclops bicuspidatus (Claus), Monchenko, 1974)	–	–	+	r	1-20	Soft soils	
	A bisetosus (Rehb., 1880) (Diacyclops bisetosus (Rehb.), Monchenko, 1974)	–	M.More	+	r	3.5-30	Sand, stones	
	A virtdis (Jurine, 1820)	–	M More	+	r	1-45		

Continuation of list of CYCLOPOIDA species

	Species and subspecies	Endemic or not	Open Baikal	Coastal-sor zone & bays	Biocoenotic role	Depth, m	Bottom	Ecological characteristic
	(A (Megacyclops) vindis (Jur, 1820)							
	A gigas (Claus, 1857) *(•>)*	-	M More'[1]	–	r	30-35?		
	(A (Megacyclops) gigas (Claus, 1857)							
	A vernahs (Fisch, 1853) (?)	-	–	+	r		Pelagic	
Genus	Diacyclops							
	D neglectus Flossn , 1984	+	–	Selenga Shallows	r	100	Silt	
	D euhtorahs Alekseev et Arov, 1986	+	SB,M More	–	us		Sand	**Pm**
Genus	Mesocyclops							
	Mesocyclops leuckarti (Claus, 1857)	–	–	+	m		Pelagic	
	Mesocyclops (Th) crassus (Fisch), 1853	–	–	+	r		Pelagic	
	(Thermocyclops crassus (Fisch), Monchenko, 1974)							
Genus	Cyclops							
	Cyclops vicmus UJjanin, 1875	–		+	r		Pelagic	
	C kolensis Lill, 1901	–	All	+	m		Pelagic	
Subfamiha	Eucyclopinae							
Genus	Macrocyclops							
	M baicalensis Maz , 1962	+	All	r	r	50-100	Rock, sand, silt	
	M albidus (Jurine, LS20)	-	–	+	us	2-45		
Genus	Paracyclops							
	P baicalensis Maz, 1962	+	All	-	r	20-600	Sand, silt	
	P fimbnatus fimbnatus (Fisch, 1853)	–	–	+	r	2-4	Silt	
Genus	Eucyciops							
	E serrulatus baicalocorrepus (Maz, 1955)	+	All	-	m	1-50	Stones, sand	
	E serrulatus serrulatus (Fisch, 1891)	–	–	+	r	1 5-6	Soft soils	
	E macruroides (Lill , 1901), f baicalensis Maz , f nov	+	All		us	10-20	All types	
	E macruroides macruroides (Lill, 1901)	–	All	+	us	20-max	All types	
Genus	Orthocyclops							
	O bergianus Maz. 1952	+	All	-	SB-r, NB-us	10-100	All types	
Genus	Microcyclops							
	Mbicolor (Claus, 1893)	–			r		Pelagic	

Note Five species and subspecies were found by V R Alekseev in Posolsky Sor and near Baikalsk town in 1986
Paracyclops fimbnatus onentalis Alekseev, 1992
Eucyciops serrulatus proximus (Lilljeborg, 1901)
E arcanus Alekseev, 1990
E speiatus (Lilljeborg, 1901)
E macrurus (Sars, 1863)

Comment SB - south Baikal, NB - north Baikal, MB - middle Baikal, M More - Maloye More, us - usual, r - rare, m - mass, Nben - necto benttic, Pm - psammon

List of HARPACTICOIDA species. Compiled by G.L. Okuneva (1989)

	Species and subspecies	Fndemic or not	Open Baikal	Coas-tal-SOT zone & bays	Distribution outside of Baikal	Depth, m	Bottom	Ecological characteristic
Family	Canthocamptidae G O Sars							
Subfam	Canthocamptmae Chappuis							
Genus	Canthocamptus Wcstwood							
Subgen	Baicalocamptus Borutzky	+						
	Canthocamptwi (Baicalocamptus) werestschagmi Borutzky, J931	+	SB, MB Uslikany Islands	–	–	20-30	**Sand, silt, rocks**	**Nectobenthic**
	C (**B**) longifurcatus Bo*rutzky,* 1947	+	All	–	-	to 20	Stones, rocks	**Rare**
Subgen	Canthocamptus Westwood							
	C (C) latus Borutzky, 1947	+	All	+	-	1 20 (260)	Stones, sand	
	C (C) bulbifcr Borutzky, 1947	+	Ml	+	-	0 1-15	Stones, sand	
	C (C) baicalcnsis Borutzky, **1931**	+	Ml	–	-	2-36 10-100	Stones, sand Silt	**Nectobenthic**
	C (C } gibba Okuneva 1983	+	SB	–	—	05-1, 14	Silted sand	
Genus	Paracamptus Chappuis							
	P schmeili (Mrazek)	–	M More	+	Holarctic	2-5	Silt	
	P baicalensis Borutzky, 1931	+	All	–	–	5-100 (300-400)	Sand, silt	
Genus	Bryocamptus Chappuis							
Subgen	Pentacamptus Willey							
	Bryocamptus (Pentacamptus) longifurcatus Borutzky, 1931	+	All	–	-	3-24	Sand, silted sand	
	B (P) chappuisi Borutzky, 1948	+	NB, SB Barguzm Gulf, Bolshiye Koty	+	–	to 100	Silted sand, sand, silt	
	B (P)longisctosus Borutzky, 1931	+	MB, NB	–	-	10-20 (30)	Silted sand	
	B (P) mccrtus Borutzky, 1931	+	All	–	-	1-260	Silt, sand,	Psammophile
	B (P) bulbochaetus Borutzky, 1931	+	All	+	-	1 5 100	silted sand	Nectobenthic
	B (P) coken Borutzky, 1948	+	All	+	—	1 5-20 (100)	Sand, pebbles	Psammophile
	B (P) elaphoides Borutzky, Okuneva 1972	+	SB	–	-	1-5	Stones	
	B (P) tenuis Borutzky, Okuneva, 1971	+	SB	–	-	42	Silt, silted sand	Rare
	B (P) longitaudatus Bor et Okun , 1972	+	All	+	-	6 50	Silted sand	Psammophile
	B (P) kozhowi Bor et Okun , 1971	+	All	+	-	1-10	Silted sand	Psammophile
	B (P) sinuatus Boret Okun , 1972	+	SB, NB	–	-	14-100	Sand, silted	Rare

Continuation of list of HARPACTICOIDA species

	Species and subspecies	Endemic or not	Open Baikal	Coas- tal sor zone & bays	Distubution outside of Baikal	Depth, m	Bottom	Ecological characteristic
							sand	
	B (P) abyssicola Buret Okun , 1972	+	SB, NB	+	–	20-100 (260)	Silted sand	
	B (P) tuberculatus Bor , 1948	+	MB, NB	+	–	3-20 (65)	Silt, silled sand	
Subgen	Rheotdinptus Borutzky	+						
	Bryocamptus (Rheocamptus) baicalensis Borutzky, 1931	+	All	+	–	0 3-20	Stones, sand	Lithophile
	B (R) rylovi Borutzky 1931	-f	All	-	–	3-50	Stones, silted sand	Lithophile
	B (R) brevipcs Borutzky, 1948	+	All	+	–	0-20	Stones, sand	
	B (R) saxicola Borutzky et Okuneva, 1972	+	All	-	–	0-10	Stones	
	B (R) crassipes Borutzky ct Okuneva, 1972	-f	All	-	–	0-20	Stones, water plants	Lithophile
	B (R) denticulatus Borutzky et	+	All	-	–	0-10	Stones	Lithophile
	B (R) enstatus Borutzky et Okuneva, 1972	+	All	-	–	9-200	Sand, silted sand, silt	
	B (R) litloralis Borutzky et Okuneva, 1972	+	All?	–	–	1-5	Stones	Rare
	B (R) albidus Okuneva, 1983	+	NB	-	–	12-40	Silted sand	
	B (R) enstatus Borutzky et Okuneva, 1972	+	SB, NB	–	–	9-200	Sand, silt	
	B (R) spinulosus Borutzky	–	–	–	Pnbaikalye			
Genus	Echinocamptus Chappuis							
Subgen	Limot-amptus Chappuis							
	Echinocamptus (Limocamptus) hicmalis werestschagini Borutzky, 1931	+	All	–	–	1 5-74	Sand, silt, silted sand	
	E (L) baicalensis Borutzky, 1931	+	All	–	–	0 5-40	Stones, sand	Lithophile
	E (L) smirnovi Borutzky, 1931	+	All	+	–	4-47 (26!)	Sand, silt. silled sand	
	E{L) parvus Borutzky, 1931	+	All	+	–	15-225	Sand, silt. silted sand, stones	Rare
Genus	Maraenobiotus Mrazek							
	Maraenobiotus insignipes insignipes (Lilljeborg) Rylov, 1928	–	–	+	Palaearctic	8		

Continuation of list of HARPACTICOIDA species

	Species and subspecies	Endemic or not	Open Baikal	Coa?>tal-sor zone & bays	Distribution outside of Baikal	Depth, m	Bottom	Ecological characteristic
	M insignipes alpinus Keilhack	-	-	-	Pnbaikalye			
Genus	Attheyella Brady							
Subgen	Brehmiella Chappuis							
	Attheyelld (Brehmiella) dogiclli (Rylov, 1923)	–	–	+	Palaearctic	to 10	Sand, silt	
Subgen	Ryloviella Borutzky							
	AttheycUa (Rylovietla) baicalensts Borutzky, 193)	+	All	+	–	1-20 (down to 300)	Sand, silt	**Psammophile**
Subfam	Morarnnae							
Genus	Morana Scott							
Subgen	Morana s str							
	Morana duthiei (Scott)	–	SB, M More	+	Palaearctic	5-15	Silt	**Rare**
	M schmeih van Douwe	–	SB, M More	-\	Palaearctic	15-20	Silt, silted sand	
	M gracilipes Borutzky et Okuneva, 1972	+	SB (Bolshiye Koty)	–	–	25	Rock, silt, silted sand	
	M pseudobrevipes Borutzky **et** Okuneva, 1972	+	SB (Bolshiye Koty)	–	–	6,4	Silted sand	
Subgen	Baicalomorana Borutzky							
	Morana (Baicalomorana) brevicauda Borutzky, 1952	+	SB, NB	+	–	**1** 5-80	Sand	Pelophile
	M (B) phyllura Borutzky, 1952	+	SB, NB	+	–	1-30	Sand, silt, silted sand	
	M (B) longicauda Borutzky, 1952	+	All	–	–	5-300	Sand, silt, silted sand	Nectobenthic
	M (B) sinuata Borutzky, 1952	+	SB, NB	–	–	6-260, 14-89	Silt, silted sand	
	M (B) litorahs Borutzky et Okuneva, 1972	+	All	+	–	1-20	Stones	Lithophile
	M (B) dentata Borutzky, 1952	+	SB	–	–	2-100	Sand, silt	
	M (B) spinulosa Borutzky et Okuneva, 1972	+	SB	–	–	6-100	Silted sand, grey silt	Rare
	M (B) tenuicauda Borut?ky, 1931	+	SB, NB	+	–	2-100	Sand, silt, silted sand	
	M (B) ovicauda Borutzky, 1952	+	All	–	–	1-100	Sand, silt	
	M (B) intermedia Borutzky, 1931	+	All	+	+	1 100	Sand, silt	

Continuation *of list of* HARPACTICOIDA species

	Species and subspecies	Endemic or not	Open Baikal	Coastal-sor zone, bays	Distribution outside of Baikal	Depth, m	Bottom	Ecological characteristic
	M (B) baicalensis Borutzky, 1931	+	All	+	–	1-300	Sand, silt, stones	
	M (B) laticauda Borutzky, 1931	+	M More	–	-	2-11	Grey silt, sand	
	M (B) acuta Borutzky, 1952	+	SB, NB	–	–	9-100	Sand	
	M (B) stylata Borutzky, 1949	+	SB, NB	–	–	2-35	Grey sand	
	M (B) wcrestschagini Borutzky, **1949**	+	SB, NB	-	-	10	Grey silt, gravel	
	M (B) coronata Borutzky, 1949	+	NB	-	-	3-25	Sand	
	M (B) hncvitchi Okuneva, 1981	+	MB Bolshiye Koty, Boguchanskaya Bay	–	–	3-4	Stones	
	M (B) magna Borutzky, 1949	+	SB	–	–	5-10	Silted sand	
	M (B) mazepovi Okuneva, 1983	+	NB	-	-	10-20	Red silted sand	
	M (B) arenosa Okuneva, 1983	+	NB	+	-	15-20	Red silted sand	
	M (B) minor Okuneva, 1983	+	NB	+	-	3-35	Red silted sand	
Genus	Moranopsis Borutzky							
	Moranopsis typica Borutzky, 1931	+	All	-	-	15-300	Silt, silted sand	
	M baicalensis Borutzky ct Okuneva, 1975	+	SB	-	-	74	Silt, silted sand	
	M latifurcata Borutzky, 1931	+	NB	-	-	29-50	Sand, silted sand	Rare
Subfam	Epactophaninae Chappuis							
Genus	Epactophanes Mrazek							
	Epaetophanes nchardi Mrazek	–	M More	–	Pnbaikalye			
Family	Harpacticidae Sars							
Genus	Harpacticella s str							
	H mopinata Sars	–	All	+	Asia	0-20 *(230)*	Stones, sand, silted sand	**Nectobenthic**

List of CALANOIDA (GYMNOPLEA) species. Compiled by N.G. Sheveleva & G.I. Pomazkova

	Species and subspecies	Endemic or not	Open Baikal	Coastal-sor zone & bays	Bio-coenotic role	Distribution outside of Baikal	Ecological characteristics	Habitat
Family	Temondae Sars, 1903							
Genus	Epischura Forbes. 1882							
	Epischura baicalensis Sars. 1900	+	All	+	D	–	P	Pz,L
Genus	Heterocope Sars, 1863							
	Heterocope appendiculata Sars, 1863	–	SB,NB	+	F	Palaearctic	P	Pz,L
Family	Diaptomidae Sars, 1903							
Subfamily	Diaptominae Sars, 1903							
Genus	Eudiaptomus Kieter, 1932							
	Eudiaptomus graciloides (Lill,1888)	–	All	+	Sd,Nn	Palaearctic	P	Pz,L
Genus	Neutrodiaptomus Kiefer, 1937							
Subgenus	Neutrodiaptomus Kiefer, 1937							
	Neutrodiaptomus mcongruens (Poppe, 1888)	–	NB	+	F	Asia	P	Pz,L
Subgenus	Manaediaptomus Step , 1991							
	N (Manaediaptomus) pachypoditus (Ryl 1925)		NB	+	F	Asia	P	Pz,L

Comment P - planktonic, B - benthos, PB - plankto-benthos, Pm - psammonic, PI - among the plants, Pz - pelagic zone L - littoral, Pm - psammal D dominant Sd - subdominant, Nn - not numerous, F - few

List of CLADOCERA species. Compiled by N.G. Sheveleva & G.I. Pomazkova

	Species and subspecies	Endemic or not	Open Baikal	Coastal-sor zone & bays	Biocoenotic role	Distribution outside of Baikal	Ecological characteristics	Habitat
Family	Chydondae Stebbmg, 1902							
Genus	K.ozhowia Vas et Smirn , 1969	+						
	Kozhowia baicalensis Vaset Smirn, 1969	+	All	+	D	Angara	B	L, stones, silted sand
	K pnmigenia Vas et Smirn, 1969	+	SB	-	Nn	Angara	B	L, stones, sand
	K gajewskajae Vas et Smirn, 1969	+	All exept M More	+	Sd,Nn	Angara	B	L, stones,sand
	K brevidentata Vas et Smirn, 1969	+	SB	-	F	-	B	L, stones,silt
	K. kozhowA Vas et Smirn, 1969	+	SB	-	Sd,Nn	-	B	L, clay
Genus	Alona Baird, 1843							
	Alona setosocaudata Vas et Smim,1969	+	All	+	D.Sd	Angara	B	L, stones,sand,silt
	A Jabrosa Vas et Smirn , 1969	+	All	+	D,Sd	Angara	B	L stones,sand
	A rectangula Sars, 1862	-	-	+	F	Palaearctic	B,PB	L, stones,sand
	A guttata Sars,1986	-	+		F	Palacarctic	B,PB	L, stones
	A quadrangulans (O F Mull)	-	+		Nn,F	Palaearctic	B.PB.P1	L
	A costata Sars, 1862	-	NB	-	F	Palaearctic	PB	L
Genus	Biapertura Smirn,1971							
	Biapertura affinis (Leyd,1860)	-	-	+	F	Angara	P1,PB	L, sand
Genus	Disparalona FryeT, 1968							
	Dispamiona rostrata (Koch ,1841)	-	-	+	F	Palaearctic	PB.P1	L
Genus	Alonella Sars, 1862							
	Alonella exigua (Lill 1853)	-	-	+	F	Palaearctic	PB	L
	A excisa (Fisch , 1854)	-	-	+	F	Cosmopolitan	PB	L
Genus	Chydorus Leach ,1816							
	Chydorus sphaencus (OF Mull ,1785)	-	All	+	D,Sd,Nn	Cosmopolitan	B,PB,P1,P	PZ,L
	Ch piger Sars, 1862	-	SB	+	D,Sd,Nn	Palaearctic	B,PB	L
Genus	Eurycercus Baird, 1843							
	Eurycercus lamellatus (OF Mull 1785)	-	-	+	F	Palaearctic	PI, p	L PZ
Genus	Graptoleberis Sars, 1862							
	Graptoleberis testudinana (Fisch ,1851)	-	-	+	F	Cosmopolitan	PB,P1	L
Genus	Acroperus Baird, em Smirnov, 1966							
	Acroperus harpae (Baird, 1834)	-	-	+	F	Holarctic	PI	L
Genus	Pleuroxus Baird 1843							
	Pleuroxus tngoncllus (OF Mull,1785)	-	NB	+	F	Holarctic	P.P1	L
	P *unanatus, Band,* 1850	-	-	+	*t*	Holarctic	*Pl,P*	[illegible]
	Paduncus (Jur 1820)	-	-	+	F	Cosmopoliitan	Pl,t>	L
Genus	Monospilus Sars, 1862							
	Monospilus dispar Sars,							

Continuation of list of CLADOCERA species

	Species and subspecies	Endemic or not	Open Baikal	Coastal-sor zone & bays	Bio-coenotic role	Distribution outside of Baikal	Ecological characteristics	Habitat
	1862	-	-	+	F	Holarctic	PI	L
Family	Sididae Baird, 1850							
Genus	Sida Straus, 1820							
	Sida crystalhna (OF Mull 1776)	-	-	+	Sd,Nn	Palaearctic	P1,P	L
Genus	Limnosida Sars, 1862							
	Limnosida frontosa Sars, 1862	-	-	+	F	North Europe	Pl,P	L
Genus	Diaphanosoma Fischer, 1860							
	Diaphanosoma brachyurum (Liev , 1848)	-	-	+	F	Cosmopolitan	P1,P	L
Family	Daphrmdae Straus, 1820							
Genus	Daphnia Muller, 1785							
	Daphnia longispina OF Mull,1787	-	-	+	Sd,Nn	Cosmopolitan	P	PZ,L
	Dhyalma Leyd , 1860	-	All	+	Sd,Nn	Holarctic	P	PZ,L
	D galeata Sars, 1863	-	All	+		Holarctic	P	PZ
	D enstata Sars, 1862	-	All	+	Nn	North Europe	P	PZ,L
	Dcucullata Sars, 1882	-	All	+	F	Europe	P	PZ.L
Genus	Cenodaphma Dana, 1855							
	Cenodaphma pulchella Sars, 1862	-	All	+	Nn	Cosmopolitan	P	PZ,L
	C pulchella pseudohamata Bowk, 1925	-	-	+	F	Cosmopolitan	P	L
	C quadrangula (OF Mull, 1785)	-	All	+	F	Cosmopolitan	P	PZ,L
	C affinis Lill, 1900	-	-	+	F	Cosmopolitan	P	PZ,L
	C reticulata (Jur , 1825)	-	-	+	F	Cosmopolitan	P	PZ,L
Genus	Simocephalus Schoedler, 1858							
	Simocephalus vetulus (OF Mull, 1776)	-	-	+	F	Cosmopolitan	P,Pl	PZ,L
Genus	Scapholebens Schoedler, 1858							
	Scapholebens mucronata (OF Mull, 1785)	-	-	+	F	Cosmopolitan	P,Pl	L
Family	Holopcdidae Sars, 1865							
Genus	Holopedium Zaddach, 1848							
	Holopedium gibberum Zadd, 1848	-	All	+	Nn	Holarctic	P	PZ,L
Family	Polyphemidae Baird, 1849							
Genus	Polyphemus O F Mull , 1785							
	Polyphemus pediculus (Linnaeus, 1761)	-	-	+	F	Europe, Asia, North America	PI, P	L
Family	Leptodondae Lilljeborg, 1861							
Genus	Leptodora Lill , 1861							
	Leptodora kindtn (Focke, 1844)	-	-	+	Nn	Holarctic	P	PZ,L

Continuation of list of CLADOCERA species

	Species and subspecies	Endemic or not	Open Baikal	Coastal-sor zone & bays	Bio-coenotic role	Distribution outside of Baikal	Ecological charactenstics	Habitat
Family	Macrothncidae Baird, 1843							
Genus	Macrothrix Baird, 1843							
	Macrothnx sp	-	-	+				
Genus	Ilyocryptus Sars, 1862							
	Ilyocryptus sordidus (Liev, 1848)	-	All	+	F	Cosmopolitan	B,PB	L
Family	Bosminidae Sars, 1865							
Genus	Bosmina Baird, 1850							
	Bosmma longirostns {OF Mull,1785)	-	All	+	D,Sd	Cosmopolitan	P	PZ,L
Subgenus	Eubosmina Sehgo, 1900							
	E longispina Leyd , 1860	-	All	+	Nn	Palaearctic	P	PZ,L
	E obtusirostns Sars, 1862	-	All	+	F	Palaearctic	P	PZ,L
	E coregom Baird, 1857	-	-	+	F	Palaearctic	P	PZ,L

Comment P - plankton B - benthos, PB - plankton-benthos, PI - among the plants, PZ - pelagic zone, L - littoral, Pm - psammal, D - dominant, Sd - subdominant, Nn - not numerous, F - few

Note Although 'Cladocera' is no longer a valid monophyletic taxon, the term is still used here for convenience

List of GAMMARIDAE species. Compiled by M.Yu. Bekman, R.M. Kamaltynov, I.V. Mekhanikova, V.V. Takhteev

	Species and subspecies	Endemic or not	Open Baikal	Coas-tal-sor zone	Depth in m	Bottom	Ecology
Genus	Abyssogammarus Sow, 1915						All nectobenthic
	A gracilis gracilis Sow, 1915	+	NB	–	625	Rock	
	A gracilis minor Baz , 1945	+	NB	-	354	Silt	
	A sarmatus sarmatus (Dyb, 1874)	+	All	-	300-1329	Silt	
	A sarmatus echinatus Baz, 1935	+	SB	-	500-758	Silt	
	A swartschewsku Sou, 1915	+	AH	-	185-1300	Silt	
Genus	Acanthogammarus Stebb, 1899[1]						
	A albus (Garj , 1901)	+	All	–	5-825	Silted sand	
	A brevispinus Dor, 1922	+	hast shore	+	3-200	Silted sand	
	A flavus tlavus (Garj , 1901)	+	NB	-	5-100	Sand, rock	
	A flavus curtus Baz . 1945	+	All, east shore	-	9 53	Sand	
	A flavus rodionowi Dor, 1922	+	SB	-	8-11	Rock	
	A flavus sowinskn Baz, 1945	+	AH, east shore	-	4-70(810)	Rock, sand	
	A godlewskn (Dyb, 1874)	+	All	-	2-180	Sand, silt	
	A grewingkn (Dyb , 1874)	+	Ail	-	138 1380	Silt	
	A korotnewi (Garj , 1901)	+	NB	-	23-600	Rock	
	A maximus (Garj, 1901)	+	NB	-	3 121	Rock, sand	
	A nassonowi (Dor, 1922)	+	SB	-	151-758	Silt	
	A reichcrti (Dyb, 1874)	+	All	-	25-1371	Silt	
	A subbrevispinus Baz , 1945	+	NB	-	6-25	Sand	
	A victon victon (Dyb, 1874)	+	SB	-	3-90	Sand, rock	
	A ucton maculosus Dor, 1930	+	MB, NB	-	5-200	Silted sand	
Genus	Baicalogammarus Stebb, 1899						
	B pullus (Dyb, 1874)	–	All	+	0-50	Rock, sand	
Genus	Brandtia Bate, 1862[2]						
	B armata armata (Dyb, 1874)	+	SB, M More	–	4-342	Silted sand	
	B armata ongurem (Garj , 1901)	+	NB	–	140	Rock	
	B birstemi Baz, 1948	+	SB	–	200	Silted sand	
	B msulans (Dor, 1930)	+	NB	–	20	Rock	**On a sponge**
	B latissima latissima (Gerstf, 1858)	+	All	–	3-32(170)	Rock, sand	
	B latissima extima Dor, 1930	+	NB	–	>	?	
	B latissima intermedia Dor, 1930	+	SB	–	1-2	Rock	
	B latissima lata (Dyb, 1874)	+	All	–	1-65	Rock, sand	
	B latissima latior (Dyb, 1874)	+	All	–	1-50(400)	Rock, sand	
	B latissima polyspina Dor, 1930	+	NB	–	4-25	Rock	
	B margantae Baz, 1959	+	NB, M **More**	–	10	Rock	
	B parasitica (Dyb , 1874)	+	All	–	1-60(200)	Rock	**On a sponge**
Genus	Cannogammarus Stebb, 1899						

Continuation of list of GAMMARIDAE species

	Spcues and subspecies	Endemic or not	Open Baikal	Coas-tal-sor zone	Depth in m	Bottom	Fcology
	C cinnamomeus (Dyb, 1874)	+	All	–	3->200	Sand, hilt	
	C wagi wagi (Dyb , 1874)	+	All	-	16-284	Sand, rock	
	C wagi pallidus (Dor, 1922)	+	SB	-	14-400	Silt, rock	
Genus	Carmurus Sow , 1915						
	C amentatus G Karaman, 1977	+	NB, MB	–	136-800	Silt	
	C bazikalovae G Karaman, 1977	+	NB, SB	-	6-200	Silted sand	
	C belkini (Garj , 1901)	+	All	-	27-731	Silted sand	
	C brcannatus Baz, 19^5	+	SB	-	200	Silt	
	C bifrons G Karaman, 1977	+	All	-	149-270	Silt	
	C microphthalmos (Sow , 1915)	+	NB	-	80		
	C obscurus Dor 1922	+	SB	-	6 225	Silted sand	
	C platycannus (Sow , 1915)	+	All	-	23-125	Silt, sand	
	C reissnen (Dyb, 1874)	+	SB, KB	-	200 1380	Silt	
	C soiskn (Dyb, 1874)	+	SB	-	5 192	Silted sand	
	C werestschagim Baz, 1935	+	NB, MB	-	50-160	Silt, sand, rock	
Genus	Ceratogammarus Sow, 1915						
	C accrus Ba7 ,1937	+	NB	–	210-1370	Silt	
	C cornutus (Sow , 1915)	+	All	-	82-1073	Silt	
	C dybowskn Sow, 1915	+	All	-	82-1370	Sand, silt	
Genus	Cheirogammarus Sow, 1915						
	Cinflatus Sow, 1915	+	NB	–	790	Silt	
Genus	*Comurus* Sow, 19)5						
	C palmatus Sow ,1915	+	NB, SB	–	282-980	Silt	
	C radoschkowskn (Dyb. 1874)	+	SB, NB	–	10-830	Silt	
	C wadimi Sow, 1915	+	SB		140	·›	
Genus	Crypturopus Sow, 1915						
	C mfldtus (Dyb, (874)	+	Ail	+	2-800	Sand, silt	
	C pachytus (Dyb, 1874)	+	All	+	1-629	Sand, rock	
	C rugosus (Dyb , 1874)	+	SB	–	3-17(50)	Sand	
	C tenuipes Baz, 1945	+	All	+	1-37	Sand, rock	
	C tubercLilatus (Dyb , 1874)	+	All	+	1-100	Sand, silt, rock	
Genus	Echmropus Sow 1915[1]						
	E bathyphilus (Baz, 1975)	+	MB, NB, east shore	–	62-232	Silt	
	E gulekani (Ba* , 1975)	+	NB	–	I I	Rock	
	E levis (Baz, 1975)	+	All	–	1 78	Sand, rock	
	E macronyehus macronychus Sow 1915	+	All	–	2 165	Sand	
	E macronychus brevicaudatus Sow , 1915	+	All	–	2-66	Sand	

Continuation of list of GAMMARIDAE species

	Species and subspecies	Endemic or not	Open Baikal	Coas-tal-sor zone	Depth in m	Bottom	Ecology
	E macronychus sempercannatus (Baz, 1975)	+	NB, MB	-	2-34	Silted sand, rock	
	E. macropsis (Baz. 1975)	+	SB, NB	-	8-320	Silt	
	E. morawitzii (Dyb , 1874)	+	All	-	6-68	Silt, sand, rock	
	E pcrplexus (Baz, 1975)	+	SB, NB	-	48-50	Rock, sand	
	E pucr (Baz., 1975)	+	SB	-	36-1115	Silt	
	E. pulchelliformis (Baz, 1975)	+	SB	-	32-920	Silt	
	E. pulchellus (Dyb, 1874)	+	All	-	(32)87-1250	Silt	
	E rhodophthalmus rhodophlhalmus (Dyb, 1874)	+	All	-	3-300	Sand	
	E. rhodophthalmus brachyurus (Baz, 1975)	+	All	-	8-286		
	E rhodophthalmus microphthalmus (Dyb, 1874)	+	All	-	1-1350	Silted sand, silt	
	E. rhodophthalmus strenuus (Baz, 1975)	+	NB, M More	-	120	Silt	
	E seidhtzi (Dyb, 1874)	+	All	-	6-1131	Silted sand, silt	
	E smaragdmus (Dyb, 1874)	+	All	~	0, 5-150	Sand, rock	
Genus	Euhmnogammarus Baz, 1945[4]						
	E. affims {Sow, 1915)	+	NB	-•	50-120	Clay	
	E. aheneus aheneus (Dyb, 1874)	+	All	-	10-500	Rock, silt	
	E aheneus asetus Baz, 1945	+	All	-	62-594	Rock, silt	
	E. aheneus setosus (Dyb, 1874)	+	?	-	?	?	
	E. aheneoides Baz., 1945	+	MB, NB	-	1-860	Silt	
	E. bifasciatus (Dyb, 1874)	+	SB	-	0-2	Rock	
	E. brachycoxahs Baz., 1945	+	SB, NB	-	115-950	Silt	
	E. burkani Baz, 1945	+	SB	-	49	Rock	
	E *byrkim* (Sow, 1915)	+	MB	-	10-50	Rock, sand	
	E calceolatus (Sow, 1915)	+	MB	-	1240	Silt	
	E. capcllus capellus (Dyb., 1874)	+	SB, NB	-	82-100	Silt	
	E capellus sowrrtskn Baz., 1945	+	SB, NB	-	3-300	Silt, sand	
	E caprcolus (Dyb , 1874)	+	All	-	7-200	Sand, rock	
	E. crassicornis (Sow., 1915)	+	SB	-	90-294	Rock, silt	
	E cruentus (Dor., 1930)	+	All	-	1-100	Rock, sand	
	E cyanellus Baz , 1945	+	SB, NB	-	1 5-54	Rock, sand	
	E. cyaneus (Dyb, 1874)	+	All	+	0-20	Rock	
	E cyanoidcs (Sow., 1915)	+	SB, NB	-	2-165	Rock	
	E czerskn (Dyb, 1874)	+	All	_	1-125	Rock, sand	
	E epimeralis (Sow, 1915)	+	SB	-	14		
	E exiguus Baz , 1945	+	NB	-	26	Rock, sand	
	E fuscus fuscus (Dyb., 1874)	+	All	+	2-273	Sand, silt	

Continuation of list of GAMMARIDAE species

Species and subspecies	Endemic or not	Open Baikal	Coastal-*sor* zone	Depth in m	Bottom	Ecology
E. fuscus (ongicornis Baz., 1945	+	All	–	2-97	Sand, silt	
E. gracilicornis Baz., 1945	+	SB, MB	–	53-252	Silted sand, rock	
E. grandimanus Baz., 1945	+	All	–	0-15(102)	Rock	
E. heterochirus Baz., 1945	+	MB	–	10	Silt	
E hyacinthinus (Dyb., 1874)	+	SB,NB	–	2-256	Sand, silt	
E. ibex ibex (Dyb., 1874)	+	SB, NB	–	7-200	Rock	
E. ibex atnehus Baz., 1945	+	AH	–	4-290	Rock, sand	
E. ignotus (Dyb, 1874)	+	SB	–	800-900	–	
E lmtnundus Baz, 1945	+	-	–	–	–	
E incertus (Sow, 1915)	+	MB	–	890	–	
E. inconspicuus Baz., 1945	+	SB	–	0-1	Rock	
E kietlinskn (Dyb., 1874)	+	SB, NB	–	1-1200	Sand, rock	
E. kusnezowi (Sow, 1915)	+	All	–	189-950	Silt, clay	
E. laevis (Sow, 1915)	+	MB, NB	–	120	–	
E. hvidus (Dyb, 1874)	+	All	–	0-10(100)	Rock	
E. maacki (Gerst, 1858)	+	All	–	0-40	Rock	
E. macrochirus (Baz., 1945)^s	+	SB, NB	–	2-3	Rock, sand	
E macrophthalmus Baz, 1945	+	AH	–	9-800	Silt	
E *mantuji* Baz , 1945	+	SB	–	2-3	Rock	
E. rnelanochlons (Dor, 1930)	+	SB	–	0-2	Rock	
E. minimus Baz., 1975	+	NB, MB	–	8-51	Sand	
E. munniformis Baz., 1945	+	?	–	?	?	
E. munnus (Dyb, 1874)	+	All	–	3-297	Sand, silt	
E. obsoletus Baz , 1945	+	SB	–	1-8	Rock	
E. paehycerus Baz , 1945	+	All	–	53-838	Rock, sand	
E parvexi (Dyb, 1874)	+	All	–	20-1300	Silt, sand	
E. parvexiformis Baz, 1945	+	SB	–	560-610	Silt	
E polyarthrus (Dyb., 1874)	+	SB, NB	–	6-700	–	
E. proximus (Sow, 1915)	+	NR	–	25-40	Rock	
E. rachmanowi (Sow, 19(5)	+	NB	–	900	–	
E. saphinnus (Dyb, 1874)	+	SB	–	300	–	
E. schamanensis (Dyb, 1874)	+	All	–	42-440	Silt, sand, rock	
E. similis (Sow, 1915)	+	All	+	4-107	Sand, rock	
E. simplex (Sow, 1915)^	+	All	–	3-35	Sand, silt	
E. simpliciformis Baz., 1975	+	SB	–	5	Rock	
E. sophiae (Dyb, J874)	+	All	–	28-625	Rock, sand	
E sophianosi (Dyb, 1874)	+	SB, NB	–	1-100	Rock, sand	
E. stamslavi (Dyb, 1874)	+	SB	–	100	–	
E. stenophthalmus (Dyb, 1874)	+	SB, MB	–	290-298	Rock	
E. tenuipes (Sow , 1915)	+	All	–	9-891	Silt	

Continuation of list of GAMMARIDAE species

	Species and subspecies	Endemic or not	Open Baikal	Coas-tal-sor zone	Depth in m	Bottom	Ecology
	E tenuis Baz , 1945	+	–		5-1400	Silted sand	
	E tesiaccus (Dyb , 1874)	+	SB	–	1	Rock	
	E. toxophthalmus (Dyb, 1874)	+	SB	–	120	–	
	E. ussolzewi ussolzewi (Dyb, 1874)	+	All	–	36-697	Rock, silt	
	E. ussolzewi dbyssorum (Dyb, 1874)	+	SB	–	200-1000	Silt	
	E. verrucosus verrucosus (Gerst , 1858)	+	All	+	0-12	Rock	
	E verrucosus oligacanthus Baz , 1945	+	-	+	0-5		
	E. violaceus (Dyb, 1874)	+	SB, NB	–	1-110	Rock, sand	On a sponge
	E virgatus (Dor., 1930)	+	SB	–	200	Silt	
	E vindiformis (Sow, 1915)	+	NB	–	140	–	
	E vindis vindis (Dyb, 1874)	+	All	–	0-30	Rock	
	E vindis canus (Dyb, 1874)	+	All	+	0-123	Rock, sand	
	E vindis olivaceus (Dyb, 1874)	+	All	+	0-100	Rock, sand	
	E. vindulus Baz, 1945	+	SB	–	0-30	Rock	
	E vittatus (Dyb, 1874)	+	All	–	0-30	Rock	
	E Habyssalis (Sow , 1915)	+	SB	–	1200	Silt	
Genus	Gammarus t-abncius, 1775						
	G lacustris Sars, 1863	–	–	+	0-6	Silt	On algae
Genus	Gajjdjcwia Sow., 1915						*AM ncctobenthic*
	G cabanisi cabanisi (Dyb, 1874)	+	All	–	20-1250	Silt	
	G cabanisi dershawim Sow, 1915	+	NB, MB	+	36-125	Silt	
	G. cabanisi ninae Baz, 1945	+	NB, MB	–	37-640	Silt	
	G dogieli Baz, 1945	+	SB, NB	–	300-950	Silt	
	G sarsi Sow. 1915	+	All	–	250 1131	Silt	
Genus	Gmclmoides Baz, 1945						
	G fasciatus (Stebb , 1899)	+	All	+	0-192	Rock, sand, silt	
Genus	Hakonboeckia Stebb, 1899						
	H strauchi (Dyb, 1874)	+	SB, NB	–	1-15	Rock, sand	
Genus	Homocensca Baz., 1945						
	H caudata Baz , J945	+	NB	–	430-900	Silt	
	H perla (Dyb, 1874)	+	All	–	10-900	Sand, silt	
	H. perloidcs Baz., 1945	+	Ail	–	6-1450	Silt	
	H tenuicauda Baz, 1975	+	SB	–	60-300	Silt	
Genus	Hyalellopsis Stebb, 1899[6]						
	H bicolorata Baz., 1948	+	SB	–	3-10	Rock	
	H cannata Sow , 1915	+	MB, NB	–	3-50	Rock, sand	
	H carpentcn carpenter: (Dyb, 1874)	+	All	–	2-336	Silted sand	
	H carpenten elegans (Dor, 1930)	+	NB, M More	–	13-106	Silted sand	
	H carpentcn profunddlis (Baz., 1945)	+	NB	–	100-860	Silt, sand	
	H. castanea (Dor, 1930)	+	NB	–	10-100		

Continuation of list of GAMMARIDAE species

	Species and subspecies	Endemic or not	Open Baikal	Coas-tal-sor zone	Depth ın m	Bottom	Ecology
	H costata Sow., 1915	+	SB, NB, M. More,	–	2-40	Rock, sand	
	H czyrnianskn (Dyb , 1874)	+	All	-	3-50	Algae on sand	
	H depressirostns Sow., 1915	+	M. More	-	?	9	
	H. eugeniae Sow, 1915	+	i.	–	?	9	
	H gnsea Dor, 1930	+	SB	-	15	Rock	
	H hamata Sow ,1915	+	NB, M. More	-	2-10	Rock	
	H insularis (Baz , 1936)	+	NB	-	125	Rock	
	H mnae Baz., 1959	+	M More	-	140	Rock	
	H latipes latipes Baz,, 1945	+	SB	-	28-270	Sand	
	H latipes selengensis Baz, 1945	+	MB	-	50-284	Silt	
	H macrocephala Ba7 , 1945	+	NB	-	62	Rock	
	H nana Baz, 1959	+	M. More	-	31-37	Sand	
	H. potanini (Dor., 1922)	+	MB, NB	-	14-320	Silted sand	
	H. rubra (Gar] , 1901)	+	NB	-	12-125	Sand, rock	
	H. setosa Sow ,1915	+	NB	-	4-8	Rock	
	H stebbingi Sow., 1915	+	NB	-	1-52	Rock, sand	
	H taczanowskn (Dyb, 1874)	+	All	-	30-150 (1200)	Sand, rock	
	H tixtonae tixtonae Sow, 1915	+	All	–	5-38	Sand	
	H tixtonae glabra Baz., 1945	+	All	-	13-64(221)	Sand, silt	
	H. variabilis. Dor, 1930	+	SB	-	2-40	Sand	
Genus	Koshovia Baz , 1975						
	K mirabihs Baz, 1975	+	NB, MB	-	28-810	Silt	
Genus	Lcptostenus Baz, 1945						
	L. leptocerus (Dyb, 1874)	+	SB	–	150-877	Silt	
Genus	Lobogammanis Baz, 1945						
	L latus Baz, 1945	+	NB	–	731	Silt	
Genus	Macrohectopus Stebb , 1906						
	M, branickn (Dyb, 1874)	+	All	–	0-1600	–	Pelagic
Genus	Macropereiopus Sow., 1915						
	M. albulus (Dyb, 1874)	+	All	–	4-1615	Silt	
	M, flon (Dyb., 1874)	+	All	–	8-1371	Silted sand	
	M, grandimanus Baz, 1975	+	SB	–	42-1450	Silt	
	M lcucophthalmus (Sow, 1915)	+	All	–	22-1350	Silt	
	M mirus Baz, 1975	4-	NB, cast shore	–	11 39	Sand	
	M, parvus Baz , 1945	+	All	–	4-1340	Silt	
	M. wagnen wagnen Sow., 1915	+	All	–	5-1380	Silted sand	
	M. wagnen dagarskii Sow , 1915	+	All	–	7-778	Silted sand	

Continuation of list of GAMMARIDAE species

	Species and subspecies	Endemic or not	Open Baikal	Coastal-sor zone	Depth in m	Bottom	Ecology
Genus	Metapallasea Baz., 1959						
	M galinae Baz., 1959	+	SB, NB	–	3-71	Sand	
Genus	Micruropus Stebb , 1899						
	M asper Baz., 1962	+	SB	-	1-7	Sand	
	M, brevicauda Baz., 1945	+	SB, M More	-	4-36	Rock, sand	
	M cihodorsalis ciliodorsalis Sow., 1915	+	All	+	0-76	Silted sand	
	M ciliodorsalis rostratus Baz, 1962	+	NB	+	6-186	Silted sand	
	M cristatus Dor, 1936	+	MB	+	6-9	Silted sand	
	M, dybowsku Baz, 1945	+	SB, MB	-	1-80	Sand	
	M. eugenn Baz, 1959	+	SB, NB	-	3-20	Rock, sand	
	M fixseni (Dyb., 1874)	+	All	+	2-110	Silted sand	
	M galasu Baz., 1962	+	NB, MB	-	3-14	Sand, rock	
	M glaber glaber (Dyb , 1874)	-f	AH	+	0-44	Sand, rock	
	M glaber munni Baz, 1945	+	SB	-	4-71	Sand	
	M lvanowi ivanowi Baz, 1945	+	All	-	1-132	Silted sand	
	M lvaniwi garjajewi Baz, 1945	+	NB, MB	-	1-37	Silted sand	
	M kluki (Dyb, 1874)	+	All	-	0-88	Sand	
	M koshowi koshowi Baz, 1945	+	All	+	0-25	Rock, sand	
	M koshowi crassicauda Baz, 1962	+	MB, NB	-	2-20	Sand, rock	
	M koshowi setosus Baz., 1945	+	All	-	0-6	Silted sand	
	M laeviusculus laeviusculus (Sow., 1915)	+	All	–	1-124	Sand, rock	
	M laeviusculus dubius Baz, 1962	+	All	-	1-25	Sand, rock	
	M littorahs littoralis (Dyb, 1874)	+	All	+	0-25(100)	Sand, rock, silt	
	M, littoralis crassipes Sow, 1915	+	SB, MB	-	5-10(100)	Rock, sand	
	M macroconus macroconus Baz, 1945	+	All, east shore	—	2-71	Rock, sand	
	M macroconus calceolans Baz , 1945	+	AJI	-	3-37(255)	Rock, sand	
	M. macroconus gurjanowae Baz, 1945	+	All, west shore	—	3-44	Rock, sand	
	M macroconus tenuis Baz., 1962	+	Ushkany Islands	-	2-42	Sand	
	M mmutus (Sow., 1915)	+	All	-	0-54	Rock, sand	
	M. mozi Baz, 1945	+	MB	+	3	Silt	
	M parvulus Baz., 1945, 1962	+	All	+	6-680	Silted sand	
	M. possolskn Sow., 1915	+	MB, M More	+	0-9	Silted sand	
	M pupilla Baz., 1962	+	Ushkany Islands,	—	16-20	Rock	
	M pusillus Baz., 1962	+	MB	+	11	Rock	
	M, semenowi Baz, 1945	+	All	–	20-119	Silted sand	

Continuation of list of GAMMARIDAE species

	Species and subspecies	Endemic or not	Open Baikal	Coastal-sor zone	Depth in m	Bottom	Ecology
	M tahtroides talitroides (Dyb , 1874)	+	All	+	0-63	Sand, rock	
	M tahtroides eurypus Baz , 1945	+	All	+	0-60	Sand	
	M talitroudcs latus Baz, 1962	+	SB, NB	-	1-16	Sand, rock	
	M ushkani Baz 1945	+	Ushkany Islands	-	1-47	Sand	
	M vortex vortex (Dyb, 1874)	+	All	-	*0-88*	Rock, sand	On algae
	M vortex vorticcllus Baz, 1945	+	All	-	1-54	Rock	On algae
	M wahln wahln (Dyb, 1874)	+	All	+	0-42	Sand	
	M wahln platyccrcus (Dyb, 1874)	+	All	+	0 77	Sand, rock, silt	
Genus	Odontogammarus Stebb , 1899						
	O calcaratus calcaratus (Dyb, 1874)	+	All	+*?	5-800	Silt, sand	
	O calcaratus brevipes Dor, 1930	+	NB	-	3-70	Sand, rock	
	O calcaratus improvisus Dor 1930	+	NB	-	6-170	Silt, sand, rock	
	O calcaratus pulchcrrimus Dor, 1930	+	SB	-	27 565	Silt, sand	
	O korotnewi (Sow, 1915)	+	NB, MB	-	28-246	Silt, sand	
	O margantaceus margantaccus (Dyb, 1874)	+	All	-	480-1300	Silt	
	O margantaceus demianowiczi Dor, 1930	+	SB	-	200-400	Silt	
Genus	Omniatogammarus Stebb, 1899						All necrophage
	O albinus (Dyb, 1874)	+	All	+ >	47-1313	Silt	
	O carneolus carncolus (Dyb, 1874)	+	SB, NB	-	35 1320	Silt	
	O carneolus amethystinus (Dyb, 1874)	+	SB	-	35-1313	Silt	
	O carneolus melanophthalmus Baz , 1945	+	SB	–	200	Silt	
	O flavus (Dyb, 1874)	+	All	-	2-1313	Silt	
Genus	Pachyschcsis Baz 1945						
	P bazikalovae G Karaman, 1976	+	All	–	8 1380		Parasite in the marsupia of amphipods
	P bergi Baz, 1945	+	SB, NB	–	102-500		
	P branchiahs (Dyb, 1874)	+	SB, NB	–	200-880		In the marsupia of amphipods
	P crassus (Sow , 1915)	+	SB, NB	–	300 1200		’
Genus	Pallasea Bate, 1862[7]						
	P baicah baicah Stebb, 1899	+	All	+	N25	Silt, sand, rock	On algae
	P bdicali inermis Sow, 1915	+	MB		2		
	P baicali nigromaculata Dor, 1922	+	SB	–	8-20	Sand, rock	
	P bicornis Dor, 1930	+	M More	–	35-40	Sand	
	P brandti brandti (Dyb, 1874)	+	All	–	1-442	Sand, rock	

Continuation of list of GAMMARIDAE **species**

	Species and subspecies	Endemic or not	Open Baikal	Coas-tal-sor zone	Depth in m	Bottom	Ecology
	P brandti flaviceps Dor, 1922	+	MB	+	7-92	Silt, sand	
	P brandti tenera Sow., 1915	+	All	-	7-350	Silt, sand	
	P. canccllоides (Gerst, 1858)	+	All	-	0-178	Sand, rock	
	P. cancellus canccllus (Pall, 1776)	+	All	-	1-52	Rock, sand, silt	
	P. cancellus gerstfeldti (Dyb, 1874)	+	All	-	1-100	Sand, rock	
	P dawydowi (Sow., 1915)	+	?	?	9		
	P dryshcnkoi (Gar) , 1901)	+	All	-	10-1300	Silt, rock, sand	
	P. dybowskn Stebb , 1899	+	SB, NB	-	1-30	Silted sand	
	P. grubei grubei (Dyb, 1874)	+	All	+	1 175	Sand, silt	
	P grubei arenicola Dor., 1922	+	MB	+	2-15	Sand, silt	
	P kesslen (Dyb., 1874)	+	All	+	1-61	Sand, rock, silt	
	P lamelhspinis Baz , 1945	+	SB, NB	-	30-565	Silt	
	P meissnen (Baz, 1935), 1945	+	NB, Ushkany Islands	-	82-884	Silt	
	P meyen (Garj, 1901)	+	NB	-	20C)-96	Silt	
	P vindis (Garj, 1901)	+	All	-	0-63	Silt, **sand**	
Genus	Paragarjajewia Baz, 1945						**All nectobenthic**
	P petersi petersi (Dyb, 1874)	+	All	–	85-1580	**Silt**	
	P. petersi microphthalma Baz, 1948	+	SB	-	500-800	Silt	
Genus	Parapallasea Stebb., 1899						
	P. borowskn borowskn (Dyb, 1874)	+	All	–	33-1176	Silt	
	P. borowskn wos-nessenskit Dor, 1922	+	SB	-	25-200	Rock	
	P. lagowskn (Dyb., 1874)	+	All	-	50-1350	Silt	
	P. nigra (Garj., 1901)	+	NB	-	140	Sand	
	P puzilloi puzilloi (Dyb, 1874)	+	All	-	7-350	Sand, silt	
	P. puzilloi cannulata Dor, 1922	+	MB, NB	+	4-250	Sand, silt	
Genus	Plesiogammarus Stebb., 1899						
	P. gerstaecken gerstaecken (Dyb, 1874)	+	All	–	*3-16W*	Silted sand	
	P. gerstaecken brevis Baz, 1975	+	All	-	40-1520	Silt	
	P. longicornis Sow, 1915	+	SB, NB	^	40-350	Silt	Nectobenthic
	P zienkowiczi (Dyb, 1874)	+	All	-	112-1350	Silt	Nectobenthic
Genus	Poekilogammarui> Stebb, 1899^{s}						
	P araneolus (Dyb, 1974)	+	All	+	2-40(125)	Sand, rock	
	P crassimanus Sow, 1915	+	SB, NB	-	2-10(253)	Rock	Benthic
	P. curvimanus Sow, 1915	+	SB	—	108	Rock	
	P curvirostns Baz, 1945	+	SB, NB	-	10-350	Silted sand	
	P ennaceus Tachteew, 1992	+	All	-	5-38	Rock,	
	P jedorensis Ba7 , 1945	+	M More	-	55	Sand	
	P longipes Baz , 1945	+	MB	-	8	Sand	
	P lydiae (Baz., 1935)	+	SB	_	877-1250	Silt	**Nectobenthic**

Continuation of list ot GAMMARIDAE species

	Species and subspecies	Endemic or not	Open Baikal	Coas-tal-sor zone	Depth in m	Bottom	Ecology
	P macrurus (Sow, 1915)	+	NB	+	50-108	Sand, rock	
	P mcgonychoides Baz, 1945	+	SB	-	24-162	Silted sand	**Nectobenthic?**
	P megonychus Sow, 1915	+	NB	-	9	?	
	P orchestes (Dyb , 1874)	+	SB	-	150		
	P pictoidcs Sow , 1915	+	SB NB	-	3-100	Sand, rock	
	P pictus (Dyb, 1874)	+	All	-t-	*4-350 (1000)*	Silted sand	
	P recnrostns Baz, 1945	+	All	-	14-105	Silted sand	
	P rostratus rostratus Sow, 1915	+	SB NB	-	33-790	Silted sand	
	P rosiratus amblyops Baz , 1945	+	MB, NB	-	503-650	Silt, sand	
	P rosiratus brevirostns Baz, 1945	+	SB, NB	-	2-122	Sand, silt, rock	
	P rosiratus longirostns Baz, 1945	+	SB, NB	-	2-336	Silt, rock	
	P semenkewitschi semenkewitschi (Sow, 1915)	+	All	-	93 1200	Silt	Nectobenthic
	P semenkewitschi unguisetosus (Sow, 1915)	+	All	–	125 1250	Silt	Nectobenthic
	P sukaczewi Sow, 1915	+	All	-	5-877	Silted sand	
	P talitrus (Dyb, 1874)	+	SB, MB	-	80-200		
Genus	Polyacanthisca Baz, 1937						
	P calceolata Baz, 1937	+	SB, MB	-	1195 1610	?	**Nectobenthic** ?
Genus	Pseudomicruropus Baz , 1962						
	P chargoensis (Sow, 1915)	+	NB	–	5-54	Sand, rock	
	P lepidiformis Baz, 1962	+	NB, MB	-	5-39	Sand, rock	
	P lepidus (Baz, 1945)	+	All	-	12-100	Sand, silt	
	P rotundatulus rotundatulus (Baz, 1945)	+	SB, NB	–	0-71	Sand, rock	
	P rotundatulus magnus Baz, 1962	+	All	-	0-20	Sand, rock	

Notes ' - includes subgenus Brachyuropus Stebb, 1988, [2] - includes subgenus Spinacanthus Doz, 1930, [5] - includes subgenera Asprogammams Baz, 1975 and Smaragdogammarus Baz, 1975, [4] - includes, subgenera Corophiomorphus Baz, 1945, Eurybiogammarus Baz, 1945, Heterogammarus Stebb, 1899, and Phylohmnogammarus Baz, 1945, [5] - transferred from the genus Micruropus (Bazikalowa, 1962), [6] - includes subgenera Boeckaxcha Schell , 1940 and Dorogammarus Baz, 1945, [7] - includes subgenera Homalogammarus Baz, 1945 and Propachygammarus Baz, 1945, * - includes subgenera, Bathygammarus Baz, 1945, Gymnogammarus Sow, **1915,** Onychogammarus Sow, 1915 and Rostrogammarus Baz, 1945

Comment SB south Baikal, NB - north Baikal, MB - middle Baikal, M More - Maloye More

List CHIRONOMIDAE species. Compiled by E.A. Erbaeva

	Species *and* subspecies	Endemic or not	Open Baikal	Bays	Coas-tal-sor zone	Distribution outside of Baikal	Depth, m	Bottom
Family	Cluronomidae							
Subfamily	Tanypodinae							
Genus	Macropelopia Thienemann, 1916							
	Macropelopia sp	–	+	–	–	Palaearctic	to 15	Silted sand
Genus	Procladius Skuse, 1889	–	–	–	–			
	P conf choreus Meig , 1804	–	+	–	–	Palaearctic	to 15	Silted sand
Genus	Thienemannimyia Fittkau, 1957							
	T lentiginosa Fries, 1823	–	+	–	–		2-10	Sand, silted sand, sdt
	Thienemannimyia ^ sp	–	+	–	–	Palaearctic	5	Stones
Genus	Guttipelopia Fittkau, 1962							
	G guttipennis v d Wulp , 1874	–	–	–	+	Palaearctic	2	Silt
Genus	Ablabesmyia Johannsen, 1905							
	A monihs L , 1758	–	–	–	+	Palaearctic	2	Silt
Subfamily	Diamesinae							
Genus	Diamesa Meigen, 1935							
	D baicalensis Tshern , 1949	+	+	–	–	Angara and its reservoirs	5	Stones
	D gr insignipes Kieff, 1908	–	+	–	–	Palaearctic	5	Stones
	D conf coronata Tshern , 1949	–	+	–	–	Palaearctic	5	Stones
Genus	Potthastia (Kieffer, 1922) Pagast, 1933							
	P longimana Kieff, 1922	–	+	–	–	Palaearctic	2	Stones
	P lanceolata (Tokunaga, 1936)	–	+	–	–	Palaearctic	2	Stones
Genus	Pseudodiamcsa Goetghebuer, 1939							
	P nivosa Goetgh, 1928	–	+	–	–	Palaearctic	5	Stones
Genus	Pdgdstia Oliver, 1959							
	P oncntatis Tshern , 1949	–	+	–	–	Palaearctic	1 5	Stones, algae
Genus	Monodidmesa Kieffer, 1921							
	M *batbyphiU* Kieff, 1918	–	+	–	–	Palaearctic	0-20	Silt with detritus
Genus	Prodiamesa Kieffer, 1906							
	P ohvacea Meig , 1818	–	+	–	–	Palaearctic	0-20	Silt with detritus
Subfanuly	Orthocladnnac							
Genus	Diplocladius Kieffer, 1908							
	D cultnger Kieff, 1908	–	+	–	–	Palaearctic	2 5-5	Stones
Genus	Tnssocladius Kieffer, 1908							
	Tnssocladius sp	–	+	–	–	Palaearctic	2 5-8	Stones, algae
	T potamophilus Tshern, 1949	–	–	+	–	Palaearctic	2-10	Sand, silted sand, **silt**
Genus	Heterotnssocladius Sparck, 1922							

Continuation of list CHIRONOMlDAh species

	Species and subspecies	Endemic or not	Open Baikal	Bays	Coas-tal-sor zone	Distribution outside of Baikal	Depth, m	Bottom
	H marcidus Walker, 1856	–	+	–	–	Palacarctic	2 5-8	Stones, algae
	H gnmschawi Edw , 1929	–	+	–	–	Palaearcttc	2 5-8	Stones, algae
Genus	Eukieffcnclla Thienemann, 1926							
	E longicalcar Kieff, 1911	–	+	–	–	Palaearctic	2	Stones
	E gr similis Goetgh , 1930	–	+	–	–	Palacarctic	5	Stones
	E atrofasciata Goetgh, 1930	–	+	–	–	Palaearctic	5	Stones
	E quadndentata Tshern , 1949	–	+	–	–	Palaearctic	5	Stones
	E dzintan Pancr , 1950	–	+	–	–	Palaearctic	5	Stones
	E hospita Edw, 1929	–	+	–	–	Palaearctic	2	Stones
	Eukieftenella sp	–	+	–	–		2	Stones
Genus	Synorthocladius Thienemann, 1935							
	S semivirens Kieff, 1909	–	+	–	–	Palaearctic	2	Stones
	S murvanidzei Tshern, 1949	–	+	–	–	Palacarctic	2 5-5	Stones
	S nudipennis Kieff, 1908	–	+	–	–	Palaearctic	2-5	Stones
Genus	Orthoclddius (Van der Wulper, 1874) Brundm, 1956							
	O compactus Linevitsh, 1970	+	+	–	–	–	2-5	Stones
	O grcganus Linevitsh, 1970	+	+	–	–	-	2-5	Stones
	O conf tngonolabis Edw, 1922	-	+	–	–	Palaearctic	! 5	Stones
	O setosus Tshern, 1949	+	+	–	–	-	2	Stones
	O frigidus Zett, 1852	-	+	–	–	Palaearctic	2 5	Stones
	O saxicola Kieff, 1911	-	+	–	–	Palaearctic	2 5	Stones
	O olivaceus Kieff, 1911	-	+	–	–	Palaearctic	1 5	Stones
	O thienemanm Kieff, 1906	_	+	–	–	Palaearctic	25	Stones
	O consobnnus Holmgren, 1869	–	–	–	+	Palaearctic	2	Silt
	O sp Nl	–	+	–	–		2	Stones
	O sp N2	–	+	–	–		2	Stones
Genus	Cncotopus {Van der Wulper, 1874) Edvards, 1929							
	C silvestris Fabr, 1794	–	+	–	–	Palaearctic	1-2 5	Stones, algae
	C gr algarum Kieff, 1911	–	+	–	–	Palaearctic	2	Stones
	C gr bicinctus Mg , 1818	–	+	–	–	Palacarctic	2	Stones
	C biformis Edw, 1929	–	+	–	–	Palaearctic	2	Stones
	C sp Ni	–	+	–	–		2	Stones
	C sp N2	–	+	–	–		2	Stones
	C sp N3	–	+	–	–		2	Stones
Genus	Paratrichoclddius Thienemann, 1918							
	P triquctra Tshern, 1949	–	+	–	–	Palaearctic	5	Silted sand
	P inaequahs Kieff, 1926	–	+	–	–	Palaearctic	5	Silted sand
Genus	Psectrocladius Kieffer, 1906							

Continuation of list CHIRONOMIDAE species

	Species and subspecies	Endemic or not	Open Baikal	Bays	Coastal sor zone	Distribution outside of Baikal	Depth, m	Bottom
	P psilopterus Kieff, 1906	–	+	–	-	Palaearctic	2	Stones, algae
Genus	Rheocncotopus Thienemann ct Harmsch, 1932							
	R doncri Goetgh , 1931	–	+	–	–	Palaearctic	2	Stones
	R brunensis Goetgh , 1937	–	–	–	+	Palaearctic	5	Sand, silted **sand, silt**
Genus	Microcncotopus Thienemann et Harmsch, 1932							
	M bicolor Zett, 1929	–	–	–	+	Palaearctic	5	Sand, silted **sand, silt**
Genus	Limnophyes Eaton, 1875							
	L transcaucasicus Tshern , 1949	–	+	–	–	Palaearctic	2	Stones
	Limnophyes sp	–	+	–	-		2	Stones
Genus	Pseudosmittia (Goetghelner, 1932) Biundin, 1956							
	P virgo Strenzke, 1950	–	+	–	-	Palaearctic	5	Stones
Genus	Paraphaenocladius Thienemann, 1926							
	P impensis Walk, 1856	–	–	–	+	Palaearctic	5	Sand, silted sand silt
Genus	Smittia (Holmgren, 1869) Brandin, 1956							
	Smittia sp	–	+	–	–		2	Stones
Subfamily	Corynoneunnae							
Genus	Corynoneura (Winner, 1846) Edwards, 1929							
	C scutellata Winner, 1846	–	+	–	–	Palaearctic	2	Stones, algae
Genus	Thienemanniclla Kieffer, 1911							
	T clavicornis Kiett, 1911	–	–	–	+	Palaearctic	5	Sand, silted sand, **silt**
Subfamily	Chironominae							
Genus	Einfeldia Kieffer, 1924							
	E pagana Meig , 1818	–	–	–	+	Palaearctic	2	Silt
	E gr carbonana Meig , 1818	–	–	–	+	Palaearctic	1 5-2	Silt
	E longipcs Staeg , 1840	–	–	–	+	Palaearctic	2	Silt
Genus	Chironomus Meigen, 1803							
	C fl plumosus L, 1758	–	+	–	–	Palaearctic	0-20	Silt
	C annulanus Meig, 1818	–	+	–	–	Palaearctic	0 20	Silt
	C nignfrons Linevitsh et Erbaeva, 1971	–	–	–	+	Angara reservoirs	2	Silt
	C anthracinus Zett, I860	–	+	–	–	Palaearctic	0-20	Silt
	C fl salinanus Kieff , 1915	–	–	–	+	Palaearctic	4 5-5	Silt, sand
	C obtusidens Goetgh, 1921	–	–	–	+	Palaearctic	4 5-5	Silt, sand
Genus	Chernovskua Saether, 1977							
	C ra Ulomsky, 1941	–	–	–	+	Palaearctic	>	Sand, silted sand, **silt**
Genus	Cryptochironomus Kieffer, 1918							

Continuation of list CHIRONOMIDAE species

	Species and subspecies	Endemic or not	Open Baikal	Bays	Coastal-sor zone	Distribution outside of Baikal	Depth, m	Bottom
	C gr defectus Kieff, 1921	-	-	–	+	Palaearctic	2	Silt
	C ussounensis Goetgh , 1933	-	-	–	+	Palaearctic	4 5-5	Silt, sand
Genus	Cryptotendipes Lenz, 1959							
	C nigronitens Edw , 1929	-	-	–	+	Palaearctic	2	Silt
Genus	Cryptocladopelma Lenz, 1941							
	C vindula Fabr, 1805	-	-	–	+	Palaearctic	4 5-5	Silt, sand
Genus	Demicryptochironomus Lcnz, 1941							
	D vulnerdtus Zett, 1860	-	-	–	+	Palaearctic	2	Silt
Genus	Harnischia Kieffer, 1921							
	H curtilamellata Mall, 1915	-	-	–	+	Palaearctic	2-10	Sand, silted sand, silt
Genus	Leptoehironomus Pdgast, 1931							
	L tener Kieff, 1918	-	-	–	+	Palaearctic	)	Sand, silted sand, silt
Genus	Paracladopclma Harmsch, 1923							
	P camptolabis Kieff, 1913	-	-	–	+	Palaearctic	2-10	Sand, silted sand, silt
Genus	Parachironomus Lenz, 1921							
	P pararostratus Harn , 1923	-	-	–	+	Palaearctic	4 5-5	Silt, sand
Genus	Limnochironomus Kieffer, 1920							
	H gr tntomus Kieff, 1916	-	-	–	+	Palaearctic	3 5	Silty bottom soils
Genus	Fndochironomus Kieffer, 1918							
	E albipennis Meig , 1830	-	-	–	+	Palaearctic	?	Sand, silted sand, silt
	E impar Walk, 1856	-	-	–	+	Palaearctic	2	Silt
	E tendens Fabr, 1794	-	-	–	+	Palaearctic		Silt
Genus	Glyptotendipcs Kieffer, 1913						2	
	CJ gr gnpekoveni Kieff, 1913	-	-	–	+	Palaearctic		Silt, sand
Genus	Sergentia Kieffer, 1921						4 5-5	
	S gr longiventns Kieff, 1924	-	+	–	+	Palaearctic		Silt, sand
	S baicalensis Tshcrn, 1949	+	+	–	+	–	4 5-5	Silt, sand
	S flavodentata Tshern , 1949	+	+	–	+	–	4 5-5	Sand, silt
	S conf flavodentata Nl	-	+	–	–	–	5-5 5	Silt
	S conf flavodentata N2	-	+	–	–	–	20	Silt
	Sergientia sp Nl	-	+	–	–	–	20	Silt
	Sergientia sp N2	-	+	–	–	–	10	Silt
	S koshowj Linevitsb, 1948	+	+	–	+	–	10	Silt
	S conf koshowi N5	-	+	–	–	–	200-300	Stones, silt
	S conf koshowi N7	-	+	–	–	–	2 5	Stones, silt
	S conf koshowi N9	-	+	–	–	–	2 5	Stones, silt
	S conf koshowi N10	-	+	–	–	–	2 5	Silt
	S conf koshowi Nl 1	-	+	–	–	–	5	Silt
	S bathyphila Tshern, 1949	-	+	–	–	–	5	Silt
	S nebulosa Lmevitsh et all, 1984	+	+	–	–	–	50-120	Silt
							up to 50	

Continuation of list CHIRONOMIDAE species

	Species and subspecies	Endemic or not	Open Baikal	Bays	Coas- tal sor zone	Distribution outside of Baikal	Depth, m	Bottom
Genus	Pentapedilum Kieff, 1913							
	Pcntapedilum sordens vd Wulp. 1874	–	–	–	+	Paiaearctic	2	Silt
	Pen cxseclum Kieff, 1915	–	–	–	+	Paiaearctic	2 100	Silt
Genus	Polypedilum Kieffer, 1913							
	P gr scalaenum Schr, 1803	–	–	–	+	Paiaearctic	*2*	Silt
	P gr nubeculosum Meig , 1818	–	–	–	+	Paiaearctic	*2*	Silt
	P Lonvictum Walk , 1856	–	–	–	+	Paiaearctic	*2*	Silt
	P bicrenatum Kieff, 1921	–	–	–	+	Paiaearctic	*2*	Silted sand
Genus	Lipmiella Shilova, *1961*							
	L arenicola Schilova, 196!	–	–	–	+	Paiaearctic	4 5-5	Silt, sand
Genus	Microtendipcs Kieffer, 1921							
	M pcdclius De Geer, 1776	–	+	–	+	Paiaearctic	1-2 5	Stones, algae
Genus	Paratendipcs Kieffer, 1911							
	P albimanus Meig , 1818	–	–	–	+	Paiaearctic	)	Sand, silted sand, **silt**
	P gr intermedius Tshern , 1949	–	–	–	+	Paiaearctic	100	Silt
Genus	Paralauterborniella Lenz, 1941							
	P nigrochaltcralis Mall, 1915	–	–	–	+	Paiaearctic	2	Silt
Genus	Stictochironomus Kieffer, 1919							
	S histno Fabr, 1794	–	+	–	–	Paiaearctic	20	Silt
	S crassiforceps Kieff, 1922	–	–	–	+	Paiaearctic	4 5-5	Si It, sand
Genus	Stempelhna (Bausc, 1913) Brundin, 1947							
	S gr bauscj (Kieff) Edwards,]929	–	–	–	+	PaJaearcrit	2	Sill
Genus	Cotistempellina Brundin, 1947							
	C brevicosta Edw , 1937	–	+	–	–	Paiaearctic	25	Sand
Genus	*Tanytarsus* Van der Wulp, 1874							
	T gr lobatifrons Kieff,	–	–	–	+	Paiaearctic	2 10	Sand, silted sand, silt
	T lestagei Goetgh , 1922	–	–	–	+	Paiaearctic	2	Silt
	T greganus Kieff, 1909	–	–	–	+	Paiaearctic	4 5-5	Silt, sand
Genus	Paratanytarsus Bausc, 1913							
	P baicalensis Tshern, 1949	+	+	–	+	–	0-50	Silt
	P lauterborni Kieff, 1909	–	–	–	+	Paiaearctic	4 5-5	Silt, sand
Genus	Cladotanytarsus Kieffer, 1922							
	C mancus Walker, 1856	–	–	–	+	Paiaearctic	2	Silt
Genus	Rheotanytarsus Bause, 1913							
	R exiguus Joh 1905	–	+	–	–	Paiaearctic	5	Stones
Genus	Miuopseetra Kieffei, 1909							
	M praecox Meig 1818	–	–	–	+	Paiaearctic	2	Sand, silted sand, s>ilt
	Micropsectra sp	–	+	–	–		1 5	Stones
	M tnvialis Kieff, 1909	–	–	–	+	Paiaearctic	2	Silt

Continuation of list CHIRONOMIDAE species

	Species and subspecies	Endemic or not	Open Baikal	Bays	Coastal-sor zone	Distribution outside of Baikal	Depth, m	Bottom
Genus	Neozavrelia Goetghebuer et Thienemann, 1941							
	N minuta Linevitsh, 1963	+	+	–	–	–	1 5	Stones
	N conf minuta	–	+	–	–	–	1 5	Stones
Genus	Lauterbornia Kieffer, 1911							
	L coracina Kieffer, 1911	–	+	–	–	Palaearctic	5	Stones, sand

List of MOLLUSCA species. Compiled by Va.I. Starobogatov & T.Ya. Sitnikova

	Species and subspecies	Endemic or not	Open Baikal	Bays	Coastal-sor zone	Distribution outside of Baikal	Depth, m	Bottom
Class	Bivalvia							
Ordo	Uniomformes Stoliczka, 1871							
Family	Unionidae Rafinesqiie, 1820							
Subfamily	Anodontinae Rafinesque, 1820							
Genus	Colletopterum Bgt, 1880	–						
Subgenus	Ponderosiana Bgt, 1881	-						
	C (P) pondeimum sedakovi (Siem 1848)	–	–	+	+	South of Siberia, Mongolia	0-3	Silted sand
Ordo	Luciniformes Stoliczka, 1871							
Family	Sphaerndae Jeffr, 1862							
Subfamily	Sphaerunae Jeffr, 1862							
Genus	Amesoda Rafin, 18(5	-						
Subgenus	Asiocyclas Star et Korn, 1986	–						
	A (A) korotmewu (W Dyb, 1902)	+	–	+	–	–	0-3	Silted sand
Genus	Sphaenum Scopoli, 1777	–						
Subgenus	Parasphaerium Alim et Star, 1968	–						
	S (P) ievinodis West, 1876	–	-	-	+	Siberia	0 5	Sand, silt
	S (P) capiduliferum Ldh, 1909	–	-	+	+	Siberia	0-5	Sand, silt
	S (P) baicalense W Dyb, 1902	+	All	+	-	Angara	1 5-60	Sand silted sand
	S (P) westerlundi Cless 1873	–	—	~	+	North Asia, North Europe	0-5	Sand, silt
	S (P) dybowskn Ldh, 1909	+	-	+	-	-	0-3	Silted sand
	S (P) kozhovi Star m Star et Korn, 1986	+	All	+	-	-	0-5	Silted sand
Subgenus	Nucleocyclas Alim ct Star, 1968	–						
	S (N) mansminus Star in Star et Korn, 1986	+	M More	-	-	-	0-3	Silted sand
	S (N) radiata West, 1897 (=S (N) mtidum Var Cless in West, 1876)	–	–	–	+	Europe, Siberia	0 3	Silt, water plants
Subfam	Musculnnae Star in Stadn, 1984							
Genus	*Musculium* Link,)807	-						
Subgenus	Parvimuscuhum Star et Korn, 1986	–						
	M (P) compressum (Midd, 1851)	–	–	–	+	Palaearctic	0-3	Silt
Fam	Pisidndae Gray, 1857							
Subfam	Pisidunae Gray, 1857							
Genus	Pisidium Pfeiffer, 1S}21	–						
	P amnicum (Mull, 1774)	-	–	–	+	From Europe to Lena	0-10	Silted sand
	P baicalense W Dyt,, 1902 (=P dubium Ldh, 1909)	+	–	+	+	–	2-15	Sand, silt

Continuation of list of MOLLUSCA species

	Species and subspecies	Endemic or not	Open Baikal	Bavs	Coastal-sor zone	Distribution outside of Baikal	Depth m m	Bottom
	P decurtatum Ldh , 1909 (=P baicalertse var)	–	–	–	+	Pnbaikalye Pnamurye	0-10	Silted sand
Famıly	Euglesidac Pir et Star, 1974							
Subfamıly	Lacustnninae Korn , 1989							
Genus	Lacustnna Stcrki, 1916	–						
	Ldilatata West, 1886 (= Pisidium maculatum W Dyb , 1902, P subtilestnatum Ldh, 1909)	–	All	+	+	North Asia, North-East Furope, North America	1-50	Sand
Subfamıly	Euglesinae Pir ct Star, 1974							
Genus	Euglesa Leach in Jenyns, 1832	–						
Subgenus	Cascrtiana Fagot, 1892	–						
	E (C) korotncwi (Ldh, 1909)	+	All	+	–	–	1 2-60	Silted sand
	E (C) granum {Ldh, 1909)	+	All	+	–	–	1 2 20	Silted sand
	E (C) minuta (Kozh , 1936)	+	All	+	-	–	1 40	Silted sand
Subgenus	Cyclocalyx Dall, 1903	–						
	E (Cycl) cor (Star et Strel , 1967) (= (iahleja japponica ssp)	–	–	–	+	North Asia	0 3	Silt
Genus	Henslowiana Fagot, 1892	–						
Subgenus	Henslowiana s str							
	H (H) czerkn (Star ct Strel , 1967)	–	–	–	+	Siberia	1-10	Silted sand
Subgenus	Arcteuglesa Pir ct Star, 1974	–						
	H (A) semenkewitschi (Ldh 1909)	+	All	+	–	–	1-3	Sand, silt
	H (A) tngonoides (W Dyb , 1902)	+	All	+	-	-	1-3	Sand, silt
Genus	Pseudewpera Germain, 1913	–						
Subgenus	Pseudeupera s str							
	P (P) mucronata (Cless in West , 1877)	–	–	–	+	Siberia	0-5	Sand, silt
	P (P) tahevi (Star et Str, 1967)	–	–	–	+	Pnbaikalye	0-5	Sand, silt
Genus	Cmgulipisrdium Pir et Star, 1974)	–						
Subgenus	Ongulipisidium s str	–						
	C (C) kozhovi {Star et Str, 1967)	–	–	–	+	Pnbaikalye	0-5	Sand, silt
Genus	Convcntus Pir et Star, 1974	–						
	C raddei <W Dyb , 1902)	+	All	–	–	–	2-100	Sand, silt, aleuntc
Class	Gastropoda							
Subclass	Pectin i branchia							
Ordo	Vivi pan formes Sitn et Star, 1982							
Family	Valvatidac Gray, 1840							
Subfamily	Valvatinae Gray, 1840							
Genus	Cincmna Hubner, 1810	–						

Continuation of list of MOLLUSCA species

	Species and subspecies	Endemic or not	Open Baikal	Bays	Coas-tal sor zone	Distribution outside of Baikal	Depth in m	Bottom	Biocoe-notic role
Subgcnus	Sibirovalvata Star et Str , 1967	–							
	C (S) aliena (West, 1909)	–	–	–	–	Middle & Eastern Siberia, North of the Far East	0 5-2	Sand, silt	
	C (S) ssorensis (W Dyb , 1886)	–	–	+	+		0 5-8	Silt	
	C (S) korotnevi (ldh 1909)	–	–	–	+	Pnbaikalye	1 5 2	Silt	
	C (S) brevicula (Kozh, 1936)	–	–	+	+	Pnbaikalye	1 5-2	Sand, silt	
	C (S) sibinca (Midd, 1857)	–	–	–	+	North Asia, North-East Europe	1 5	Sand, silt	
Subgenus	Pseudomegdiovalvata Kozh, 1936	+							
	C (P) tenagobia (Beck et Star , 1975)	+	M More	–	–	–	32-39	Silted sand	
	C (P) olkhonica (Beck et Ster, 1975)	+	M More	–	–	–	32-39	Silted sand	
	C (P) bathybia (W Dyb , 1886)	+	SB	–	–	–	50-400	Aleuntc	
	C (P) profundicola (Beck et Star, 1975)	+	NB	–	–	–	300-800	Aleunte	
	C (P) laethmophild (Beck et Star, 1975)	+	SB	–	–	–	1380	Aleunte	
Genus	Megalovalvata Ldh, 1909	–							
Subgenus	Megalovalvata s str	+							
	M (M) baicalensis (Gerst 1859)	+	All	–	–	–	3-20 (to 50-70)	Sand stones	
	M (M) demersa Ldh ,1909 (=Valvata baicalensis var)	+	All	–	–	–	3-50	Sand, stones	
	M (M) piligera piligcra (Ldh , 1909) (= Valvata baicaJensis var)	+	M More	—	–	–	2-40	Sand	
	M (M) piligera nudicannatd (Ldh , 1924)	+	AN	–	–	Angara	2-40	Sand	
	M (M) lauta (ldh, 1909)	+	NB, East coast	-	–	–	2 70	Sand	
	M (M) kozhovi Sitn, 1983	+	All	+	–	–	3-20	Silted sand	r
	M (M) parvula (Kozh , 1936) (= Valvata lauta var)	+	South-East littoral	-	–	–	2 10	Sand	
Ordo	Rissoifbrmes Slav, 1983								
Family	Benedictndae Cless , 1880								
Genus	Benedictia W Dyb, 1875	+							
Subgenus	Bcncdictid s str	+							
	B (B) fragihs W Dyb , 1875	+	SB	–	–	–	50-200	Sand, silt, aleunte	r
	B (B) pulchella pulchella Sitn , 1987	+	SB, MB	–	–	–	30-180	Sand, silt, aleunte	
	B (B) pulchella sdrmtnsis Sitn 1987	+	NB, M More	-	–	–	30 180	Sand silt, aleunte	
	B (B) distmgucnda distinguenda Ldh , 1909 (=B fragihs var)	+	NB, MB, M More	–	–	–	20-120	Sand, silt, aleunte	
	B (B) distinguenda lamudna Sitn, 1987	+	SB	–	–	–	20-120	Sand, silt, aleunte	
	B (B)hmnaeoides limnaeoides (Sehrcnck, 1867)	+	SB, MB	–	–	–	10-40-100	Sand, silted sand	

Continuation of list of MOLLUSCA species

	Species and subspecies	Endemic or not	Open Baikal	Bays	Coastal-sor zone	Distribution outside of Baikal	Depth in m	Bottom	Biocoenotic role
	B (B) limnaeoides ongurensis Kozh., 1936	+	NB, M More	–	–	–	10-40-100	Sand, silted sand	
	B (B.) litorahs Kozh, 1936 (=B. limnaeoides var, B. baicalensis part. Mat. et. Dzub., 1986)	+	All	–	–	–	3-50	Sand	r
	B. kotyensis Mat, Dzub , Sitn., 1988	+	All	–	–	–	10-40	Sand, silted sand	
	B (B) nana Beck, et Star., 1975	+	NB	–	–	–	300-400	Aleunte	r
Subgenus	BaicalocochJea Ldh , 1927	+							
	B (Baic.) baicalensis (Gerstf, 1856)	+	All	–	–	–	3-50	Stones, sand	
	B (Baic) maxima maxima (W Dyb., 1875)	+	SB, MB	–	–	–	20-180	Sand, silt	
	B (Baic) maxima mansminus Sitn., 1987	+	NB, M More	–	–	–	20-180	Sand, silt	
	B (Baic.) shadini Beck et Star, 1975	+	NB, M. More	–	–	–	30-180	Sand, silt	
	B (Baic.) pumyla (Ldh , 1924)	+	All	–	–	–	270-790	Aleunte	
Genus	Kobeltocochlea Ldh , 1909	+							
Subgenus	Kobehocochlea s.str	+							
	K. (K) martcnsiana (W.Dyb , 1875)	+	All	–	–	–	3-40	Stones, sand	
	K. (K) olehonensis Ldh., 1909 (=K martensiana var)	+	NB, ME1, M More	–	–	–	2-40	Sand, silted sand	
	K. (K) lindholmiana Sitn., 1987	+	NB, M More	–	–	–	2-30	Silted sand, stones	r
Subgenus	Pseudobenedictia Sitn, 1987	+							
	K. (P.) michnoi Ldh, 1929	+	All	–	–	–	3-30	Stones	r
Family	Bithymidae Gray, 1857								
Subfamily	Parafossaruhnae Star, 1983								
Genus	Boreoelona Star ct Strel , 1967	–							
	B contortnx (Ldh, 1909)	–	–	+	+	Middle Siberia, Priam urye	0 5-3	Silt	
Family	Baicalndae Clcssin, 1880								
Genus	Liobaicaha Martens, 1876	+							
	Lstiedae (W Dyb , 1875)	+	SB	–	–	–	15-40 (100)	Sand, silted sand	
Genus	PseudobaikaJia Ldh, 1909	+							
Subgenus	Pseudobaikaha s.str	ı							
	P. (P.) jenttenana (Ldh, 1909)	+	NB, M More	+	–	–	15-100	Sand, silted sand	
	P (P) contabulata (W Dyb , 1875)	+	All	–	–	–	10-40	Sand, silted sand	
	P. (P) eanccllata (Ldh, 1909)	+	NB	–	–	–	20-100	Sand, stones	
	P (P) elegantula (Ldh , 1909)	+	M More	–	–	–	2-5 (25)	Stones	
	P (P.) zachwatkmi (Kozh., 1936)	+	All	–	–	–	2-30	Stone;,, sand	
Subgenus	Microbaicaha Kozh, 1936	+							
	P (M) pulla pulla (W Dyb , 1875)	+	SB, MB	+	–	–	15-40	Sand, silted sand	

Continuation of list of MOLLUSCA species

	Species and subspecies	Endemic or not	Open Baikal	Bays	Coas-tal-sor zone	Distribution outside of Baikal	Depth in m	Bottom
	P (M) pulld tenuicosta (Ldh , 1909)	+	NB, M More	–	–	–	15-40	Sand, silted sand
	P (M) subcylindnca (Ldh, 1909)	+	M More	–	–	–	15-40	Sand, silted sand
Genus	Teratobaikalia Ldh, 1909	+						
Subgenus	Teratobdikaha s str	+						
	T(T) macrostoma (Ldh, 1909)	+	NB, M More	–	–	–	1 40	Stones, sand
Subgenus	Tnchobaikalid Ldh, 1909	+						
	(=Dybowskiola Ldh, 1913)							
	T (Tr) duthiersii duthiersii (W Dyb , 1875)	+	All	–	–	–	15-50	Rocks with silt
	T (Tr) duthiersii pachypleura (Ldh. 1924)	+	SB	–	–	–	15-35	Rocks
	T (Tr) duthiersii ireutica nom n	+	–	–	–	Angara	2-10	Stones
	(=Bdicaha duthiersii vdr angarensis							
	B Dyb, 1913)							
	T(Tr) ciliata (W Dyb, 1875)	+	All	–	–	–	2-50	Stones, sand
Subgenus	Baicalielld Ldh 1909	+						
	T(B) nana (Ldh, 1909)	+	All	–		–	10 100	Sand, silt
	T(B) productd (Kozh, 1936)	+	NB, M More	–	–	–	13	Sand
	(=Baitaha nana *var*)							
	T(B) clandestma (Beck et Star, 1975)	+	SB	–	–	–	240	Sand, aleunte
	T (B) humerosa (Beck et Star, 1975)	+	N-E B	–	–	–	20-24	Sand
Genus	Maackia Clessin, 1880	+						
Subgenus	Maackid s str	+						
	M <M) costata (W Dyb , 1875)	+	SB, MB,					
			M More	–	–	–	10-40	Stones
Subgenus	Fubaicdha Ldh, 1924	+						
	M (h) angarensis (Gerstf, 1859)	+	SB	–	–	Angara	1 5-10	Stones
	M (E) ventrosula (Ldh, 1909)	+	NB	–	–	–	15 10	Sand, stones
	M (b) herdenana herdenana (Ldh , 1909)	+	SB, MB	–	–	–	0 5-20	Stones
	M (E) herdenana laevis (Kozh, 1936)							
	(=Bithinia raphidma Bgt)	+	SB	–	–	Angara	0 5-10	Stones
	M (E) herdenana semicostulata (Ldh , 1924)	+	SB	–	–	–	0 5-20	Sand
	M (E) herdenana parvula (Kozh , 1936)	+	MB	+	–	–	0 5 5	Sand
	M (E) vdneseulpta (Ldh, 1909)	+	NB, M More	+	–		1-25	Stones
	M (E) bythmiopsis (Ldh, 1909)	+	All	–	–	–	5-15	Stones
	M (E) umbihfera (Starostin, 1926)	+	Ushkany					
			Islands	–	–	–	50	Sand
	M (E) pusilla (Ldh, 1909)	+	M More	–	–	–		
	(=Bdieaha umbilicitera Kozh , 1936)						1 5-10	Stones, sand
	M (h) werestschagini Kozh, 1936	+	M More	–	–	–		
Genus	Bdicahd Martens, 1876	+					2 3	Stones
	B carmata cannata (W Dyb , 1875)	+	SB, MB,	–	–	–		
							10-100	Sand, silt

	Species and subspecies	Endemic or not	Open Baikal	Bays	Coas-tal-sor zone	Distribution outside of Baikal	Depth in m	Bottom
			M More					
	B tannata rugosa Ldh , 1909	+	NB	-	–	–	7-100	Sand, silt
	B cannato-costata (W Dyb 1875)	+	All	-	–	–	10-100	Sand, silt
	B dybowskiana dybowskiana Ldh, 1909	+	SB, MB, M More	+	–	–	10 20	Sand, silt
	B dybowskiana carmatoides Kozh, 1936	+	N-F B,	+	–	–	10-20	Sand, silt
	B turnformis (W Dyb , 1875)	+	SB, MB	-	–	–	7-40	Rocks
Genus	Korotncwia Kozh, 1936	+						
	K korotnevi korotnevi (Ldh, 1909)	+	NB, M More	+	–	–	10-100	Silted sand
	K korotnevi gracilis (Kozh, 1936)	+	M More	-	–	–	10 100	Silted sand
	K korotnevi selengcnsis (Kozh, !936)	+	Selcnga Shallows	+	–	–	8-20	Sand
	K semenkewitschi semenkewitschi (Ldh, 1909)	+	S-W B, MB, NB, M More	—	–	–	5 70	Silted sand
	K semenkewitschi nitida (Kozh, 1936)	+	S-E B	-	–	–	5 70	Silted sand
	K angigyra (Ldh , 1909)	+	NB, M More	-	–	–	10-200	Silted sand
Genus	Parabaikaha Ldh , 1909	+						
	P florn floni (WDyb, 1875)	+	SB, MB	-	–	–	5-100	Sand
	P flom kobeltiana (Ldh, 1909)	+	NB, M More	-	–	–	5-100	Sand
	P oviformis oviformis (WDyb, 1875)	+	SB, MB, N-W B, M More	+	–	–	4-20	Sand
	P oviformis milaschewUschi (Ldh, 1909)	+	N-E B	+	–	–	4-20	Sand
	P elata (WDyb, 1875)	+	SB, MB, M More	-	–	–	5-20	Silted sand
	P dubiosa (Kozh, 1936)	+	NB	+	–	–	*5-20*	Silted sand
Genus	Godlewskia Gr et Hsch , 1897	+						
	G godlewskn godlewskn (WDyb, 1875)	+	SB, MB	–	–	–	8-40 (200)	Sand, silled sand
	G godlewskn spcciosa (Kozh, 1936)	+	NB, M More	-	–	–	8-40	Sand, silted sand
	G pulchelld pulchella (WDyb, 1875)	+	SB, MB	–	–	–	8 40 (200)	Sand silted sand
	G pulchelld intermedia (Kozh, 1936)	+	NB, M More	-	–	–	8 40	Sand silted sand
	G wrzesniowskn wrzesniowsku (W Dyb , 1875)	+	SB	–	–	–	15-100	Sand
	G wrzesniowskn profunda (Ldh, 1924)	+	NB	–	–	–	3-40	Sand
	G wrzesniowskn olchoncnsis (Kozh, 1936)	+	M More	–	–	–	15-45	Sand, silted sand
	G columella (Ldh 1909)	+	SB	–	–	–	3-140	Sand, silted sand
	G bacilliformis (Kozh , 1936)	+	SB, NB, M More	–	–	–	20-100	Silted sand

Continuation of list of MOLLUSCA species

	Species and subspecies	Endemic or not	Open Baikal	Bays	Coas-tal-SOr zone	Distribution outside of Baikal	Depth ın m	Bottom
Subclass	Pulmonata							
Ordo	Lymnaeiformes Ferussac, 1822							
Famıly	*Acroiox/dde Thiele, 19}}*							
Genus	Acroloxus Beck, 1837	–						
	A baicalensis Kozh , 1936	–	–	+	+	Pnbaikalye Yenisei	0-5	Water plants, stones
	(=A lacustns var)							
Genus	Pseudancylastrum Ldh , 1909	+						
	P sibmcum (Gcrstf., 1859)	+	SB	–	–	Angara	2.5-10	Large stones
	P dybowskn (Cless , 1882)	+	SB	–	–	Angara	2 5-10	Stones
	P olgae Star, 1989	+	S-E B	–	–	–	2 5-10	Pebbles
	P beckmanae Star., 1989	+	N-W B, M More	–	–	–	4-20	Large stones
	P cornu Star, 1989	+	SB	–	–	–	2.5-10	Large stones
	P korotnevi Star, 1989	+	S-W,	N-W B	–	–	4-10	Large stones
	P. wcrestschagini Star., 1989	+	SB	–	–	Angara	3-20	Stones
	P troscheli (W Dyb , 1875)	+	SB	–	–	–	5-25	Middle and small stones
	P acuUfcrum Star , 1989	+	SB, M More	-	–	–	4-36	Large stones
	P. poberezhnyi Star., 1989	+	All	–	–	–	4-15	Stones
	P dorogostajskii Star, 1989	+	All	–	–	–	3-35	Middle and small stones
	P. inndaense Star, 1989	+	NB	–	–	–	2-10	Large stones, rocks
Genus	Gerstfeldtiancylus Star, 1989	+						
	G gerstfeldti Star, 1989	+	All	–	–	–	4-25	Stones
	G kozhovi Star, 1989	+	S-W, N-W B, M More	-	–	–	5-40	Stones
	G kotyensis Star, 1989	+	All	–	–	–	4-40	Stones
	G rcnardi (W Dyb., 1884)	+	All	–	–	–	4-20	Stones
	G capuliformis Star, 1989	+	N-E B, M. More	–	–	–	3-10	Pebbles
	G benedictiae Star., 1989	+	All	–	–	Angara	4-20	Benedictia's snails, stones
	G porfinevae Star., 1989	+	NB	–	–	–	4-12	Pebbles
	G pilcolus Star, 1989	+	NB	–	–	–	3-4	Pebbles
Genus	Baicalancylus Star, 1967	+						
	B. lancensis (W Dyb., 1913)	+	All	–	–	–	2-10	Rocks
	(-Ancylus dybowskn var)							
	B boettgenanus (Ldh., 1909)	+	All	–	–	–	2-10	Rocks
	B njurgonicus Star, 1989	+	NB, M. More	–	–	–	2-10	Rocks
	B kobelti (WDyb, 1885)	+	SB, M. More	–	–	–	5-10	Rocks
Famıly	Lymnaeidae Rafinesque, 1815							
Genus	Lymnaea Lamarck, 1799	–						

Continuation of list of MOLLUSCA species

	Species and subspecies	Endemic or not	Open Baikal	Bays	Coastal-sor zone	Distribution outside *of* Baikal	Depth in m	Bottom
Subgenus	Lymnaea s str	–						
	L(L) *stagnahs* (L , 1758)	–	–	+	+	East Siberia, Europes	0 5-3	Plants
	L(L} fragilis (L , 1758)	–	–	-	+	East Siberia, Europe	0 5-3	Plants
Subgenus	Stagnicola Leach, 1830	–						
	L (S) terebra lindholmi (W Dyb , 1913)	–	–	—	+	Pnbaikalye	0-3	Plants, silt
	L(S) ventricosella (WDyb, 1913)	–	–	—	+	Middle Siberia	0-3	Plants, silt
	L (S) atra zebrella (W Dyb , 1913)	–	–	–	+	Siberia, North Europe	0-3	Plants, silt
Subgenus	Sibingalba Krugl ct Star, 1985	–						
	L (S) sibinca West, 1885 [= Limnaea truncatula var)	–	–	–	–	South Siberia, Priamurye, Far East	0-0 5	Clay
Subgenus	Galba Schrank, 1803	–						
	L(G) truncatula (Mull, 1774)	–	–	–	–	From hurope to Enisey	0-0 5	Plants, clay
Subgenus	Radix Montfort, 1810	–						
	L(R) aunculana (L , 1758)	–	–	+	+	Palaearctic	0 2	Plants
	L(R) intercisa Ldh , 1909	–	–	+	+	Pnbaikalye, Altay	0 2	Plants
	L(R) hakusyensis Krugl et Star, 1989	–	–	-	-	Khakusi, Goryachinsk	0 03	Thermal waters
	L(R) thcrmobaicalica Krugl et Star, 1989	–	–	-	-	Khakusi, Goryachinsk	0-0 3	Thermal waters
Subgenus	Peregnana Servam, 1881	–						
	L (P) zazurmensis Moz , 1934	–	–	–	+	North Asia	0 5	Plants, sill, stoiics
	L(P) fontmalis (Stud, 1820)	–	–	-	+	From Europe to Lena	0-3	Plants
	L(P) baithica (L , 1758)	–	–	-	+	From Furopc to Yenisei	0-3	Plants
	L(P) ovata Drap , 1805	–	–	-	+	Horn Europe to Lena	0-3	Plants
	L(P) ampullacca Rossm , 1855	–	–	—	+	From Europe to Pnbaikalye	0-3	Plants
Subgenus	Onentogalba Krugl et Star, 1985	–						
	L(O) hooken Reeve, 1950	–	–	–	–	Middle Asia	0-0 5	Clay
	L(O) lenaensis Krugl et Star, 1985	–	–	–	–	South Siberia, Priamurye, Far East	0-0 5	Clay
Family	Physidae Fitzinger, 1883							
Subfamily	Aplexinae Star, 1967							
Genus	Aplexa Fleming, 1820	–						

Continuation of list of MOLLUSCA species

	Species and subspecies	Endemic or not	Open Baikal	Bays	Coas-tal-sor zone	Distribution outside of Baikal	Depth in m	Bottom
Subgenus	Amuraplcxa Star et Pro7 , 1989	–						
	A (Am) amurensis Star et Proz , 1989	–	–	–	–	Pribaikalye, Pnamuryc, Far hast	0-0 5	Clay
Genus	Sibirenauta Star et Strel , 1967	–						
	S elongata (Say, 1821)	–	–	–	–	North Asia, North America	0-0 5	Clay
	S aemgma (West 1877) (Physa kultukiana W Dyb , 1913)	–	–	–	–	South of Middle Siberia	0-0 5	Clay
Subfamily	Physinae Fitzmger, 1883							
Genus	Physa Drap 1801	–						
Subgenus	Physa S Str	–						
	Ph(Ph) adversa (da Costa, 1778)	–	–	–	–	From Europe to Yenisei	0-8	Plants
Fam	Buhnidae Herrmansen 1846							
Subfamily	Camptoceratinae Dall, 1870							
Genus	PlanorbanuS Dumenl, 1806	–						
Subgenus	Planorbanus s str	–						
	P (P) purpura (Mull, 1774)	–	–	–	+	From Europe to Yenisei	0 3	Plants
Fdmily	Pldnorbidae Rafmesque, 1815							
Subfamily	Planorbinac Rafmesque, 1815							
Genus	Planorbis Muller, 1774	–						
	P pldnorbis (L, 1758)	–	–	–	+	From Europe to Yenisei	0-1	Plants, silt, clay
Genus	Armiger Hartmann, 1840	–						
	A crista (L 1758)	–	–	–	+	Palaearctic	0 8	Plants
Genus	Amsus Studcr, 1820	–						
Subgenus	Amsus s str	–						
	A (A) leucosloma (Millet, 1813)	–	–	–	–	From Europe to Lena and Uda	0-0 5	Clay
Subgenus	Bathyomphalus Agassi7 in Charpentier, 1837	–						
	A (B) crassus (da Costa, 1826)	–	–	–	+	From Europe to Lena	0-3	Plants
Subgenus	Gyraulus Agassiz in Charpentier, 1837	–						
	\ *(G) baicahcus* (WDyb, 1913)	–	–	+	+	Middle Siberia, Upper Zeya	*0 5-2*	Sand, plants
	A (G)ignotellus (B Dyb, 1915)	+	SB	–	–	–	2-100	Silt, sand
	A (G) umbihciferus (Kozh , 1936)	+	NB, M More	+	–	-	1-5	Stones
	A (G) stroemi (West, 1881)	–	–	+	+	From Europe to		

Continuation of list of MOLLUSCA species

	Species and subspecies	Endemic or not	Open Baikal	Bays	Coas- tal- sor zone	Distribution outside of Baikal	Depth in m	*Bottom*
						Lena and Amur	0 5-10	Plants, silt
	A (G) acronicus (Fer., 1807)	–	–	+	+	Palaearctic	0 5-50	Plants, stones, silt
Genus	Choanomphalus Gerstf, 1859	–						
Subgenus	Choanomphalus s str	+						
	Ch (Ch) patuiaeformis Ldh , 1909	+	NB, MB	–	–	–	2-10	Stones
	Ch. (Ch) incertus incertus Ldh, 1909	+	NB, M. More	-	–	–	2-30	Stones, sand
	Ch. (Ch) incertus mesospirahs B Dyb et Grochm, 1925	+	SB	–	–	Angara	2-30	Stones, sand
	Ch (Ch) maacki maacki Gerstf, 1859 (= Ch bicarmatus W Dyb , 1910)	+	SB	–	–	Angara	1 5-20	Stones
	Ch (Ch) maacki korotnevi Ldh, 1909	+	M More	–	–	–	1 5-20	Stones, sand
Subgenus	Achoanomphalus Ldh , 1909	–						
	Ch (A) amauronius amauronius Bgt., 1862	+	SB	–	–	Angara	0-20	Stones
	Ch (A) amauronius wester! undian us Ldh , 1909	+	S-E B	–	–	-	2-40	Sand
	Ch (A.) valvatoides valvatoides W Dyb , 1875(=Ch intermedius W Dyb , 1901)	+	SB, MB	+	–	Angara	1 5-30	Sand
	Ch (A) valvatoides olehonensis nom n. (=Ch. amauronius var valvatoides f. olehonensis ICozh., 1936)	+	NB, M More	-	–		3-20	Sand
	Ch (A) eurystomus Ldh, 1909	+	All	–	–	Angara	3-35	Sand
	Ch (A) aorus Bgt.. 1862	+	SB	–	–	Angara	1-20	Stones
	Ch. (A) angulatus B Dyb et Grochm, 1925	+	All	+	–	Angara	2-20	Stones
Subgenus	Omphalocrypta Tomlm, 1929	+						
	Ch (O (cryptomphalus cryptomphalus W Dyb., 1901 (=Ch subrimatus Ldh, 1909)	+	SB	–	–	–	1 5-20	Pebbles
	Ch (O) cryptomphalus tumidus Kozh, 1936 (=Ch amauronius var)	+	NB, MB	–	–	–	2-20	Sand
	Ch. (O) anomphalus W Dyb ,1901 (=Ch dybowskianus Ldh., 1909)	+	All	–	–	–	1-35	Sand
	Ch (O) rmcrotrochus Ldh., 1909	+	NB	–	–	–	10-12	Sand
Subgenus	Sulcifcr Ldh., 1909	+						
	Ch (S) parvus Kozh, 1936	+	NB, M More	-	–	–	5 25	Sand
	Ch (S) pygmaeus Ldh, 1909	+	MB, M. More	-	–	–	1.5-15	Sand
	Ch. (S) schrencki W Dyb , S875	+	All	–	–	–	2-20	Sand
Subgenus	Baicalarmiger Beck et Star, 1975	+						
	Ch (B) gerstfeldtianus gerstfeldtianus Ldh, 1909	+	SB, MB	–	–	–	1 5-10	Stones
	Ch. (B) gerstfeldtianus striatus Kozh, 1936	+	MB, M More	-	–	–	1.5-10	Stones
	Ch (B.) baicalensis (West, 1897)	+	SB	–	–	–	1.5-10	Stones
Subgenus	Baicaloplanorbis Beck, et Star., 1975	+						

Continuation of list of MOLLUSCA species

	Species and subspecies	Endemic or not	Open Baikal	Bays	Coas-tal-sor zone	Distribution outside of Baikal	Depth in m	Bottom
	Ch. (Baic) kozhovi Beck et Star, 1975	+	N-W B	–	-	–	12-70	Sand
Subgenus	Antichoanomphalus Beck et Star, 1975	+						
	Ch. (An) planorbiformis Beck et Star., 1975	+	NB	–	-	-	260-580	Aleunte
Subgenus	Kozhovi sulci fer Beck et Star, 1975	+						
	Ch (K) anmihformis Kozh , 1936	+	NB, M. More	–	–	–	1 5-10	Stones
	Ch (K) bathybius bathybius Beck et Star, 1975	+	NB	–	-	-	400	Sand
	Ch. (K) bathybius mendianus Beck et Star , 1975	+	SB	–	–	–	170	Sand, silt
	Ch. (K.) lindholmi Beck et Star, 1975	+	NB	–	–		12-70	Sand
	Ch. (K) huzhirensis Beck et Star, 1975	+	M More	–	–	:	65	Sand
Genus	Kolhymorbis Star, et Strel , 1967	–						
	K. angarensis (B. Dyb ct Grochm., 1925 (=Planorbis nitidus var., K maacki Star et Strel., 1967)	–	–	–	+	South of Eastern Siberia, Pnamurye, Far East	0-0 5	Plants. silt, clay
Genus	Polypyhs Pilsbry, 1906	–						
	P sibmca Star, et Stiel , 1967	–	–	+	+	South *of Eastern* Siberia	*0-0.5*	Plants
Genus	Helicorbis Benson, 1855	–						
	H kozhovi Star et Strel, 1967	–	–	–	+	Lake Kotokel	0-2	Plants, silt

Comment- SB south Baikal, NB - north Baikal, MB - middle Baikal, M.Morc - Maloye More, N-W - North-West, N-E - North-East, S-W - South-West, S-E - South-East, r = rare.

List of PISCES species. Compiled by B.K. Pavlov & V.A. Ostroumov (after Taliev, 1955)

	Species and subspecies	Endemic or not	Open Baikal	Coastal-sor zone & bays	Biocoe-notic role	Depth, m	Bottom
Ordo	Ac ipensen formes						
Family	Acipcnsendae						
Genus	Acipenser						
	Acipcnser baen stenorhynchus Nik, 1896	–	–	Shallows & estuaries	r		
Ordo	Clupeidae						
Subordo	Salmonoidei						
Family	SaJmomdae						
Genus	Salvelinus						
	Salvclinus alpinus crythnnus Georgi, 1775	–	-	Shallows of NE	very r		
Genus	Hucho						
	Hucho taimen Pallas, 1773	–	Littoral near rivers	-	r		
Genus	Brachymystax						
	Brachymystax lenok Pallas, 1773	–	–	Estuaries of rivers	us		
Family	Coregonidae						
Genus	Coregonus						
	Coregonus autumnahs migratonus Georgi, 1775	+	All	–	m		
	C lavaretus L., 1758	–	All	–	m		
Family	Thymallidae						
Genus	Thymallus						
	Thymallus arcticus Pall., 1776	–					
	T arcticus baicalensis Dyb, 1876	–	All, littoral	–	m		Stones
	T arcticus brevipinnis Swetow, 1931	+	All, littoral	–	m		Sand
Ordo	Esociformes						
Family	Esocidac						
Genus	hsox						
	Esox lucius L , 1758	–	–	+	m		
Ordo	Cypnm formes						
Family	Cypnnidae						
Genus	Rutilus						
	Rutilus rutilus L , 1758	–	–	+	m		
	Rrutilis lacustns Pallas, 1811	–					
Genus	Leuciscus						
	Leuciscus leuciscus L., 1758	–	–	+	m		
	L.leuciscus baicalensis Dyb., 1874	+					
	Lidus L., 1758	–	–	+	us		
Genus	Phoxinus						
	Phoxinus percnurus Pallas, 1811	–	–	+	r		

Continuation of list of PISCES species

	Species and subspecies	Endemic or not	Open Baikal	Coastal-sor zone & bays	Biocoenotic role	Depth, m	Bottom
	P czekanowskii Dyb, 1869	–	–	+	r		
	Pphoxinus L, 1758	–	–	+	r		
Genus	Tinea						
	Tinea tinea L , 1758	–	–	Estuaries	very r		
Genus	Gobio						
	Gobio gobio L, 1758	–	–	Estuaries of SE	very r		
	G gobio cynocephalus Dyb, 1869	–					
Genus	Carassius						
	Carassius carassius L, 1758	–	–	+	very r		
	C. auratus L , 1758	–	–	+	very r		
	C auratus gibelio *Bloch* , 1 783	–			very r		
Genus	Cypnnus						
	Cyprmus carpio L , 1758	in	–	+	us		
	C carpio haematopterus Temm et Schlcg , 1842						
Family	Cobitidae						
Genus	Nemachilus						
	Ncmachilus barbatulus L., 1758	–	–	+	r		
	N barbatulus torn Dyb. 1869	–			r		
Genus	Cobitis						
	Cobitis taenia L, 1758	–	–	+	very r		
	Cobitis taenia sibirica Gladkov, 1935	–			very r		
Family	Silundae						
Genus	Parasilurus						
	Parasilurus asotus L, 1758	in	–	+	r		
Ordo	Gadlformes						
Family	Gadidae						
Genus	*Lota*						
	Lota lota L, 1758	–	–	+	us		
Ordo	Perciformes						
Subordo	Percoidei						
Family	Percidae						
Genus	Perca						
	Perca fluviatilis L., 1758	–	–	+	m		
Subordo	Cottoidci						
Family	Cottidac						
Subfamilia	Cottocomephonnae						
Genus	Paracottus						
	Paracottus knen Dyb., 1874	–	All	–	m	< 100	Stones

Continuation of list of PISCES species

	Species and subspecies	Endemic or not	Open Baikal	Coastal sor zone & bays	Biocoenotic role	Depth, m	Bottom
	P insulans Tal, 1948	+	Ushkany Islands	–	r	< 1	Under stones
	P kesslen Dyb , 1874	–	–	+	m	< 50-70	Stony sands
	P kesslen lubncus Tal, 1955	+	–	+	r	20-80	Sand
	P pelagicus Tal , 1955	+			very r		
Genus	Batrachocottus						
	Batrachocottus baicatensis Dyb, 1874	+	All	–	m	< 100	Stones
	B baicalensis pachytus Tal , 1955	+	–	–	very r	80-180	Stony sands
	B uschkam Tal, 1955	+	Ushkany Islands		r	< 100	Stones
	B nikolsku Berg, 1900	+	All	–	r		Silt & stones
	B multiradiatus Berg, 1933	+	All	–	us	30-940	Silt
Genus	Cottocomephorus						
	Conocomephorus grewingki Dyb., 1874	+	All	–	m	400-450	
	C grewingki alexandrac Tal, 1935	+	All	–	m	10-400	
	C inermis Jak , 1890	+	All	–	m	< 1000	
Genus	Metacottus						
	Metacottus gurwici Tal, J 946	+	All	–	very r		
Genus	Procottus						
	Procottus jeittelesi Dyb 1874	+	All	–	us	< 200	Silt & stones
	P jeittelesi minor Tal , 1946	+	All	–	r	60-200	Silt
	P jeittelesi major Tal , 1944	+	All	–	r	100 600	Silt & stones
Subfamily	Abyssocottinae						
Genus	Asprocottus						
	Asprocottus herzensteini Berg, 1906	+	All	–	us	20-800	Silt
	A herzensteini parmiferus Tal, 1955	+	All	–	very r	20-350	Stones
	A herzensteini abissahs Tal , 1947	+	All	–	r	450-1000	Silt
	A herzensteini platycephdlus Tdl, 1948	+	All	–	r	100-250	Silt & sand
	A herzensteini intermedins Tal, 1938	+	All	–	r	150-330	Silt & sand
	A pulcher Tal , 1955	+	NB	–	r	60-310	Silt
	A megalops Gratz , 1902	+	NB	–	r	30-380	Silt
	A megalops eurystomus Tal, 1955	+	AH	–	r	30-400	Silt & sand
	A gibbosus Berg, 1906	+	All	–	us	240-1200	Silt
Genus	Cottmella						
	Cottmella boulengen Berg, 1906	+	All	–	us	600 1200	Silt & stones
	C werestschaginj Tal, 1955	+	All	–	r	800-1200	Silt
Genus	Abyssocottus						
	Abyssocottus korotneffi Berg, 1906	+	All	–	us	170-1200	Silt
	Aelochmi Tal , 1955	+	All	–	very r	250-300	Stones
	Agodlewskn Dyb, 1874	+	All	–	r	70-380	Silt & stones
	A godlcwskn gnseus Tal, 1948	+	All	–	r	160-700	

Continuation of **list** of PISCES species

	Species and subspecies	Endemic or not	Open Baikal	Coastal-sor zone & bays	Biocoenotic role	Depth, m	Bottom
	A pallidas Berg, 1906	+	All	–	us	80 850	Silt
	A bergianus Tal, 1935	+	All	–	us	120-1100	Silt
Family	Comephoridae						
Genus	Comephorus						
	Comephorus baicalensis **Pall, 1776**	+	All	–	m		
	C dybowskn Korotneff, 1905	+	All	–	m		
Subordo	Gobioidei						
Family	Elcotndae						
Genus	Percottus						
	Percottus glehni Dyb , 1876	in	–	Selenga Shallows	us		

Comment r - rare, m - mass, us - usual, in - introduced

List PARASITOFAUNA species. Compiled by N.M. Pronin

	Species and subspecies	Endemic or not	Open Baikal	Coastal-sor zone & bays	Final hosts	Intermediate hosts	Additional hosts
	Protozoa						
Type	Mastigophora Diesing, 1866						
Class	Kinetoplastomonada Honigberg, 196^						
Family	Trypanosomidae Doflein, 1911						
Genus	Trypanosoma Gruby, **1841**						
	T carassn (Mitrophanov, 1883)	un		+	Carassms carassius (3 12%)	–	–
	T percae Brumpt, 1906	un		+	Perca fluviatilis (30-80%)	–	–
Class	Parasitomonada Seravin, 1980						
Ordo	Diplomonadida Wenyon, 1926						
Genus	Hexamita Dujardin, 1838						
	H truttae (Schmidt, 1920)	un	+	+	Coregonus autumnal is migratonus (5-12%), Lota lota (60%)	–	–
Type	Sporozoa Zeuckart, 1872						
Class	Coccidiomorpha Doflein, 1901						
Family	Eimendae Leger, 1911						
Genus	Eimena Schneider, 1875						
	F carpelh Leger et Stankovitch, 1921	SB	+	+	Phoxinus phoxinus (2-7%), Paracottus kesslen (20%), Asprocottus megalops (15%), Batrachocottus baicalensis (19%)	–	–
	E percae (Riviere, 1914)	S		+	Perca fluviatilis (10-40%)	–	–
	E esoci Schulman et Zaika, 1962	S		+	Esox lucius (30%)	–	–
	E leucisci Schulman et Zaika, 1964	S		+	Leuciscus leuciscus baicalensis (13%)	–	–
Type	Microspondia Balbiam, 1882						
Class	Microspondea Corliss et Levine, 1963						
Family	Glugeidae Gurley, 1893						
Genus	Glugea Thelohan, 1891						
	G anomala (Moniez, 1887) Gurley, 1893	SB	+		Asprocottus megalops (+)		
	G fennica Lorn et Weiser, 1969	un		+	Lota lota (10-30%)	–	–
Type	Cnidospondia Doflein, 1901						
Class	Myxospondia Butschli, 1881						
Family	Myxidndae Thelohan, 1892						
Genus	Myxidium Butschli, 1882						
	M rhodei Leger, 1905	S		+	Rutilus rutilus lacustns (30-75%), Leuciscus leuciscus baicalensis (4-36%), Leuciscus ldus (10-20%)	–	–
	M heberkuehni Butschli, 1882	S		+	Esox lucius (60-80%)	–	–
	M noblei Konovalov in Schulman, **1966**	un	+		Thymallus arcticus baicalensis (5-10%)	–	–

Continuation of list PARASITOFAUNA species

	Species and subspecies	Endemic or not	Open Baikal	Coastal-sor zone & bays	Final hosts	Intermediate hosts	Additional hosts
	M omuli Zaika, 1961 (Syn M perniciosum subsp omuli Zaika, 1961, M omuli Schulman, 1965)	B	+	+	Coregonus autumnalis migratonus (10-20%)	–	–
	M pfeiffen Auerbach, 1908	S		+	Rutilus rutilus lacustris (30-45%), Perca fluviatilis (20%)	–	–
	M perniciosum Dogiel, 1957	B	+		Paracottus kesslen (+), P insulans (2-7%), Batrachocottus nikolskn (20%), B multiradiatiis (+), B uschkani (+), Cottocomephorus grewingki (8%), C inermis (40-60%), Asprocottus herzensteini (30-50%), A megalops (30%), Abissocottus pallidus (+), A bcr gianus (70%), Comephorus dybow skn (7%), C baicalensis (15-30%)	– –	–
Genus	ZschokkcJla Auerbach, 1910						
	Z nova Klokačewa, 1914	S		+	Rutilus rutilus lacustris (18%), Leuciscus leuciscus baicalensis (27%), L idus (()	–	–
Family	Ceratomyxidae Doflein, 1899						
Genus	Leptotheca Thelohan, 1895						
	L subsphaenca Zaika, 1963	SB	+		Coregonus autumnalis migratonus *(4-8%)*, Thymallus arcticus baicalensis (9%)	–	–
Family	Sphaerospondae Davis, 1917						
Genus	Sphaerospora Thelohan, 1892						
	S rota Zaika, 1961	SB		+	Brachymystax lenok (+), Cobitis taenia (11 %)	–	–
	S cnstata Schulman, 1962	SB	+		Lota lota (46%)	–	–
	S pectinacea Botscharova et Donee, 1974	un		+	Perca fluviatilis (10%)	–	–
Genus	Chloromyxum Mingazzini, 1890						
	C fluviatile Thelohan, 1892	**S**		+	Rutilus rutilus lacustris *(64%)*, Leuciscus leuciscus baicalensis (20%), Phoxinus Phoxinus (+)	–	–
	C mucronatum Gurley, 1893	SB		+	Lota lota (40%)	–	–
	C dubium Auerbach, 1908	SB		+	Lota lota (40-54%)	–	–
	C thymalh Lcbzelter, 1912	SB	+		Thymallus arcticus baicalensis (9%)	–	–
	C esocinum Dogiel, 1934	S		+	Esox lucius (10%)	–	–

Continuation of list PARASITOPAUNA species

	Species and subspecies	Endemic or not	Open Baikal	Coastal-sor zone & bays	Final hosts	Intermediate hosts	Additional hosts
Genus	Caudomyxum Bauer, 1948						
	C nanum Bauer, 1948	SB		+	Lota lota (61%)	–	–
Family	Myxobilatidae Schulman, 1953						
Genus	Myxobiiatus Davis, 1944						
	M paragasterostei Zaika, 1963	SB		+	Rutilus rutilus lacustris (10%), Leuciscus leuciscus baicalensis (15-20%), Paracottus kesslen (60 80%), Batrachocottus baicalensis (6%), Asprocottus megalops (30%), C ottocomephorus grewingki (17%)	–	–
	M baicalensis (Dogiel, 1957 (Syn Henneguya baicalensis Dogiel, 1957)	B	+		Paracottus knen (27%), P kesslen (60-80%), Batrachocottus baicalensis (6%), Cottocomephorus grewingki (15-25%), Asprocottus her7ensteini (5-8%), A megalops (15%)	–	–
Family	Myxosomatidae Poche, 1913						
Genus	Myxosoma Thelohan 1892						
	M anurum (Cohn, 1895)	S		+	Esox lucius (20%)	–	–
	M dujardini Thelohan, 1899	S		+	Leuciscus leuciscus baicalensis (+), Phoxinus phoxinus (+), Esox lucius (6 13%), Cobitis taenia (5%)	–	–
	M pseudoanurum Pronin, 1977	un		+	Esox lucius (6-13%)	–	–
Family	Myxobolidae Thelohan, **1892**						
Genus	Myxobolus Butschli, 1882						
	M tahevi Dogiel, 1957	B	+		Paracottus knen (27%), P kesslen (8-13%), Batrachocottus baicalensis (19%), B uschkani (+) B nikolskn (20%), Procottus jcittelesi (10%), Asprocottus megalops (15%) Abyssocottus pallidus (+), A bergianus (15-20%)	–	–
	M muellen Butschli, 1882	SB	+	+	Hucho tdimen (+), Thymallus arcticus baicalensis (+), Esox lucius (+), Perca fluviatilis (5-40%) Lota lota (23%)	–	–
	M bramae Reuss, 1906	S		+	Rutilus rutilus lacustris (73%), Leuciscus leuciscus baicalensis (10 20%), Leuciscus idus (+)	–	–
	M ellipsoides Thelohan, **1892**	un		+	Carassius auratus gibelio (7-11%)	-	–

Continuation ot list PARASITOFAUNA species

	Species and subspecies	Endemic or not	Open Baikal	Coastal-sor zone & bays	Final hosts	Intermediate hosts	Additional hosts
	M spatulatus Dogiel, 1957	B	+		Paracottus knen (+)	–	–
	M intimus Zaika, 1965	S		+	Rutilus rutilus lacustns (36%)	–	–
	M dispar Thélohan, 1895	S		+	Rutilus rutilus lacustns (3-10%), Leuciscus leuciscus baicalensis (7-42%), L ldus (7-40%)	–	–
	M pseudodispar **Gorbunova, 1936**	S		+	Rutilus rutilus lacustns (6 33%)	–	–
	M carassu Klokačeva, **1914**	S		+	Leuciscus leuciscus baicalensis (40-60%), Carassius auratus gibelio (4-47%)	–	–
Genus	Henneguya Thelohan, 1892						
	H zschokkei (Gurley, 1894)	S	+		Coregonus autumnalis migratonus (3-5%), C lavaretus baicalensis (5-15%)	–	–
	H oviperda (Cohn, 1895)	un		+	Esox lucius (3-6%)	–	–
	H cerebralis Pronin, 1972	SB	+		Thymallus arcticus baicalensis **(1-2%)**	–	–
	H psorospermica Thelohan, **1895**	S		+	Esox lucius (3-6%), Pcrca fluviatihs (3-6%)	–	–
	H lobosa (Cohn, 1895)	S		+	Esox lucius (6-10%)	–	–
Genus	Thelohanellus Kudo, 1933						
	T pyriformis (Thelohan, 1892)	S		+	Cobitis taenia (30-40%)	–	–
	T fuhrmanni (Auerbach, **1909)**	un		+	Rutilus rutilus lacustns (+), Leuciscus leuciscus baicalensis (+)	–	–
Type	Cihophora Doflein, 1901						
Class	Hymenoslomata Delage et Hérouard, 1896						
Family	Tetrahymenidae Corliss, 1952						
Genus	Tetrahymena Furgason, 1940						
	T pyriformis (Ehrenberg, 1830)	un		+	Perca fluviatilis (1-2%)	–	–
Family	Ophryoglenidae Kent, 1882						
Genus	Ichthyophthinus Fouquet, 1876						
	I multifiliis Fouquet, 1876	un		+	Coregonus autumnahs migratonus (+), Thymallus arcticus baicalensis (+)	–	–
Class	Suctoria Claparède et Lachmann, 1858						
Family	Tnchophryidae Butschh, 1889						
Genus	Capnniana Mazzarelli, 1906						
	C piscium (Butschli, 1889) Jankowski, 1973	**un**		+	Thymallus arcticus baicalensis (+), Coregonus autumnalis migratonus (+)	–	–

Continuation of list PARASITOFAUNA species

	Species and subspecies	Endemic or not	Open Baikal	Coastai-scor zone & bays	Final hosts	Intermediate hosts	Additional hosts
Class	Pentncha F Stein, 1859						
Famıly	Epistylididae Kahl, 1933						
Genus	Apiosoma Blanchard, 1885						
	A *campanulatum* (Timofeev, 1962) typica	S		+	Perca fluviatilis (3-35%)	–	–
	A paracotti (Zaika, 1965) (Syn Glossatella paracotti Zaika, 1965)	B	+		Paracottus insularis (+)	–	–
	A mucusani (Zaika, 1965) (Syn Glossatella mucusani Zaika, 1965)	B	+		Paracottus kesslen (+)	–	–
	A baicalense (Zaika, 1965) (Syn Glossatella baicalense Zaika, 1965)	B	+		Paracottus insularis (+)	–	–
	A uschkani (Zaika 1965) (Syn Glossatella uschkani Zaika, 1965)	B	+		Paracottus insularis (+)	–	–
	A kesslen (Zaika, 1965) (Syn Glossatella kesslen Zaika, 1965)	B	+		*Paracottus* kesslen (+)	–	–
	A incertum Pugachev, 1983	SB	+		Thymallus arcticus baicalensis (+), Esox lucius (30-50%), Leuciscus leuciscus baicalensis (30-47%), Phoxinus phoxinus (+), Cobitis taenia (40-66%), Parasilurus asotus (+), Perca fluviatilis (70-94%), Procottus jeittelesi (50-70%), Asprocottus herzensteim (40-61%), A megalops (60-80%), Paracottus kneri (50-60%), P msularrs (100%), P kesslen (70-93%), Batracho cottus baicalensis (60-87%), B nikolskii (+), B uschkani (+), Cottocomephorus grewingki (4-8%), C inermis (1-20%), Abyssocottus godlewskn (+), A pallidus (+), A bergianus (+)	–	–
	A megamicronucleatum (Timofeev, 1962)	SB		+	Perca fluviatilis (6-11%), Lota lota (10-15%)	–	–
Family	Tnchodinidae Claus, 1874						
Genus	Tnchodma Ehrcnberg, 1830						
	T intermedia Lorn, i960	un		+	Esox IUCJUS (+), Rutilus rutilus lacustns (+), Phoxinus phoxinus (87,5%), Perca fluviatilis (+)	–	–
	T nemachili Lorn, 1960	un		+	Leuciscus leuciscus baicalensis	–	–

Continuation **of list** PARAS1TOFAUNA **species**

	Species and subspecies	Endemic or not	Open Baikal	Coastal-sor zone & bays	Final hosts	Intermediate hosts	Additional hosts
					(+), L ldus (+), Rutilus rutilus lacustns (+), Phoxinus phoxmus (56,2%)		
	T mira Kaschkovsky, 1974	un		+	Rutilus rutilus lacustns (+), Phoxinus phoxinus (81,2%)	–	–
	T nigra Lom, 1960	un	+	+	Thymallus arcticus baicalensis (40%), Coregonus autumnahs migratonus (+), Coregonus !avaretus baicalensis (+), Lcuciscus leuciscus baicalensis (+), Phoxinus phoxinus (+), fcsox lucius (6-50%), Perca fluviatilis (1-4%)	–	–
	T esocis Lom, 1960	un		+	Perca nuviatihs (10-40%)	–	–
	T domerguei domerguei (Wallengren, 1897)	SB		+	Rutilus rutilus lacustns (5-27%), Leuciscus leuciscus baicalensis *(20 53%),* Phoxinus phoxinus (+), Brachymystax lenok (+)	–	–
	T tcnuiformis G Stein, 1979	B	+		Paracottus knen (68,4%) P kessleri (3,7%), Batrachocottus baicalensis (43,7%)	–	–
	T baicalensis Dogiel, 1957	B	+		Asprocottus hcrzensteini (4%), A megalops (23%), Procottus jeitleJcsi (70%), Cottocomephorus inermis (47%), Paracottus knen (86%), P kessleri (47%), P insulans (100%), Batrachocottus uschkani (+), Cottocomephorus grewingki (100%), Batrachocottus baicalensis (18,7%)	–	–
	T *cottocomephon G Stem,* J 979	B	+		Cottocomephorus grewingki (87,5%)	–	–
Genus	Paratnchodina Lom, 1963						
	P incisa **(Lorn, 1959)**	un	+	+	Phoxinus phoxinus (81,3%), Leu uscus lcuciscus baicalensis (+), Leuciscus idus (+), Thymallus arcticus baicalensis(53,3%), Rutilus rutilus lacustns(21,1 *%),* Cottocomephorus grewingki (2,5%), Paracottus kessleri (2%), Procottus jeittelesi (+),	–	–

Continuation of list PARASITOFAUNA species

	Species and subspecies	Endemic or not	Open Baikal	Coastal-sor zone & bays	Final hosts	Intermediate hosts	Additional hosts
					Perca fluviati/is (+)		
Genus	Tnpartiella Lorn, 1959						
	T copiosa {Lorn, 1959)	un		+	Leuciscus leuciscus baicalensis (+), Leuciscus ldus (+)	–	–
Genus	Trichodinella Šramek-Hušek, 1953						
	T epizootica (Raabe, 1950)	S		+	Esox lucius (20-60%), Leuciscus baicalensis (+), Rutilus rutilus lacustns (+), Cobitis taenia (+), Perca fluviatihs (50-75%)	–	–
	T percarum (Dogiel, 1940)	un		+	Esox lucius (+), Rutilus rutilus lacustns, (+), Leuciscus leuciscus baicalensis (+), Lota lota (+)	–	–
	Protozoa tncertae sedis						
Genus	Dermocystidium Peres, 1907						
	D percae Reichenbach-Klinke, 1950	un		+	Perca fluviatihs (3-12%)	–	–
	D lenoki Pronin, 1977	un		+	Brachymystax lenok (+)	–	–
Type	Coelenterata						
Class	)						
Famıly	’						
Genus	Polypodium						
	P hydnforme Ussov, 1885	un	+	+	Acipenser baen (16,6%)	–	–
Typc	Plathelminthes						
Class	Monogenea (Van Beneden, 1858) Bychowsky, 1937						
Famıly	Dactylogyndae Bychowsky, 1933						
Genus	Dactylogyrus Diesmg, 1850						
	D colonus Bogolepova, 1950	B	+		Cottocomephorus grewingki (5-8%), Abyssocottus godlewski (+), A pallidus (+), A bergianus (100%), Asprocottus megalops (4-8%)	–	–
	D mtermedius Wegener, 1910	un		+	Carassius auratus gibeho (10-50%)	–	–
	D nanus Dogiel et Bychowsky, 1934	un		+	Rutilus rutilus tacustns (20-40%)	–	–
	D vistulae Prost, 1957	un		+	Rutilus rutilus lacustns (50 70%)	–	–
	D crucifer Wagener, 1857	S		+	Rutilus rutilus lacustns (40 73%)	–	–
	D alatus Linstow, 1878 f major Sidorov, 1956	un		+	Leuciscus leuciscus baicalensis (+)	–	–
	D boreahs Nybelin, 1936	S		+	Phoxinus phoxinus (+)	–	–
	D ramulosus Malewitzkaja, 1941	S		+	Leuciscus leuciscus baicalensis (8-13%), Rutilus rutilus lacustns (+), Leuciscus idus (+)	–	–

Continuation of list PARASITOFAUNA species

	Species and subspecies	Endemic or not	Open Baikal	Coastal-sor zone & bays	Final hosts	Intermediate hosts	Additional hosts
	D sphyrna Linstow, 1878	S		+	Rutilus rutilus lacustns (5-10%)	–	–
	D yinwenyingae Gussev, 1962	un		+	Rutilus rutilus lacustns (12-30%)	–	–
	D cordus Nybelin, 1937	S		+	Lcuciscus leuciscus baicalensis (3-6%), Leuciscus ldus (+)	–	–
	D tuba Lmstow, 1878	S		+	Leuciscus leuciscus baicalensis (20-35%), Leuciscus ldus (+)	–	–
Genus	Pellucidhaptor Price et Mizelle, 1964						
	P merus (Zaika, 1961)	S		+	Phoxinus phoxinus (+)	–	–
Family	Ancyrocephalidae Bychowsky, 1937						
Genus	Ancyrocephalus Creplin, 1839						
	A percae Ergens, 1966	un		+	Perca fluviatilis (5-15%)	–	–
Family	Tetraonchidae Bychowsky, 1937						
Genus	Tetraonchus Diesing, 1858						
	T monenteron (Wagener, 1857)	S		+	Esox lucius (60-75%)	–	–
	T borealis (Olsson, 1893) *f* typica	SB	+		Thymallus arcticus baicalensis (60-100%)	–	–
	T roytmam Strelkow, 1963	S	+		Hucho taimen (50-60%)	–	–
	T lenoki Achmerow, 1952	SB	+		Brachymystax lenok (30-50%)	–	–
Family	Gyrodactylidae Van Beneden et Hesse, 1863						
Genus	Gyrodactylus Nordmann, 1832						
	G lotae Gussev, 1953	un		+	Lota lota (7-10%)	–	–
	G bychowskianus Bogolepova, 1950	B	+		Cottocomephorus grewinglu (25-33%), C inermis (30-40%)		
	G comephon Bogolepova, 1950	B	+		Comephoms dybowskii (13%)	–	–
	G macronychus Malmberg, 1957	S		+	Phoxinus phoxinus (+)	–	–
	G thymalh Žitňan, 1960	un	+	+	Thymallus arcticus baicalensis (5-10%)	–	–
	G baikalensis Bogolepova, 1950	B	+		Paracottus knen (60-80%), P kesslen (40-80%), P insulans (100%) Batrachocottus mkolskn (3-7%), B multiradiatus (+), Asprocottus hcrzensteim (5-8%), A megalops (4-8%), Abissocottus godlewskn (+)	–	–
	G anudanni Ergens et Dulmaa, 1968	un		+	Cobitis taenia (+)	–	–
	G macracantus Hukuda, 1940	S		+	Cobitis taenia (20 33%)	–	–
	G lucn Kulakowskaja, 1951	S		+	Esox lucius (10-20%), Perca fluviatilis (3-6%)	–	–
Family	Diclybothnidae Bychowsky et Gussev, 1950						

Continuation of list PARASITOFAUNA species

	Species and subspecies	Endemic *or not*	Open Baikal	Coastal sor zone & bays	Final hosts	Intermediate hosts	Additional hosts
Genus	Diclybothnum Leuckart, 1835						
	D armatum Leuckart, 1835	S	+	+	Acipenser baen (50-75%)	–	–
Family	Diplozoidae Palombi, 1949						
Genus	Paradiplozoon Achmerov, 1974						
	P megan (Bychowsky et Nagibina, 1959)	un		+	Leuciscus idus (3-6%)	–	–
	P homoion homoion (Bychowsky et Nagibina, 1959)	S		+	Rutilus rutilus lacustns (12-24%), Leuciscus leuciscus baicalensis (7-10%)	–	–
Class	Amphilinida Dubinma, 1974						
Family	Amphilimdae *Ciaus,* 1879						
Genus	Amphilina Wagner, 1858						
	A foliacea (Rudolphi, 1819)	S	+	+	Acipenser baen (50%)	Gammandae	–
Class	Cestoda Rudolphi, 1808						
Family	Caryophyllaeidae Leuckart, 1878						
Genus	Caryophyllaeus Muller, 1787						
	C laticeps (Pallas, 1781)	un		+	Rutilus rutilus lacustns (2-4%), Leuciscus leuciscus baicalensis (6-24%)	Oligochaeta	–
Family	Lytocestidae Hunter, 1927						
Genus	Caryophyllaeides Nybehn, 1922						
	C fenmca (Schneider, 1902)	S		+	Leuciscus leuciscus baicalensis (+), L idus (+), Rutilus rutilus lacustns (10%)	Oligochaeta	–
Family	Tnaenophondae Loennberg, 1889						
Genus	Tnaenopboms Rudolphi, 1793						
	T nodulosus (Pallas, 1781)	SB	+	+	Esox lucius (60-90%)	Cyclopoida and Calanoida Cyclops vicinus (0,08-0,12%)	Perca fluviatilis (10-80%), Thymallus arcticus baicalensis (5 20), Leuciscus leuciscus baicalensis (2-6%), Lota lota (15-40%), Paracottus kesslen (3-7%), Batrachocottus baicalensis (40 56%), B nikolskn (5-13%), Cottocomephorus grewingki (15-33%), C inermis (13%), Procottus jeittelesi (10%), Comephorus baicalensis (10-20%),

Continuation of list PARASITOFAUNA **species**

	Species *and* subspecies	Endemic *or not*	Open Baikal	Coastal-sor *zone* & bays	*Final hosts*	Intermediate hosts	Additional hosts
	T. *crassus* ForeJ, 1868	S	+	+	*Esox lucius* (10-20%)	Cyclopoida and Calanoida	C. dybowskii (7%) *Coregonus* lavaretus baicalensis (5-44%), Coregonus autumnahs migratonus (4-33%), Thymallus arcticus baicalensis (+)
Family	Amphicotylidae Anola. 1899						
Genus	Eubothnum Nybelin, 1922						
	E. crassum (Bloch, 1779)	**S**	+	+	Hucho taimen (+), Brachymystax lenok (20-70%), Coregonus lavaretus baicalensis (15-30%), Coregonus autumnahs migratonus (13-16%)	**Cyclopoida**	–
Family	Diphyllobothriidae Luhe, 1910						
Genus	Diphyllobothnum Cobbold, 1858						
	D latum (Linnaeus, 1758)	un		+	Homo sapiens	Cyclopoida	Esox lucius (5-33%), Perca fluviatihs (1-2%)
	D dendnticum (Nitzsch, 1824) (Syn. D minus Cholodkovsky, 1916; D stnctum Talysin, 1932)	un	+	+	Larus canus (17%o), L argentatus (41,5%), L ndibundus (17%), Podiceps cnstatus (11,1%), P. auntus (14%), Gavia stellata (13%), O arctica (100%), Mergus serrator (33%), M. merganser (25%), Corvus corone (20%), Homo sapiens (1-10%), Phoca sibinca (+)	Cyclops kolensis (+), C. strenuus (+), Diaptomus incongruens (+), Eucyclops serrulatus (+), Mesocyclops leuckarti (+)	Hucho taimen (+), Brachymystax lenok (+), Coregonus autumnahs migratonus (70-100%), Coregonus lavaretus baicalensis (30-60%), Thymallus arcticus baicalensis (42-50 %), Batrachocottus baicalensis (+), B uschkani (+), B nikolskn (+), Cottocomephorus *mermis* (+), Comephorus baicalensis (+)
	D. ditremum (Creplin, 1825) (Syn. D. osmen Linstow, 1878)	**un**	+	+	Gavia stellata (10%), **Mergus** merganser (8%)	**Cyclopoida**	Coregonus autumnahs migratonus (6-13%o), Thymallus arcticus baicalensis (10-12%)
Family	Liguhdae Claus, 1885						
Genus	Ligula Bloch, 1782						

Continuation of list PARASITOFAUNA species

	Species and subspecies	Endemic or not	Open Baikal	Coastal-sor zone & *buys*	Final hosts	Intermediate hosts	Additional *hosts*
	L intestinalis (Linnaeus, 1758)	S	+	+	Larus argentatus (14,2%), L canus, (9%), L. ndibundus (21%), Mergus serrator (30-50%), Podiceps enstatus (54%), P. auntus (10%), Gavia stcllata *(30-50%)*	Cyclopoida	Rutilus rutilus lacustm (10%), Leuciscus (euciscus baicalensis (10-27%), Paracottus kesslen (+), P. knen (+)
	L. columbi Zeder, 1803	un		+	Podiceps enstatus (18%), Mergus serrator (+), Larus canus (+), Gavia stellata (+)	Cyclopoida	Cobitis taenia (+)
Genus	Digramma Cholodkovsky, 1914						
	D interrupta (Rudolphi, 1810)	un		+	Podiceps enstatus (1-4%)	Cyclopoida	Carassius auratus gibelio (+)
Genus	Schistoccphalus Creplm, 1829						
	Sch ncmachili Dubimna, 1959	un	+		Podiceps enstatus (1-4%), Mergus merganser (10-25%)	Cyclopoida	Paracottus kesslen (+), P. knen (+)
	Sch. solidus (Miiller, 1776)	S	+		Larus canus (3%), L. ndibundus (7%), Gavia stellata (14%), Podiceps enstatus (1-10%), Phoca sibinca (+)	Cyclopoida	Paracottus kesslen (2-7%)
Family	Cyathocephalidae Nybelin, 1922						
Genus	Cyathocephalus Kessler, 1868						
	C. truncatus (Pallas, 1781)	S	+		Coregonus lavaretus baicalensis (+), Coregonus autumnalis migratonus (1-6%), Brachymystax. lcnok (+), Thymallus arcticus baicalensis (50-80%)	Gmelmoides fascials (4,2%), Pallasea cancellus (0,02%), P. caneelloides (1%), Poekilogammarus pictus (1,1%). Eulimnogammarus fuscus *(0,03%)*	–
Family	Proteocephalidae La Rue, 1911						
Genus	Proteocephalus Weinland, 1858						
	P. exiguus La Rue, 1911	SB	+		Coregonus autumnalis migratonus (87-100%), Coregonus lavaretus baicalensis (75-90%), Abissocottus pallidus (+), A bergianus (50-80%), Asprocottus herzensteini (4%), A. megalops (+), Batrachocottus baicalensis (60-87%), B. uschkani (+), B. mkols-	Epischura baicalensis (0,02%)	–

Continuation of list PARASITOFAUNA species

	Species and subspecies	Endemic or not	Open Baikal	Coastal-sor zone & bays	Final hosts	Intermediate hosts	Additional hosts
					kn (40-67%), B multiradiatus (+), Cottocomcphorus grewingki (100%), C inermis (100%), Comephorus baicalensis (10-20%), C dybowskn (13%), Procottus jeittelesi (10%), Paracottus kesslen (40-67%)		
	P percae (Muller, 1780)	**S**		+	Perca fluviatilis (5-82%)	Cyclopoida	–
	P thymalli (Annenkowa-Chlopina, 1923)	SB	+	+	Thymallus arcticus baicalensis (25-100%)	Epischura baicalensis (+), Cyclops kolensis (+), C vicmus (+)	–
	P torulosus (Batsch, 1786)	un	–	+	Rutilus rutilus lacustns (4-6%), Leuciscus leuciscus baicalensis (10-30%), Leuciscus ldus (35 50%)	Cyclopoida	–
Family	Dilepididac Fuhrmann, 1912						
Genus	Latenporus Fuhrmann, 1907						
	L skrjabini Spassky, 1945	un	-	+	Aythya ferula (8%), Anas platyrhynchos (3%)	Crustacea	–
	L teres (Krabbe, 1869) Fuhrmann, 1907	un	-	+	Larus argentatus (3-9%), L ndibundus (2-4%) Chlidonias Icucoptera (2%), Sterna hirundo (8%), Anas crecca (4%) Aythya fuligula (8%)	Crustacea	–
	L clerci (Johnston, 1912) Fuhrmann, 1932	**un**	–	+	Larus argentatus (2-21%), L canus (1-23%) L ndibundus (18-47%), Sterna hirundo (8%), Chlidonias leucoptera (6%), Podiceps cribtatus (+), P auntus (+), Gavia stcllata (+)	Crustacea	–
Genus	Pancterotaenia Fuhrmann, 1932						
	P porosa (Rudolphi, 1810)	**un**	–	+	Larus argentatus (2-28%) L canus (11-15%), L ndibundus (11-13%), Sterna hirundo (2 15%), Chlidonias leucoptera (4%), Hydroprogne tschegrava (+)	Crustacea	–
	P sternina (Krabbe 1869)	**un**	–	+	Larus argentatus (3%) L canus (6%) Sterna hirundo (23%), Larus ndibundus (30%)	Crustacea	–
Genus	Anomotaenia Cohn, 1900						
	A micracantha (Krabbe 1869)	**un**	–	+	L canus (2 9% %), Larus argen-	Crustacea	–

Continuation *of* list PARASJTOFAUNA species

	Species and subspecies	Fndemic or not	Open Baikal	Coastal-sor zone & bays	Final hosts	intermediate hosts	Additional hosts
					tatus (3%), Chhdonias leucoptera (2%), Sterna hirundo (2%)		
Genus	Paradilepis Hsü, 1935						
	P scolecina (Rudolphi, 1819)	un	–	+	Phalacrocorax carbo (+)	Crustacea	–
Genus	Gryporbynchus Nordmann, 1832						
	G pusillus Nordmann, 1832	un	–	+	Ardea cinerea	Crustacea	–
Genus	Platyscolex Spasskaja, 1962						
	Platyscolex ciliata (Fuhrmann, 1913) Spasskaja, 1962	un	–	+	Larus ridibundus (22%), L canus (7%), Anas strepera (8%), A platyrhynchos (0,5%), Aythya fuligula (4%)	Crustacea (Simosephalus elizabetae, Eucyclops serrulatus, Cyclops strenuus)	-
Family	Hymenolepididae (Anola, 1899)						
Genus	Aploparaksis Clerc, 1903						
	A lanna (Fuhrmann, 1921)	un	–	+	Larus argentatus (3-5%), L n-dibundus (5%), L canus (3-5%)	Oligochaeta	–
	A furcigera (Rudolphi, 1819)	un	–	+	Anas strepera (39%), A platyrhynchos (7%), A crecca (+), Aythya ferina (4%)	Oligochaeta	–
Genus	Dicranotaenia Railliet, 1892						
	D coronula (Dujardin, 1845)	un	–	+	Anas strepera (3%), A platyrhynchos (+), A crecca (4%), Aythya fuhgula (17%)	Oligochaeta	–
Genus	Lancanthus Spassky, 1962						
	L lateralis (Mayhew, 1925) Spassky, 1962	un	–	+	Larus argentatus (3%)	Crustacea	–
Genus	Confluana Ablasov, 1953						
	C furcifera (Krabbe, 1969)	un	-	+	Podiceps cnstatus (18%)	Crustacea	–
	C podicipina (Szymanski, 1905)	un	-	+	Podiceps auritus (+)	Crustacea	–
Genus	Wardium Mayhew, 1925						
	W cirrosa (Krabbe, 1869)	un	-	+	Larus canus (7%), L ridibundus (7%)	Crustacea	–
	W fusa (Krabbe, 1869)	un	–	+	Larus argentatus (12%), L ndibundus (2%)	Crustacea	–
Genus	Tatna Kowalewski, 1904						
	T biremis Kowalewski, 1904	un	–	+	Podiceps cnstatus (4%)	Larvae *of insecta*	~
Genus	Retinometra Spassky, 1955						
	R longicirrosa (Fuhrmann, 1906)	un	–	+	Anas platyrhynchos (+)	Crustacea	–
Genus	Microsomacanthus Lopes-Neyra, 1942	un	–	+	Anas strepera (13%), A platyrhynchos (8%), A crecca (6%), Aythya fuligula (2%)	Crustacea	–
	M abortiva (Linstow, 1904) Lopez-Neyra, 1942						
	M fausti (Tseng-Shen, 1932)	un	–	+	Mergus albellus (+)	Crustacea	–

Continuation of list PARASITOFAUNA **species**

	Species and subspecies	Endemic or not	Open Baikal	Coastal-sor zone & bays	Final hosts	Intermediate hosts	Additional hosts
	Lopc?-Neyra, 1942						
	M parvula (Kowalcwski, 1904) Spassky et Spasskaja, 1954	un	–	+	Anas platyrhynchos (3%), Authya fuligula (12%)	Crustacea, Hirudinea	–
	M compressa (Linton, 1892)	un	–	+	Anas platyrhynchos (5%), A strepera (10%), A. crecca (6%)	Crustacea, Hirudinea	–
	M. paramicrosoma (Gasowska, **1932)**	un	–	+	Anas platyrhynchos (+), Mergus albellus (+)	Crustacea	–
Genus	Myxolepis Spassky, 1959						
	M. collans (Batsch, 1786) Spassky, **1959**	un	–	+	Anas platyrhynchos (+)	Crustacea	–
Genus	Sobolevicanthus Spassky et Spasskaja, 1954						
	S fragilis (Krabbe, 1869) Spassky et Spasskaja, 1954	un	–	+	Bucephala clangula (+)	Crustacea	–
	S gracilis (Lcder, 1803) Spassky et Spasskaja, 1954	Un	–	+	Bucephala clangula (9%), Anas crecca (9%), A. strepera (8%), A platyrhynchos (+), Aythya fuligula (9%), A. fenna (+)	Crustacea (Eudiaptomus graciloidcs)	–
	S octacantha (Krabbe, 1869) Spassky et Spasskaja, 1954	un	–	+	Anas crecca (2%)	Crustacea	–
	S. crabbeella (Hughe;., 1940) Ryjikov, 1956	un	–	+	Anas crecca (2%)	Crustacea	–
Genus	Cloacotaenia Wolffhügel, 1938						
	C. megalops (Nitzsch in Creplin, 1829) Wolffhugel, 1938	un	–	+	Bucephala clangula (18%), Anas strepera (5%), A. crecca (4%), A. penelope (+), A platyrhynchos (+), Aythya ferina (4%), A fuligula (4%)	Crustacea Cladocera (Eurycercus lamcllatus), Cyclopoida (Acanthocyclops vindis)	–
Genus	Echinocotyle Blanchard, 1891						
	E. ryjikovi Jogis, 1963	un	–	+	Aythya fuligula (16%), Anas crecca (2%)	Crustacea	–
	E. rosseten Blanchard, 1891	un	–	+	Aythya fuligula (12%), Anas crecca (4%)	Crustacea	–
Genus	Diploposthe Jacobi, 1896						
	D. laevis (Bloch, 1782)	un	–	+	Aythya fuligula (16%), A fenna (44%)	Crustacea	–
Genus	Diorchis Clerc, 1903						
	D ransomi Schultz, 1940	un	–	+	Anas strepera (8%), A platyrhynchos (6%), A crecca (2%), Aythya ferina (30%), A fuligula (12%), Fuhca atra (+)	Crustacea Cyclopoida (Macrocyclops albidus), Cladocera (Eurycercus iamellatus	–
	D elisae (Skrjabin, 1914)	un	–	+	Anas strepera (3%), A platyr-	Crustacea Cala-	–

Continuation of list PARASITOFAUNA species

	Species and subspecies	Endemic or not	Open Baikal	Coastal-sor zone & bays	Final hosts	Intermediate hosts	Additional hosts
	Spassky et Frese, 1961				hynchos (5%), Aythya fuhgula (5%)	noida (Eudiaptomus graciloides)	
	D bulbodes Mayhew, 1929	un	–	+	Anas clypeata (8%), A platyrhynchos (7%), Aythya fenna (2%), A fuhgula (4%)	Crustacea	–
	D lintoni (Lopez-Neyra, 1932)	un	–	+	Anas platyrhynchos (6%), Aythya fenna (2%)	Crustacea	—
	D stefanskn Czaphnski, 1956	un	–	+	Anas platyrhynchos (3%), Aythya fuhgula (4%), A fenna (4%), Fuhca atra (3%)	Crustacea	–
	D sobolevi Spasskaja, 1950	un	–	+	Aythya fenna (6%), Anas platyrhyncnos (4%), A strepera (3%), Fuhca arta (3%)	Crustacea	–
Genus	Gastrotacnia Wolffhugel, 1938						
	C dogieh (Gynezinskaja, 1944) Spassky, 1958	un	–	+	Anas clypeata (8%), A crecca (4 Aythya fenna (10%), A fuhgula (4%)	Crustacea	–
Genus	Fimbnana Frohlich, 1802						
	F fasciolans (Pallas, 1781)	un	–	+	Anas strepera (39%), A platyrhynchos (7%), A crecca (4%), A poecilorhyncha (+), Authya fenna (18%), A fuhgula (4%), Tadorna ferruginea (+)	Crustacea	–
Genus	Confluana Ablosov, 1953						
	C podicipina (Szymanski, 1905)	un	–	+	Podiceps auritus (+)	–	–
	C furcifera (Krabbe, 1869)	un	–	+	Podiceps cnstatus (+), P auritus (+)	–	–
Family	Tetrabothrndae Linton, 1891						
Genus	Tetrabothnus Rudolphi, 1819						
	T macrocephalus (Rudolphi, 1810)	un	–	+	Podiceps auritus (+), Gavia stellata (+)	–	–
Class	Trematoda Rudolphi, 1808						
Family	Bucephahdae Poche, 1907						
Genus	Rhipidocotyle Diesing, 1858						
	R campanula (Dujardin, 1845)	S		+	Esox Jucius (+)	Anodonta sedakovi (16%)	Perca fluvjatili^ (3-7%)
Family	Bunodendae Nicoll, *1914*						
Genus	Crepidostomum Braun, 1900						
	C fanonis (Mueller, 1780)	SB	+	+	Coregonus autumnahs migratonus (+) Thymalius arcticus baicalensis (9-66%), Paracottus kne	Mollusca	Gmehnoides fascials (0,2-23%), Micruropus possolskn

Continuation of list PARASITOFAUNA species

	Species and subspecies	Endemic or not	Open Baikal	Coastal-sor zone & bays	Final hosts	Intermediate hosts	Additional hosts
					n (10-27%), P kesslen (20-67%), P insularis (50-84%), Batrachocottus baicalensis (56%), Cottocomephorus grewingki (2-8%), Comephorus dybowskn (2-7%)		(0,2-18%)
	C aunculatum (Wedl, 1857)	un		+	Acipenser baen (+)	Mollusca	~
Genus	Bunodera Railliet, 1896						
	B luciopercae (Mueller, 1776)	S	+	+	Perca fluviatilis (50-66%)	Mollusca	Cladocera
Family	Gorgodendae Looss, 1899						
Genus	Phyllodistomum Braun, 1899						
	Ph folium (Offers, 1926)	un		+	Esox iucius (3-6%), Leuciscus leuciscus baicalensis (+), Carassius auratus gibelio (+), Nemachlilus barbatulus torn (+), Paracottus kesslen (+)	Sphaenum baicalense (3,3%)	–
	Ph conostomum (Olssen, 1876)	S	+	+	Coregonus autumnalis migrdtonus (40-60%), Coregonus lavaretus baicalensis (22-80%), Thymallus arcticus baicalensis (+), Rutilus rutilus lacustm (+), Leuciscus leuciscus baicalensis (+)	Sphaenum baicalense (0,4%)	–
	Ph elongatum Nybelin, 1926	un		+	Leuciscus leuciscus baicalensis (2-57%)	Mollusca	–
Family	Azygudae Odhner, 1911						
Genus	Azygia Looss, 1899						
	A robusta Odhner, 1911	S		+	Hucho taimen (+), Lota lota (+)	Mollusca	–
Family	Allocreadndae Looss, 1902						
Genus	Baicalotrema Layman, 1951						
	B polymorphum (Layman, 1933)	un	+		Abyssocottus godlewskn (+), A pallidus (+), A bergianu;. (10-50%), Asprocottus herzenstcini (1 4%), Batrachocottus baicalensis, (1-6%), B nikolskn (2-7%), Paracottus knen (+), Procottus jeittelesi (5-10%)	–	–
Genus	Allocreadium Looss, 1900						
	A isoporum (Looss, 1894)	S		+	Rutilus rutilus lacustns (5-10%), Leuciscus leuciscus baicalensis (+), Leuciscus ldus (+)	–	–

Continuation of list PARASITOFAUNA species

	Species and subspecies	Endemic or not	Open Baikal	Coastal-sor zone & bays	Final hosts,	Intermediate hosts	Additional hosts
Family	Diplostomidae Poiner, 1886						
Genus	Diplostomum Nordmann, 1832						
	D. commutatum (Diesing, 1850)	S	+	+	Larus canus (5-27%), L **ndibundus** (2,2%), Stema hirundo (7,7%)	Lymnea pereger (2,6%), L aunculana (1,3%)	Thymallus arcticus baicalensis (2,5%o), Leuciscus leuciscus baicalensis (30-72 %), Leuciscus idus (12%), Rutilus rutilus lacustns (5-11%), Perca fluviatihs (2-8%), Lota lota 20-35%)
	D. helveticum Dubois, 1929	S	+	+	Larus canus (9%), L. **ndibundus** (4,5%), L argentatus (20,5%), Sterna hirundo (5-15%)	Lymnea pereger (2,6%)	Coregonus autumnalis migratonus (3-7%), Thymallus arcticus baicalensis (10-20 %), Rutilus rutilus lacustns (5-10%), Leuciscus idus (20-40%)
	D. paracaudum lies, 1959	un	+	+	Larus canus (13-22%), L ndibundus (2-5%), L argentatus (10-21%), Sterna hirundo (6-15%)	Lymnaea aunculana (+), L. pereger (+)	Coregonus autumnalis migratonus (2-10%), Thymallus arcticus baicalensis (15-35 %), Leuciscus leuciscus baicalensis (20-57%), L idus (50%), Rutilus rutilus lacustns (35-53%), Perca fluviatihs (2-7%), Lota Iota (30-50%)
	D. spathaceum (Rudolphi, 1819)	S	+	+	Larus canus (27-30%), L. ndibundus (lQ-20%>), L. argentatus (20-30%), Sterna **hirundo** (13-23%)	**Mollusca**	Coregonus lavaretus baicalensis (+), Thymallus arcticus baicalensis (5-10%), Rutilus rutilus lacustris (60-80%), Leuciscus leuciscus baicalensis (30-50 %), Leuciscus idus (20-38%), Carassi-

Continuation of list PARASITOFAUNA species

	Species and subspecies	Endemic or not	Open Baikal	CoastaUsor zone & bays	Final hosts	Intermediate hosts	Additional hosts
							us auratus gibelio (50-70%), Parasilurus asotus (10-16 %), Perca fluviatihs (3 10%), Paracottus kesslen (50-70%), Lota lota (2-8%), Acipenser baen (16,6%)
	D mergi Dubois, 1932	un	+	+	Mergus merganser (50%), M albellus (+)	Mollusca	Thymalius arcticus baicalensis (2 8%), Rutilus rutilus lacustns (10-15%)
	D volvens Nordmann, 1832	un		+	Larus canus (3,7%), L argentatus (5,2%)	*Lymnea* auriculana (+)	Rutilus rutilus lacustris (70-100%), Leuciscus ldus (14 %), Perca fluviatilis (30-72%), Lota lota (20-66%)
	D gobiorum Schigin, 1965	un		+	–	Mollusca	Carassius auratus gibelio (3,8%)
Genus	Tylodelphys Diesing, 1850						
	T clavata (Nordmann, 1832)	S		+	Podiceps enstatus (14,8%)	Lymnaed auricularia (+), L pereger (+), L ovata (+)	Esox lucius (1-2%), Rutilus rutilus lacustris (3-7%), Parasilurus asotus (+), Perca fluviatilis (6-12%)
Family	*Strigeidac* RjjJJjeJ, J 9] 9 Szidat, 1925						
Genus	Ichtycotylurus Szidat, 1925						
	I vanegatus (Creplin, 1825)	un	+	+	Larus argentatus (+), L canus (+), L ridibundus {+), Sterna hirundo (+), Podiceps enstatus (+)	Valvata piscinalis (+)	Esox lucius (+), Leuciscus leuciscus baicalensis (+), Leuciscus idus (+), Cobitis taenia (+), Parasilurus asotus (+), Perca fluviatihs (40-100%), Paracottus kesslen (+), Lota lota (+)

Continuation of list PARASITOFAUNA species

	Species and subspecies	Endemic or not	Open Baikal	Coastal-sor zone & bays	Final hosts	Intermediate hosts	Additional hosts
	1 pileatus (Rudolphi, 1802)	S		+	Larus argentatus (3-17%), L canus (13%), L ridibundus (4,4%)	Mollust-a	Esox lucius (+), Rutilus rutilus lacustns (2-12%), Leuciscus leuciscus baicalensis (+), Parasi/urus asotus *(+),* Pcrca fluviatihs (20-60%), Lota lota (+>
	I erraticus (Rudolphi, 1809)	**un**	+	+	**Podiceps** enstatus (3,7%)	Mollusca	Coregonus autumnalis migratonus (1-3%) Coregonus lavdretus baicalensis (+), Brachymystax lenok <+)
	1 echinata Diesing 1858	un	+	+	Leuuscus idus (+), Esox lucius (+)	Mollusca	–
Genus	Apatemon Szidat, 1928						
	A annuligerum (Nordmann, 1832)	un		+	Anas platyrhyiichos (5%), A crccca (13%) A strepcra (10,5%), A querquedula (+), Aythya fuliguld (25%), A fennd (20,4%), Fulica atra *(3,6%), Mcrgus* dlbellus (+), Bucephald clangula <+)	Anisus stroemi (0,1%)	Perca fluviatihs (30-90%), Esox lucius (+)
Famıly	Echinostomatidae Dietz, 1909						
Genus	Echinostoma Rudolphi, 1809						
	E revolutum (Frohlich, 1802) Dietz, 1902	**un**	–	+	Larus argentatus (1-28%), L ridibundus (32%), L canus (16%), Chhdonids leucoptera (4%), Sterna hirundo (2%), Podiceps tnstatus (4%), Anas plathyrynchos (5%), A crecca (4%), A strepera (+), A poecilorhynchd <+), Aythya fuliguld (10%), A fenna (8%)	Gastropoda (Anisus stoemi, Lymnaea stdgnalis)	–
	F turkestdmea Kurova 1927	un	–	+	Aythya fenna (+)	Gastropoda	–
	E miyagawai Jschu, 1932	un	–	+	Anas acuta (+)		
	E paraulurn Dietz, 1909	un	–	+	Larus ridibundus (7%), L canus (5%), Podiceps enstatus (3%), *P auntus* (+), *Aythya fuhgula*	Gastropoda	–

Continuation of list PARASITOFAUNA species

	Species and subspecies	Endemic or not	Open Baikal	Coastal-sor zone & bays	Final hosts	Intermediate hosts	Additional hosts
					(4%), Anas platyrhynchos (3%), A strepera (2%)		
Genus	Echinoparyphium Dietz, 1909						
	Ech bacillus (Diesing, 1850)	un	–	+	Anas platyrhynchos (3%), A penclope (+), A qucrquedula (+), Aythya fenna (+)	Gastropoda	–
	Ech clerci Skrjabin, 1915	un	–	+	Larus ridibundus (16%), L canus (7%), Bucephala clangula (9%), Aythya fenna (8%), Larus argentatus (0,5%), Chhdonias leucoptera (2%), Anas acuta (4%), A strepera (3%), Aythya fuligula (4%)	Gastropoda	–
	Ech. recurvatum (Linstow, 1873)	un	–	+	Anas clypcata (17%), A crccca (7%), Bucephala clangula (1-9%), Aythya fenna (8%), Larus argentatus (1-2%), L ridibundus *(10%), L canus (2-5%),* CWidnnias leucoptera (5%), Podiceps cnstatus (4%)	Gastropoda (Anisus stroemi, Sphaerum corneum)	–
	Ech aconiatum Dietz, 1909	un	–	+	Larus ridibundus (5%), Anas crecca (2%), A strepera (3%), Aythya fuligula (4%)	Gastropoda	–
	Ech macrovitellatus Oschmann, 1947	un	–	+	Phalacrocorax carbo (+)	Gastropoda	–
Genus	Petasiger Dietz, 1909						
	P neocomense {Fuhrmann, 1927)	un	-	+	Podiceps cnstatus (4%)	Gastropoda	–
	P spasskyi Oschmann, 1947	un	-	+	Ardca cinerea (+)	Gastropoda	–
	P megacanha (Kotlan, 1922)	un	-	+	Podiceps cnstatus (33%)	Gastropoda	–
	P skrjabini Baschkirova, f?4f	un	-	-i-	Podiceps crrsrarus (•+}, Ardea cinerea (+)	*Gastropoda*	–
Genus	Hypodaereum Dietz, 1909						
	H. conoideum (Bloch, 1782) Dietz, **1909**	un	–	+	Aythya fenna (24%), A fuligula (4%), Bucephala clangula (9%), Anas crecca (7%), A. strepera (5%), A platyrhynchos (5%), Larus canus (i%), L. ridibundus (0,6%), L argentatus (0,4%)	Gastropoda	–
	H gncdini Baschkirova, **1941**	un	–	+	Aythya fenna (2%)	Gastropoda	–
Genus	Echinochasmus Dietz, 1909						
	Ech coaxatus Dietz, 1909	un	–	+	Podiceps cnstatus (+)	Gastropoda	–

Continuation of list PARASITOFAUNA species

	Species and subspecies	Endemic or not	Open Baikal	Coastal-sor zone & bays	Final hosts	Intermediate hosts	Additional hosts
	Ech skrjabini Mathevossian et Krotov, 1949	*un*	–	+	Gavia stellata (+)	Gastropoda	–
	Ech spmulosus (Rudolphi. 1809)	un	–	+	Podiceps enstatus (+)	Gastropoda	–
Family	CyclocoeJidae Kossack, 19]]						
Genus	Cyclocoelum Brandes, 1892						
	C microstomum (Creplin, 1829)	*un*	–	+	Anas crecca (2%), A clypeata (+), Fulica atra (+)	Gastropoda	–
Genus	Typhlocoelum Stossich, 1902						
	T cucumennum (Rudolphi, 1809)	un	–	+	Anas plalyrhynchos (+), A *twccn* (+), Aythya fenna (+)	Gastropoda	–
	T sisowi (Skrjabin, 1913)	un	–	+	Aythya fuligula (4%), Anas platyrhynchos (+)	Gastropoda	–
Family	Notocotyhdae Lũhe, 1909						
Genus	Notocotylus Diesing, 1839						
	N attenuates (Rudolphi, 1809)	S	–	+	Anas strepera (21%), A clypeata (43%), A platyrhynchos (13%), A penelope (+), Aythya fenna (8%), A fuligula (4%), Fulica atra (4%), Mergus albcllus (+)	Gastropoda (Amsus stroemi)	–
	N linearis (Rudolphi, 1819)	un	–	+	Anas strepera (10%), A penelope (+), Aythya fenna (2%)	Gastropoda	–
	N globus (Mehlis, 1846)	un	–	+	FuliLd atra (+)	Gastropoda	–
Genus	Catatropis Odhner, 1905						
	C verrucosa (Frohhch, 1789) Odhner, 1905	un	–	+	Anas platyrhynchos (5%), A clypeata (4%)	Gastropoda (Bit-*hynid* conrortnx)	–
Family	Plagiorch]dae Luhe, 1901						
Genus	Plagiorchis Luhe, 1899						
	P lancola Skrjabin, 1924	un	–	+	Chlidontas leucoptera (78%), Sterna hirundo *(63%)*, *Larus* ndibundus (68%), L canus (59%), L argentatus (1-55%), Hydroprogne tsthegrava (+)	Gastropoda	–
	P elegans (Rudolphi, 1802)	S	–	+	Larus *ndtbundus* (5060%), L canus (39%), L argentatus (10-20%), Anas plathyrhynchos (3%), A strepera (3%)	Gastropoda	Crustacea, larvae of insecta
	P maculosus (Rudolpi, 1802)	*un*	–	+	Aythya *fenna* (10%)	Gastropoda	Crustacea, larvae of insecta
	P multiglandulans Semcnov, 1927	un	–	+	Sterna hirundo (13%), Larus ndibundus (5-14%), L argentatus (1-11%), L canus (1-6%)	Gastropoda	Crustacea, larvae of insecta
	P nyrocae Ryjikov et Timofecva, 1962				Aythya fenna (+)	Gastropoda	–

Continuation of list PARASITOFAUNA species

	Species and subspecies	Endemic or not	Open Baikal	Coastal-sor zone & bays	Final hosts	Intermediate hosts	Additional hosts
	P arcuaius Strom, 1924	un	–	+	Anas crecca (2%), A platyrhynchos (2%)	Gastropoda	–
Family	Prosthogommidae (Luhc, 1901)						
Genus	Prosthogonimus Luhc, 1899						
	P ovatus (Rudolphi, 1803)	un	–	+	Larus argentatus (1-3%), L. canus (1-3%), L ndibundus (4%), Podiceps enstatus (3%), Anas platyrhynchos (+)	Gastropoda	–
	P anatinus Markov, 1902	un	–	+	Mergus albellus (+)	Gastropoda	–
	P cuncatus (Rudolphi, 1809)	un	–	+	Larus ndibundus (2-10%), Podiceps enstatus (40%), Fulica atra (+)	Gastropoda	–
Family	Eucotylidac Skrjabin, 1924						
Genus	Tanaisia Skrjabin, 1924						
	T fedtschenkoi Skrjabin, 1924	un	–	+	Larus argentatus (1-3%), L canus (30%), L. ndibundus (10%)	Gastropoda	–
Famyly	Orchipcdidac Skrjabin, 1925						
Genus	Orchipedum Braun. 1901						
	O tracheicola Braun. 1901	un	–	+	Larus argentatus (1%), L. canus (0,5%), Podiceps enstatus (4%)	Gastropoda	–
Class	Nematoda Rudolphi, 1808						
Family	Capillanidae Neveu-Lemairc, 1936						
Genus	Capillana Zcdcr, 1800						
	C salvclini Poljansky, 1952	SB	+		Braehymystax lenok (+), Batrachocottus baicalensis (+)	Oligochaeta	–
Genus	Thominx Dujardin, 1845						
	T contorla (Creplin, 1839)	un	–	+	Larus canus (+), L ndibundus (+)	-	–
Family	Rhabdochonidae Skrjabin, 1946						
Genus	Rhabdochona Railliet, 1916						
	R denudata (Dujardin, 1845)	un	–	+	Rutilus rutilus lacustns (10-15%), Leuciscus leuciscus baicalensis (+)	**Ephemeroptera**	–
Genus	Cystidicola Fischer, 1798						
	C fanonis Fischer, 1798	SB	+		Coregonus autumnalis migratoris (5-10%), Coregonus lavaretus baicalensis (+), Braehymystax lenok (+), Thymallus arcticus baicalensis (9-73%)	**Gmelinoides fasciatus (4%)**	–
Family	Ascarophididac Trofimenko, 1967						
Genus	Comephoronema Layman, 1933						
	C oschmanni Trofimenko, 1974	un		+	Lota lota (+)	**Gammandae**	– –

Continuation of list PARASITOFAUNA species

	Species and subspecies	Endemic or not	Open Baikal	Coastal-sor zone & bays	Final hosts	Intermediate hosts	Additional hosts
	C. werestschagini Layman, 1933	B	+		Brachymystax lenok (+), Thymallus arcticus baicalensis (4-9%), Comephorus baicalensis (10-20%), C dybowskn (10-33%), Cottocomephorus grewingki (+), Paracottus kesslen (20%), P. knen (53%), Lota lota (10-40%)	Gammandae	–
Genus	Cystidicoloides Skinker, 1931						
	C tennuissima (Zeder, 1800)	un	+		Salmonidae	Ephemeroptera	Nemachilus barbatulus torn (+)
Genus	Ascarophis Van Bcneden, 1871						
	A skrjabini (Layman. 1933)	SB	+		Coregonus autumnalis migratorius (+), Tymallus arcticus baicalensis (40-62%), Acipenser baen **(+)**	-	–
Family	Camallanidae Railhet et Henry, 1915						
Genus	Camallanus Railhet et Henry, 1915						
	C lacustns (Zoega, 1776)	**un**	**+**	**+**	Salmonidae, Cypnmdae, Esocidae, Perca fluvratilis (2-15%)	Cyclopoida	**–**
Family	Philomelndae Baylis et Daubney, 1926						
Genus	Philometra Costa, 1845						
	Ph nschta Skrjabin, 1923	**S**		**+**	Leuciscus leuciscus baicalensis (1-6%), Phoxinus phoxinus (+)	Cyclopoida	**–**
Genus	Philonema Kuitunen-F-kbaum, 1933						
	Ph. sibinca (Bauer, 1946)	**SB**		**+**	Coregonus autumnalis migratorius (+), Thymallus arcticus baicalensis (+)	Cyclopoida	–
Family	Cucullanidac Cobbold, 1864						
Genus	Cucullanus Muller, 1777						
	C lebedevi E. Skrjabma, 1966	**un**		**+**	Acipenser baen (16,6%)	**–**	–
Family	Haplonematidae *Sudankov* c(Ryzhikov, 1952						
Genus	Haploncma Ward et Magath, 1917						
	H hamulatum Moulton, 1931	SB	+		Paracottus knen (20%), P kesslen (20-60%), Cottocomephorus inermis (7%), C grewingki (25%), Procottus jeittelesi (30-50%), Asprocottus rnegalops (15%), Abyssocottus godlewskn (+), A	Diptera, Ephemeroptera	–

Continuation ot list PARASITOFAUNA species

	Species and subspecies	Endemic or not	Open Baikal	Coastal-sor zone & bays	Final hosts	Intermediate hosts	Additional hosts
					pallidus (+), A. bergianus (40%), Batrachocottus baicalensis (60-87%), B uschkani (+), B nikolsku (40%), Comephorus dybowskn (13%)		
Family	Amsakidae Skrjabin et Karokin, 1945						
Genus	Raphidascans Railliet et Henry, 1915						
	R acus (Bloch, 1779)	SB	+	+	Coregonus autumnalis migratorius (4,5%), Esox lucius (20-50%), Perca fluviatilis (6-12%)	Oligochaeta, Copepoda	Rutilus rutilus lacustris (+), Leuciscus leuciscus baicalensis (10-20%), Leuciscus idus (+)
Genus	Contracaecum Railliet et Henry, 1912						
	C. osculatum baicalensis Mosgovoy et Ryjikow, 1950	B	+		Phoca sibinca (70-100%)	Macrohectopus branickn (+)	Brachymystax lenok (+), Coregonus autumnalis migratorius (1-19%), Coregonus lavaretus baicalensis (30-50%), Thymallus arcticus baicalensis (20%), Cottocomephorus inermis (80%), C grewingki (30%), Abyssocottus bergianus (10%), Paracottus knen (+), P. kesslen (13%), Batrachocottus uschkani (+), B. nikolskn (27%)
	C. spiculigerum (Rudolphi, 1809)	**un**	–	+	Larus argentatus (15-19%), L. canus (5-7%), L. ndibundus (6-8%), Podiceps cristatus (18%), P auritus (+), Phalacrocorax carbo (+)	Crustacea	–
	C ovale (Linstow, 1907) Baylis, 1920	un	–	+	Podiceps cristatus (37%)	Crustacea	Insecta
	C spassky Mosgovoy, 1950	u n	–	+	Podiceps cristatus (+)	Crustacea	Insecta
	C microcephalum (Rudolphi, 1819) Baylis, 1920	un	–	+	Larus ndibundus (7%)	Crustacea	Insecta

Continuation of list PARASITOFAUNA species

	Species and subspecies	Endemic or not	Open Baikal	Coastal-sor zone & bays	Final hosts	Intermediate hosts	Additional hosts
Family	Streptocandae Skrjabin, Sobolev, Ivaschkin, 1965						
Genus	Streptocara Railliet, Henry et Sisoff, 1912						
	S crassicauda (Creplin, 1829)	un	–	+	Lams argentatus (1-7%), L. canus (3%), L. ndibundus (3%), Podiceps cristatus (7%), Gavia stellata (+)	Crustacea	–
Family	Desmidocercidae Cram, 1927						
Genus	Desmidocercella Yorke et Maplestone, 1926						
	D numidica (Seurat, 1820)	un	–	+	Ardea cinerea (+)	Crustacea	un
Family	Tctramendae Travassos, 1914						
Genus	Tetrameres Creplin, 1846						
	T skrjabim Panova, 1926	un	–	+	Larus canus (7%)	Crustacea	un
	T fissispina (Diesing, 1861)	un	–	+	Anas strepera (8%), A clypeata (9%), A crccca (2%), Aythya fuligula (12%), A. fenna (8%)		
Family	Trichostrongulidae Leiper, 19J2						
Genus	Epomidiostomum Skrjabin, 1915						
	E. uncinatum (Lindal, 1848) Seurat, 1918	un	–	+	Podiceps cristatus (7%), Anas platyrhynchos (10%), A penelope (+), A crecca (2%), Aythya fenna (10%)		
Family	Syngamidae Leiper, 1912						
Genus	Syngamus Siebold, 1836						
	S anterogonimus Ryjikov, 1949	un	–	+	Larus ndibundus (+)		
Genus	Hovorkonema Turernuratov, 1963						
	H bronchialis (Muhhng, 1884) Turernuratov, 1963	un	–	+	Larus ndibundus (+)	Oligochaeta	un
Family	Amidostomatidae Bayhs et Daubney, 1926						
Genus	Amidostomum Railliet et Henry, 1909						
	A acutum (Lundahl, 1848) Seurat, 1918	un	–	+	Anas platyrhynchos (8%), A querquedula (+)		
	A ansens (Zeder, 1800)	un	–	+	Aythya fenna (12%), A fuligula (8%), Anas strepera (8%), A. crecca (8%)		
Class	Acanthocephala Rudolphi, 1808						
Family	Neoechinorhynchidae Ward, 1918						
Genus	Neoechinorhynchus Hamann, 1892						
	N. rutih (Mullcr, 1780)	un		+	**Acipenser baeri (16,6%), Leu-**	**Ostracoda**	–

Continuation of list **PARASITOFAUNA species**

	Species and subspecies	Endemic or not	Open Baikal	Coastal-sor zone & bays	Final hosts	Intermediate hosts	Additional hosts
					ciscus ldus (+), Leuciscus leuciscus baicalensis (+), Phoxinus phoxmus {+)		
Family	FchinorhynchiddC Cobbold, 1876						
Genus	Pseudoechmorhynchus Petrotschenko, 1956						
	P borealis (Linstow, 1901)	SB	+	+	Acipenser baeri (8 3%), Brachymystax lenok {+), Thymallus arctucus baicalensis (5-13%), Rutiius rutilus laeustris (+), Paracottus knen (100%), P kesslen (40-67%), P insularis (40-70%), Cottocomephorus grewingki (33%), Batrachocottus baicalensis (25%), B uschkani (+), Asprocottus herzensteini (20%), Procottus jeittelesi (30%), Comephorus dybowskn (11%)	Micruropus possolskn (+), M cihodorsahs (+), Gmelmoides fasciatus (0,5%)	–
Genus	Metechinorhynchus Petrotschenko, 1956						
	M salmonis MulIer, 1780	SB		+	Coregonus autumnahs migratonus (+), Coregonus lavaretus baicalensis (+), Acipenser baeri (16,6%)		–
Family	Polymorphidae Meyer, 1931						
Genus	Polymorphus Lune, 1911						
	P minutus (Goeze, 1782) Luhe, 1911	S		+	Larus canus (0,5%), L ridibundus (3%), Podiceps cnstatus (7%), Anas ciypeala *(8%)*, A crecca (2%), Bucephala clangula (18%)	Crastacea	–
	P magnus Skrjabin, 1913	S	–	+	Larus argentatus (2%), L canus (1%), Podiceps cnstatus (11%), A crecca (22%), Anas clypeata (16%), A platyrhynchos (37%), A strepera (18%), Aythya fenna (10%), A fuligula (33), Bucephala clangula (54%), Fulica atra (32%), Mergus merganser (32%), M albellus (+)	Crustacea	–
	P acutis Van Cleave et Starctt, 1941	un	–	+	Larus canus (+), Bucephala clangula (+)	Crustacea	

Continuation of list PARASITOFAUNA species

	Species and subspecies	Endemic or not	Open Baikal	Coastal-sor zone & bays	Final hosts	Intermediate hosts	Additional hosts
Family	Filicolhdae Petrotschcnko, 1956						
Genus	Filicolhs Liihc, 1911						
	F anatis (Schrank, 1788)	un	–	+	Anas platyrhynchos (8%), A crccca (4%), A strepera (3%), Aythya fuhgula (8%), Fulica atra (4%)	Crustacea	
Family	Gigantorhynchidae Hamann, 1892						
Genus	Centrorhynchus Liihe, 1911						
	C lancea (Westrumb, 1821) Skrjabm, 1913	un	–	+	Anas platyrhynchos (7%), Aythya fuligula (4%)		
Type	Annelida						
Class	Hrrudinea Lamarck, 1818						
family	Acanthobdellidae Livanow, 1905						
Genus	Acanthobdclla Livanow, 1905						
	A peledina Grube, 1851	SB		+	Salvelmus alpinus (10-15%), Thymallus arcticus baicalensis (10-20%)	–	–
Family	Glossrphonidae Vaillant, 1890						
Genus	Hcmiclepsis Vejdowsky, 1884						
	H. marginata (O 1- Muller, 1774)	un	+		Esox lucius (+), Leuciscus leuciscus baicalensis (10-20%)	–	–
Family	Piscicolidae Johnston, 1865						
Genus	Cystobranchus Diesing, 1859						
	C mamiDillalus (Malm, 1863)	un		+	Lota Iota (+)	–	–
Genus	Piscicola Blainville, 1818						
	P geometra (Linnaeus, 1761)	un	+	+	Acipenser baen (-*-), Bracbymystax lenok (7%), Thymallus arcticus baicalensis (4%), Rutilus rulilus lacustns (2-5%), *Core*gonus autumnalis migratonus (+), Perca fluvratihs (5-10%)	–	–
Genus	Baicalobdella Dogiel, 1957						
	B torquata (Grube, 1871) (Syn Piscicola torquata, Grube, 1871)	B	+		Cottocomcphorus grewingki (5%)	Eulimnogammarus verrucosus (+)	–
	B cottidarum Dogiel, 1957	B	+		Cottocomephorus grewingki (+)	-	–
Genus	Acipenserobdella Epstein, 1969						
	A, voigensis (Zykoff, 1903)	un	+		Acipenser baen (+)	–	–
Genus	Codonobdella Grube, 1872						
	C truncata Grube, 1872	**B**	+		Cottinella boulcngeri (+)	Acantogammarus sp. (+)	–

Continuation of list PARASITOFAUNA species

	Species and subspecies	Endemic or not	Open Baikal	Coastal-sor zone & bays	Final hosts	Intermediate hosts	Additional hosts
Type	Mollusca						
Class	Bivalvia Linnaeus, 1758						
Family	Unionidae						
Genus	Anodonta						
	A cygnea (Linnaeus, 1758)	S		+	Perca fluviatilis (1-5%)	–	–
Type	Arthropoda						
Class	Crustacea Lamarck, 1801						
Family	Ergasilidae Edwards, 1840						
Genus	trgasilus Nordmann, 1832						
	E bnani *Markewitsch*, 1932	S		+	Leuciscus leuciscus baicalensis (6%), Rutilus rutilus lacustns (5-10%), Phoxinus phoxinus (+)	–	–
	h sicboldi Nordmann, 1832	S	+	+	Coregonus autumnalis migratorius (5-11%), Thymallus arcticus balcalensis (35-55%), Esox lucius (20%), Leuciscus leuciscus bajcalensis (S-13%)	–	–
Genus	Paraergasilus Markewitsch, 1937						
	P rylovi, Markewitsch, 1937	S		+	Acipenscr baen (8,3%), Leciscus leuciscus baicalensis (6%)	–	–
Family	Cahgidae Latreille, 1829						
Genus	Caligus Miiller, 1785						
	C Jacustns Steenstrup et Lutken, 1861	un		+	Leuciscus leuciscus baicalensis (+), Rutilus rutilus lacustns (+)	–	–
Family	Lemaeopodidae Edwards, 1840						
Genus	Salmincola Wilson, 1915						
	S thymalli (Kessler, 1868)	SB	+		Thymallus arcticus baicalensis (32-42%)	–	–
	S cottidarum Messjatzeff, 1926	B	+		Paracottus kesslen (40-60%), Cottocomephorus grewingki (+), Procottus jeittelesi (10%), Paracottus knen (60%), Asprocottus herzensteini (4%), A. megalops (15%), Abyssocottus godlewskn (+), Batrachocottus multiradiatus (+), Comcphorus baicalensis (+), C. dybowskn (+)	–	–
	S extumescens (Gadd, 1901)	SB	+		Coregonus autumnalis migratorius (5-50%), Coregonus lavaretus baicalensis (+)	–	–
	S cxtensus (Kessler, 1868)	SB	+		Coregonus autumnalis migratorius	–	–

Continuation of list PARASITOFAUNA species

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					(0,5%), Coregonus lavaretus baicalensis (0,2%)		
Genus	Achtheres Nordmann, 1832						
	A percarum Nordmann, 1832	S	+		Perca fluvial]lis (7 57%)	–	–
Genus	Basanistes Nordmann, 1832						
	B woskobojnikovi Markewitsch, 1936	S	+		Hudio taimen (5-10%)	–	–
	B bnani Markewitsch, 1936	SB	+		Brachymystax lenok (40-60%)	–	–
Genus	Coregonicola Markewitsch, 1936						
	C baicalensis Korjakov, 1951	B	+		Abbyssocottus bcrgianus (+)	–	–
Genus	Trachehasteb Nordmann, 1832						
	T polycolpus Nordmann, 1832	S		+	Rutilus rutilus lacustns (10%), Leuciscus leuciscus baicalensis (10-60%)	–	–

Comment B - Baikalian, S - **Siberian, SB** - **Sibero-Baikalian, un** - **unknown, dash** - no data