Ця монографія – результат багаторічних комплексних міжнародних досліджень в українській та румунській частинах пониззя Дунаю на ділянці ріки від впадіння р. Прут до Ізмаїльського Чаталу, вершини дельти, місця біфуркації ріки на Тульчинський та Кілійський рукави і далі у водних об'єктах по обидва боки транскордонного Кілійського рукава. До рукопису ввійшли матеріали трьох міжнародних проектів: «ECAQUDAN – Assessing the impact of environmental change on aquatic ecosystems in the Danube delta» (Оцінка впливу змін довкілля на гідроекосистеми дельти Дунаю), «Спільний екологічний моніторинг, оцінка та обмін інформації з метою інтегрованого управління регіоном дельти Дунаю», в рамках якого було проведено дослідження «The Joint Danube Delta Survey» (JDDS) (Спільне обстеження дельти Дунаю) та WWF «Оцінка відновлення островів Єрмаков та Малий Татару». Видання містить також результати наукової роботи «Кліматогенні перебудови угруповань гідробіонтів та їхній вплив на екологічний стан та біопродуктивність транскордонних з ЄС річок України», яка проводилася за цільовою програмою наукових досліджень Відділення загальної біології НАН України «Фундаментальні засади прогнозування та попередження негативного впливу змін кліматичних умов на біотичні системи України» на 2018–2019 рр. і в рамках якої отримано додаткові матеріали та проведено узагальнення результатів усіх зазначених тем.

КАФЕДРА
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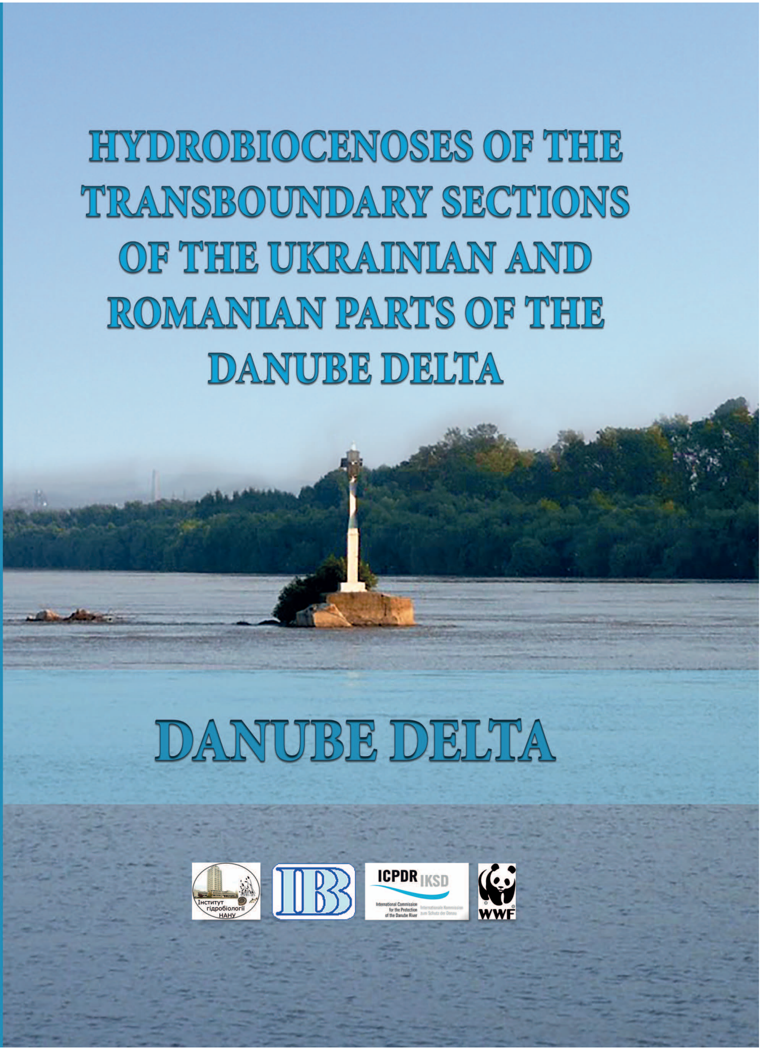
HYDROBIOCENOSES OF THE TRANSBOUNDARY SECTIONS OF THE UKRAINIAN
AND ROMANIAN PARTS OF THE DANUBE DELTA



HYDROBIOCENOSES OF THE TRANSBOUNDARY SECTIONS OF THE UKRAINIAN AND ROMANIAN PARTS OF THE DANUBE DELTA

DANUBE DELTA

Інститут гідробіології НАНУ

ICPDR IKSD
International Commission for the Protection of the Danube River
Internationale Kommission zum Schutz der Donau

WWF

HYDROBIOCENOSES OF THE TRANSBOUNDARY SECTIONS OF THE UKRAINIAN AND ROMANIAN PARTS OF THE DANUBE DELTA

ГІДРОБІОЦЕНОЗИ ТРАНСКОРДОННИХ ДІЛЯНОК УКРАЇНСЬКОЇ ТА РУМУНСЬКОЇ ДЕЛЬТИ ДУНАЮ

HIDROBIOCENOZELE SECTOARELOR TRANSFRONTALIERE ALE DELTEI UCRAINENE ȘI ROMÂNEȘTI ALE DUNĂRII

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Г46

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Г46 **Hydrobiocenoses of the transboundary sections of the Ukrainian and Romanian parts of the Danube delta:** Гідробіоценози транскордонних ділянок української та румунської дельти Дунаю: монографія / А. В. Ляшенко, С. О. Афанасьєв, К. Санду, К. Є. Зоріна-Сахарова, О. В. Мантурова, Л. В. Гулейкова, Т. М. Дьяченко, О. Л. Савицький, В. В. Маковський, І. І. Абрам'юк, А. Думітраче, Д. Іоніка; за заг. ред. к. б. н., ст. н. с. А. В. Ляшенка. – К.: Кафедра, 2018. – 312 с.

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The book summarizes the results of three comprehensive international projects, which were implemented in the Ukrainian and Romanian parts of the Lower Danube for the years 2006 to 2018, and is supported by the target scientific research program of General Biology Department of National Academy of Sciences of Ukraine "Fundamental principles of forecasting and prevention of the negative impact of the climatic changes on the biotic systems of Ukraine". According to the field surveys at 45 monitoring sites, the abiotic and biotic characteristics of water objects of different types are presented, the comparative characteristics of hydrologic-hydrochemical and structural-functional variables are performed, certain regularities of biodiversity formation and water coenoses functioning are described, the bioproductive potential and quality of the Delta waters are estimated, the main groups and species of hydrobionts, compiled separately according to specific types of surface waters and different observation sites, are listed. On the basis of retrospective materials analysis, the reference metrics for the ecological status assessment are given and the proposals for implementation of international hydroecological monitoring are elaborated.

For a wide range of scientists, hydrobiologists, ecologists, specialists in water management.

У роботі представлено узагальнення результатів трьох комплексних міжнародних проектів, проведених в українській та румунській частинах пониззя Дунаю в період з 2006 по 2018 роки, яке виконано за підтримки цільової програми наукових досліджень Відділення загальної біології НАН України «Фундаментальні засади прогнозування та упередження негативного впливу змін кліматичних умов на біотичні системи України». За матеріалами експедиційних обстежень на 45 станціях спостережень наведено абіотичні та біотичні характеристики водних об'єктів різного типу, виконано порівняльні характеристики гідролого-гідрохімічних та структурно-функціональних показників, відзначено певні закономірності формування біорізноманіття, функціонування водних ценозів, проведено оцінки біопродукційного потенціалу і якості вод дельти, наведено переліки видів основних груп гідробіонтів, складених окремо за конкретними типами масивів поверхневих вод та по різним станціям спостережень. На основі аналізу отриманих ретроспективних матеріалів наведено значення референсних показників для оцінки екологічного стану та розроблено пропозиції проведення міжнародного гідроекологічного моніторингу.

Для широкого кола науковців, гідробіологів, екологів, фахівців водного менеджменту.

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PREFACE

This book is a result of the prolong integral international investigations in the Ukrainian and Romanian sections of the lower Danube reaches, from the Prut River mouth to the Izmayil Cheatal – point of the river bifurcation to the Tulcea and Kiliya arms, and downstream – in the water bodies at both sides of the border Kiliya arm. The book comprises results of three international projects: «ECAQUDAN – Assessing the impact of environmental change on aquatic ecosystems in the Danube delta»; Joint ecological monitoring, assessment and information exchange with the aim of integrated Danube delta region management, within which the Joint Danube Delta Survey (JDDS) was carried out; and WWF Project «Assessment of the Ermakov and Small Tataru islands rehabilitation». The book also includes results of the scientific work «Climate-induced restructuring of the hydrobionts' communities and their impact on ecological state and biological productivity of the transboundary with EC rivers of Ukraine», which was realized according to the special-task program of the General Biology department of the NAS of Ukraine «Fundamental principles of forecasting and prevention of the negative impact of the climatic changes on the biotic systems of Ukraine for the years 2018–2019», which enabled to obtain additional material and results of all mentioned projects were comprehended.

On the whole investigations covered more than ten-year period, the first stage started in 2006–2007 by six joint integral seasonal field surveys of the water bodies and water courses of the Kiliya arm of the Danube delta. Their peculiarity consisted in the surveys' continuity, which started at one side of the border (in the Romanian section) and ended at the other side (in the Ukrainian section). The works were supported by the Swiss national scientific fund SCOPES, which was aimed at initiation and support of scientific cooperation between Switzerland and East-European countries within the Swiss-Romanian-Ukrainian project ECAQUDAN. These studies were additionally supported by the bilateral interacademic Agreement on scientific and technical cooperation between NAS of Ukraine and Romanian academy. Among the most essential tasks was adjustment of the common approaches to sampling, analysis and presentation of the results, intercalibration and harmonization of the methods and methodologies, presentation of common results, which were trustworthy in the water-management authorities in both countries and in the European community.

The second stage – realization of the International project «Joint ecological monitoring, assessment and information exchange with the aim of integrated Danube delta region management» (2010–2012), which was initiated by ENVSEC (Environment and Security Initiative) and realized by the Centre for Regional Studies (Odesa) with ICPDR (International commission for protection of the Danube River) support. Within the frames of this project in 2011 scientists from Ukraine, Romania and Moldova carried out joint Danube delta survey (JDDS), which was the first practical step to harmonization of the monitoring system of three countries. In hydrobiological investigations participated scientists from the institutions of Ukraine (The Danube biosphere reserve, Vylkove; Institute of marine biology, Odesa; Institute of hydrobiology, Kyiv), Moldova (Center of State hydrometeorological service, Chisinau) and Romania (The Danube Delta National Institute for Research and Development, Tulcea). The main task of the survey consisted in intercalibration of the environmental monitoring methods in the lower Danube section over the joint hydrobiological sampling, assessment and exchange of information on hydroecosystems' state in the region. Hydrobiological material in the Ukrainian section of the Danube delta was taken from the board of the research vessel "Cyclone" and high-speed motor boat (Danube hydrometeorological observatory, Izmayil) and in the Romanian side – from the board of the research "ROUA" (Danube delta biosphere reserve, Tulcea). In the transboundary section sampling was carried out simultaneously at Ukrainian and Romanian or Moldavian side, Scientists of the Institute of hydrobiology performed the «benthos» block of hydrobiological studies (macrozoobenthos, phytobenthos, higher aquatic plants), which results are considered in this book.

The third stage was associated with realization of the National Academy of sciences of Ukraine Project «Fundamental basis for forecasting and prevention of the negative impact of the climate changes on biotic systems of Ukraine» and WWF Project «Evaluation of the Ermakov and Small Tataru islands rehabilitation», realized in 2018 with WWF-NL financial support. Ecosystems of these islands, located in the Kiliya arm in the Ukrainian section of the delta, in the 1990ies were subjected to the destructive anthropogenic impact owing to almost total aging by dams and further drying. The wetlands with significant biological diversity, spawning areas of many commercial, rare and endangered fishes, birds' nesting were transformed into homogenous reed areas, which were unsuccessfully used for the pulp-and-paper production, salted lands, not usable for agriculture, and into pastures for the cattle and horses. Ecosystem of the Ermakov island was even more damaged owing to earth deposition after the Kiliya arm dredging. So, in 2003 in the Small Tataru island and in 2009 in the Ermakov island activities started aimed at rehabilitation of the natural ecosystems and regimes of their functioning, supported by WWF. In 2018 WWF posed task of evaluation of the actual state of hydrobiocenoses of the considered islands, degree of their «naturality», ecosystems' rehabilitation, similarity of the islands' biological diversity with parameters of other analogous water bodies of the delta. Under the aegis of WWF in May 2018 specialists of the Institute of hydrobiology carried out hydrobiological survey of the actual state of hydrobiocenoses of the internal water bodies (lakes and channels) of the islands. Structural and functional parameters of macroinvertebrates (zoobenthos and phytophilous fauna) and ichthyofauna (larvae and early juveniles) were determined with the aim to evaluate degree of the ecosystems' rehabilitation after the dams' destruction and restoration of hydrological connections with the river channel.

This book presents relatively small portion of all investigations, carried out by the Institute of hydrobiology in the Danube River over the last decades. But these materials are characterized by integrity and work in the transboundary sections of the lower Danube and delta as a part of international scientific teams, common approaches to solution of the urgent issues.

Actually, the climatic changes become one of the most essential among numerous ecological problems of the Danube River. At the background of anthropogenic pollution and intensive water-management activity, climate changes cause modifications of the hydrological regime, chemical composition and properties. At this in hydrobiocenoses occur structural modifications, caused first of all by changes of biota's taxonomic composition and abundance. In this view, profound investigations are needed of all complex of the factors, their impact on structural and functional modifications of the aquatic communities and biocenoses. Knowledge of mechanisms of the ecosystems' functioning and the hydrobionts' adaptations are very important, because gives possibilities for advances development of the main provisions of the theory of the aquatic ecosystems functioning, and thus for the effective forecast of their development under the impact of biotic and abiotic factors, elaboration and implementation of practical environment-protective measures and optimization of the biological resources management for the social needs.

From the water management viewpoint the main task is development, adjustment and further implementation into the practice of hydroecological monitoring in Ukraine of methodology of the aquatic ecosystems' ecological state (potential) assessment, based on the WFD principles and national approaches, along with adjustment of the descriptors' reference values with account of degree of the climate-induced and human-induced, etc. disturbances, and development of measures for rehabilitation and protection of the natural biological diversity, nature-management optimization and sustain use of the bioproductive potential of the river ecosystems.

Nowadays, when Ukraine pursues a course towards European integration, joint development with the EU member states, mutual understanding with scientists and officials of the neighboring countries became of essential importance. For the many years, negotiations are carried out regarding organization of the joint international monitoring of the transboundary river sections. The main problem of its realization was and still is implementation of the WFD 2000/60/EC provisions in Ukraine. Taking into account, that according to the European strategy, given in this document, the ecological state is determined with priority of biological quality elements, and hydromorphological, chemical and physico-chemical elements as supporting biological, we expect that our work on investigation of hydrobiocenoses of the transboundary sections of the Ukrainian and Romanian Danube delta will be a certain step towards knowing of the fundamental nature's laws and towards achievement of the Ukraine' strategic goal – entry to the European community.

ПЕРЕДМОВА

Ця монографія – результат багаторічних комплексних міжнародних досліджень в українській та румунській частинах пониззя Дунаю на ділянці від впадіння р. Прут до Ізмаїльського Чаталу, вершини дельти, місця біфуркації на Тульчинський та Кілійський рукави і далі у водних об'єктах по обидва боки транскордонного Кілійського рукава. До рукопису увійшли матеріали трьох міжнародних проектів: ECAQUDAN – Assessing the impact of environmental change on aquatic ecosystems in the Danube delta (Оцінка впливу змін довкілля на гідроекосистеми дельти Дунаю), «Спільний екологічний моніторинг, оцінка та обмін інформації з метою інтегрованого управління регіоном дельти Дунаю», в рамках якого було проведено The Joint Danube Delta Survey (JDDS) (Спільне обстеження дельти Дунаю) та WWF «Оцінка відновлення островів Єрмаков та Малий Татару». А також наукової роботи «Кліматогенні перебудови угруповань гідробіонтів та їхній вплив на екологічний стан та біопродуктивність транскордонних з ЄС річок України», яку проводили за цільовою програмою наукових досліджень Відділення загальної біології НАН України «Фундаментальні засади прогнозування та попередження негативного впливу змін кліматичних умов на біотичні системи України» на 2018–2019 рр. і в рамках якої отримано додаткові матеріали та проведено узагальнення результатів усіх зазначених тем.

Загалом дослідженнями охоплено понад десятирічний період – перший етап розпочато у 2006–2007 роках шістьма спільними комплексними україно-румунськими посезонними експедиціями, проведеними на водоймах та водотоках дельти Кілійського рукава. Їхньою особливістю була неперервність обстежень, що розпочинались з одного боку кордону (на території румунської дельти), а закінчувалися з іншої сторони (в українських акваторіях). Роботи було виконано за фінансування програми Швейцарського національного наукового фонду SCOPES, метою якої була ініціація та підтримка наукового співробітництва між Швейцарією та країнами Східної Європи в рамках швейцарсько-українсько-румунського проекту ECAQUDAN. Додатковою підтримкою стала двостороння міжакадемічна Угода про науково-технічну співпрацю НАН України та Румунської Академії. Одними з найважливіших серед багатьох поставлених виконавцями завдань були напрацювання спільних підходів щодо відбору, аналізу та представлення матеріалів, інтеркалібрація та гармонізація методів та методик досліджень, надання спільних результатів, що мають довіру в установах водного менеджменту по обидва боки кордону та в європейському співтоваристві.

Другий етап – участь у виконанні міжнародного проекту «Спільний екологічний моніторинг, оцінка та обмін інформації з метою інтегрованого управління регіоном дельти Дунаю» (2010–2012), який було ініційовано ENVSEC (Environment and Security Initiative) і реалізовано Центром регіональних досліджень (м. Одеса) за підтримки ICPDR (Міжнародної комісії із захисту р. Дунай). В рамках виконання цього проекту восени 2011 р. науковцями України, Румунії та Молдови було проведено спільне дослідження дельти р. Дунай (JDDS), яке стало першим практичним кроком у гармонізації системи моніторингу цих трьох країн. До виконання гідробіологічних досліджень були залучені науковці науково-дослідних установ України (Дунайський біосферний заповідник (м. Вилкове), Інститут морської біології (м. Одеса) та Інститут гідробіології (м. Київ)), Молдови (Центру державної гідрометеорологічної служби Республіки Молдова (м. Кишинів) та Румунії (Національного інституту досліджень та розвитку дельти Дунаю (м. Тульча)). Головним завданням експедиції стала інтеркалібрація методів моніторингу довкілля в пониззі р. Дунай під час спільного відбору гідробіологічного матеріалу, оцінки та обміну інформацією про стан гідроекосистем у регіоні. Відбір гідробіологічного матеріалу в акваторіях української частини дельти Дунаю здійснювався з використанням науково-дослідного судна «Циклон» та швидкісного моторного катеру (Дунайська гідрометобсерваторія м. Ізмаїл, Україна), а в акваторіях румунської частини дельти – з борту науково-дослідного судна «ROUA» (Управління біосферного заповідника дельти Дунаю, м. Тульча, Румунія). На суміжних (транскордонних) ділянках відбір проб здійснювався водночас із румунської та української або молдовської сторони. Науковці Інституту гідробіології виконували «бентосний» блок гідробіологічних досліджень (макрозообентос, фітобентос та вищі водяні рослини), результати якого і включено в цю монографію.

Третій етап пов'язано з виконанням теми НАН України «Фундаментальні засади прогнозування та упередження негативного впливу змін кліматичних умов на біотичні системи України» проектом WWF «Оцінка відновлення островів Єрмаков та Малий Татару», що виконувався у 2018 році за фінансуванням WWF-NL. Екосистеми цих островів, розташованих у Кілійському рукаві в українській частині дельти, в 90-х роках XX століття зазнали нищівного антропогенного впливу внаслідок майже повного віддамбування по периметру та подальшого осушення. Водно-болотні угіддя з великим біологічним різноманіттям, місцями нересту цінних і рідкісних видів риб, гніздування та розвитку птахів перетворилися на доволі одноманітні очеретяні зарості, що безуспішно намагалися використовувати для целюлозно-паперового виробництва, на засолені землі, малопридатні для вирощування сільськогосподарських культур, та на пасовища для коней і великої рогатої худоби. Додаткової руйнації екосистема о. Єрмаков зазнала від відвалів ґрунтів, що складалися у верхів'ї острова після днопоглиблюваних робіт у Кілійському рукаві. Тому у 2003 році на острові Малий Татару та 2009 на острові Єрмаков за підтримки WWF були розпочаті роботи щодо відновлення природніх екосистем та режимів їхнього функціонування. Цього 2018 року WWF в Україні поставило завдання оцінки сучасного стану гідробіоценозів островів, ступеня їхньої “природності”, відновлення екосистем, схожості різноманіття з показниками інших аналогічних водних об'єктів дельти. Науковцями Інституту гідробіології з 20 по 25 травня 2018 року під егідою київського відділення WWF проведено гідробіологічне обстеження островів Малий Татару та Єрмаков української частини дельти Дунаю. Головним завданням дослідження була оцінка сучасного стану гідробіоценозів внутрішніх водойм островів (озер та протоків) за структурно-функціональними характеристиками макробезхребетних (зообентосу та фітофільної фауни) та іхтіофауни (мальків та ранньої молоді риб) для визначення наявності та ступеня відновлення їхніх екосистем після роздамбування та поновлення гідрологічного зв'язку з Дунаєм.

Матеріали, наведені в монографії, становлять порівняно невелику частку в загальних дослідженнях Інституту гідробіології НАН України на Дунаї, проведених в останні десятиліття. У першу чергу їх об'єднує комплексність та робота на транскордонних ділянках пониззя та дельти ріки у складі міжнародних наукових колективів, спільне ставлення до вирішення нагальних питань.

У нинішніх умовах серед численних екологічних проблем Дунаю надзвичайної ваги набуває проблема змін клімату. На тлі антропогенного забруднення та активної водогосподарської діяльності зміни клімату зумовлюють зміни водного режиму, хімічного складу і властивостей води. При цьому у гідробіоценозах відбуваються модифікації структури, викликані насамперед змінами кількісної представленості та таксономічного складу біоти. З огляду на це необхідні глибокі дослідження всього комплексу чинників та їхнього впливу на структурно-функціональні перебудови водних угруповань та біоценозів. Пізнання механізмів функціонування водних екосистем та адаптацій гідробіонтів має важливе наукове значення, оскільки відкриває можливості для поглибленої розробки основних положень теорії функціонування водних екосистем, а відтак і для ефективного прогнозування їхнього розвитку в умовах дії біотичних і абіотичних чинників, розробки і впровадження практичних природоохоронних заходів і оптимізації використання водних біологічних ресурсів для потреб суспільства.

Із позицій водного менеджменту на перший план виступає завдання створення, апробації та подальшого впровадження в практику гідроекологічного моніторингу в Україні методології оцінки екологічного стану (потенціалу) гідроекосистем, що базується на принципах ВРД і національних підходах із коригуванням референційних значень дескрипторів на величини порушень внаслідок кліматичних змін, антропогенного впливу тощо, а також у розробці заходів відновлення та збереження природного біорізноманіття, оптимізації природокористування та сталого використання біопродукційного потенціалу річкових екосистем.

На сьогодні, коли Україна впевнено взяла курс на європейську інтеграцію, спільний розвиток з країнами ЄС, надзвичайно важливим стало питання взаєморозуміння з науковцями та державцями сусідніх країн. Багато років ідуть перемовини про організацію об'єднаного міжнародного моніторингу транскордонних ділянок річок. Основною проблемою його запровадження була й залишається імплементація в Україні положень Директиви 2000/60/ЄС. Відповідно до Європейської стратегії, викладеної у цьому документі, визначення екологічного стану водних об'єктів проводиться за пріоритетністю показників структури біотичної складової та гідроморфологічними, хімічними та фізико-хімічними складовими як допоміжними, які підтримують біологічну складову. Сподіваємося, що наша робота, присвячена вивченню гідробіоценозів транскордонних ділянок української та румунської дельти Дунаю, буде певним кроком вперед як по дорозі пізнання фундаментальних законів природи, так і на шляху досягнення стратегічної мети України – входження в Європейське співтовариство.

PREFAȚĂ

Această monografie este rezultatul studiilor de mai mulți ani de cercetare internațională cuprinzătoare în părțile ucrainene și românești din vaia inferioară a Dunării de pe sectorul fluviului de la vărsarea râului Prut până la Ceatal Izmail, culmea deltei, bifurcația râului în brațele Tulcea și Chilia și mai departe în obiectele acvatice de pe ambele părți ale brațului transfrontalier Chilia. Manuscrisul include materialele din trei proiecte internaționale: ECAQUDAN – Assessing the impact of environmental change on aquatic ecosystems in the Danube delta (Evaluarea impactului schimbărilor de mediu asupra ecosistemelor acvatice din Delta Dunării), ”Monitorizarea comună a mediului, evaluarea și schimbul de informații în scopul gestionării integrate a regiunii Deltei Dunării”, în cadrul căreia s-au desfășurat The Joint Danube Delta Survey (JDDS) (Studiul comun al Deltei Dunării) și WWF ”Evaluarea restabilirii insulelor Ermakov și Tataru Mic”. Precum și din lucrarea științifică „Transformările climatogene ale grupurilor de hidrobionți și influența lor asupra stării ecologice și bioproductivității râurilor din Ucraina transfrontaliere cu UE” realizată conform programului de cercetare țintă al Departamentului de Biologie Generală al Academiei Naționale de Științe din Ucraina „Principii fundamentale de prognoză și prevenire a impactului negativ al schimbărilor climatice asupra sistemelor biotice din Ucraina” pentru perioada anilor 2018–2019 și în cadrul căreia au fost obținute materiale suplimentare și sa realizat o generalizare a rezultatelor tuturor subiectelor indicate.

În general, cercetarea a acoperit o perioadă mai mult de zece ani, prima fază s-a început în anii 2006-2007 în cadrul unor șase expediții complexe sezoniere comune ucrainene-române, efectuate în bazinele de apă și fluxurile din delta brațului Chilia. Acestea se caracterizează printr-un studiu continuu, care s-a început dintr-o parte a frontierei (pe teritoriul deltei române) și s-a încheiat pe de altă parte (în apele ucrainene). Lucrările au fost realizate în temeiul programului finanțat de Swiss National Science Foundation SCOPES al cărui scop a fost inițierea și susținerea cooperării științifice dintre Elveția și țările din Europa de Est în cadrul proiectului elvețian-ucrainean-român

ECAQUDAN. Un sprijin suplimentar a fost Acordul interuniversitar bilateral privind cooperarea științifică și tehnică între Academia Națională de Științe a Ucrainei și Academia Română. Una dintre cele mai importante sarcini ale executanților a fost dezvoltarea unor abordări comune pentru selectarea, analiza și prezentarea materialelor, intercalibrarea și armonizarea metodelor și tehnicilor de cercetare, prezentarea rezultatelor comune de încredere către instituțiile de management al apei de pe ambele părți ale frontierei și în comunitatea europeană.

A doua fază – participarea la proiectul internațional ”Monitorizarea comună a mediului, evaluarea și schimbul de informații cu scopul gestionării integrate a regiunii Delta Dunării” (2010–2012), care a fost inițiat de ENVSEC (Environment and Security Initiative) și implementat de Centrul de Studii Regionale (orașul Odessa) cu sprijinul ICPDR (Comisia Internațională pentru Protecția Fluviului Dunărea). În cadrul acestui proiect, în toamna anului 2011 savanții din Ucraina, România și Moldova au realizat un studiu comun de cercetare a Deltei fluviului Dunărea (JDDS), care a fost primul pas practic în armonizarea sistemului de monitorizare a acestor trei țări. Pentru efectuarea studiilor hidrobiologice au fost implicați savanți din cadrul instituțiilor de cercetări științifice din Ucraina (Rezervația Biosferei Dunării (or. Vilcovo), Institutul de Biologie Marină (or. Odessa) și Institutul de Hidrobiologie (or. Kiev)), Republica Moldova (Centrul Serviciului Hidrometeorologic de Stat din Republica Moldova (mun. Chișinău) și România (Institutul Național de cercetare-dezvoltare Delta Dunării (mun. Tulcea)). Obiectivul principal al expediției a fost intercalibrarea metodelor de monitorizare a mediului în cursul inferior al Dunării în timpul prelevării comune a materialului hidrobiologic, evaluarea și schimbul de informații cu privire la starea sistemelor hidroecologice din regiune. Prelevarea materialului hidrobiologic în acvatoriul ucrainean al Deltei Dunării a fost realizată cu ajutorul navei de cercetare ”Ciclon” și barca cu motor de mare viteză (Observatorul hidrometeorologic Dunărean din or. Izmail, Ucraina.), precum și în acvatoriul român al Deltei – de la bordul navei de cercetare „ROUA“ (Direcția Rezervației Biosferei din Delta Dunării, mun. Tulcea, România). În zonele adiacente (transfrontaliere), prelevarea de probe a fost efectuată simultan din partea română și ucraineană sau moldovenească. Savanții de la Institutul de Hidrobiologie au efectuat blocul ”bentonic” de cercetare hidrobiologică (macrozoobentos, fitobentos și plante acvatice superioare), ale căror rezultate sunt incluse în această monografie.

A treia etapă este legată de studierea temei Academiei Naționale de Științe a Ucrainei „Principii fundamentale de prognoză și prevenire a impactului negativ al schimbărilor climatice asupra sistemelor biotice din Ucraina” și proiectul WWF „Evaluarea restabilirii insulelor Ermakov și Tataru Mic” în anul 2018, finanțat de WWF-NL. Ecosistemul acestor insule, situate în brațul Chilia în partea ucraineană a Deltei, în anii ,90 a suferit un impact devastator antropogen în rezultatul construcției de diguri și uscării ulterioare. Terenurile acvatice mlăștinoase cu o biodiversitate sporită, cu locuri de bătaie a speciilor valoroase și rare de pești, de încuibare și creștere a păsărilor s-au transformat în stufăriș uniform, care au încercat fără succes să îl folosească pentru producția de hârtie și celuloză, terenuri saline, nepotrivite pentru creșterea culturilor agricole și pășuni pentru cai și bovine. Ecosistemul insulei Ermakov a fost supuse unei distrugeri suplimentare în rezultatul haldei de sol, care s-a adunat în partea superioară a insulei, după lucrările de dragaj din brațul Chilia. Prin urmare, în anul 2003, pe insula Tataru Mic și în 2009 pe insula Ermakov, cu sprijinul WWF au fost începute lucrările de restabilire a ecosistemelor naturale și a regimurilor de funcționare a acestora. În anul acesta, WWF în Ucraina a stabilit sarcina de evaluare a stării actuale a hidrobiocenozelor insulelor, gradul de „naturalețe” a acestora, restabilirea ecosistemelor, asemănarea diversității cu indicatorii altor obiecte acvatice similare ale deltei. Savanții Institutului de Hidrobiologie au efectuat un studiu hidrobiologic al insulelor Ermakov și Tataru Mic din partea ucraineană a Deltei Dunării în perioada 20-25 mai 2018, sub auspiciile Departamentului WWF de la Kiev. Sarcina principală a studiului a constat în evaluarea stării actuale a hidrobiocenozelor în acvatoriile interne ale insulelor (lacuri și brațuri) în funcție de caracteristicile structurale și funcționale ale macrobentosului (zoobentos și fauna fitofilă) și ihtiofauna (pui de pește) pentru determinarea existenței și gradului de restabilire a ecosistemelor acestora după înlăturarea digurilor și reînnoirea legăturii hidrologice cu Dunărea.

Materialele prezentate în monografie sunt o parte relativ mică a studiilor generale a fluviului Dunărea desfășurate de Institutul de Hidrobiologie al Academiei Naționale de Științe a Ucrainei în ultimele decenii. În primul rând, acestea sunt combinate prin complexitatea și lucrul în sectoarele transfrontaliere din cursul inferior și delta fluviului, efectuat de către colectivele științifice internaționale, rezolvarea unor probleme urgente.

În condițiile actuale, printre problemele ecologice numeroase a fluviului Dunărea, problema schimbărilor climatice devine primordială. În contextul poluării antropice și activității active în domeniul gospodării apelor, schimbările climatice contribuie la schimbarea regimului acvatic, compoziției chimice și proprietăților apei. În același timp, hidrobiocenozii suferă modificări structurale, cauzate în primul rând de modificări ale reprezentării cantitative și compoziției taxonomice a biotei. Luând în considerație acest fapt, este necesar un studiu aprofundat a întregului complex de factori și influența acestora asupra transformării structural-funcționale a grupurilor acvatice și a biocenozelor. Cunoașterea mecanismelor de funcționare a ecosistemelor acvatice și adaptarea hidrobionților are o importanță științifică deosebită, deoarece deschide noi posibilități pentru elaborarea aprofundată a principalelor prevederi ale teoriei funcționării ecosistemelor acvatice și, prin urmare, pentru prognoza efectivă a dezvoltării acestora în condițiile acțiunii factorilor biotici și abiotici, pentru dezvoltarea și implementarea măsurilor practice de protecție a mediului și optimizarea utilizării resurselor biologice acvatice pentru necesitățile societății.

Din punctul de vedere al gospodăriei apelor în prim-plan este sarcina elaborării, testării și implimentării ulterioare în activitatea de monitorizare hidroecologică din Ucraina a metodologiei de evaluare a stării mediului (potențialul) sistemelor hidroecologice, bazate pe principiile DCA și abordările naționale, cu ajustarea valorilor referențiale a descriptorilor pentru valorile de încălcălcare în rezultatul schimbărilor climatice, impactului uman, precum și sarcina de elaborare a măsurilor de restabilire și conservare a biodiversității naturale și de optimizare a utilizării naturii și de utilizare stabilă a potențialului biologic de producție al ecosistemelor fluviale.

Astăzi, când Ucraina a făcut cu încredere un pas spre integrarea europeană, dezvoltarea comună cu țările UE, problema înțelegerii reciproce între savanți și suveranii din țările vecine a devenit extrem de importantă. Timp de mulți ani durează negocierile privind organizarea monitorizării comune internaționale a sectoarelor transfrontaliere ale fluviilor. Principala problemă a implimentării a fost și rămâne în continuare implimentarea dispozițiilor Directivei 2000/60/CE în Ucraina. Având în vedere că, în conformitate cu strategia europeană, prevăzută în acest document, determinarea stării ecologice a obiectelor acvatice se realizează în funcție de prioritatea indicatorilor structurii componentei biotice și componentelor hidro-morfologice, chimice și fizico-chimice, în calitate de subsidiari, care mențin componenta biologică, sperăm că munca noastră, dedicată studiului hidrobiocenozelor din sectoarele transfrontaliere ale deltei ucrainene și românești ale fluviului Dunărea, va fi un pas înainte, atât pe calea de cunoaștere a legilor fundamentale ale naturii, cât și pe calea către atingerea obiectivului strategic al Ucrainei – aderarea la Comunitatea Europeană.

CHAPTER 1.

MATERIAL AND METHODS

1.1. AREA OF IVESTIGATIONS

Transboundary sections of the lower Danube were investigated in the territory of three neighboring countries (Ukraine, Moldova, Romania).

Hydrobiological investigations have been carried out in spring, summer and autumn 2006 and 2007, on both sides of the Danube Delta – in Matita-Merhei lacustrine complex of the Danube Delta Biosphere Reserve, Romania, and in Kiliya Delta, Danube Biosphere Reserve, Ukraine. In total 11 water bodies have been examined (Fig. 1.1).

The investigations were carried in the following points:

- Lopatna – channel, near the inflow to Matita lake,
- Suez – channel, near the outflow from Matita lake,
- Sulimanca – channel, at the outflow from Small Merhei lake;
- Matita – lake, two transects, in the Northern and Southern parts;
- Merhei – lake, two transects, in the Western and Eastern parts
- Small Merhei – lake, one transversal transect.
- Bystryi and Vostochniy – branches, inflow and outflow.
- Anankin Kut – lake, one longitudinal transect
- Deliukiv Kut and Potapiv Kut – bays, one longitudinal transect.

In JDDS project aquatic macrophites, phytobenthos and macrozoobenthos were studied in autumn in 2011 (September 27. 2011 – October 04. 2011) at 16 stations in the Danube delta and up-river areas: main channel (sites 1, 2, 3), Kiliya arm and Bystryi branch (sites 4, 5, 6, 7), Tulcea arm (site 8), Sulina arm (sites 9, 10) and St Gheorge arm (sites 11, 12). We also examined 3 lakes of Gorgova-Uzlina system (site 14 of Uzlina lake, site 15 of Isak lake and site 16 of Cuibul cu Lebede lake) and Erenciuc lake (site 13).

Water bodies of the Small Tataru and Ermakov and Ochakivskyi islands were examined in 2018. Detailed scheme of the sampling sites is given in the corresponding chapter.

The sampling in the Ukrainian water area was carried out from the research vessel "Cyclone" and high-speed motorboat "Hydrologist", in the Kiliya delta – with motorboats. In the Romanian water area the sampling was carried out from the "Nutria" and "RoUa" research vessels and the motorboats. Danube branches are characterized by the significant stream and significant depths that was why the benthos study was limited only to coastal area with the depths not exceeding 3 m.

The hydrobiological research on the Danube islands was carried out with the help of a fishing rowing boat on Small Tataru island, and with a motorboat on Ermakov island, which was transferred over the dam from the Danube to the inland island waters.

1.2. SAMPLING

Physico-chemical parameters

The water samples were taken on column, with a modified Patalas device. The sub-samples taken along the transect were pooled together and an average sample per transect/ecosystem was obtained. The same methodology was used for microbiological and plankton samples.

The depth and transparency were determined with a Secchi disk; temperature, pH, redox potential, conductivity, salinity and dissolved oxygen were measured on site with a WTW 340i field equipment. Part of the hydrochemical analyses were performed in the field on a portable spectrophotometer HACH DR 2400 (ammonium, nitrites, orthophosphates, chlorophyll-a); another part of the samples were frozen and taken at the laboratory for further analyses (nitrates, total phosphorus, chemical oxygen demand) and 1 l of water was taken for toxicological analyses in the lab (phenols, oil products).

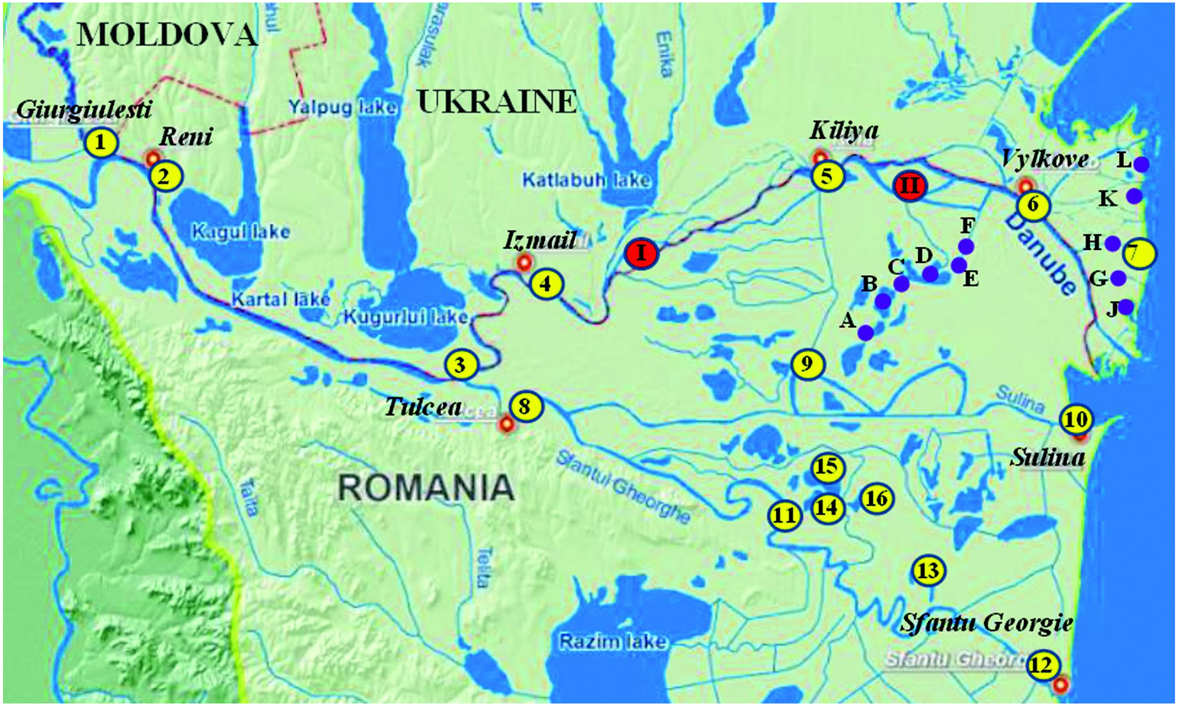

Fig. 1.1. Objects of investigations: in purple – sites of ECAQUDAN project (A – Lopatna, B – Matita, C – Suez, D – Merhei, E – Small Merhei, F – Sulimanka, G – Vostochnyi, H – Bystryi, J – Anankin Kut, K – Deliukiv Kut, L – Potapiv Kut), in yellow – JDDS sites (1 – Giurgiulesti, 2 – Reni, 3 - Cheatal, 4 – Izmail, 5 – Kiliya, 6 – Vylkove, 7 – Bystryi, 8 – Tulcea, 9 –Mila 23, 10 – Sulina, 11 – Uzlina, 12 – St. Gheorge, 13 – Erenciuc lake, 14 – Uzlina lake, 15 – Isak lake, 16 – Culibul cu Lebede lake), in red – WWF project sites (I – Small Tataru island, II – Ermakov island, III – Ochakivskyi island).

In the field were determined: NH_4^+ as blue-green indophenol, NO_2^- as red compound with naphthyl-ethylenediaminhydrochloride (EAWAG), SRP as blue phosphomolibdate, reduced by ascorbic acid [TARTARI & MOSELLO, 1997], and chlorophyll-a after extraction in 90% ethyl alcohol (ISO 10260-1992).

In the lab were determined: NO_3^- as yellow compound with sodium salicylate (EAWAG), TP by oxidation with potassium peroxodisulphate (TARTARI & MOSELLO 1997) and chemical oxygen demand by oxidability with $K_2Cr_2O_7$ (EAWAG). Oil products were determined by extraction with carbon tetrachloride and chromatographic separation of hydrocarbons (according ISO 9377-4); phenols were extracted with hexane and determined according ISO 8165.

The sediment samples were taken with a corer device from the undisturbed upper layer (0-5 cm) and frozen until determination of organic matter content by loss on ignition; another part was kept on ice for later analysis of phenols and oil products. Oil products in sediment were determined by extraction of organic matter in chloroform and chromatographic separation of hydrocarbons (MBB №081/12-0116-03); phenols in sediment were determined according ISO 8165.

Microbiology. Water sampling was carried on column, with a sterilized glass bottle. Part of the sample was preserved with 4% formaldehyde for the further assessment of bacterioplankton abundance. The other part was filtered immediately after sampling through the zooplankton net (65 µm mesh size) to remove the zooplankton and phytoplankton; this part was used to assess the bacterioplankton biomass. As for the chemical samples, the sediment was taken with a Corer device and 2 ml from the undisturbed upper layer were processed for determination of bacteriobenthos biomass.

The bacterioplankton abundance was determined by filtering 50-100 ml water sample through a Millipore membrane filter (0,22 µm) and staining the filter with phenolic erythrosine 5% for 1 hour. After the staining, the filter was washed to remove the colorant excess and dried. One fragment of the filter was examined at the microscope and the pinkish stained cells were counted using an ocular micrometre grid.

The number of bacteria is given by the formula: x = SN/sV, where: S – filter's surface (μm^2), s – surface of vision field (μm^2), N – the number of cells on every vision field, V – the volume of filtered sample (ml).

The bacterioplankton biomass was assessed by determining the phospholipids phosphates [WHITE et al. 1979, FINDLEY et al. 1989]. After zooplankton and phytoplankton removal, the sample was filtered through a membrane filter (0.22 μm) from cellulose nitrate and the biological material from the 8filter is further processed for the extraction of phospholipids [IONICA & GRUITA 1985]. The phospholipids were initially extracted with a mixture chloroform-methanol; after adding a second mixture of chloroform and water 1:1, the system was split in two phases, the phospholipids being extracted in the organic phase and digested with potassium persulphate to release the phosphate (determined spectrophotometrically at 700 nm).

The bacteriplankton biomass is calculated using the relationship:

$$\text{mg C} = \mu\text{moli PO}_4 / 10.$$

The bacteriobenthos biomass is determined by the same method, using 2 ml of fresh sediment instead of the water sample.

Aquatic macrophytes. Macrophytes investigations have been carried out in parallel with water and sediment sampling, according to standard hydrobotanical methods [DYACHENKO 2006, KATANSKAYA 1981, RASPOPOV 1985]; hydrophytes and helophytes were considered [PAPCHENKOV 2003] and the vegetation coverage was assessed visually. Species composition was estimated using Ukrainian keys of higher plants [DOBROCHAEVA, KOTOV, PROKUDIN et al 1987]. In plant communities apportionment Braun-Blanquet ecologic-floristic approaches have been used [WESTHOFF, MAAREL 1973].

Aquatic macrophytes species list is presented for the period of investigations, and vegetation description – for the period of its mass development (June–August).

Phytoplankton. Phytoplankton samples were taken on water column, using a modified Patalas device. Bottles of 0,5 l were filled and preserved with 4% formaldehyde. After 10–15 days of sedimentation, samples were concentrated to the volume 0,05–0,1 L and analyzed.

Phytobenthos. The sampling was performed in the photic zone of the water bodies. A layer of the benthic deposits was cut using pipe benthometer to take samples. The upper layer of water was carefully poured out leaving the benthic layer of 2–3 cm. The water layer and the upper layer of the benthic deposits were poured out into the vessel and fixed with formalin solution [METODY… 2006].

Zooplankton. The zooplankton samples were taken with a five-litter Patalas in the Sulina delta and with a four-litter Patalas in the branches of Kiliya delta (Bystryi and Vostochnyi); due to the reduced depth in the lakes the samples were taken with a bucket (10 l). In total, 50 l of water taken from different layers (surface, middle and bottom) were filtered through a 65 μm pore-size net and concentrated to 100 ml; the samples were preserved with formaldehyde to 4% final concentration.

The zooplankton samples were analysed in the lab, using inverted microscope, microscope and a binocular. Detailed examination in different counting chambers was performed [TSEEB 1947]. Identification of some species was carried out using light microscope Carl Zeiss "Primo Star". For determination were used the keys [BALUSHKYNA, WINBERG 1979, KUTIKOVA 1970, MANUYLOVA 1964, MONCHENKO 1974, RYLOV 1978].

The biomass was determined by calculation: the length of the organism was either measured using ocular-micrometer or its average value was taken from keys. Biomass was calculated by the body mass–body length relation:

$$w = q\, l^{3},$$

where w – body mass; l – length; q – proportionality coefficient, taken from [BALUSHKINA, WINBERG 1979].

Benthic invertebrate fauna. As *benthic invertebrate fauna* was considered the animals with size ranging between 1-100 mm, inhabiting the bottom of the aquatic ecosystems (zoobenthos) or attached on aquatic vegetation (phytophilous fauna). These two ecological groups are closely linked as during different stages of the life cycle the same invertebrates may belong to both categories. Structure and quantitative characteristics of these groups are considered in different chapters, but for comprehension of species composition, phytophilous and benthic invertebrates were combined in the unified list under the general name – macrofauna.

Phytophilous fauna. In all the investigated ecosystems, the samples of phytophilous fauna were taken considering the different ecological type of vegetation: emerged plants (EP), submerged plants (SP) and plants with floating leaves (PFL). As in different water bodies the structure of macrophytes community developed differently, the analysis of phytophilous communities will be presented at the ecosystem scale.

For phytophilous fauna sampling the method developed by L. N. Zimbalevska [1981] was used. Whole or part of plants were collected from the area of 0,25 m^2 into a container filled with native water. The hard steams and over-water parts of emerged plants were cut with garden pruner. Plants fragments were thoroughly washed and the water containing washed off animals was rinsed through the net (mesh N 23); the organisms were transported into the 0,2 l container and conserved with 4% formaldehyde. The plant fragments were weighted with technical balance (accuracy 0,01 mg).

Macrozoobenthos. At each site sampling was carried out by two methods: using the dredge (quantitative samples) and using the kick-net (qualitative samples). For sampling in the Sulina delta in 2006–2007 a Corer device was used (sampling area 0,004 m^2) and in 2011 the pole-mounted dredge with the surface area of 15x15 cm^2. In the Kiliya delta the section dredge was used (sampling area 0,01 m^2 [*]) or small Petersen dredge with the seizing of 10×10 cm^2 [METODY... 2006]. Kick-net with mesh size of 500×500 μm^2 was used for sampling in the macrophyte beds, among the tree roots, at the fouling of the wooden constructions and stones and from the surface of the benthic deposits. The samples were rinsed through the net (mesh № 23) and preserved with 4% formaldehyde solution.

In the old delta in 2006–2007, the zoobenthos samples were taken following the transects. In the Kiliya delta, owing to the shallowness and high macrophytes coverage (100 %) the access to the middle of the lake in summer and autumn was impossible, so sampling was carried at the mouth of the lake/bay.

In 2011 for each country three samples were taken at each station of the

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[*] In fall 2007 samples on the Romanian territory were also taken by the section dredge.

main river channel and delta branches: 1 dredge sample from each bank and 1 integral qualitative sample (except site 1). Two samples were taken at delta lakes: one using the dredge (in the plant-free area) and one qualitative sample. Totally 128 samples of the benthic invertebrate fauna were taken over the study (Moldova – 44, Romania – 41, Ukraine – 43).

After sampling the quantitative and qualitative samples were rinsed through the dip net (of the mesh size of 500 × 500 μm^2) and put into the plastic vessels. The large Bivalvia mollusks were weighed immediately after the sampling on PHILIPS electronic balance, identified up to the species, taken photos and released. Other organisms in the sample were fixed by 4% formaldehyde solution in the Ukrainian area. In the Romanian area the quantitative samples were fixed by 70% alcohol and qualitative samples – by 96% alcohol.

Besides, at the outflow of the Lypovanska branch from the Ermakov island to Danube (site 10) integral samples of ichthyofauna and invertebrates drift were taken by the conic ichthyoplankton net, invertebrates were processed by standard methods as it was mentioned above.

Ichthyofauna. Ichthyofauna samples in the Small Tataru island were taken in the channels (sites 1, 6, 7), overgrown and free areas of the lake (sites 2, 3, 4), duckweed-covered shallow areas (site 5), in the coastal section of the Danube at the northern side of the island (see Fig. 1). In the Ermakov island samples were taken in the channels (sites 10, 11, 15), lakes (sites 12, 13, 14) and in the Solomonov branch of Danube (site 16). Totally 20 samples of juvenile fishes were taken, 10 in each island. In the taken material totally 3677 specimens were counted (2076 from the Small Tataru island and 1601 from the Ermakov island).

Sampling was carried out mainly using the paddle boat and from the bank. In the near-bank zone juvenile fishes were caught using the standard net of the mill gauze N 14 with the inlet orifice diameter 0,35 m. For each sample the net was lifted 1–6 times, depending of the juveniles' density and degree of overgrowth. Juveniles' number per unit of the water area was calculated with account of the net lifts number and area of the inlet orifice (0.1 m^2). In pelagial samples were taken by the he conic ichthyoplankton net with the inlet orifice diameter 0,55 m, with cone of the mill gauze N 12 1,5 m long. The net was transported after the boat with moderate velocity, at this track length and depth of the net was registered. At the presence of current the boat was anchored and the net was located against the current for 15 min., at this flow velocity was measured by the float flowmeter.

Taken samples were preserved by the standard method in the special vessels by adding of 1/10 volume portion of 40% formaldehyde solution.

1.3. LABORATORY ANALYSIS

The lab investigations of phytoplanctom and phytobenthos regarding species diversity, abundance and biomass were carried using a Laboval-4 microscope using the following determinative keys [ASAUL 1975, KONDRATIEVA 1968, MATVIENKO 1965; PALAMAR-MORDVINTSEVA 1984, 1986, TSARENKO, 1990]. The phytoplankton cell numbers were counted in a chamber of 0,02 ml volume; the counting was repeated three times.

Abundance calculation was done according to the formula:

$$N = \frac{n \times v \times 1000}{V},$$

where: N – number of cells in 1 L of water; n – number of cells in the counting camera; v – volume of concentrated sample; V – initial sample volume.

The biomass was calculated by multiplying the number of individuals from each species with the individual cell volume.

At the laboratory the samples of phytobenthos were examined in the counting chamber of 0,02 mm^3 volume. The algal biomass was determined by counting – volumetric method. The number and biomass were calculated per 10 cm^2.

The invertebrates in laboratory were divided into taxonomic groups. In each group the organisms were identified up to species or up to maximum possible lower taxon with using identification keys [ZHADIN 1952;

CHEKANOVSKAYA 1962, PANKRATOVA 1970, 1983, KUTIKOVA, STAROBOGATOV (EDS) 1977, TSALOLIKHIN (ED.) 1994, 1995, 1997, 1999, 2004]. Sorting of the samples and identification of the organisms was performed using biological stereoscopic microscope (MBS-10) and NIKON ECLIPSE E-200 binocular microscope. The organisms were weighed on RADWAG electronic balance to 0,0001 g. The abundance and biomass of the organisms in dredge samples was transferred into ind/m^2 and g/m^2 and for phytophilous fauna for 1 kg of wet weight of plants respectively.

Fish larvae and juveniles were determined using the binocular microscope MBS using the determinative key and guidances [KOBLITSKAJA 1981, VOSKOBOJNIKIVA, PAVLOV 2006, URHO 1996]. Specimens' length was measured using the ocular-micrometer to 0,5 mm, weight – by the torsion balance to 1 mg.

Juveniles' numbers in pelagial (C, spec/m^3) was calculated by formula:

$$\mathrm{C} = \frac{Q}{S \times L} \;;$$

where: Q – number of specimens, caught in the net (spec.); S – area of the inlet orifice (m^2); L – net track length (m).

1.4. DATA ANALYSIS

MICROSOFT EXCEL 2007 worksheets were used for the samples' mathematical treatment, calculation of the majority of the parameters, graphs and charts plotting.

For each species of phytoplankton, phytobenthos, zooplankton and macroinvertebrates ***occurrence frequency*** was calculated using the following formula:

$$P = \frac{m}{n} * 100 \text{,}$$

where: m – number of aquatic ecosystems where the given species was registered; n – total number of the considered waterbodies.

Assessment of biological diversity of communities was carried out using ***Shannon* – *Wiener*** index (calculation based on abundance and biomass) [PESENKO, 1982]:

$$H = -\sum p_i \times \log_2 p_i \,,$$

where p_i – share of the i^{th} species numerical density (biomass) in total numerical density/biomass of the community.

For evaluation of the species' domination in the communities the Mordukhay-Boltovskoy's cenotic significance index (domination index DI_i) was used [MORDUCHAY-BOLTOVSKOY 1975]:

$$DI_i = p_i \sqrt{B_i / B_s} \,,$$

where: $p_i = m_i/M$ – frequency of the species i occurrence; m_i – number of samples, where the i species was found; M – total samples' number; B_i – biomass of the i^{th} species; B_s –total biomass of biocenoses. As dominants we consider species with index value within 0,1–1,0.

The assessment of pollution level was based on the following indices: *Woodiwiss (TBI)* [LIASHENKO, ZORINA-SAKHAROVA 2012], *Pantle & Buck in Sladechek modification* [PANTLE, BUCK 1955] and *Zelinka & Marvan*. The latter three biotic indexes for macroinvertebrates communities were calculated using the ASTERICS 3.1.11 tool [AQEM, 2002]. For water quality assessment ARI (average rank index) was used of the ecological and sanitary classification, valid in Ukraine [METODIKA…, 1998]. This classification includes a set of 5 groups of indices indicating abiotic and biotic parameters of the aquatic ecosystems: hydrophysical, hydrochemical, hydrobiological, bacteriological and saprobity.

Saprobity indexes *Zelinka & Marvan* were calculated separately for qualitative samples (abundance ind/m^2) as well as for the aggregate ones (dredge+kick-net) (abundance ind/sample). The correspondence of saprobity indexes to ecological classes was provided according to the methodology approved in JDS2 [JOINT 2007; SOMMERHAUSER et al. 2003].

Similarity of the macrozoobenthos species composition was evaluated by the Sørensen coefficient with further plotting of the cluster dendrogram in BioDiversityPro program.

CHAPTER 2.

ASSESSING THE IMPACT OF ENVIRONMENTAL CHANGE ON AQUATIC ECOSYSTEMS IN THE DANUBE DELTA (ECAQUDAN)

2.1. HYDROCHEMICAL INVESTIGATIONS

2.1.1. WATER

Depth. The floods of spring 2006 determined an increased water level in the whole Danube Delta. Consequently, in the investigated ecosystems of Sulina delta and annual average depths were generally higher than in 2007 (Fig. 2.1.1), ranging within 1,93–2,67 m in channels and 1,48–2,34 m in the lakes; different hydrological and thermal conditions in 2007 determined notable decrease of water depth, the annual averages ranging from 1,53–2,07 in channels and 0,63–1,51 m in the lakes.

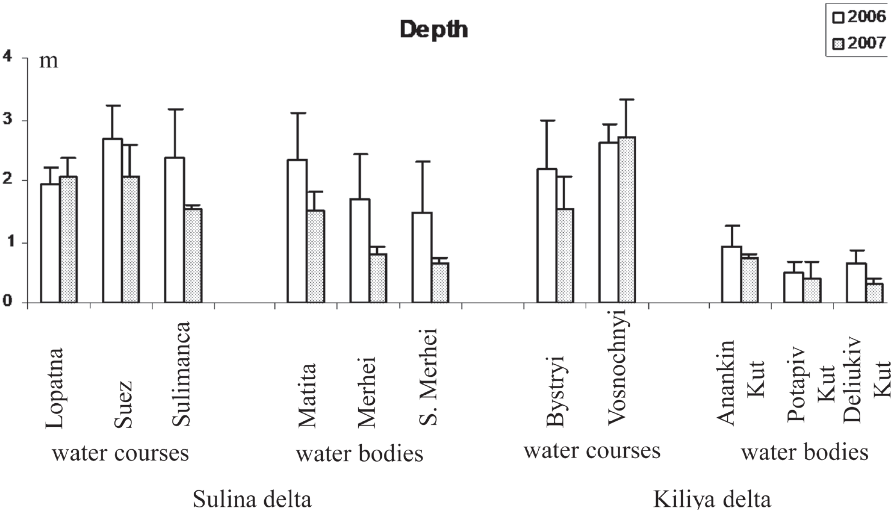

Fig. 2.1.1 Depth dynamics in the investigated ecosystems between 2006–2007

In the younger Kiliya delta the trend was similar – depths in 2006 were higher, but the differences within the annual averages in 2006 and 2007 in the lakes and lagoons were not so high (on average 0,1–0,3 m); much higher was the depth fluctuation recorded in the Bystryi branch (from 2,18 m in 2006, to 1,53 m in 2007).

Transparency. Owing to different hydrological and thermal conditions in 2006–2007, high fluctuations were recorded in the elder part of the delta. In spite of the floods of 2006, due to the filtering capacity of reedbed areas and to longer distance within the water source (Sulina arm) and the investigated ecosystems, the suspended matter brought by Danube River could settle and the transparency was high, annual averages ranging within 1,17–1,27 m in the channels and 1,28 1,64 m in the lakes (Fig. 2.1.2)

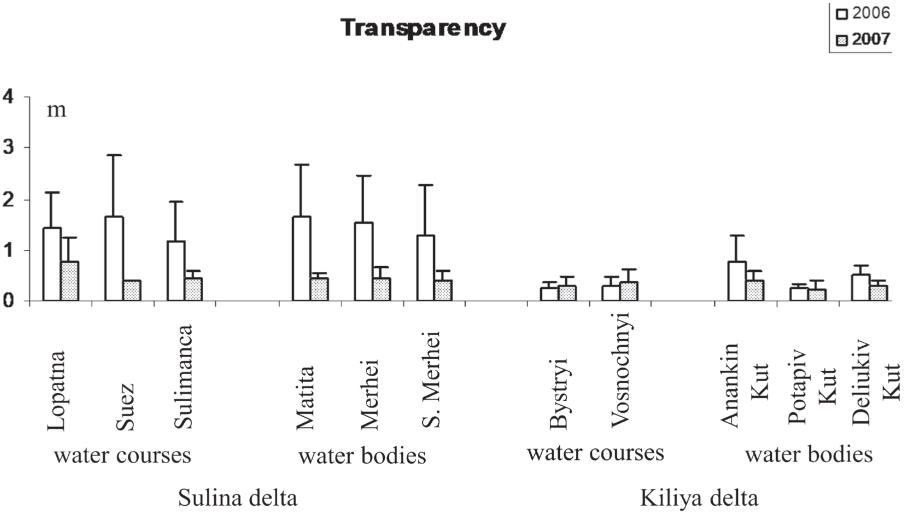

Fig. 2.1.2 Transparency dynamics in the investigated ecosystems between 2006–2007

In the Kiliya delta, owing to the high content of suspended matter brought by the Danube, the transparency was lower in braches in both years; in lakes, as at the Romanian side, the transparency was higher in 2006.

As absolute value of transparency does not give much information, a transparency index (T/D) was determined as the ratio within the Secchi depth (transparency) and the depth of the aquatic ecosystem (D). This characteristic is extremely important in view of the of primary producers functioning: value below 0.2 means reduced development of macrophytes as the light can not penetrate the water column.

For the elder part of the delta, the transparency index was higher in 2006 than in 2007; possible explanation of this fact is the increased temperature in 2007, which favored algal “bloom” from spring until autumn, decreasing water transparency (Fig. 2.1.3).

In the arms of the Kiliya delta the transparency index was lower in 2006 owing to high amount of suspended matter carried by the flood.

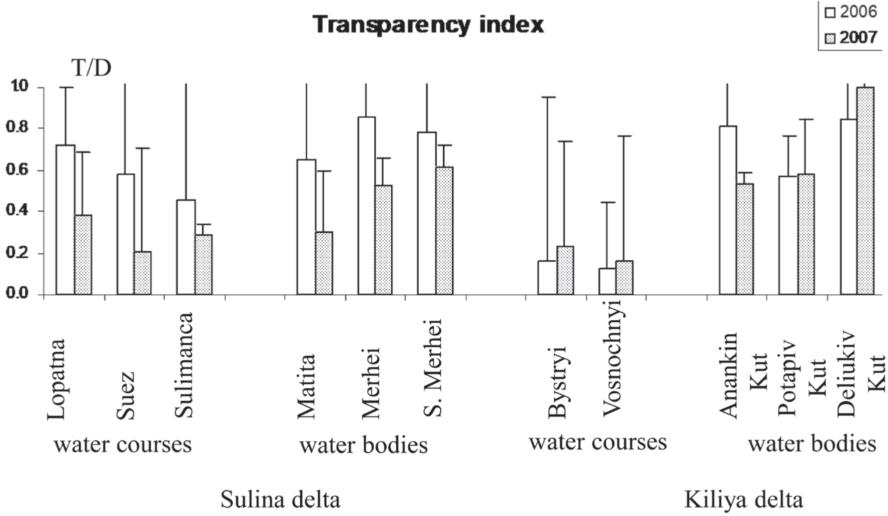

Fig. 2.1.3 Transparency index (T/D) variation in the investigated ecosystems between 2006–20072007

In the Anankin Kut lake and Deliukiv Kut lagoon the highest transparency index was registered even in 2006, as the access to these water bodies can be done through the long channel, which enabled the sedimentation of the suspended matter carried by Danube.

Potapiv Kut lagoon, located in the proximity of Potapiv branch, was more influenced by the Danube's water, so, the transparency index was low in both years.

Temperature. In general, in the investigated ecosystems the annual average temperature increased in 2007 (Fig. 2.1.4); the temperature difference was higher in Sulina delta than in the Kiliya delta. In the channels of Sulina delta the temperature increase ranged within 1,1–3,1°C, while in lakes the amplitude was lower, ranging within 1,3–2,4°C.

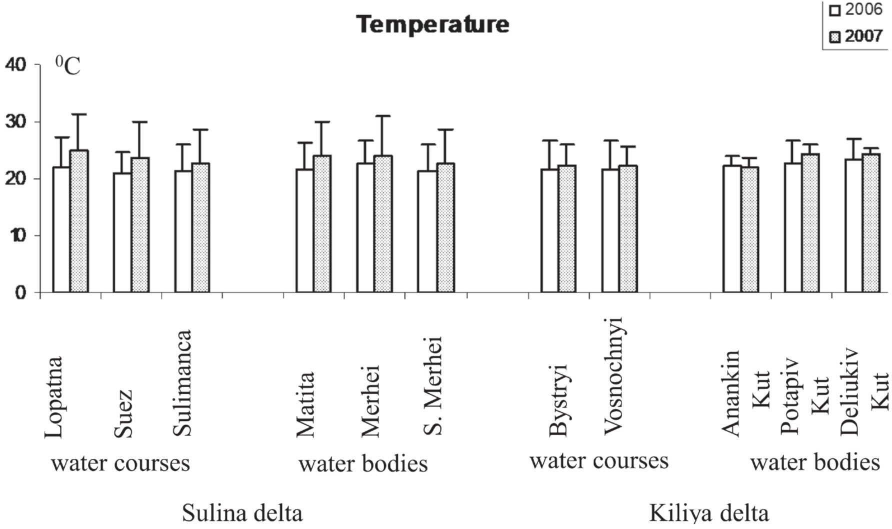

Fig. 2.1.4 Temperature variation in the investigated ecosystems between 2006–2007

In the arms of the Kiliya delta were less affected by the temperature increase in 2007: difference amounted to 0,44–0,67°C. Maximal increase was registered in the Potapiv lagoon (1,9 °C) whereas in the Anakin lake the annual average temperature in 2007 demonstrated the unusual decrease (0,5°C).

pH. Though normally the pH values of the Danube water is slightly alkaline, ranging within 8–9, during the study we recorded higher values, especially in Romania in 2007, – even above 10, probably as a consequence of the intensive algal blooms in this year (Fig. 2.1.5). During photosynthesis, the carbon dioxide is absorbed from the aquatic environment and pH increase temporarily; also oxygen oversaturation might occur as well. As in 2007 the temperatures increased since early spring, algal blooms occurred during the whole vegetation season.

In the Sulina delta the pH increased in 2007, the amplitude of variation ranging within 0,6–2,0 units in channels, and 0,6–1,8 units in lakes; in Ukrainian part, in the Bystryi branch pH increased in 2007 by 1,23 units, whereas the average value in the Vostochnyi branch was almost constant (9,33–9,35). In the Anankin Kut and Potapiv Kut water bodies the pH slightly decreased in 2007, whereas in Deliukiv Kut it slightly increased.

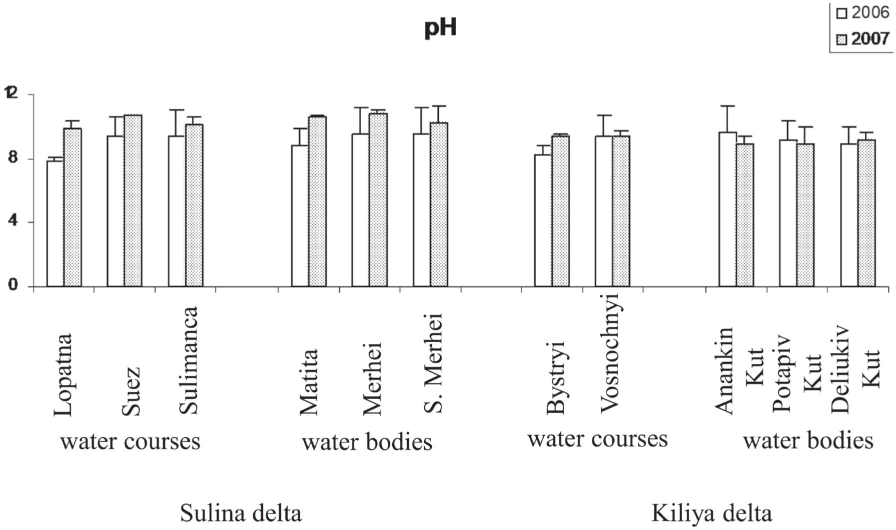

Fig. 2.1.5 pH variation in the investigated ecosystems between 2006–2007

Redox potential. In all the investigated ecosystems the oxidation-reduction potential (ORP) of the water column showed negative values, indicating the reducing environment; following the pH fluctuations, it decreased drastically in 2007 in Sulina delta, while in the Kiliya delta the amplitude of fluctuations was lower (Fig. 2.1.6).

In the channels of Sulina delta, the decrease ranged within 50–120 mV, whereas in the lakes – 40–110 mV. In the arms of the Kiliya delta, the trends were different: in the Bystryi branch it decreased in 2007 by 80 mV, and in Vostochnyi it slightly increased. In Anankin Kut and Potapiv Kut it slightly increased in 2007, and in Deliukiv Kut – slightly decreased.

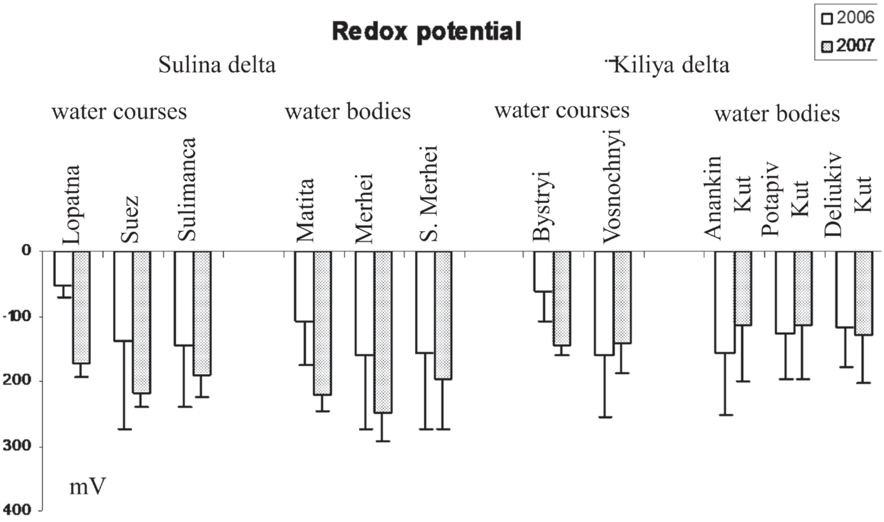

Fig. 2.1.6 ORP variation in the investigated ecosystems between 2006–2007

Conductivity and salinity. The conductivity over the studied period was almost constant, the annual average values ranging within 334–430 µS/cm, typical for freshwaters; in the Potapiv Kut lagoon the conductivity was maximal among all the investigated ecosystems (802–793 µS/cm); in the Deliukiv Kut lagoon the annual average conductivity ranged within 391–587 µS/cm (Fig. 2.1.7).

The salinity was zero, except the Potapiv Kut lagoon, where a slight influence of the sea water could be felt, the average value of salinity ranging within 0,15–0,17‰.

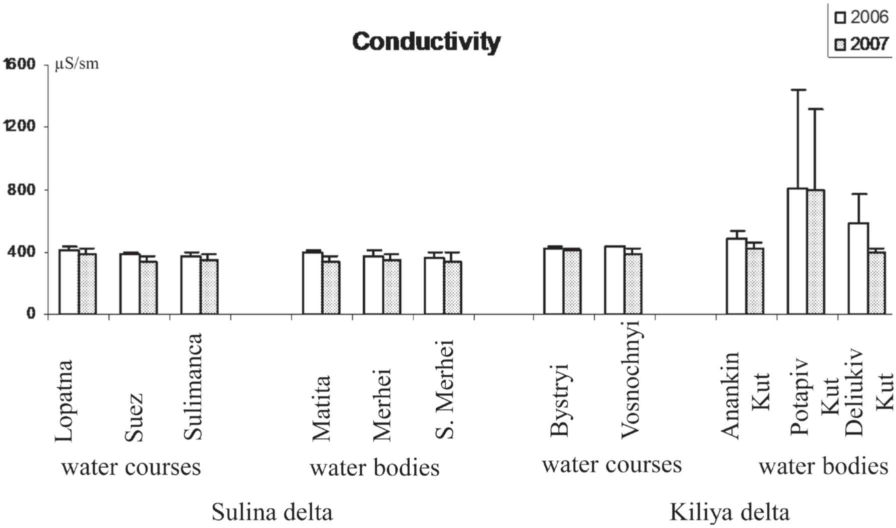

Fig. 2.1.7 Conductivity variation in the investigated ecosystems between 2006–2007

Oxygen content. Dissolved oxygen is a vital parameter in the aquatic ecosystems; in the eutrophic ecosystems, as the ones from Danube Delta, the oxygen content may drop severely over the night, when oxygen consuming processes (decomposition of organic matter, respiration) prevail over its production. Consequently, for short periods, hypoxia or even anoxia may occur, especially in summer, when oxygen solubility decreases along with temperature increase.

In the channels of Sulina delta, the oxygen concentration ranged within 4,91–9,37 mg/l, the higher values were registered in 2007; similar situation occurs in the lakes, where oxygen content fluctuated within 7,05–11,52 mg/l, the maximum level was reached in Merhei lake in both years (Fig. 2.1.8).

In the Kiliya delta, the dynamics of oxygen content differs significantly in the arms and lakes: in the arms it was almost constantly high (6,85–6,88 mg/l), whereas in the Anakin Kut lake it reached critical levels, the annual averages ranging within 3,44–2,31 mg/l. Especially in summer it was critical as the oxygen content dropped to 0,13 mg/l in 2006 and 0,5 mg/l in 2007. In Potapiv Kut and Deliukiv Kut lagoons the oxygen level was within 4,34–6,91 mg/l; also here the oxygen content decreased during summer, but the lowest level found was 2,44 mg/l in Deliukiv Kut in 2007.

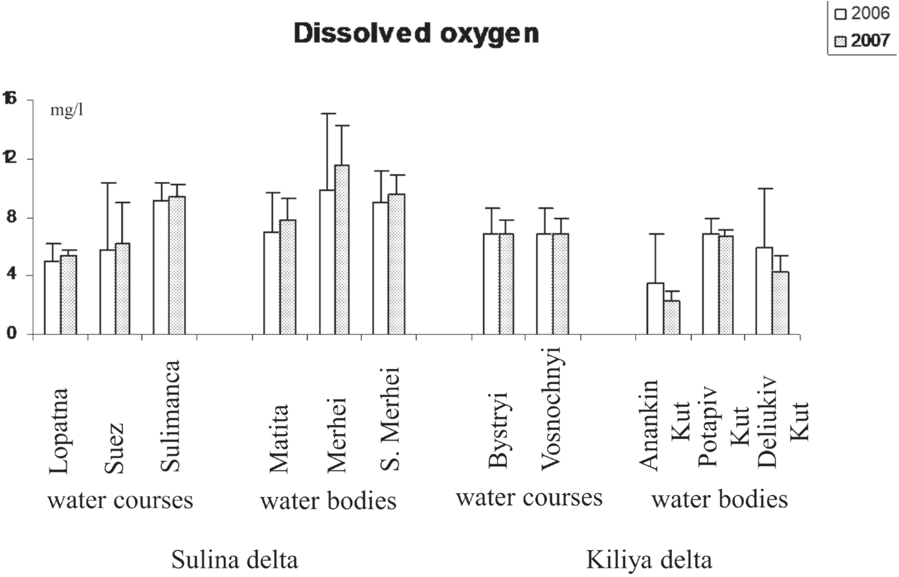

Fig. 2.1.8 Dynamics of dissolved oxygen content in 2006-2007.

The drop of oxygen content below certain limit (usually considered as 4 mg/l), may endanger the aquatic organisms, who rely on the dissolved oxygen for respiration; as the organic matter settle and the decomposing processes occur mostly at the water-sediment interface, at the bottom may occur hypoxia (or even anoxia), resulting in the decline of benthic invertebrates community or even fish death.

Beside of the dissolved oxygen content (mg/l), in the aquatic ecosystems it is useful to express also the level of oxygen saturation, determined as the ratio within the actual concentration of dissolved oxygen in water and the theoretical amount of oxygen soluble at given temperature (Fig. 2.1.9).

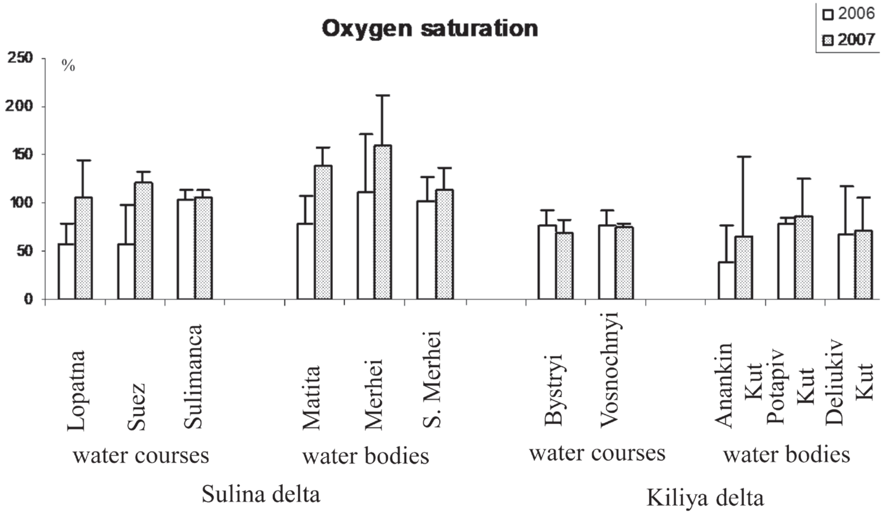

Fig. 2.1.9 Dynamics of oxygen saturation in 2006–2007

In the channels of Sulina delta the oxygen saturation varied within 6–00% in 2006, and increased in 2007 to 105–120%; though paradoxal, oxygen saturation may increase over 100% during algal blooms, when intensive photosynthesis lead to over-saturation of the aquatic environment. In the lakes the oxygen saturation ranged within 80–110% in 2006, whereas in 2007 the over-saturation reached very high levels, the annual averages ranging within 113–160%. As in 2007 the temperature increased earlier, algal blooms were recorded since spring; still, the highest over-saturation was reached in summer. The occurrence of this phenomenon is dangerous, as high over-saturation may cause algal buoyancy and their consequent destruction, increasing the amount of decaying organic matter in the water column; during night, when photosynthesis ceases, the oxygen is consumed in respiratory processes, but also for the organic matter decomposition, disappearing from the water column.

In the Bystryi and Vostochnyi brunches the annual average values of the oxygen saturation varied within 70–77%. In the Potapiv Kut and Deliukiv

Kut lagoons it reached a slightly higher level – 68–85%, and in the Anakin Kut lake in 2006 it was critically low (39%).

Chemical oxygen demand. The chemical oxygen demand (COD) is an indicator of the organic matter amount in the water column. Two substances are generally used to oxidize the organic matter: potassium permanganate and potassium dichromate, but the second one is stronger, and therefore able to decompose more stable organic compounds.

In the Sulina delta, COD increased in 2007, except for the Merhei lake; among channels the highest increase was recorded in Suez (from 42 mg O/l in 2006 to 69 mg O/l in 2007), while in Lopatna and Sulimanca COD increased insignificantly (by 5–6 mg O/l) (Fig. 2.1.10).

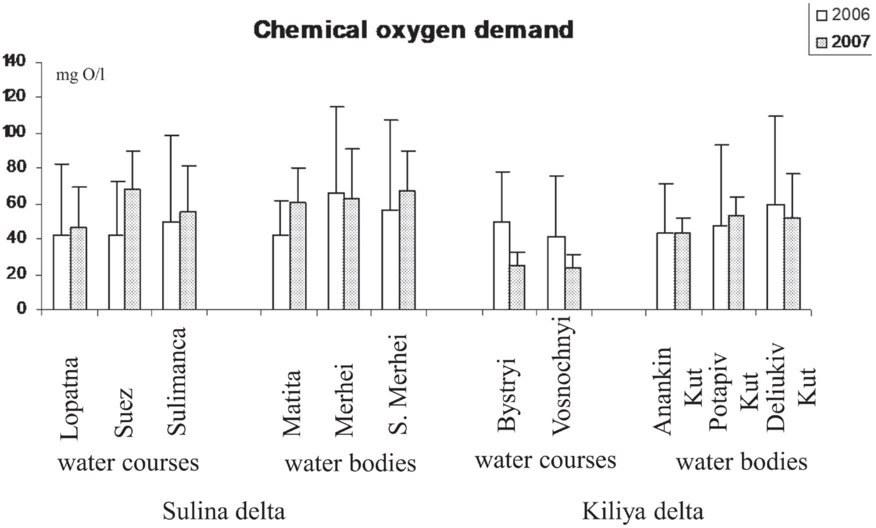

Fig. 2.1.10 Dynamics of chemical oxygen demand in 2006–2007

In Matita and Small Merhei lakes COD ranged within 42–67 mgO/l, while in Merhei it slightly decreased (in 2006 in this lake the COD value was the highest among the investigated ecosystems). This decrease might be a consequence of the shift appeared at the level of primary producers: in summer 2006 the Merhei lake was covered with a dense vegetation carpet (mostly Chara), while in 2007, the earlier increase of temperature favored the phytoplankton development during the whole vegetation season.

In the Kiliya delta the dynamics was different: in the arms the COD level decreased in 2007 to 25 mg O/l, in Anankin Kut lake remained constant (43 mg O/l), whereas in Potapiv Kut and Deliukiv Kut it fluctuated about 52 mg O/l.

Nutrients. Though nitrogen and phosphorus normally occur in low concentrations in the aquatic environment, they have an essential role in the development of the primary producers, influencing consequently the structure of the whole food web.

Nitrogen is contained in amino acids, proteins, enzymes, vitamins, vegetal hormones, photosynthetic pigments, while phosphorus has an essential role in the algal metabolism being involved in the cellular division, chlorophyll synthesis, photosynthesis, organic matter production, etc. Their inorganic forms (ammonium, nitrates, nitrites for nitrogen, and orthophosphates for phosphorus) are absorbed from the environment by the algae; through photosynthesis, the algae synthesize organic matter available for the upper links of the trophic chain.

Their absence can have negative effect on the aquatic biocenoses, but on the other hand, their excess may have negative impact by stimulating a hyper-production of organic matter and inducing eutrophication as well.

Dissolved inorganic nitrogen (DIN). In the Sulina delta the annual average DIN content ranged within 620–780 µg N/l in the channels and 640–830 µgN/l in the lakes (Fig. 2.1.11); the general trend for 2006–2007 was increasing, except for Lopatna channel, where decrease was noted.

The highest amount of DIN was found in the arms of the Kiliya delta, the annual averages ranging within 830–1037 µgN/l, while in the lakes it ranged within 550–830 µgN/l.

Soluble reactive phosphorus (SRP) In the channels of Sulina delta the annual average values of SRP ranged within 20–80 µg P/l, the highest was reached in Sulimanca channel in 2007, while in the lakes it ranged within 30–100 µg P/l, with a maximum in Small Merhei lake in 2007 (Fig. 2.1.12).

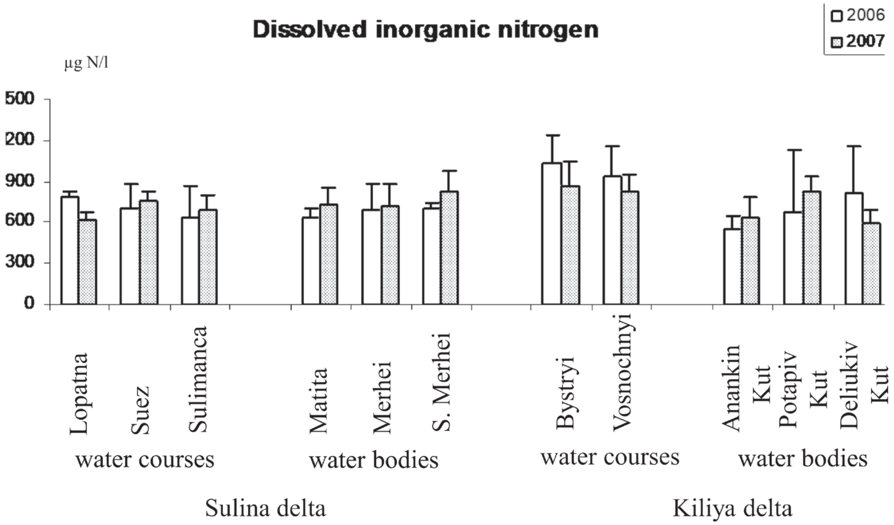

Fig. 2.1.11 Dynamics of dissolved inorganic nitrogen content in 2006–2007

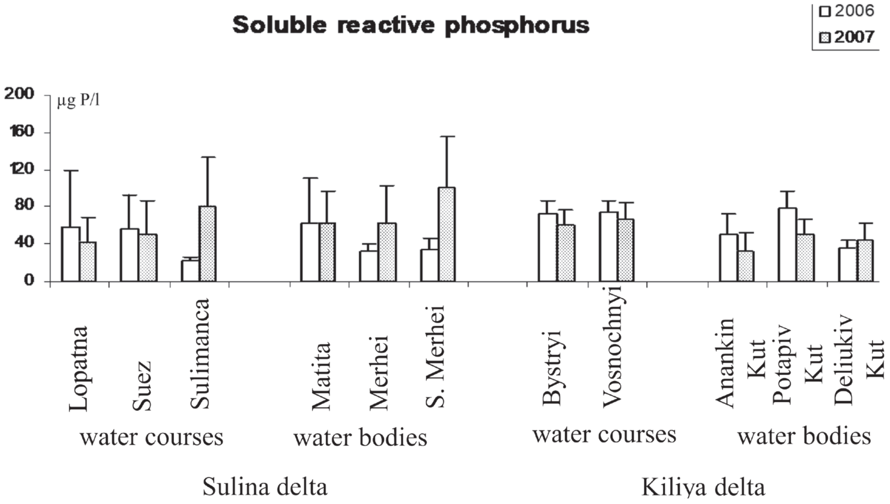

Fig. 2.1.12 Dynamics of soluble reactive phosphorus in 2006–2007

As Sulimanca channel is located at the outflow of Small Merhei, the high average in 2007 may be in correlation with the algal blooms recorded in this lake during the whole vegetation period.

In the arms of the Kiliya delta SRP varied in a narrow range – 60–80 µg P/l, these values were higher than in the lakes (30–80 µg P/l).

Total phosphorus (TP). In Sulina delta channels the annual average values of TP ranged within 75–145 µg P/l, while in the lakes it varied within 85–135 µg P/l (Fig.2.1.13); the highest values were found in the Sulimanca channel, Merhei and Small Merhei lakes.

Similar to SRP, the variation range of the annual averages in the channels of Kiliya delta was very narrow (90–100 µg P/l), while in the lakes it varied within 50–110 µg P/l, the maximum values were reached in the Anakin Kut lake in both years.

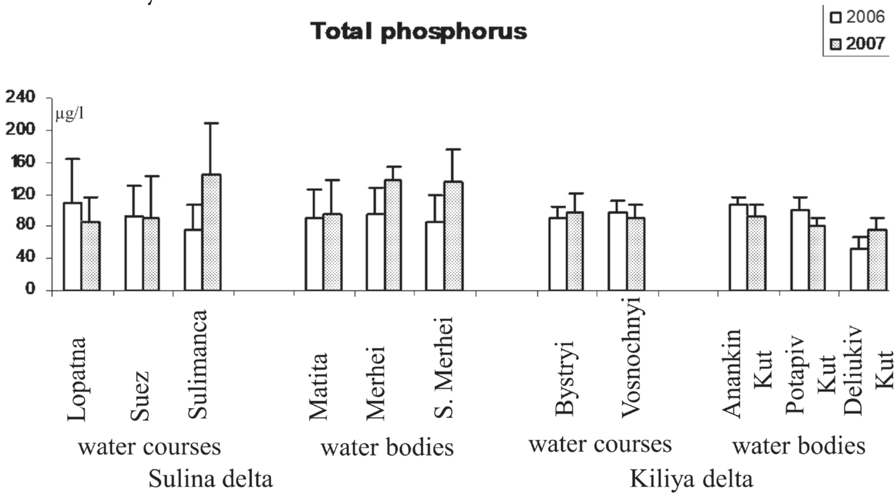

Fig. 2.1.13 Dynamics of total phosphorus in 2006-2007

DIN/SRP. When light and temperature are adequate for the algal development, nutrient availability becomes the next limiting factor – the usual way to determine the least available nutrient in the aquatic environment is the ratio TN/TP or DIN/SRP.

Though it was criticised by different authors as both DIN and SRP can vary greatly in time and their ratio may underestimate the available N as the SRP includes also organic compounds, this index is still used as it gives at least a raw estimate of the limiting element.

The critical point, when N limitation switch to P limitation is 10: a DIN/SRP ratio higher than 10 means that is enough N in the environment and P is the limiting nutrient; when this ratio is lower than 10, N is considered the limiting factor.

The annual average values in the Sulina delta were higher than 10 (Fig. 2.1.14), confirming previous studies which indicated P as limiting factor; however, in summer 2007, the ratio decreased below 10 in almost all the ecosystems (except Lopatna), indicating that during powerful algal blooms N may become limiting as well.

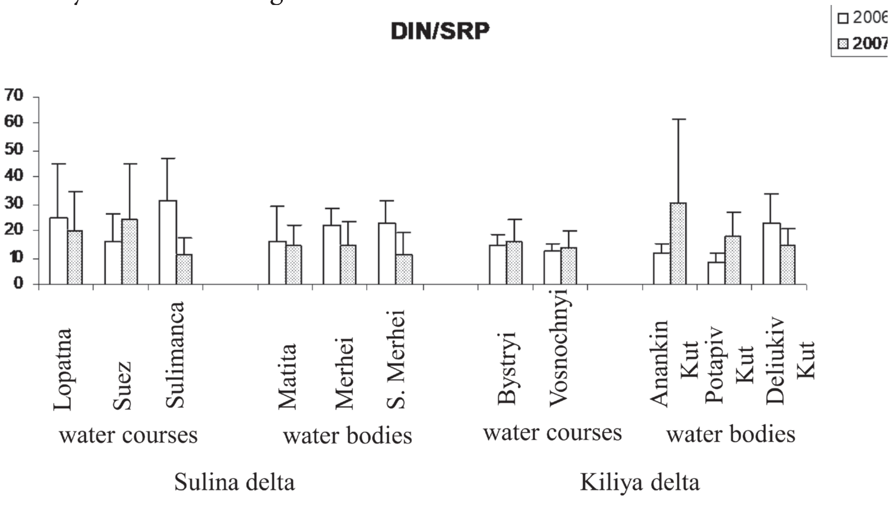

Fig. 2.1.14 Dynamics of DIN/SRP in 2006–2007

In the channels and lakes of the Kiliya delta the annual average values of the ratio indicate P as limiting element, except for Potapiv Kut lagoon, where in 2006 it amounted to 8. Though even here algal blooms were recorded in summer, DIN/SRP ratio did not decrease so drastically as in Sulina delta.

Chlorophyll-a. Though the amount of chlorophyll *a* is highly variable within the algal species, it is generally accepted as a quick indicator of algal biomass, and therefore used in the monitoring of water quality. Together with other parameters like DIN, TP and oxygen saturation, chl-*a* gives valuable information about the trophic state of the aquatic ecosystems, which further can be used for the proper management of the water bodies.

Due to the specific thermal conditions in 2007, chl-*a* level increased in all the investigated ecosystems in comparison with the values found in 2006, signalizing powerful algal blooms (Fig.2.1.15). The highest levels were reached in the Sulina delta, both in channels, where the annual averages ranged within 38–54 μg/l, and in lakes (44–53 μg/l). The highest increase occurred in the Matita lake, where the chl-a content increased 5 times in comparison with 2006, while the lowest occurred in Small Merhei (2 times). These differences were, probably, explained by the fact that in the Matita lake the phytoplankton is the primary producer, while in Small Merhei lake prevail the macrophytes.

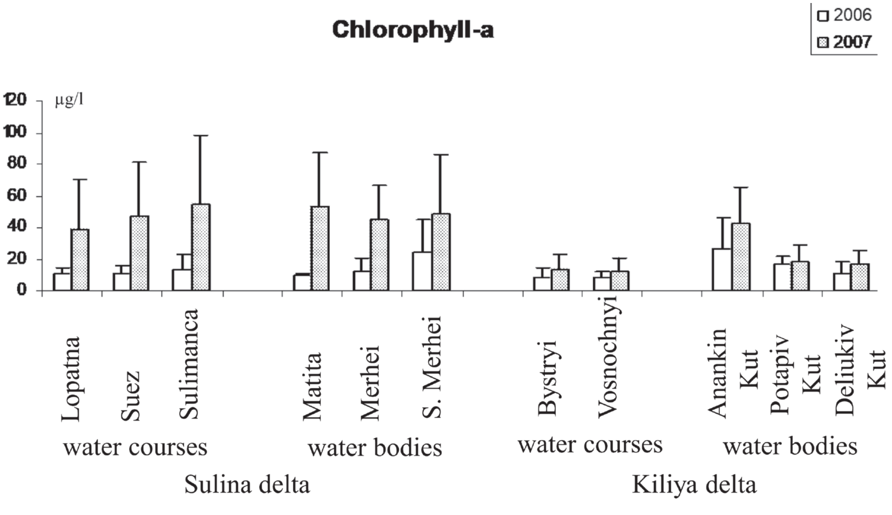

Fig. 2.1.15 Dynamics of chlorophyll-a content in 2006–2007

In the arms of the Kiliya delta the levels of chl-a were the lowest among the investigated ecosystems (8–14 µg/l). In the lakes the highest value was in the Anankin Kut lake (26–42 µg/l), while in Potapiv Kut and Deliukiv Kut the annual averages ranged within 10–18 µg/l owing to high macrophytes coverage in these lagoons.

Oil products in water column. Owing to their toxicity and persistence in the aquatic environment, the oil products are dangerous contaminant; the aromatic hydrocarbons are more difficult to decompose by bacteria and the aromatic ring may cause carcinogenic effects on the biota. Therefore, the quality standards have set very low limits of acceptance for this parameter, the usual value being 0.05 mg/l for fisheries water.

The screening done in 2007 in the studied ecosystems revealed low values in the Sulina delta, both in the channels and lakes, ranging within 0–0,04 mg/l, whereas in the Kiliya delta the admitted level was overpassed in all the investigated ecosystems. The highest levels were found in the Bystryi arm (0,5 mg/l), Deliukiv Kut lagoon (0,3 mg/l) and Vostochnyi branch (0,2 mg/l) (Fig. 2.1.16).

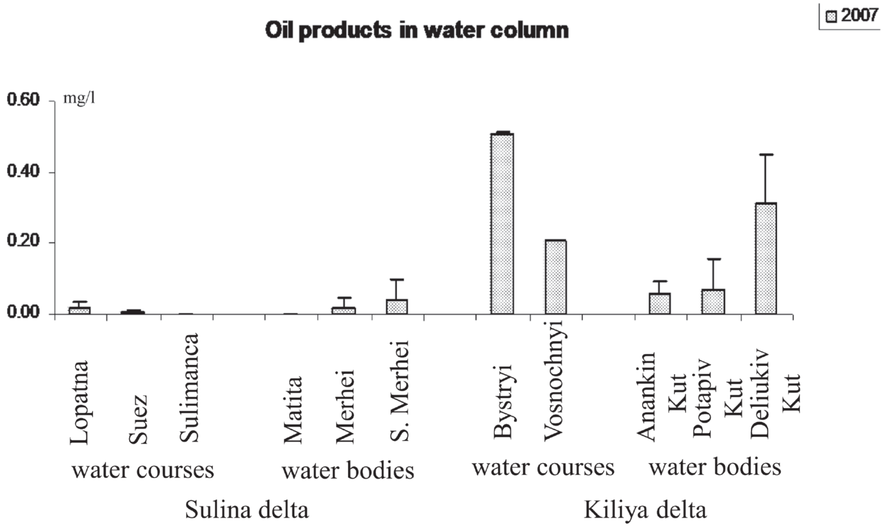

Fig. 2.1.16 Oil products content in water column in 2007.

2.1.2 Sediment

Temperature. The annual average temperature of the sediment followed in general the same trend as in the water, increasing in 2007 (Fig. 2.1.17), with higher differences in Romanian part than in the Ukrainian part of delta. The amplitude of variation was lower than for the water column, the higher increase was recorded in the Lopatna channel (2,2°C) and Merhei lake (2°C).

As for the water temperature, the arms of the Kiliya delta were less affected by the temperature increase recorded in 2007, in the Vostochnyi branch even a slight decrease was noted (0,6°C). In Potapiv Kut lagoon increase was the highest 1,6 °C, while in Anankin Kut, a similar decreasing trend as for water was noticed (1°C).

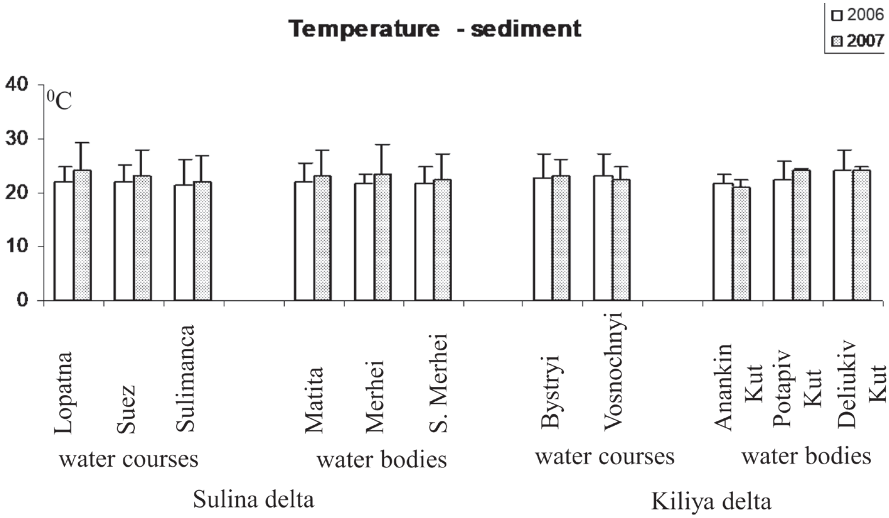

Fig. 2.1.17 Dynamics of temperature in the sediment in 2006–2007

pH. Following the general increase occurred in 2007 in the water pH, the sediment pH increased as well, but the annual average values were below 10. For Sulina delta, the highest pH differences were noticed in the Lopatna channel (2,4 pH units) and Merhei lake (1,3 units). In the Kiliya delta the highest differences were recorded for Bystryi and Vostochnyi brunches (0,8–1,2 units), while in the lakes and lagoons the differences were insignificant (Fig. 2.1.18).

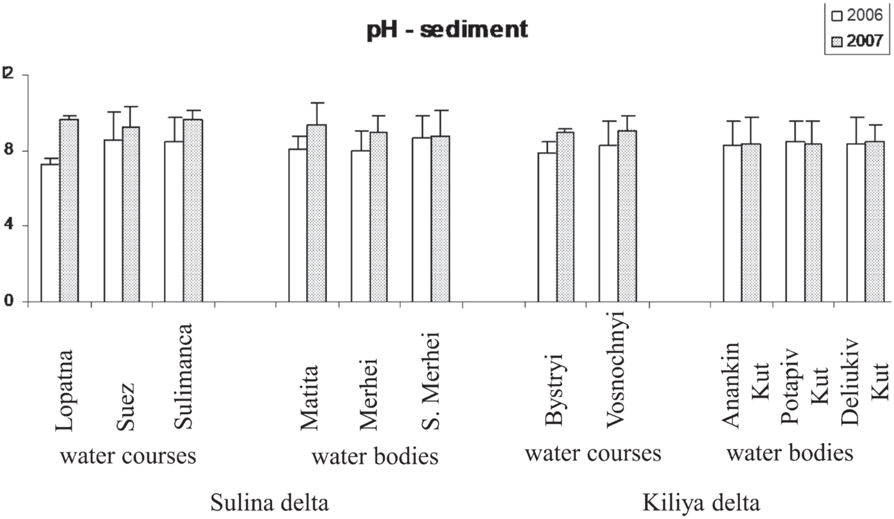

Fig. 2.1.18 Dynamics of pH in the sediment in 2006–2007

Redox potential. As for the water, the oxidation-reduction potential (ORP) of sediment showed negative values in all the investigated ecosystems, indicating a reducing environment; following the pH fluctuations, it decreased drastically in 2007 in Romanian part of delta, while in the Ukrainian part the fluctuations were significant only in the arms (Fig. 2.1.19).

Organic matter in sediment. In 2007, the amount of organic matter decreased in all the investigated ecosystems of the Danube Delta, but with different amplitude in two parts of the delta.

In Sulina delta the amplitude of variation was higher, but so was also the amount of organic matter. In the channels the highest variation was found in Sulimanca, where the organic matter content dropped from 16% in 2006 to 1,20 % in 2007 (Fig. 2.1.20).

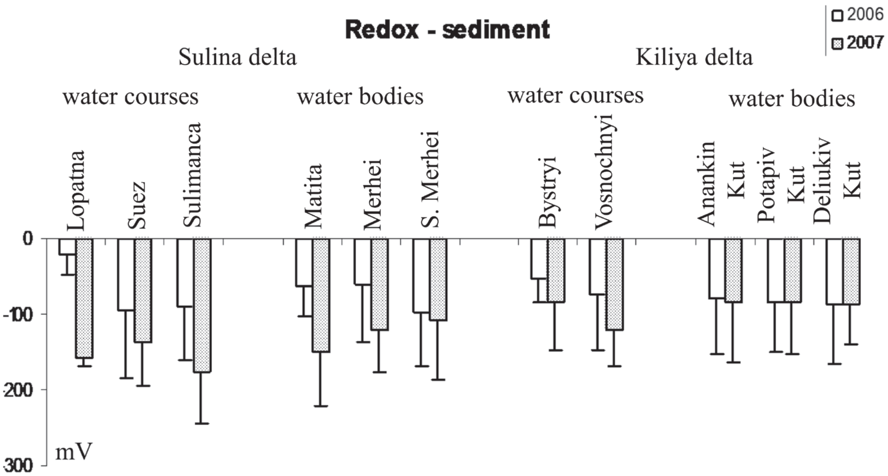

Fig. 2.1.19 Dynamics of redox potential in the sediment in 2006–2007

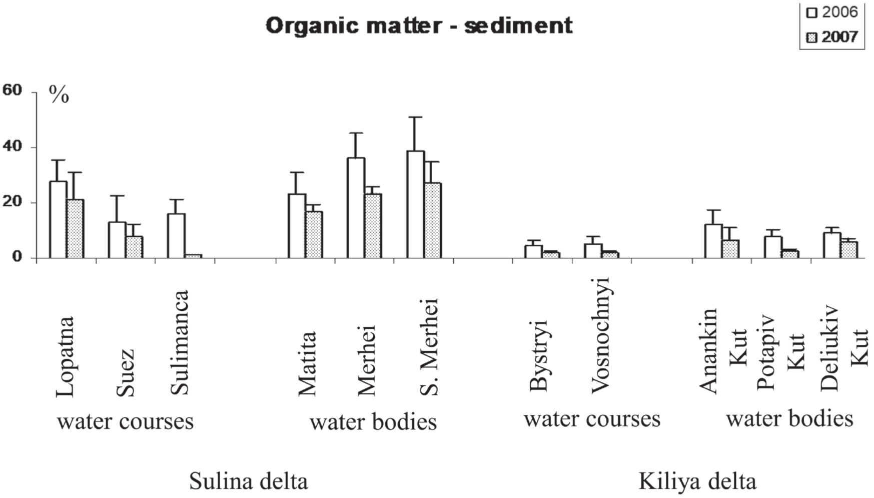

Fig. 2.1.20 Dynamics of organic matter in the sediment in 2006–2007

High differences were found also in lakes: in Merhei it dropped from 36 to 24% and in Small Merhei it dropped from 39 to 27%.

In the Kiliya delta the lowest difference was recorded in the arms (from average of 5% to average of 2%), while the highest was recorded in the Anankin Kut lake (from 12 to 6%) and Potapiv Kut lagoon (from 7,5 to 2,5%).

This can be explained by the increased temperature of water and sediment (by on average 1,4°C in water, and 0,7°C in sediment), which determined acceleration of the decomposing processes.

Oil products. In the investigated ecosystems the level of oil products in sediment was generally within the accepted limits; high content was found in the Suez channel in 2006 and in the Bystryi and Vostocnyi branches in 2007 (Fig. 2.1.21).

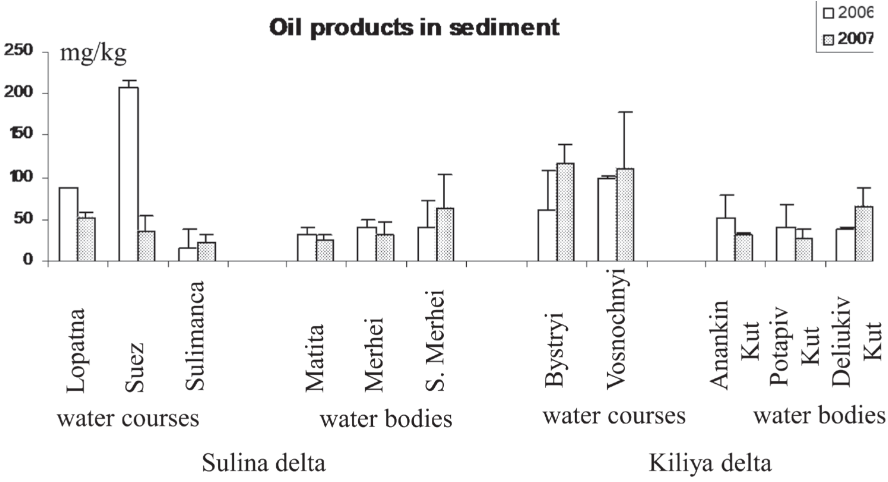

Fig. 2.1.21 Dynamics of oil products in the sediment in 2006–2007

Correlated with the high content of oil products in the water column reached in Kiliya delta arms, we can assume that the cause was the intensified navigation.

Phenols in sediment. Similar to the oil products, phenols can induce carcinogenic and genotoxic effects, but due to their relative fast biodegradation

(10–20 days), they are not considered dangerous by the European standards and, therefore, not included in the priority substances list. However, their continuous presence in the environment makes their degradation impossible as the process is inhibited when the concentration is raising.

Canadian standards list phenols on the priority list and US standards for marine sediments have set a maximum admissible level of phenols of 1200 µg/kg dry weight.

In the aquatic environment they may occur naturally, as decomposition product of plants, vegetation and animal waste, but main sources are anthropogenic: petroleum refining, chemical factories, waste water treatment plants, etc.

In the Sulina delta the phenols content in sediment was very low, except for Small Merhei, where 2,93 mg/kg were found (Fig. 2.1.22).

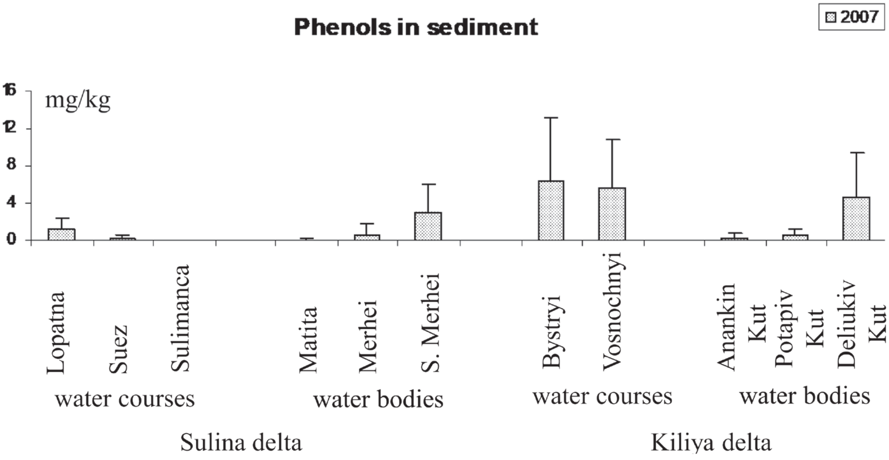

Fig. 2.1.22 Phenols content in the sediment in 2007

In the Kiliya delta the highest level was reached in the Bystryi branch (6,4 mg/kg, over-passing 5 times the American stand.), followed by Vostochnyi branch (5,6 mg/kg) and Deliukiv Kut lagoon (4,7 mg/kg).

2.2. HYDROBIOLOGICAL INVESTIGATIONS

2.2.1 BACTERIOPLANKTON – BACTERIOBENTHOS

In the aquatic ecosystems the bacterioplankton and bacteriobenthos communities represent the level of decomposers. The microorganisms (especially bacteria) decompose the organic matter in order to obtain both the necessary energy for their biomass synthesis and for their physiological needs.

In this study, the bacterioplankton and bacteriobenthos are assessed using two structural parameters: abundance and biomass, quantified in all 4 types of aquatic ecosystems.

Lakes of Sulina delta. In 2006 the seasonal dynamics of bacterioplankton abundance showed an increasing trend from spring to autumn in all the studied lakes. The lowest value was recorded in May in Small Merhei (5,45 × 10^6 cells/ml) and the highest was recorded in October in the same lake (11,8 × 10^6 cells/ml) (Fig. 2.2.1 A).

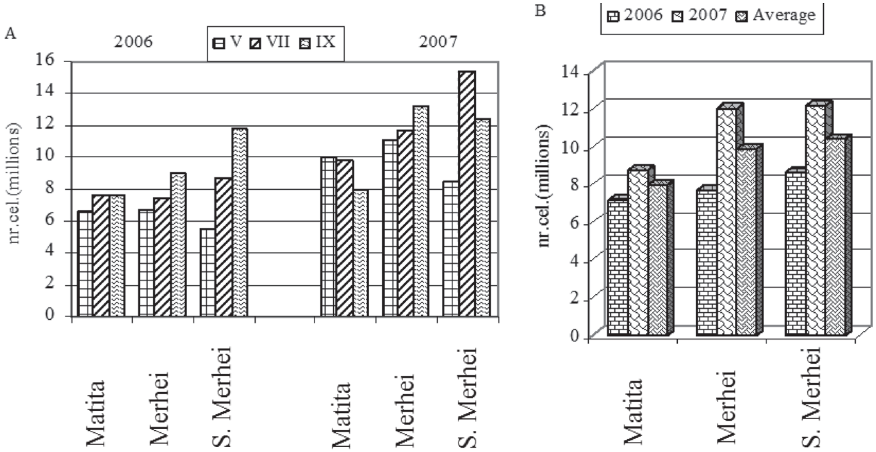

Fig. 2.2.1 Seasonal (A) and annual (B) variation of bacterioplankton abundance in the old delta

In 2007 the abundance dynamics demonstrated significant fluctuations between the lakes: the highest values were recorded in May in the Matita lake (10,1 × 10^6 cells/ml), in October in Merhei (13,2 × 10^6 cells/ml) and in July in Small Merhei (15,41 × 10^6 cells/ml).

The annual averages in 2007 were higher than in 2006 in all the investigated lakes. The lowest value was reached in 2006 in the Matita lake (7,1 × 10^6 cells/ml) and the highest was found in 2007 in the Small Merhei (12,11 × 10^6 cells/ml) (Fig. 2.2.1 B).

In 2006 the bacterioplankton biomass was maximal in July and minimal in May in all three lakes. The minimum value was found in Merhei in May (14,15 µg C/l), while the maximum was in Small Merhei in July (347,2 µg C/l). In 2007, in all three lakes, the biomass values were lower than in 2006, reaching the maximum in July. The lowest value was recorded in May in Small Merhei (21 µg C/l) and the highest – in July in Matita (170,4 µg C/l) (Fig. 2.2.2 A).

Maximal annual average value was found in Small Merhei in 2006 (166,1 µgC/l) and it was twice higher than in 2007, and the lowest was found in Matita (82,4 µgC/l) in 2006 (Fig. 2.2.2 B)

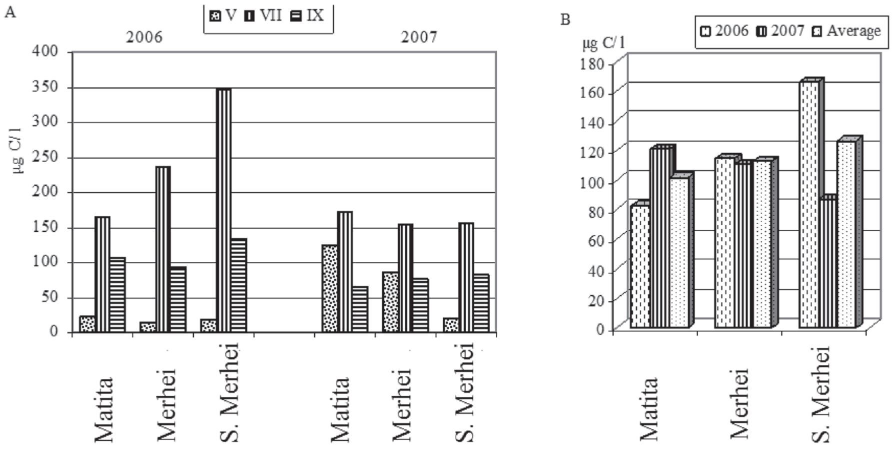

Fig. 2.2.2 Seasonal (A) and annual(B) dynamics of bacterioplankton biomass in old delta.

The seasonal dynamics of bacterioplankton during the investigated period shows maximum values in July and minimum values in October. In 2006 the biomass values ranged between 206,45 μgC/g d. w. in Matita (in May) and 1601.9 μg C/g d. w. in Small Merhei (in July, Fig. 2.2.2 A). In 2007 the seasonal dynamics of biomass showed the narrow range: 157,97–821,62 μg C/g d.w. These values were recorded respectively in Matita in May and in Small Merhei in July (see Fig. 2.2.3 A).

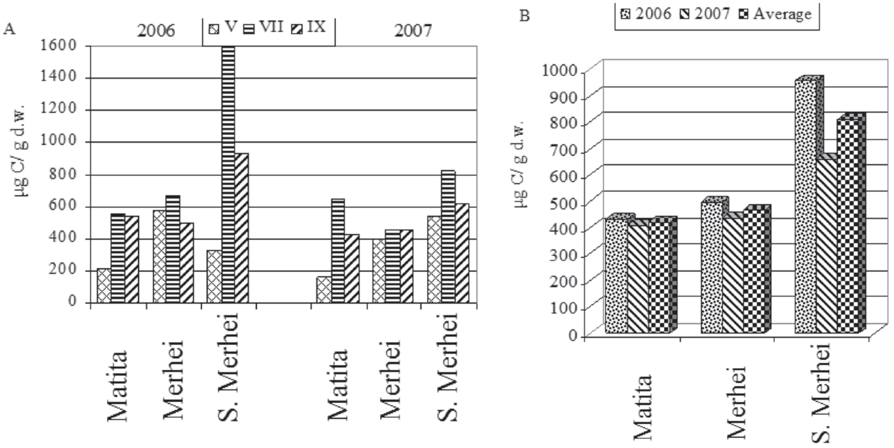

Fig. 2.2.3 Seasonal (A) and annual(B) dynamics of bacteriobenthos biomass in old delta

The annual average in Matita and Merhei shows close values, while Small Merhei recorded the maximum values for the studied period in 2006 (Fig. 2.2.3 B) – these values are almost twice as much in comparison with the values recorded in Small Merhei.

Water bodies of the Kiliya Delta. The seasonal dynamics of bacterioplankton abundance in these aquatic ecosystems shows a decreasing trend from spring to autumn, in a narrow range of values. In 2006 the extreme values of abundance were recorded in Deliukiv: the lowest in May (6,36 × 10^6 cells/ml) and the highest in July (9,4×10^6 cells/ml).

In 2007 the lowest abundance was recorded in May in Anankin Kut lake (6,06×10^6 cells/ml), and the highest was found in May in Potapiv Kut lagoon (10,42× 10^6 cells/ml) (Fig. 2.2.4A). The annual average abundances showed close values between Potapiv and Deliukiv in both years of study. The minimum annual average was found in 2007 in Anankin Kut (6,55× 10^6 cells/ml), while the maximum was recorded in Potapiv Kut in the same year (8,46 × 10^6 cells/ml). Values close to the maximum were recorded in 2006 in both Anankin Kut and Potapiv Kut (see Fig 2.2.4B).

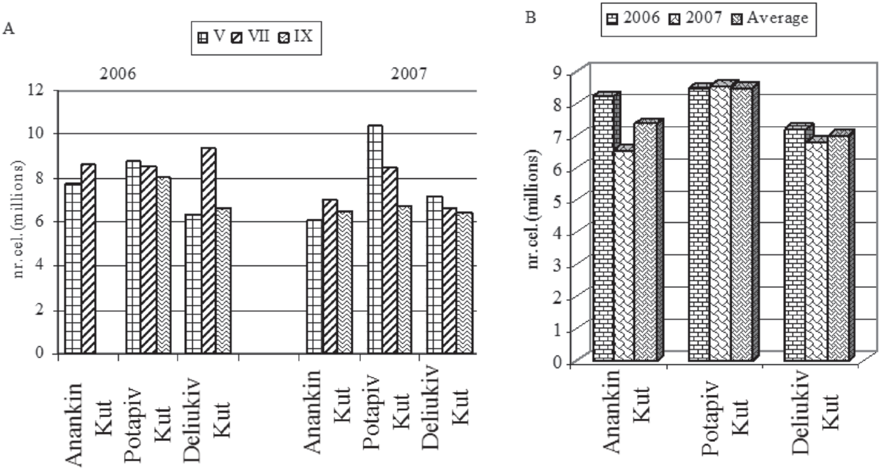

Fig. 2.2.4 Seasonal (A) and annual (B) variation of bacterioplankton abundance in Kyliya delta

In 2006 the seasonal dynamics of biomass showed the lowest values in May and the maximum in July. The lowest biomass value was recorded in Anankin Kut (23,1 μg C/l) and the highest in Potapiv Kut (566,9 μg C/l). The year 2007 was characterized by extremely low values of biomass in comparison with 2006. The limits of variation were 24,3 μg C/l in October in Deliukiv Kut and 254,2 μg C/l in July in Potapiv Kut (Fig. 2.2.5A). The analysis of annual averages shows the highest values in 2006, 2–4 times higher than in 2007. In the Anankin Kut the extreme values for biomass were: respectively 335,9 and 79,14 μg C/l (Fig. 2.2.5B).

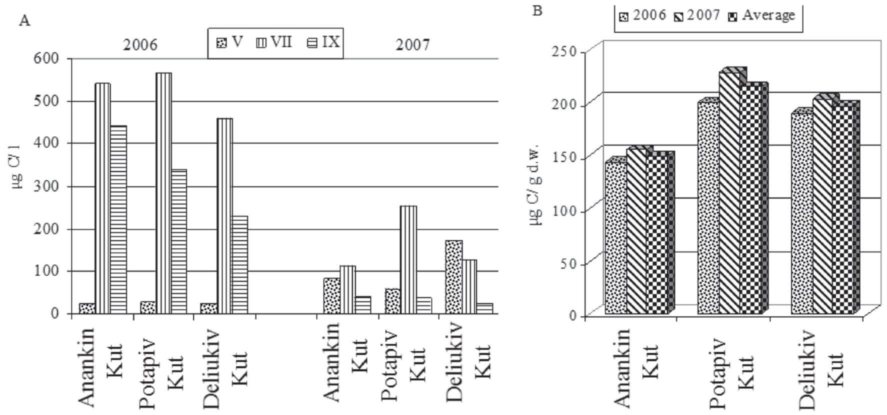

Fig. 2.2.5 Seasonal (A) and annual (B) dynamics of bacterioplankton biomass in lakes of Kiliya delta

The peculiarity of the seasonal dynamics of bacteriobenthos biomass is the high amplitude of the values. This fact was obvious in Potapiv Kut and Deliukiv Kut for the whole studied period (Fig. 2.2.6A). In 2006, the lowest value was recorded in Deliukiv in May (87,8 µg C/g d. w.) and maximum in Potapiv in July (367,4 µg C/g d. w.). The annual average in these two lagoons are higher than 200 µg C/g d. w., while in Anankin they reach only 150 µg C/g d. w. (see Fig. 2.2.6 B).

Channels of Sulina delta. The seasonal dynamics of bacterioplankton abundance for the whole period had a normal trend, with maximum values reached in summer. The lowest abundance was recorded in Suez in May ($4,89\times10^6$ cells/ml) and the maximum in Lopatna in July ($14,41\times10^6$ cells/ml). In 2007 both the minimum and maximum values were recorded in Suez channel, but with a lower amplitude of variation: $8,33\times10^6$ cells/ml, in comparison with the value reached in 2006 ($9,52\times10^6$ cells/ml) (Fig. 2.2.7A).

The annual average in Lopatna and Sulina channels have close values, while in Suez the lowest average was noted in 2006 ($7,33\times10^6$ cells/ml) and the highest in 2007 (10.59×10^6 cells/ml) (see Fig. 2.2.7B).

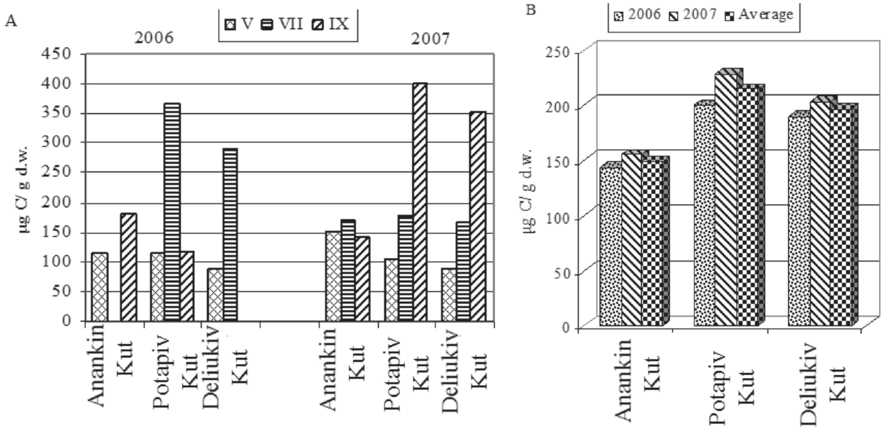

Fig. 2.2.6 Seasonal (A) and annual (B) dynamics of bacteriobenthos biomass in water bodies of Kiliya delta

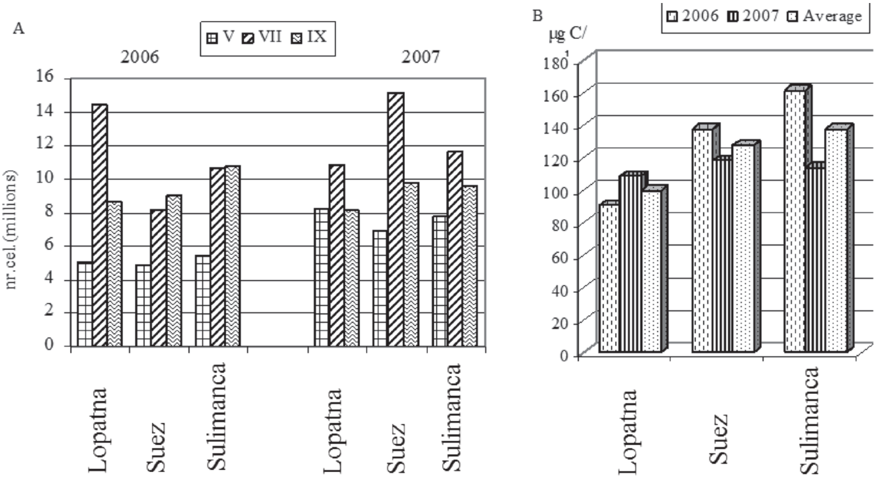

Fig. 2.2.7 Seasonal (A) and annual (B) variation of bacterioplankton abundance in Romanian channels

Due to the water connection between the lakes and channels, the seasonal dynamics of bacterioplankton biomass in the three channels was similar in both years to the trend recorded in lakes. In 2006 in all three channels maximal biomass was found in July and the lowest in May. The maximum value was recorded in July in Sulimanca (372 μg C/l) and the minimum in May in Lopatna (14 μg C/l). In 2007, the maximal value was lower than in 2006 (Fig. 2.2.8A) in the all lakes. As for the lakes, the annual average increased from Lopatna to Sulimanca channel (Fig. 2.2.8B).

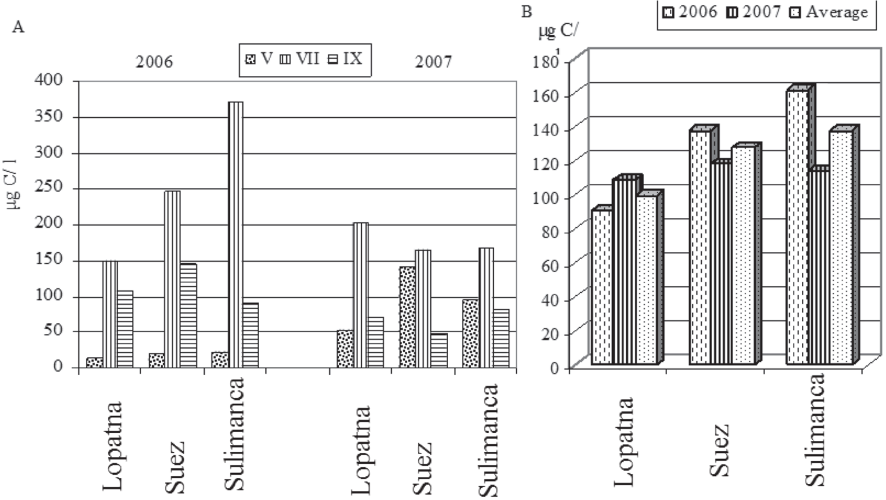

Fig. 2.2.8 Seasonal (A) and annual(B) dynamics of bacterioplankton biomass in Romanian channels

In 2006, the seasonal dynamics of bacteriobenthos biomass showed high fluctuations in Lopatna, while in the other two the range was narrower. In July the biomass in this channel reached 590,7 μg/g d. w., while in May in Suez channel it reached only 34,4 μg/g d. w. (Fig. 2.2.9 A). In 2007 similar situation was recorded in Sulimanca channel, where the extreme values were reached: in May the biomass was 520,83 μg C/g d. w. while in October it reached only 20,37 μg C/g d. w. The evolution of annual averages shows the highest biomass in Lopatna in 2006, followed by a decreasing trend in the other channels

(Fig. 2.2.9 B). The annual average in 2007 showed closer values for the three channels, the range of variation was within 216,24 – 297,45 µg C/g d. w.

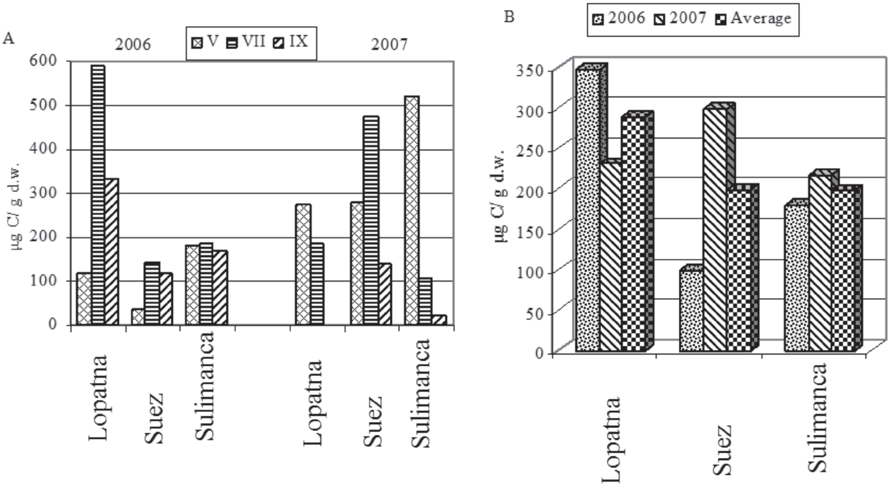

Fig. 2.2.9 Seasonal (A) and annual(B) dynamics of bacteriobenthos biomass in Romanian channels

Branches of the Kiliya delta. The bacterioplankton community of the studied branches of Kiliya Delta (Bystryi and Vostochnyi) differed from the one specific for the channels of older delta – in the younger part of the delta lower abundance and higher biomass were recorded. Bacteriobenthos biomass in these arms fluctuated within in wide limits as the water flow and velocity influence the nature and the width of the sediment layer.

In 2006 bacterioplankton abundance showed a decreasing trend from spring to autumn in both arms. Maximal was reached in May, at this in Bystryi it was 1.5 times higher than maximum in Vostochnyi branch.

In 2007 the values were more uniform, varying within $6,16\times10^6$–$8,37\times10^6$ cells/ml. The highest values were recorded in July in both arms (Fig. 2.2.10 A). There are no significant differences between the annual averages in each arm or between them, however values in Bystryi were slightly higher (see Fig. 2.2.10 B).

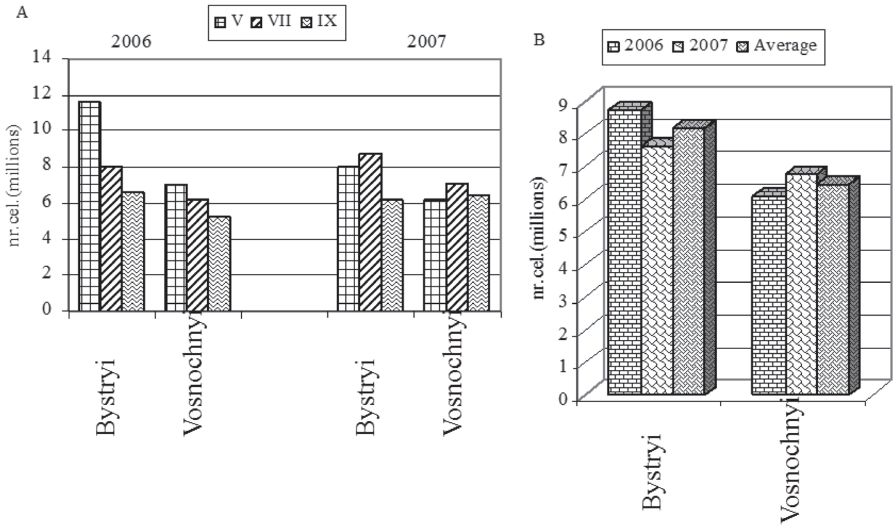

Fig. 2.2.10 Seasonal (A) and annual (B) variation of bacterioplankton abundance in branches of the Kiliya delta

The seasonal dynamics of bacterioplankton biomass shows notable fluctuations from very small values in spring of both years, to very high values in summer and autumn. In 2006 the biomass increased from 26,72 to 456 µgC/l in Vostochnyi, and from 44,8 to 521,1 µgC/l in Bystryi. In 2007 the biomass was very low during the whole year, ranging between 23,63 – 102,9 µgC/l. The highest values were in summer, but they were 5 times lower than in 2006 (Fig. 2.2.11A). Consequently, in Bystryi the annual averages in 2006 were 8 times higher than in 2007, and in Vostochnyi – 5 times (see Fig. 2.2.11B).

The seasonal dynamics of bacteriobenthos biomass recorded maximum values in July 2006 and October 2007. In 2006 the maximal values recorded in both arms were 2,5 – 3 times higher than for the same period of 2007 (Fig. 2.2.12A). In 2007 the highest biomass was 101,33 µgC/g d. w. in Bystryi and 98,77 µg C/g d. w. in Vostochnyi. The annual averages are relatively low, fluctuating around 100 µg C/g d.w: in Bystryi branch it reached 104,43 µg C/g d. w and in Vostochnyi it reached 90,84 µg C/g d. w (Fig. 2.2.12B).

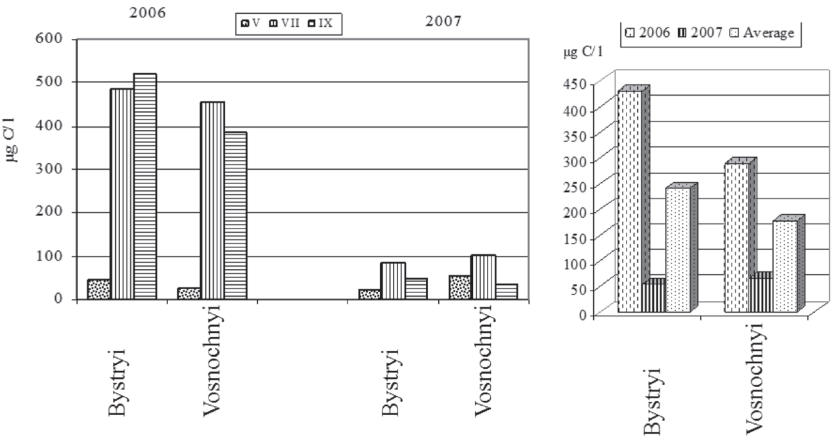

Fig. 2.2.11 Seasonal (A) and annual (B) dynamics of bacterioplankton biomass in branches of the Kiliya delta

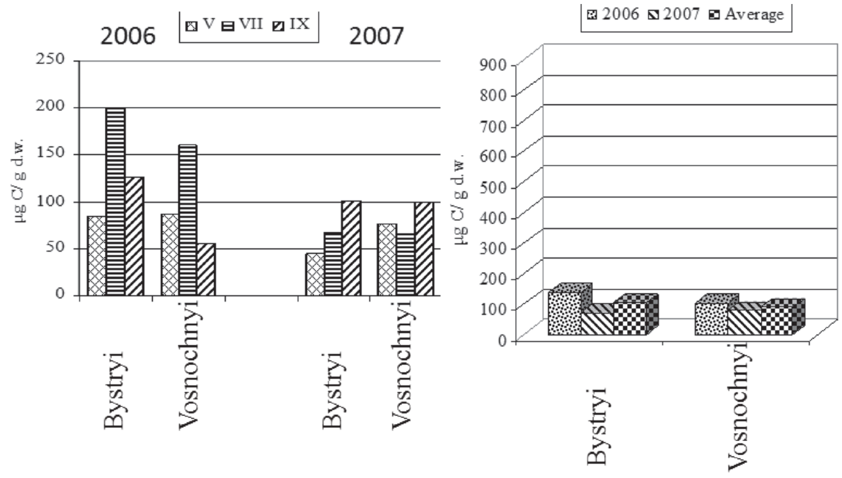

Fig. 2.2.12 Seasonal (A) and annual (B) dynamics of bacteriobenthos biomass in the Kiliya delta branches

In comparison with bacterioplankton biomass, the bacteriobenthos biomass of the investigated branches in Kiliya Delta represents only half.

Quantitative characterization. In the aquatic ecosystems of the Danube delta the heterotrophic bacterioplankton is controlled by two endogenous factors: development of primary producers (through the organic matter as a consequence of phytoplankton turnover or macrophytes decay) and the zooplankton pressure during the "crisis" period (cyanobacterial blooms).

Analysis of many-year evolution of heterotrophic bacteria in the elder part of the delta over the last 25–30 years showed its cyclic character, according to phytoplankton evolution and the nutrient charge of the Danube River.

The many-year averages of heterotrophic bacteriobenthos shows the same cyclic evolution, with maximums and minimums every 8–9 years.

Analysis of the many-year averages in the lakes of the elder part of the delta (Matita, Merhei, Small Merhei) showed the highest abundance in Small Merhei (10,35×10^6 cells/ml) and the lowest in Matita (8,18×10^6 cells/ml) (Fig. 2.2.13). Over the investigation period of these three lakes, the highest abundance was reached in 2007, with a maximum of 12,08×10^6 cells/ml in Small Merhei (see Fig. 2.2.1 B).

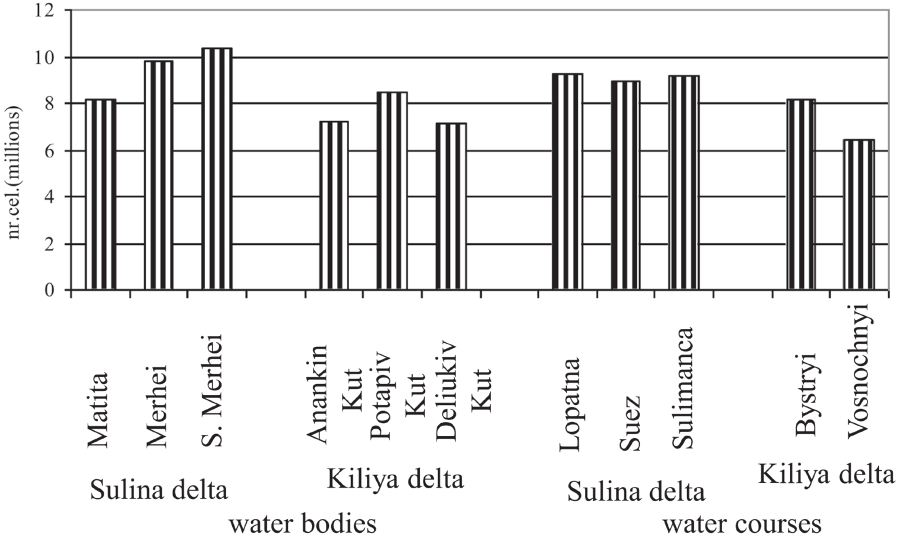

Fig. 2.2.13 Bacterioplankton abundance in all the investigated ecosystems

In comparison with the lakes from the younger part of the delta, the lakes of the elder part of the delta have higher abundances (see Fig. 2.2.13). In the Kiliya delta the highest abundance was recorded in Potapiv Kut ($8{,}5\times10^6$ cells/ml), the other two aquatic ecosystems having lower values – $7{,}21 \times 10^6$ cells/ml in Anankin Kut and $7{,}12\times10^6$ cells/ml in Deliukiv Kut (see Fig. 2.2.13). In the annual evolution of these three ecosystems the values of 2006 were slightly higher than of 2007 (see Fig. 2.2.1B).

Comparing the variation range for total bacterioplankton recorded in the Kiliya Delta in summer 1998 [BASHMAKOVA & MULLER 2003] with the summer 2006–2007 one can notice that in the recent years these limits were more restraint, fluctuating between $6{,}16 \times 10^6$ – $9{,}4 \times 10^6$ cells/ml while in 1998 the values were within $4{,}94\times10^6$ – $14{,}05\times10^6$ cells/ml.

A comparison between the elder and the younger parts over the years 2006–2007 showed that in the elder part the range of variation was larger than in the younger (respectively $4{,}89\times10^6$ – $15{,}41\times10^6$ and $5{,}22 \times 10^6$ – $10{,}42 \times 10^6$ cells/ml), reflecting the influence of the Danube water quality and discharge.

The abundance annual averages in the investigated channels of the elder part of the delta (Lopatna, Suez, Sulimanca) showed very narrow range of variation ($8{,}96\times10^6$ – $9{,}29\times10^6$ cells/ml) close to the range recorded in the lakes, as a consequence of water circulation between these ecosystems (see Fig. 2.2.13). In the investigated arms of the Kiliya delta, the highest abundance was recorded in Bystryi ($8{,}18\times10^6$ cells/ml), while in Vostochnyi it reached $6{,}44\times10^6$ cells/ml.

The increasing trend of abundance in the lakes of elder part of Danube delta from Matita to Small Merhei was reflected also in the biomass trend. The range of variation for the many-year averages was within 101,4–126,14 µg C/l; the highest was found in Small Merhei in 2006 – 166,1 µg C/l (see Fig. 2.2.2B). The analysis of bacterioplankton biomass in the elder part of the delta over the period 1998–2007 revealed that the values found during this study were lower than in other ecosystems (Fig. 2.2.14).

The highest biomass was reached in the Kiliya delta in 2006 – the highest annual average was found in Anankin Kut lake: 335 µg C/l (see Fig. 2B).

In comparison with 2007 the annual biomass of aquatic ecosystems in the Kiliya delta in 2006 was 2–4 times higher. The many-year averages have the decreasing trend from Anankin Kut (207,52 µg C/l) to Deliukiv Kut (172,85 µg C/l) (see Fig. 14).

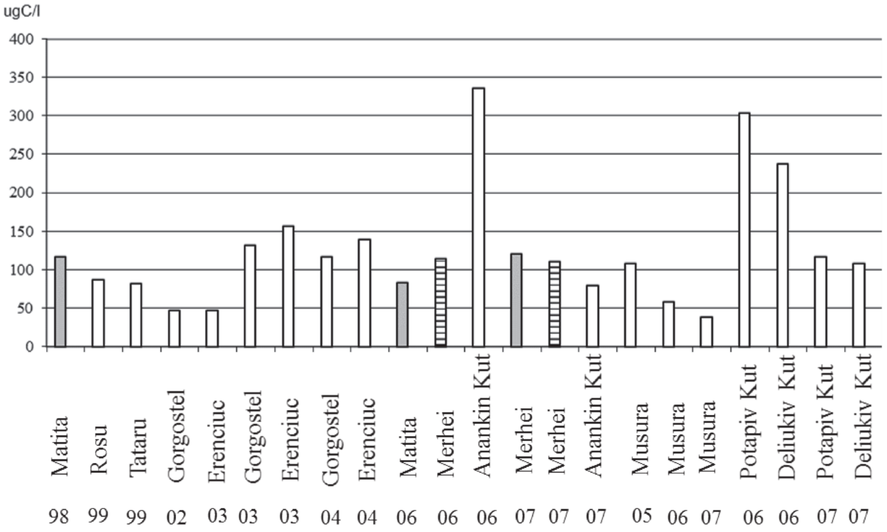

Fig. 2.2.14 Bacterioplankton biomass in lakes and lagoons in 1998–2007.

The biomass in the investigated channels had similar trend with the one recorded in the neighboring lakes: it increased from Lopatna (99.58 µg C/l) to Sulimanca (137,66 µg C/l), with very narrow variation range (see Fig. 2.2.15). The biomass in Bystryi branch was the highest from all the investigated ecosystems, reaching 241,6ºµgºC/l; the average biomass value for arms is double than the average value for channels.

The bacteriobenthos biomass showed higher values than in the water column, with the highest values in the elder part of the Danube delta. In the lakes it ranged between 379 µg C/g d. w. in Matita lake and 807 µg C/g d. w in Small Merhei (Fig. 2.2.16). In other categories of ecosystems biomass was three times lower than the average biomass of the lakes of Danube delta, the lowest values were reached in the Kiliya delta arms, where the biomass was below 100 µg C/g d. w (see Fig. 2.2.16).

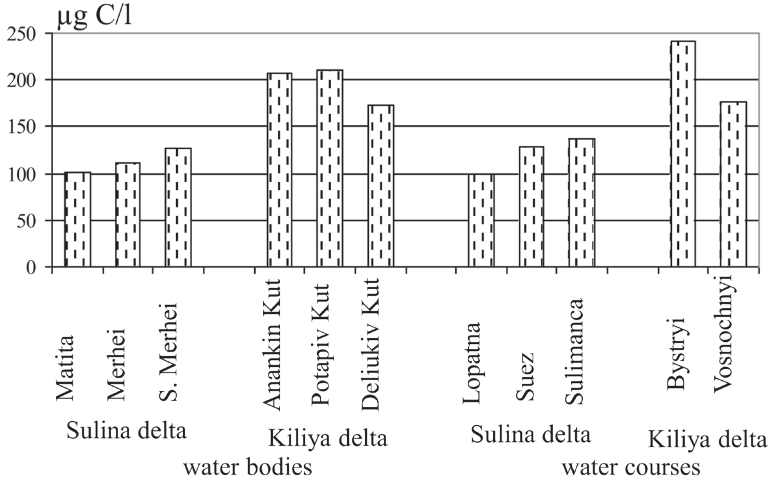

Fig. 2.2.15 Bacterioplankton biomass in the investigated ecosystems

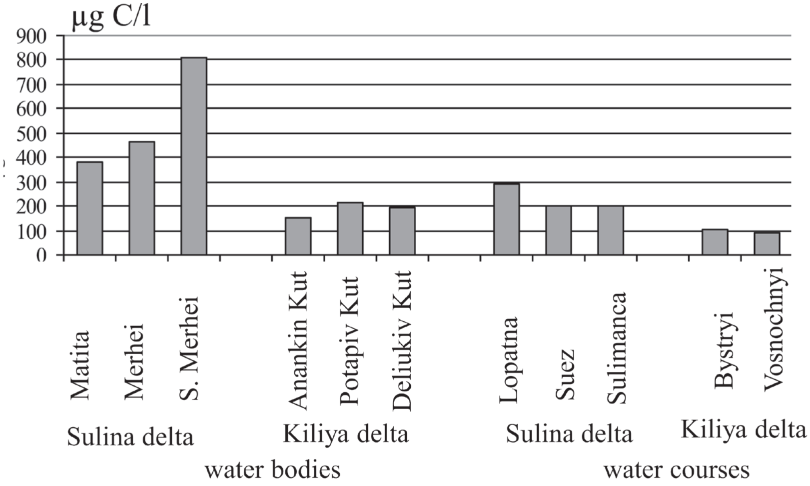

Fig. 2.2.16 Bacteriobenthos biomass in all the investigated water bodies and water courses.

Bacteriobenthos development is influenced by the quality and quantity of organic matter in sediment, as well as other factors like temperature, redox potential, oxygen saturation, etc. For channels and branches, the water velocity and discharge have the determinant role in sediment layer formation.

2.2.2. AQUATIC MACROPHYTES

The community of aquatic macrophytes has an important role in the ecosystem functioning: as bio-filters of pollutants, as shelters and nesting sites for fishes and zooplankton, together with phytoplankton they produce oxygen trough photosynthesis, increasing the amount of dissolved oxygen in the water column, etc. Due to their sensitivity to environmental quality, Annex V of WFD suggest the use of macrophytes in the assessment of the ecological state of water bodies.

As the ecosystems differ significantly, the results will be presented distinctly for lakes and channels of Sulina delta, and lakes/lagoons and arms of Kiliya delta.

Water bodies of Sulina delta

<u>**Matita lake**</u> is surrounded by the reed-cattail vegetation (***Phragmitetum communis (Gams)*** **Schmale,** ***Typho angustifoliae-Phragmitetum australis*** **Tx. et Preisign,** ***Typhetum angustifoliae*** **Pignati,** ***Typhetum latifoliae*** **G. Lang**). The vegetation coverage was quite restraint (10–30%). Along the right bank, where the depth can reach 2,0 m, the belt of vegetation with floating leaves (***Nymphaeetum albo-luteae*** **Novinski, s/ass.** ***N. a-l-nupharetosum***) occurred, its width sometimes reached 20–30 m. Projective cover (PC) in vegetations reached 90–95%. Communities of fennel-leaved and clasping-leaved pondweed (*Potamogeton pectinatus*, *P. perfoliatus*), hornwort (*Ceratophyllum demersum*), ling (*Trapa natans),* fresh-water soldier (*Stratiotes aloides*), as well as duckweed (*Lemna trisulca*), frog's bit (*Hydrocharis morsus-ranae*) and arrowhead (*Sagittaria sagittifolia*) co-existed. Along the other banks, with depths up to 1,5 m, coenosis of ***Ceratophylletum demersi*** **(Soo) Eggler** with Canada water weed (*Elodea canadensis*), *P. pectinatus* and

small pondweed (*P. pusillus)* developed, but PC was less than 15–20%. *Stratiotes aloides* occurred only rarely. In vegetation mass development of the green filamentous algae were noticed. In 2006, at high-water level, patches of *Ceratophyllum demersum* occurred throughout all lake area, but at the depth above 2,0 m PC of vegetations decreased to 5–10%.

Merhei is a big lake, where the vegetation coverage amounted up to 60–75%. Along the banks, where the depth was up to 1,0 m, in the upper part and in the center of the lake large spots (diameter from 20 to 75 m) were formed by the association ***Nymphaeetum albo-luteae*** communities with *Hydrocharis morsus-ranae* and *Trapa natans* with *Stratiotes aloides*. PC in vegetations amounted to 85–90%. Cenoses of ***Ceratophylletum demersi*** and ***Charophycea*** algae developed among spots of vegetation with floating leaves. In the middle part of the lake they covered 80% of the bottom area. Rarely, specimens of meakin (*Myriophillum spicatum)* and *Potamogeton pectinatus* were noticed. Closer to the left bank the portion of *Chara sp.* in total vegetation coverage increased.

On the near-bank sections of the lake small groups of the cattail (*Typha angustifolia),* surrounded by yellow water-lily (*Nuphar lutea)*, rarely occurred. In the submerged vegetation also prevails *Chara sp.* and *Ceratophyllum demersum,* with inclusion of *Myriophillum spicatum.* Along left bank, bottom is totally covered by Charophycea algae. At high water level, occurred in spring–summer 2006, the central part of the lake was occupied by big spots of cenoses ***Potametum perfoliati* Koch em. Pass.** and ***Myriophyllo-Potamogetonetum perfoliati* Pass.** During the fall, development of filamentous algae along with the higher aquatic plants was observed.

Small Merhei lake. This is the smallest lake, but with the largest vegetation coverage (70–80%) among the investigated lakes in Sulina delta. Along the left bank the narrow border of *Nuphar lutea* with inclusion of white water-lily (*Nymphaea alba*) developed. On the lake occurred clumps, consisting of cattail and reed, bordered with coenoses of white water lily, yellow water-lily and duckweed. The right bank was completely covered by vegetation: mostly communities of ***Phragmitetum communis, Typho angustifoliae-Phragmitetum australis, Typhetum angustifoliae*** occurred, together with small communities of *Ceratophyllum demersum* and *Myriophyllum spicatum*.

Water bodies of Kiliya delta

Anankin Kut lake, located in the inner part of the delta water, is surrounded by reed vegetation. Here, the vegetation coverage amounted up to 90–95%. Practically, the upper part of the water body was covered by solid vegetation with floating leaves, belonging to the associations ***Trapetum natantis* Muller et Gors** and ***Nymphaeetum albo-candidae* Pass.** In the middle part monodominant vegetation of hornwort (***Ceratophylletum demersi***) prevailed. The southern, more narrow part of the water body was occupied by the communities ***Trapetum natantis*** with *Ceratophyllum demersum* in the lower layer. Beside dominants, small "spots" of ***Nymphoidetum peltatae* (All.) Muller et Gors** and separate individuals of *Stratiotes aloides* were noted.

Deliukiv Kut lagoon is separated from the sea by the sand pit; it is surrounded by reed vegetation from almost all sides, except the northern part, open to Ankudinov arm. The upper part is divided in two arms by the *Phragmites australis* vegetation and its surface is totally covered by the association ***Sparganietum erecti* Roll.** In the middle part of the lake the vegetation consists of *Trapa natans* (sub-association ***S.e.-trapetosum***) together with *Nuphar lutea* (sub-association ***S.e.-nupharetosum***). In the lower part, nearby Ankudinov branch, small area is occupied by association ***Potametum nodosi* (Soo) Segal**. Beside these associations, in the water body occur rush flower (*Butomus umbellatus), Sagittaria sagittifolia, Ceratophyllum demersum*, *Potamogeton pectinatus*, *Spirodela polyrrhyza*, floating moss *(Salvinia natans*).

Potapiv Kut lagoon is not completely separated from the sea and the vegetation coverage is up to 90–95%. During the 1990ies its area increased due to the erosion of the Zhelannaya pit; today, this new part of the lagoon is occupied by associations of ***Myriophylletum spicati* Soo** and ***Ceratophylletum demersi*;** nearby the outlet to the sea, thinned vegetation of *Potamogeton pectinatus* were noticed. In the upper part, nearby the channel connecting the lagoon with Potapiv branch, small areas were occupied by coenoses ***Potametum nodosi* (Soo) Segal**). The elder part of the lagoon is covered by

Trapetum natantis association, where rarely occurred *Potamogeton pectinatus* L. and *Enteromorpha sp.* In the middle part, in the areas without *Trapa natans,* associations of ***Elodeetum canadensis* Eggler** with filamentous algae occurred. Vast areas of ***Phragmitetum communis*** and ***Typhetum angustifoliae*** are surrounded by ***Ceratophylletum demersi*** coenoses.

In spring, in most of the investigated ecosystems, communities of ***Potametum crispi Soo, Potametum pectinati Carstensen, Potametum perfoliati, Ceratophylletum demersi*** developed**.** In autumn all water bodies were characterized by the mass development of *Salvinia natans* (ass. ***Salvinio-Spirodeletum* Slavnic**, ***Lemno-Salvinietum natantis* Migan et Tx.**) and duckweed coenoses (ass. ***Lemno minoris – Spirodeletum polyrrhizae* Koch em. Muller et Gers**).

Water courses of Sulina delta

Lopatna channel. In this natural channel the vegetation coverage reached 65–70%. Along the right bank associations of *Phragmites australis*, *Typha angustifolia* and *T. latifolia* occurred, while the opposite bank was totally covered by reed vegetation. In summer the water level in the channel decreased considerably. The emerged vegetation was followed by the belt of the vegetation with floating leaves; along the right bank its width reached 15–20 m and along the left bank 20–30 m (ass. ***Nymphaeetum albo-luteae*** with inclusions of *Stratiotes aloides*). Projective cover in vegetation amounts up to 90%. Beside the dominant, the following species were noticed: *Hydrocharis morsus-ranae, Trapa natans, Sagittaria sagittifolia*, manna grass (*Glyceria maxima)*, in the lower layer – *Ceratophyllum demersum*. In autumn in vegetation developed free-floating plants – **ass. *Salvinio-Spirodeletum***, ***Lemno-Salvinietum natantis***.

Suez channel. This is an artificial watercourse within two lakes – Matita and Merhei 25–30 m wide. At the investigated section the vegetation coverage was up to 60–65%. Banks were covered by willows (*Salix sp.*) and vegetation of ***Phragmitetum communis*, *Typho angustifoliae-Phragmitetum australis*** developed up to the water edge. Among them, separate individuals of water plantain (*Alisma plantago-aquatica)*, armed bur-reed (*Sparganium erectum*), *Glyceria maxima* and wood bulrush *(Scirpus silvaticus)* occurred.

In spring 2006, in water occurred water moss *Fontinalis sp.*, while in summer 2006 among the emerged vegetation developed solid vegetation of the ass. ***Ceratophylletum demersi***; *Nuphar lutea, Nymphaea alba*, *Sagittaria sagittifolia* occurred only rarely. In 2007, at low water level, communities of white and yellow water lilies dominated along one bank, while along the other bank, with sharp bed slope, only separate "spots" of *Ceratophyllum demersum* occurred.

Sulimanca Channel – natural watercourse, which flows from the Small Merhei lake to Kiliya arm, practically opposite the town of Vylkove. At the outflow from the lake, the vegetation coverage along the banks was very low (5–10%), consisted of *Phragmites australis*. With the distance, the reed belt became narrower and *Salix sp.* bushes started to dominate. In the lower layers of the reed vegetation, up to 2 m depth, *Myriophyllum spicatum* and *Ceratophyllum demersum* occurred rarely.

Water courses of the Kiliya delta

High flow velocity, considerable depth and high turbidity impede the vegetation development in the big arms. Consequently, in **Vostochnyi** and **Bystryi** the vegetation coverage was very low (respectively up to 15 and 1–2%). Here occur only thinned communities of ***Potametum nodosi, Potameto-Ceratophylletum demersi, Potametum perfoliati, Potametum pectinati* Carstensen*, Potametum crispi* Soo**. associations. They are spread as narrow belt along banks, up to the depth of 0.6-0.7 m. The helophytes are represented by ***Typhetum angustifoliae, Typho angustifoliae-Phragmitetum australis, Phragmitetum communis*** and separate "spots" of ***Scirpetum lacustris* Schmale*, Glycerietum maximae* Hueck*, Butometum umbellate (*Konczak) Philippi** communities.

In the investigated ecosystems 32 higher aquatic plants species of three ecological groups occurred, together with aquatic moss, Charophycea and green filamentous algae.

Three species – *Nymphoides peltata, Salvinia natans, Trapa natans* are included into the Red Book of Ukraine [CHERVONA…2009], and the last two are also protected by the Bern convention. Besides, *Nymphoides peltata, Salvinia natans, Trapa natans, Nymphaea alba*, *N. candida*, *Nuphar lutea* are included in the Red List of the aquatic macrophytes of Ukraine [GEYNI, SYTNIK 1993]. The first three mentioned are considered as highly endangered species and the last three as endangered.

According to [KOKIN 1982] water quality assessment using aquatic plants has a supportive role, most of them developing mainly in β-mesosaprobic and oligosaprobic zones; according to other authors [KONONOV 1956], the occurrence of certain species is not the best indicator of water quality and the general biological characteristic should be considered. The trophic state might be assessed using botanical indicators like *Lobelia dotmanna* L., *Isoetes lacustris* L., *Myriophyllum alterniflorum*. Development of the duckweeds indicates incipient eutrophication, while mass development of the filamentous algae indicates considerable eutrophication of the water body; maintaining or even accelerating the actual trophic status can lead to major structural and functional changes within the aquatic ecosystem [*PUZACHENKO* 1989].

2.2.3. PHYTOPLANKTON

Over the years 2006–2007 in the investigated ecosystems 427 algae species (453 subspecies taxa) of 8 groups were registered (See Annex). The highest species richness was found for Chlorophyta (147 species, mainly of the order Chlorococcales) and Bacillariophyta (136 species). Other groups were represented by the following number of species: Cyanoprokaryota – 46; Euglenophyta – 44; Chrysophyta – 25; Xanthophyta – 17; Dinophyta – 7 and Cryptophyta – 5 species.

In 2006, 290 algae species were found, belonging to the following groups: Chlorophyta – 107, Bacillariophyta – 90, Cyanoprokaryota – 20; Euglenophyta– 31; Chrysophyta – 22; Xanthophyta – 12; Dinophyta – 7 and Cryptophyta – 4 species.

In 2007, the species number increased to 344: Chlorophyta – 117, Bacillariophyta – 119, Cyanoprokaryota – 44; Euglenophyta – 33; Chrysophyta – 8; Xanthophyta – 13; Dinophyta – 7 and Cryptophyta – 3 species.

In both years the phytoplankton composition was dominated by Chlorophyta and Bacillariophyta. Still, due to the different hydrological and thermal conditions, substantial changes occurred in Chrysophyta and Cyanoprokaryota within 2006 and 2007: Chrysophyta decreased from 22 (7,6% of total species number) to 8 (2,3%) and no case of significant development of this group was noticed in 2007, while the number of Cyanoprokaryota species increased from 20 (6,9% of total species number) to 44 (12,8%).

In the lakes of Sulina delta considered in this study**,** Matita, Merhei and Small Merhei, 288 algae species from 8 groups were identified. The majority of the species belongs to Chlorophyta (123), considerably lesser to Bacillariophyta (69), Cyanoprokaryota and Euglenophyta included respectively 36 and 24 species, while the number of species from other groups was minor (Fig 2.2.17).

Due to the notable differences in the hydrological and thermal regime within the years 2006 and 2007, the number of species varied within wide limits in the investigated ecosystems: the minimal were found in spring 2006 in the Matita and Merhei lakes (respectively 20 and 21 species) and the maximal (99 species) were registered in the same water bodies in autumn 2007.

The seasonal dynamics has shown high variations in phytoplankton composition, the groups number ranging within 4–8: in spring 2006, no species of Xanthophyta and Dinophyta was found and only one Cyanoprokaryota species was found. In 2007 the phytoplankton of the Small Merhei lake included 6 groups, in spring and summer no species of Chrysophyta and Xanthophyta groups was found.

Quantitative indices of the phytoplankton in the Sulina delta lakes also varied within wide limits. Similar as for species richness, the lowest quantitative indices were found in spring 2006 in the Matita and Merhei lakes, (respectively abundance 650 and 1100 th. cells/dm^3, biomass – 0,36 and 0,27 mg/dm^3). The highest indices for abundance were registered in Small Merhei lake in summer and autumn 2007 – 88 525 and 85 075 th. cells/dm^3, and for biomass – in Merhei and Small Merhei lakes in summer 2006 – 7,44 and 5,89 mg/dm^3 respectively (Fig. 2.2.18, 2.2.19).

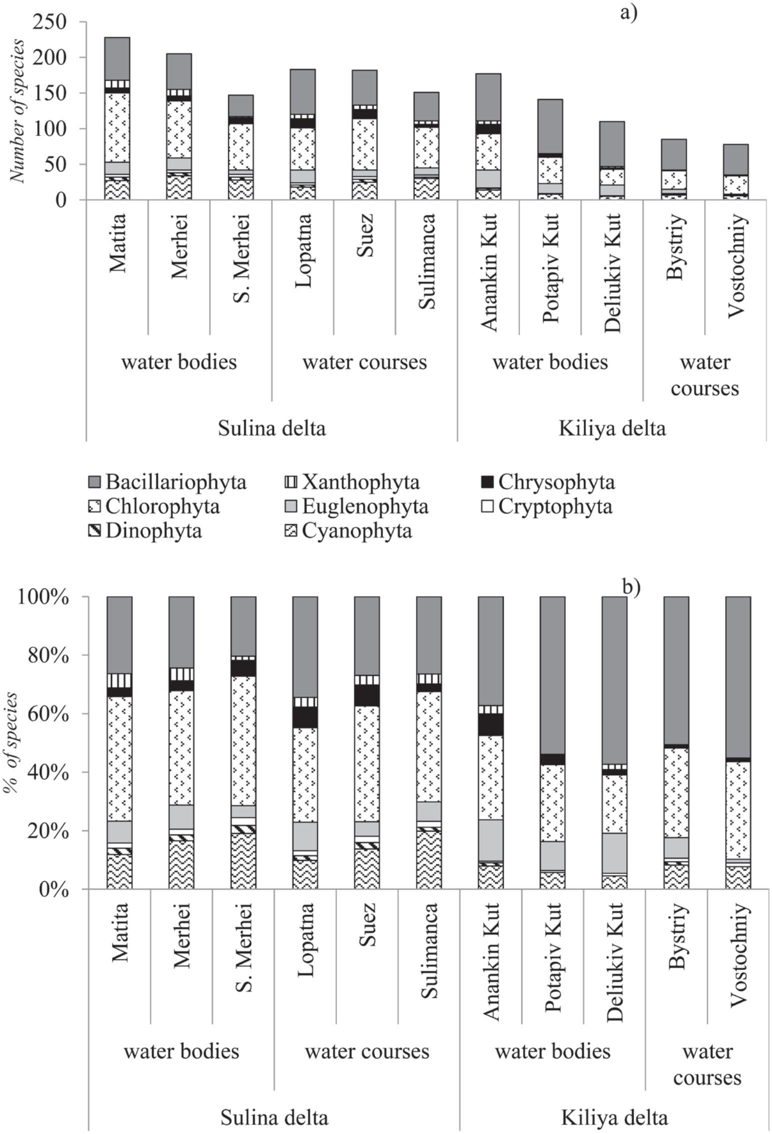

Fig. 2.2.17. Phytoplankton species composition (a – number of species, b – % of species)

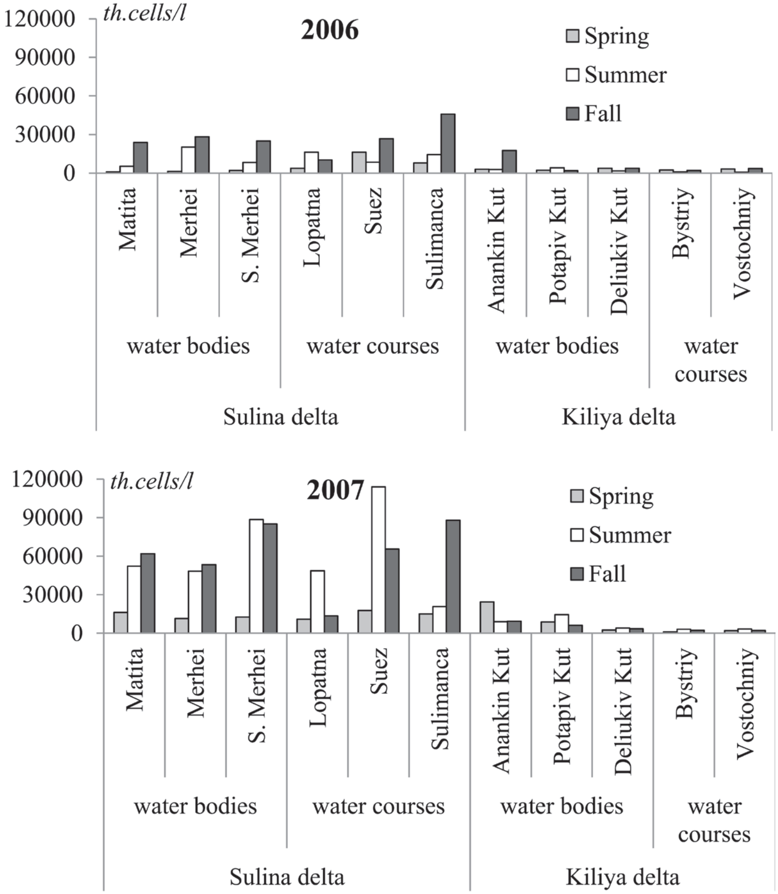

Fig. 2.2.18 Seasonal dynamics of the phytoplankton abundance

In 2007 Cyanoprokaryota dominated in terms of abundance in all seasons, while Bacillariophyta, Euglenophyta, and Chlorophyta dominated in terms of biomass.

In the investigated lakes/lagoons of the Kiliya delta, Anankin Kut lake, Potapiv Kut and Deliukiv Kut lagoons, 232 species of 8 groups were identified during the study. The highest species richness was found for Bacillariophyta (91), Chlorophyta (70), Euglenophyta (30), Cyanoprokaryota (18) and Chrysophyta (15) groups; species number of other groups was minor (see Fig. 2.2.17).

According to the season, the phytoplankton composition varied in wide limits: 3–7 groups were registered, which comprised 21–75 species. The lowest species richness was found in summer 2006 in Potapiv Kut (21) and Deliukiv Kut lagoon (26), while the highest – in summer 2007 in Potapiv Kut (75) and Anankin Kut (68 species).

Quantitative indices varied within wide limits. The lowest abundance was registered in summer 2006 in Potapiv Kut lagoon (1725 th. cells/dm^3) and the highest in spring 2007 in Anankin Kut lake (24 250 th. cells/dm^3). The lowest biomass was found in spring 2006 in Deliukiv Kut lagoon (1,19 mg/dm^3) and the highest – in Anankin Kut lake (in autumn 2006 – 5,01 and in 2007 – 5,09 mg/dm^3).

In general, Chlorophyta and Bacillariophyta were dominant in terms of abundance and biomass, but Cyanoprokaryota and Euglenophyta had also significant development; for instance, in autumn, in Anankin Kut lake, Euglenophyta was dominant in terms of biomass.

In the investigates channels of Sulina delta, Lopatna, Suez and Sulimanca 274 algae species of 8 groups were found: Chlorophyta (94), Bacillariophyta (81), Cyanoprokaryota (36), Euglenophyta (23), Chrysophyta (19); species number of other groups was minor.

Similar to the lakes, species number varied within wide limits, ranging within 19–86: the lowest was found in the Suez channel in spring 2006, and the highest – in Sulimanca channel in summer 2007. The seasonal dynamics shows the same fluctuations at the group level as for the lakes, the number of groups ranging within 4–8; for instance, in spring 2006, the phytoplankton consisted only of four groups: Cryptophyta, Chlorophyta, Chrysophyta and Bacillariophyta.

Quantitative indices of the channels also varied within wide limits. The lowest abundance was found in spring 2006 in Lopatna (3700 th. cells/dm^3) and the highest in summer 2007 in the Suez channel (113 825 th. cells/dm^3), this was maximal, registered among all the investigated ecosystems during the study period.

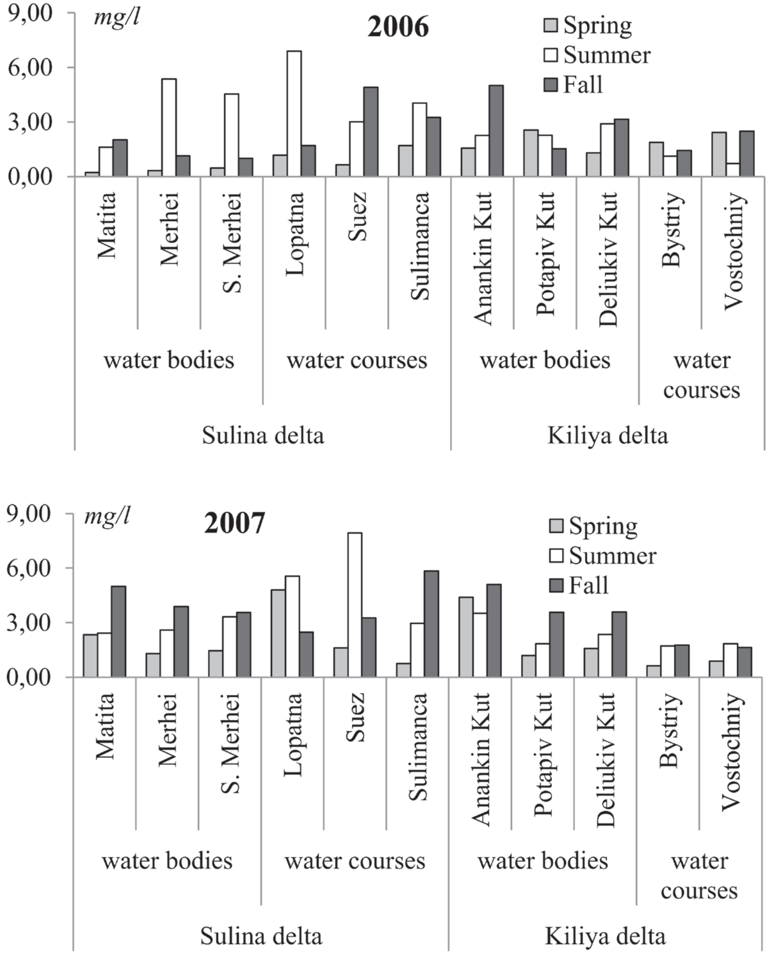

Fig. 2.2.19 Seasonal dynamics of the phytoplankton biomass

The lowest biomass was found in spring 2006 in the Suez channel (0,65ºmg/dm^3) and in spring 2007 in Sulimanca channel (0,75 mg/dm^3), while the highest was registered in summer 2006 in Lopatna channel (6,90 mg/dm^3) and in spring 2007 in Suez channel (7,93 mg/dm^3).

In 2006, Chlorophyta and Bacillariophyta dominated in terms of abundance and biomass in spring and summer, while Cyanoprokaryota dominated in autumn. In 2007 Cyanoprokaryota were the most abundant, while Bacillariophyta, Euglenophyta, and Chlorophyta dominated in terms of biomass.

In the branches of Kiliya delta, Bystryi and Vostochnyi, during the investigated period 117 algae species of 7 groups were identified. The highest species richness belonged to Bacillariophyta (57) and Chlorophyta (41), species number of other groups being minor.

Similar to the lakes of the Kiliya delta, according to the seasonal variation, 3–7 groups were found, comprising 15–44 species. The lowest species richness was found in spring 2006 in Vostochnyi and the highest – in summer 2007 in Bystryi branch.

In comparison with the wide variation limits reached in lakes, in arms the quantitative indices varied in relatively narrow limits. The lowest abundance was found in summer 2006 in Vostochnyi branch (763 th. cells/dm^3) and the highest – in summer 2007 in Bystryi brunch (3163 th. cells/dm^3). The lowest biomass was registered in spring 2006 in Bystryi (0,63 mg/dm^3) and the highest– in autumn 2007 in Vostochnyi (2,50 mg/dm^3).

Bacillariophyta was the dominant group during all the seasons, both in terms of abundance and biomass (respectively 75,4–85.1% and 91,8–96.7%); the dominant species belonged to Centrophycea class (particularly *Stephanodiscus subtilis, Cyclotella sp., Cyclotella meneghiniana*).

Species composition.

Over the years 2006–2007 in the investigated ecosystems the following number of species was identified: Matita lake – 227, Merhei lake – 203, Small Merhei lake – 146, Lopatna channel – 183, Sulimanca channel – 181, Suez channel – 150, Anankin Kut lake – 177, Potapiv Kut lagoon – 141, Deliukiv Kut lagoon – 110, Bystryi branch – 85, and Vostochnyi branch – 78 species (see Fig. 2.2.17).

In all water bodies occurred (i.e. had 100% frequency of occurrence) the following species: *Gomphosphaeria lacustris, Cryptomonas sp., Chlamydomo-*

nas sp., Monoraphidium contortum, Micractinium pusillum, Tetrastrum triangulare, Scenedesmus quadricauda (= Desmodesmus communis), Didymocystis planctonica, Melosira granulata (= Aulacoseira granulata), Stephanodiscus astraea, S. hantzschii, Synedra tenera, Navicula cryptocephala, Nitzschia acicularis, and *N. palea*.

Most of the algae species had no association to the certain group of ecosystems. However, some peculiarities were noticed: all Cryptophyta species (except *Cryptomonas sp*.) and practically all Xanthophyta species occurred only in the lakes and channels of the Sulina delta. Also only in these water bodies Cyanoprokaryota of the genera *Spirulina, Lyngbya, Romeria, Phormidium, Cylindrospermum* were registered. In 2007, *Lyngbya limnetica* reached significant abundance (up to 90% of the total) in the lakes of the Sulina delta.

Significant richness of Chrysophyta was found in spring 2006, when 11 species were identified; usually Chrysophyta species develop under low temperatures and in water with relatively low content of organic matter. In spring 2006 they were part of the dominant complexes in the Anankin Kut lake (*Kephyrion rubri-claustri* – 5,7% of the total abundance), in Suez channel (*Stenokalyx parvula* – 12,3% of the total abundance), in Matita lake (*Stenokalyx monilifera* – 10,0% of the total abundance). In summer 2006, significant development of *Chrysophyta* was found only in the Matita lake (*Dinobryon acuminatum*, 5,8% of the total abundance). Overall, the highest species number of these algae was registered in the Anankin Kut lake, Lopatna channel (13 species in each) and Sulimanca channel (12 species).

The highest number of Euglenophyta species was registered in Anankin lake (25), in Lopatna channel (18), Matita lake (17) and Deliukiv Kut lagoon (15) (see Fig. 2.2.17). In some cases, Euglenophyta reached considerable biomass: e.g. in summer 2006 in Deliukiv Kut lagoon (41,7% of the total biomass), in Anankin Kut lake in autumn 2006 and in all seasons of 2007 (respectively 25,4%, 41,4%, 39,1% and 41,8%).

Though generally Bacillariophyta were widely spread, some species occurred only in certain ecosystems. For instance, *Bacillaria paradoxa*, specific for brackish-waters, was found only in Anankin Kut lake and Potapiv Kut lagoon (in the second it was an element of the dominant complex). Other brackish-water species, for example *Nitzschia longissima v. reversa* occurred in Bystryi branch and all lakes of the Kiliya delta, *Coscinodiscus lacustris* occurred in Bystryi branch and in Deliukiv Kut lagoon. All species of the genera *Eunotia* and *Epithemia* occurred only in the ecosystems of Sulina delta.

During the period of investigations, also rare occurring species were found. In Lopatna channel we identified *Phacus megapirenoides*, *Eudorina elegans*, and *Ankyra judae*, In Matita and Merhei lakes occurred *Desmidium aptogonum* var. *acutum* (of the order Desmidiales), *Lobomonas ampla*, *Lobomonas stellata*, and *Volvulina steinii* (of the order Volvocales). Only Matita lake were found *Closterium venus, Staurodesmus cuspidatus, Staurastrum incospicuum*. In general, Matita and Merhei lakes were notable for considerable diversity of the orders Desmidiales and Volvocales (in Matita – respectively 12 and 7, in Merhei – 9 and 12 species).

Phytoplankton quantitative development indices varied within wide limits. The lowest abundance was registered in Bystryi and Vostochnyi branches (1062 and 1850 th. cells/dm^3 respectively) and the highest in Suez channel (113 825 th. cells/dm^3), Sulimanca channel (87 800 th. cells/dm^3), as well as in Small Merhei lake (88 525–85 075 th. cells/dm^3) (Fig. 2.2.18).

Seasonal dynamics of the phytoplankton quantitative indices in the investigated ecosystems presented some peculiarities. Usually, the lowest indices were recorded in spring, except Anankin Kut lake, where in spring the abundance was maximal. For Bystryi and Vostochniy branches, as well as for Deliukiv Kut lagoon, only minor seasonal variation occurred. Maximum values in summer were character for Lopatna and Suez channels, Small Merhei and Potapiv. Increase of the phytoplankton abundance in autumn was registered in Sulimanca channel, Matita and Merhei lakes.

The values of phytoplankton biomass varied within considerably narrower limits. Similar to abundance, the lowest values were registered in spring in Bystryi and Vostochnyi branches (respectively 0,63 and 0,88 mg/dm^3); the highest were found in summer in Lopatna and Suez channels (5,55 and 7,93 mg/dm^3) (Fig. 2.2.19).

Overall, seasonal dynamics of the biomass is in accordance with the abundance dynamics – in most of the ecosystems, the minimum values were registered in spring, and maximum in autumn; exceptions were Anankin Kut lake, where minimum biomass was registered in summer, and Lopatna and Suez channels, where in summer the maximum was reached.

The Shannon-Weaver diversity indices for the period of study, calculated based on phytoplankton abundance (H/N), ranged within 2,63–5,52 bit/ind; the lowest were registered in Bystryi branch in spring 2007 and in Merhei lake in summer 2006, while the highest was registered in Potapiv Kut in summer 2007. There was no clear trend in the dynamics of biodiversity indices for all the investigated ecosystems. The highest values were registered in summer 2006 in Sulimanca channel, Matita, Small Merhei and Anankin Kut lakes and in Small Merhei lake, Bystryi and Vostochnyi branches in 2007. Spring maximum was peculiar for Vostochnyi branch and Deliukiv Kut lagoon in 2006 and for Lopatna channel in 2007.

The biodiversity indices calculated based on phytoplankton biomass (H/B) also varied within narrow limits. The lowest value (2,19 bit/g) was registered in summer 2007 in Suez channel and the highest in the same season in Sulimanca channel (5,49 bit/ind). As a rule, for 2006, growth of H/B from spring to summer was noticed, for example in Lopatna channel, Matita and Merhei lakes, Bystryi branch; in Small Merhei and Anankin Kut lakes and Deliukiv Kut lagoon the maximum value was reached in summer, except for Potapiv Kut lagoon where it was minimal. During 2007, growth of H/B from spring to fall was noticed in all water bodies of the Kiliya delta. For Lopatna and Sulimanca channels, Small Merhei lake, Bystryi and Vostochnyi branches summer maximum and a slight decreasing trend in fall was registered.

2.2.4. ZOOPLANKTON

In the Sulina delta lakes (Matita, Merhei and Small Merhei) over the period of investigations 127 species (taxa) of zooplankton were found. The highest number of species belongs to Rotatoria (66), Crustacea comprised lesser number (Copepoda – 20, Cladocera – 40). Veligers of Zebra mussel (Dreissena) were found in Matita and Merhei lakes.

Total number of species in the separate water bodies varied in close limits. In Matita and Small Merhei lakes 77 and 80 species were registered. The highest species richness (102 species) was registered in the Merhei lake. Maximal values were registered in 2006 summer, and in 2007 – in spring.

In 2006 in the water bodies of the Sulina delta Rotatoria dominated in terms of abundance. Values of abundance varied in wide limits – from 15,87 to 1363,67 th. ind/m^3. The lowest values were registered in summer in the Small Merhei lake, and maximal – in the same water body in autumn, because of mass development of the limnophilous rotifers *Asplanchna priodonta* and *Brachionus diversicornis*. Rotifers and Copepoda dominated in terms of biomass. The lowest biomass (0,03 g/m^3) were registered in spring, and maximal (25,56 g/m^3) in autumn in the Small Merhei lake (like those of abundance).

In 2007 zooplankton quantitative indices varied within the following limits: abundance from 366,70 to 1285,50 th. ind/m^3, biomass – from 2,18 to 13,64 g/m^3. Minimal abundance was registered in spring in the Matita lake, and minimal biomass – in spring in the Merhei lake. Maximal quantitative indices (both abundance and biomass) were registered in autumn in the Small Merhei lake. Rotifers dominated in terms of abundance during all seasons of investigations; at the same time maximal biomass in different water bodies, especially in autumn, were formed by Copepoda and relatively big Cladocera of the limnophilous complex, particularly *Sida crystallina, Pleuroxus aduncus, Acroperus harpae*.

In the Kiliya delta water bodies (Anankin Kut lake, Potapiv Kut and Deliukiv Kut lagoons) during the period of investigations 99 species (taxa) of zooplankton were found. The richest in species were rotifers (52 species), followed by Cladocera (29) and Copepoda (17), Dreissena's veligers also were found.

Number of species in the separate water bodies varied slightly. In Anankin Kut and Deliukiv Kut – respectively 70 and 75 species were registered, in the Potapiv Kut lagoon – 56. The lowest values of zooplankton species richness were registered in autumn 2006 in Potapiv Kut (11 species), and maximal – in autumn 2007 in Anankin Kut (37 species).

Quantitative indices of the Kiliya delta water bodies varied within the wide limits. In 2006 abundance varied from 2,19 to 526,08 th. ind/m^3, and biomass from 0,01 to 4,12 g/m^3. The lowest indices were found in spring, and maximal – in autumn in the Anankin Kut, at this dominated Rotatoria and Copepoda. In 2007 the lowest indices of abundance and biomass (0,48 th. ind/m^3 and 0.01 g/m^3) were registered in autumn in Potapiv Kut, maximal abundance (526,08 th. ind/m^3) – in autumn in Potapiv Kut, and maximal biomass (2,64 g/m^3) – in spring in Anankin Kut.

The channels of the Sulina delta (Lopatna, Sulimanca and Suez channels). (In spring 2006 in the Sulimanca channel only qualitative zooplankton samples were taken). During the period of investigations 98 zooplankton species (taxa) were found, among them 56 species of Rotatoria, Copepoda – 14, Cladocera – 27 species, *Dreissena* veligers also were found. Maximal number of species was registered in the Sulimanca channel (76), in the Lopatna and Suez channels – respectively 72 and 64 species. During the period of investigations number of species in the separate water bodies varied from 9 to 41 – the lowest number was in spring 2006 in the Sulimanca channel, maximal – in spring 2006 in the Lopatna channel.

In 2006 in the channels rotifers dominated in terms of abundance. The abundance values varied within wide limits – from 0,92 to 1899,33 th. ind/m^3. The lowest indices were registered in summer in the Suez channel, maximal – in autumn in the Sulimanca channel. In 2006 rotifers also dominated in terms of biomass. The lowest values of biomass (0,01 g/m^3) were registered in summer in the Suez channel (like those of abundance), and maximal (31,80 g/m^3) – in autumn in the Sulimanca channel, at this mass development of the limnophilous rotifers *Asplanchna priodonta* (78% of the total biomass) and *Brachionus diversicornis* (16,5%) was observed.

In 2007 quantitative indices of zooplankton varied within the following limits: abundance 84,70–2093,47 th. ind/m^3, biomass 0,63–14,88 g/m^3. The lowest values of the abundance and biomass were registered in summer in the Lopatna channel, maximal abundance and biomass were registered in autumn in the Sulimanca channel. It is worth to note mass development of *Dreissena* veligers in spring, especially in the Suez and Lopatna channels.

Their number in the Suez channel was 100,0 th. ind/m^3, and in the Lopatna channel – 73,33 th. ind/m^3.

In the Kiliya delta branches (Bystryi and Vostochnyi) over the period of investigations 67 zooplankton species were registered: Rotatoria – 28, Copepoda – 16, Cladocera – 22, as well as *Dreissena* veligers. In the Bystryi branch 51 species were registered, and in Vostochnyi – 52. Number of species in different samples varied from 3 to 34 – the lowest was registered in autumn 2006, and maximal – in spring 2006 in Vostochnyi.

Quantitative indices in the Kiliya delta varied insignificantly. In 2006 abundance varied from 0,54 th. ind/m^3 and biomass – from 0,01 g/m^3 in autumn in the Vostochnyi branch to 26,00 th. ind/m^3 and 0,51 g/m^3 in spring in the Bystryi branch. In 2007 abundance varied within wider range – 0,66–222.33 th. ind/m^3. The lowest values were registered in autumn in Vostochnyi, and maximal – in spring in Bystryi. The lowest biomass (0,01 g/m^3) was registered in summer in Vostochnyi, and maximal (4,11 g/m^3) – in spring in Bystryi. In the Kiliya delta relatively high abundance of *Dreissena* veligers in spring were also registered. For example, in 2006 in Vostochnyi their abundance amounted to 0,82 th. ind/m^3, and in 2007 in Bystryi – 175,00 th. ind/m^3.

Zooplankton species composition

During the period of investigations zooplankton of the Danube delta was characterized by high species richness. Totally 148 species (and lower determined taxa) of three main taxonomic groups, belonging to 27 families and 63 genera. Among Rotatoria there were aquatic organisms of 16 families and 25 genera, the richest in species were families Brachionidae (16 species), Lecanidae (12), Trichocercidae (7), Synchaetidae (7), Asplanchnidae (6). Cladocera belonged to 7 families and 22 genera, among them the richest in species were Chydoridae and Daphniidae. Copepoda belonged to 4 families and 12 genera, among them family Cyclopidae includes most of all species.

Rotifers included maximal number of species (taxa) – 79, Copepoda were presented by 23 species, Cladocera – by 45. Zebra mussel *Dreissena* veligers were also found in zooplankton of the investigated water bodies. On the whole, during the period of investigations in the Danube delta number of species and taxa, found in all seasons and in all water bodies (that is of 100% frequency of occurrence) was low, these were: *Synchaeta* sp., *Asplanchna priodonta, Euchlanis dilatata, Brachionus quadridentatus, B. leydigii, B. calyciflorus, B. diversicornis, Keratella cochlearis, K. quadrata*, rotifers of the order Bdelloidea, Copepoda *Acanthocyclops vernalis, Thermocyclops oithonoides, T. crassus*, *Eurytemora velox, Harpacticoida* gen. sp., Cladocera *Diaphanosoma brachyurum, Moina micrura, Chydorus sphaericus*, *Pleuroxus aduncus*, *Bosmina longirostris*.

In 2006 in the Danube delta water bodies 124 species were found. Rotifers were the richest in species (51% of the total species number), among them most often occurred eurytopic and limnophilous species: *Asplanchna priodonta, Brachionus calyciflorus, B. diversicornis, Euchlanis dilatata, Keratella quadrata, Polyarthra remata* and rotifers of the order Bdelloida, Crustacea (Copepoda amounted 18% and Cladocera 30% of the total number of the found species). In all sites and during all period of investigation nauplii and juveniles (of different development stages) of Copepoda, as well as adult cyclops *Acanthocyclops vernalis, Thermocyclops oithonoides, T. crassus* were found. Among Cladocera more often occurred eurytopic pelagic species *Alona rectangula*, *Chydorus sphaericus*, *Pleuroxus aduncus*, *Bosmina longirostris*. In 2007 127 zooplankton species were registered. Portions of the main taxonomic groups were almost the same: Rotatoria – 52%, Copepoda – 16%, Cladocera – 31% and *Dreissena* veligers. Number of zooplankton species, occurred in all 2007 seasons was low. These were rotifers *Asplanchna priodonta, Brachionus calyciflorus, B. diversicornis*, rotifers of the order Bdelloidea, nauplii and juveniles of Copepoda, as well as adult cyclops *Acanthocyclops vernalis, Thermocyclops oithonoides*.

Zooplankton of the Kiliya delta water bodies in 2006 comprised 93 species of three taxonomic groups, and during 2007 – 84 species (Fig. 2.2.20). In the investigated water bodies of the Sulina delta respectively 111 and 112 zooplankton species were registered. Ratio of the taxonomic groups was very similar in two years of investigations. In 2006 *Dreissena* veligers were registered in minor quantity in all investigated water bodies of the Kiliya delta, and in the lakes of the Sulina delta – only in summer. It is worth to note their mass occurrence in the channels in spring 2007, where they were a part of the dominant complex. For example, in May 2007 their abundance amounted to 39% of total, and biomass – more than a half of total.

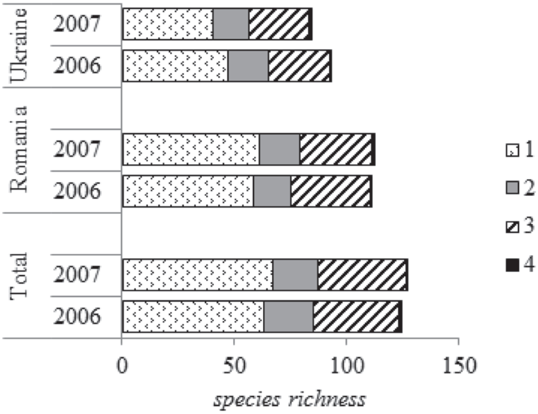

Fig. 2.2.20 Portions of the main zooplankton taxonomic groups, 2006–2007: 1 – Rotatoria, 2 – Copepoda, 3 – Cladocera, 4 – Vel. Dreissena.

During vegetation season decreasing of the species richness from spring to autumn was observed. At this ratio of the main taxonomic group was almost the same. Only in autumn portion of Crustacea species in zooplankton something decreased. It is worth to note that in the water bodies of the Kiliya delta during all seasons lesser species number was registered, then in the Sulina delta water bodies. At this rotifers prevailed in terms of species number in both sections. Domination of rotifers were extremely displayed in zooplankton of running biotopes, e. g. Kiliya delta arms (up to 67% of total species number) and in channels of the Sulina delta (up to 70%).

Zooplankton quantitative characteristic.

Seasonal dynamics of the zooplankton quantitative indices in the investigated water bodies of the Danube delta had some peculiarities. In 2006 average abundance and biomass values of the arms and lakes of the Kiliya delta gradually increased from spring to autumn (Fig. 2.2.21). On the whole, growth of values over vegetation period occurred due to the mass development of nauplii larvae and juveniles of Copepoda, as well as some adult Cyclops, like *Acanthocyclops vernalis, Thermocyclops oithonoides*. At this average abundance and biomass values of other taxonomic groups decreased. Zooplankton quantitative indices in 2007 varied within wide limits. In this year zooplankton development was character by high quantitative values in spring and their further sharp decrease.

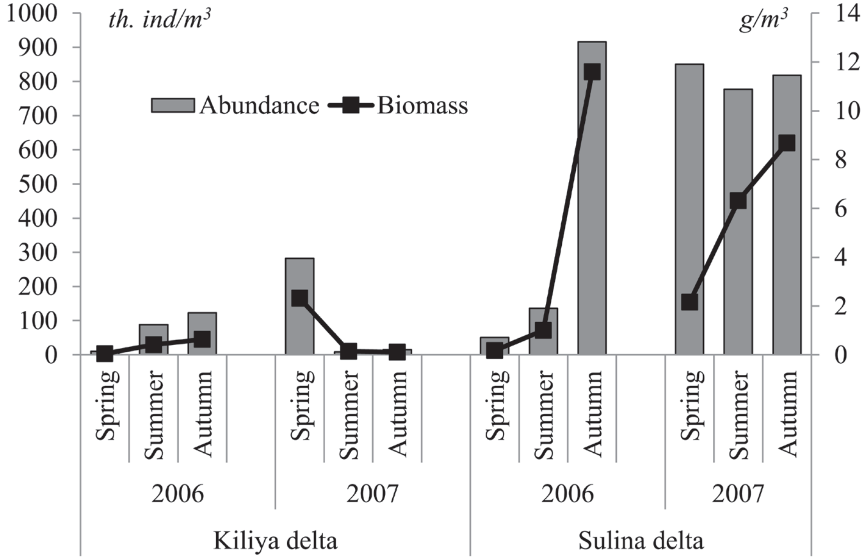

Fig. 2.2.21 Seasonal dynamics of zooplankton quantitative indices, 2006–2007

For zooplankton of the lakes and channels of Sulina delta in 2006 growth of the quantitative indices to the autumn was peculiar. At this role of rotifers of the limnophilous complex increased during vegetation period, and role of Cladocera, especially in terms of biomass, considerably decreased to autumn. During all seasons dominated rotifers *Asplanchna priodonta, Brachionus calyciflorus, B. diversicornis*, nauplii and juvenile Copepoda, as well as some Cladocera – *Ceriodaphnia pulchella, Bosmina longirostris, Chydorus* *sphaericus, Eurycercus lamellatus*. More smoothed quantitative indices (especially abundance) were registered in 2007. Zooplankton biomass, as during previous year, gradually increased from spring to autumn. Dominated rotifers *Asplanchna priodonta, Brachionus diversicornis*, in spring – *Filinia longiseta limnetica*, and also Cladocera – *Diaphanosoma brachyurum*

It is also worth to note, that level of the quantitative indices of the Sulina delta water bodies is practically by order of magnitude higher than those of the Kiliya delta. On the whole zooplankton of the lakes and arms of the Kiliya delta can be characterized as "Copepoda–Rotatoria", and zooplankton of the Sulina delta – as "Rotatoria–Cladocera".

Dynamics of zooplankton development in the lakes and branches of the Kiliya delta, lakes and channels of the Sulina delta has some peculiarities (see Fig. 2.2.20, 2.2.21). In the Kiliya delta there was clear distinction in the quantitative dynamics of the almost closed lakes and running arms. The most diverse and abundant was zooplankton in the lakes. Dominated complex of the planktonic fauna was presented mainly by eurytopic and limnophilous species, at this planktonic Crustacea prevailed in terms of quantitative indices.

Maximal number of species was registered in spring in the branches, and in summer and autumn mainly in the water bodies of the Kiliya delta (Fig. 2.2.22).

Abundance and biomass varied within close limits, with some exceptions. For example, in Anankin Kut abundance varied from 2 to 712 th. ind/m^3, and biomass – from 0,01 to 4,2 g/m^3 (Fig. 2.2.23, 2.22.24). Over the vegetation period in the lakes of the Kiliya delta dominated rotifers *Asplanchna priodonta, Brachionus calyciflorus, Platyias quadricornis,* Cyclops *Acanthocyclops vernalis,* Cladocera *Chydorus sphaericus*, and in arms prevailed the nauplii and juvenile Cyclopoida. Higher quantitative indices were registered in autumn 2006 in the lakes, and in spring 2007 in all investigated sites of the Kiliya delta.

Stably high quantitative indices were peculiar for the lakes and channels of Sulina delta. Common regularity for all channels was decrease of the species richness from spring to summer and its minor increase in autumn. In the lakes maximal number of species was registered in summer 2006 and in spring 2007 (see Fig. 2.2.22). Abundance and biomass increased, and, as a rule, reached maximal values in autumn (see Fig. 2.2.23, 2.2.24), because of mass development of limnophilous Cladocera: *Sida crystallina, Diaphanosoma brachyurum, Pleuroxus aduncus, Acroperus harpae*.

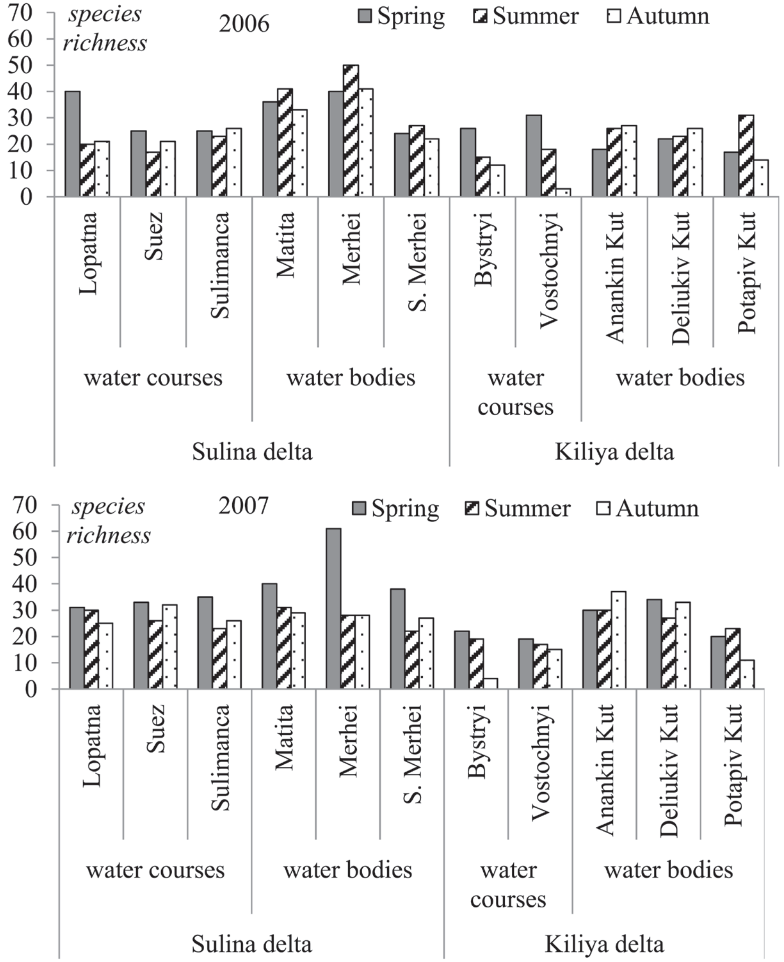

Fig. 2.2.22 Seasonal dynamics of zooplankton species richness 2006–2007

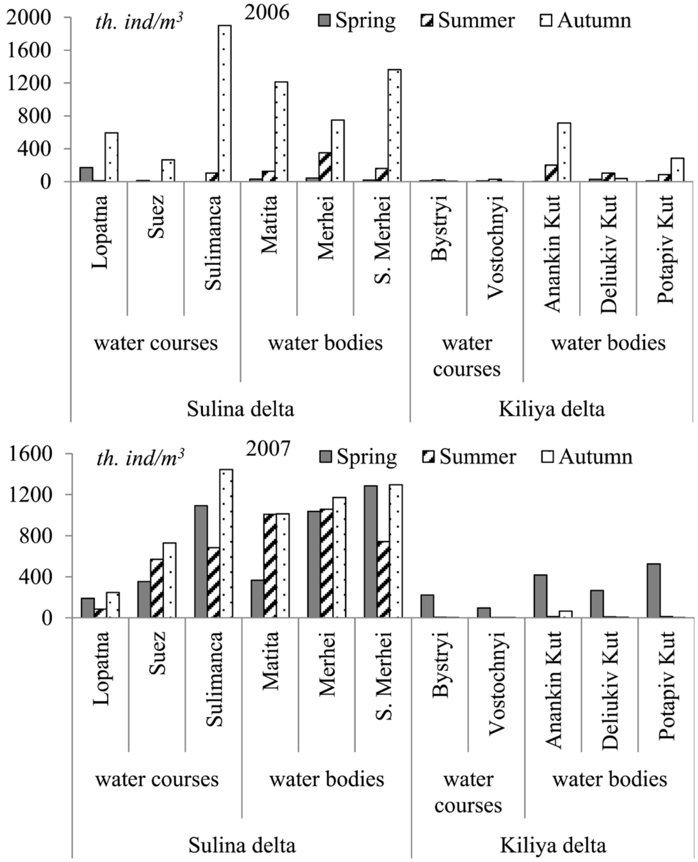

Fig. 2.2.23 Seasonal dynamics of zooplankton abundance, 2006–2007

The Shannon-Wiener diversity indices for the period of study. Minimal values of the species diversity, calculated on zooplankton abundance, were registered in spring 2006 in the lakes Matita (0,83 bit/ind) and Merhei (0,99 bit/ind), and during 2007 also in spring in the Bystryi branch (1,32), Vostochnyi branch (1,26) and the Potapiv Kut lagoon (1,12 bit/ind). High species diversity indices were peculiar for zooplankton in the Sulina delta lakes in autumn 2006 (H/N maximal values 2,94 bit/ind). In summer these indices were moderate. In 2007 maximal index values were marked in spring in the Merhei lake (3,31 bit/ind) and in Vostochnyi branch (3,33 bit/ind). Minimal indices, calculated on zooplankton biomass, were registered in autumn 2006 (in the Sulimanca channel – 1,04 bit/g), and maximal – in spring 2006 in the Kiliya water bodies (in the Anankin Kut lake – 3,42 bit/g), and in spring 2007– in the lakes of the Sulina delta (in the Merhei lake – 3,56 bit/g).

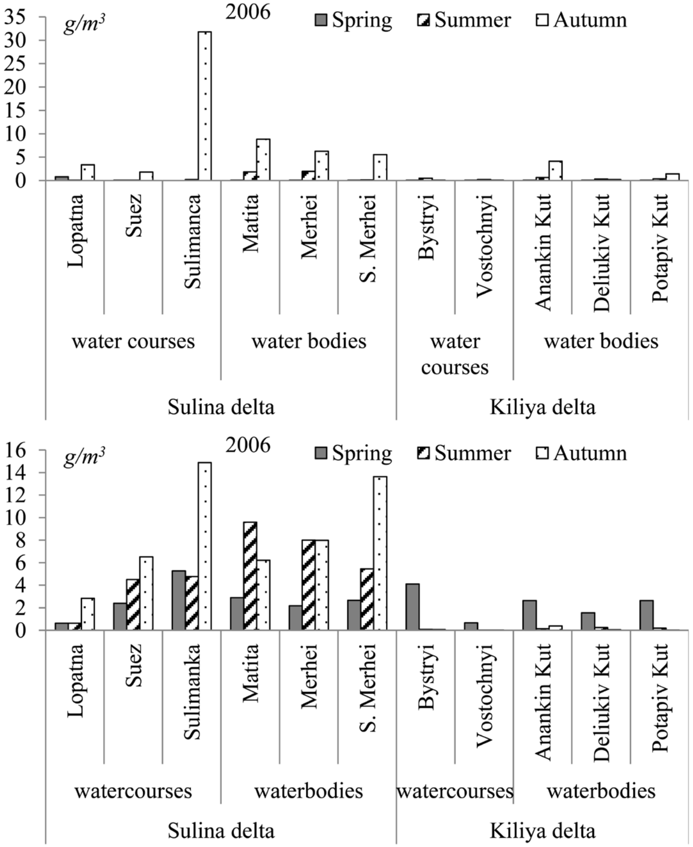

Fig. 2.2.24 Seasonal dynamics of the zooplankton biomass, 2006–2007

2.2.5. PHYTOPHILOUS FAUNA.

Lakes of the Sulina delta.

Matita lake. The phytophilous complexes included 78 species of the aquatic invertebrates, of them maximal species number belonged to Chironomidae larvae (18 species). Total species richness in two years was close (58 species in 2006, 52 – in 2007). Maximal species number was registered in summer 2006 (45), and minimum (12) – in autumn 2007.

Average abundance and biomass of the phytophilous invertebrates were 4,64 th. ind/kg and 5,72 g/kg, but these indices varied within wide limits. Maximal abundance was registered in spring 2006 (12,45 th. ind/kg) and maximal biomass in spring 2007 (14,77 g/kg). The lowest indices were in autumn 2007 (0.12 th. ind/kg and 0,75 g/kg). Chironomidae larvae dominated in terms of abundance (55%), and Gastropoda and Odonata larvae dominated in terms of biomass (19% each).

Merhei lake. Total species number (101) was maximal among all the investigated ecosystems. The richest in species were Chironomidae larvae, Oligochaeta and Gastropoda (respectively 25, 15 and 14 species). In 2007 the species number somewhat decreased (to 67) as compared with 2006 (74). Maximal species number was registered in spring 2007 (49) and minimal – in autumn 2007 (19).

Average abundance and biomass values amounted to 7,68 th. ind/kg and 10,77 g/kg; maximal highest abundance was registered in autumn 2006 (16,71 th. ind/kg) and biomass in spring 2006 (35,12 g/kg), minimal were registered in autumn 2007 (0,64 th. ind/kg and 0,51 g/kg). Oligochaeta dominated in terms of abundance (48%), Odonata larvae and Gastropoda dominated in terms of biomass (20% each).

Small Merhei lake. In this lake 74 invertebrate species were identified: 39 species in 2006, and 61 in 2007. Maximal species number was registered in spring 2007 (31) and minimal – in autumn 2007 (15). The richest species were Chironomidae larvae (20), Oligochaeta (9) and Trichoptera larvae (8).

Average abundance and biomass were 7,68 th. ind/kg and 2,83 g/kg.

Maximal abundance was registered in spring 2006 (8,70 th. ind/kg) and maximal biomass – in summer 2006 (7,27 g/kg). Minimal abundance was registered in autumn 2006 (0,43 th. ind/kg) and minimal biomass – in autumn 2007 (0,29 g/kg). Oligochaeta dominated in terms of abundance (48%), Gammaridae dominated in terms of biomass (24%).

So, totally in the Sulina delta lakes 126 species of the phytophilous invertebrates were found. In 2006 species number exceeded those in 2007 (respectively 100 and 85 species). During the investigated period the taxonomic composition of the phytophilous fauna of these ecosystems exhibited many common features: Chironomidae larvae dominated in species number, Gammaridae dominated in terms of biomass. In Merhei and Small Merhei lakes Oligochaeta dominated in terms of abundance, and in Matita lake Chironomidae larvae were dominant.

Channels of the Sulina delta.

Lopatna channel. In this ecosystem 80 species were identified: 66 in 2006 and 36 in 2007. Chironomidae larvae comprised maximal species number (18), they were followed by Oligochaeta (12 species). The maximal species number was registered in spring 2006 (32 species), and minimal – in summer 2007 (15 species).

Average abundance and biomass in this water course were 11,69 th. ind/kg and 9.38 g/kg, maximal in spring 2007 (43,13 th. ind/kg and 29,55 g/kg), minimum – in autumn 2007 (1,41 th. ind/kg and 1,40 g/kg). Chironomidae larvae dominated both in terms of abundance (56% of total) and biomass (50% of total).

Suez channel. In this ecosystem 62 species were registered, 50 in 2006 and 30 in 2007. The most diverse were Chironomidae larvae (15 species), followed by Oligochaeta (7), maximal species number was in autumn 2006 (29) and minimal – in autumn 2007 (8).

Average abundance and biomass were 5,13 th. ind/kg and 20,80 g/kg, maximal abundance were registered in autumn 2006 (19,85 th. ind/kg) and maximal biomass – in summer 2006 (68,55 g/kg); minimal abundance and biomass were registered in autumn 2007 (0,43 th. ind/kg and 0,07 g/kg). Chironomidae larvae and Oligochaeta dominated in terms of abundance (each 33% of the total), Hirudinea (29%) and Gastropoda (28%) dominated in terms of biomass.

Sulimanca channel. In this ecosystem 45 species were recorded (36 in 2006, 24 in 2007). Maximal species number belonged to Chironomidae larvae (15), followed by Oligochaeta (7); maximal species number was registered in summer 2006 (29) and minimal – in summer 2007 (only 8).

Average abundance and biomass were 9,43 th. ind/kg and 8,04 g/kg; maximal abundance was registered in autumn 2006 (15,9 th. ind/kg) and maximal biomass – in summer 2006 (21,57 g/kg). Minimal abundance and biomass were registered in summer 2007 (0,42 th. ind/kg and 0,19 g/kg). Oligochaeta dominated in terms of abundance (44%) and Odonata larvae in terms of biomass (32%).

So, totally in the channels 106 species of phytophilous invertebrates were found. The peculiar feature was notable diversity of Chironomidae larvae (totally 26 species). Gastropoda, which, as a rule, are quite diverse in the phytophilous complexes, comprised minor species number (in the Sulimanca channel they were absent). In Sulimanca channel portion of Chironomidae larvae was maximal, but all other Diptera were absent. In Suez channel, portion of Crustacea was maximal, but the number of Oligochaeta species was minor. In the Lopatna channel portion of Crustacea species was low, but maximal number of Diptera species. On general, in 2006 species richness was higher than in 2007.

Water bodies of Kiliya delta

Anankin Kut lake. 66 species of phytophilous invertebrates were found; species number in two years did not was close – 48 in 2006 and 45 in 2007. The most diverse were Chironomidae larvae (18), followed by Oligochaeta (13). Number of Gastropoda species was low (only 4). Maximal species number was registered in summer 2006 (25) and minimal (13) – in autumn 2006.

Total abundance and biomass of the phytophilous invertebrates varied within narrow limits. The average values were 0,84 th.ind/kg and 0,82 g/kg; maximal abundance and biomass were registered in spring 2007 (2,51 th. ind/kg and 1/46 g/kg), minimal abundance – in autumn 2007 (0,27 th. ind/kg and minimal biomass – in spring 2007 (0,25 g/kg). Oligochaeta dominated in terms of abundance (46%), Hirudinea (16%) and Odonata larvae (14%) dominated in terms of biomass.

Potapiv Kut lagoon. In this ecosystem 79 species were recorded: 58 in 2006 and 46 in 2007. The most diverse were Chironomidae larvae (16), Oligochaeta (12) and Gastropoda (9 species); maximal species number was registered in autumn 2006 (30) and minimal – in spring and autumn 2007 (17).

Total abundance and biomass of the phytophilous invertebrates varied within wide limits. The average values during the investigated period were 3,11 th. ind/kg and 4,84 g/kg, maximal were registered in spring 2006 (5,09 th. ind/kg and 11,28 g/kg) and minimal – in autumn 2007 (2,94 th. ind/kg and 0,93 g/kg). Oligochaeta dominated in terms of abundance (45% of total) and Gastropoda in terms of biomass (36%).

Deliukiv Kut lagoon. Phytophilous fauna of this lake comprised 76 species: 61 species were found in 2006, and 47 – in 2007. The most diverse were Chironomidae larvae and Oligochaeta (14 species each) followed by Gastropoda (10 species); maximal species number was registered in autumn 2006 (35) and minimal in spring 2006 (16 species).

The average abundance and biomass in this water body were 2,39 th. ind/kg and 1,89 g/kg. maximal abundance and biomass were registered in spring 2007 (5,39 th. ind/kg) and in autumn 2006 (2,62 g/kg), minimal abundance was registered in summer 2006 (0,67 th. ind/kg) and biomass – in spring 2006 (1,03 g/kg). Oligochaeta dominated in terms of abundance (49% of total) and Gastropoda in terms of biomass (34% of total).

So, over investigation period the phytophilous fauna of the Kiliya delta water bodies comprised 125 species; species number was higher in the year with high water level (2006) as compared with the year with low water level (2007): respectively 97 and 84. Potapiv Kut and Deliukiv Kut lagoons had more similar composition: considerable development of snails Gastropoda was noticed, whereas in Anankin Kut lake this group was almost absent.

Branches of the Kiliya delta.

Bystryi branch. 49 species of phytophilous invertebrates were identified in two years: 37 in 2006 and 30 – in 2007. The most diverse were Oligochaeta and Gammaridae (7 species each); maximal species number (23) was registered in autumn 2006 and minimal (10) in autumn 2007.

Average abundance and biomass of phytophilous invertebrates were 4,00 th. ind/kg and 29,09 g/kg; maximal abundance and biomass were registered in autumn 2006 (12,34 th. ind/kg and 120,57 g/kg), minimal were recorded in autumn 2007 (0,53 th. ind/kg and 0,37 g/kg). Chironomidae larvae dominated in terms of abundance (31% of total) and Bivalvia in terms of biomass (83% of total).

Vostochnyi branch. 79 species of invertebrates were recorded: 61 species in 2006 and 43 species in 2007. The most diverse were Chironomidae larvae (17), Gastropoda (15) and Oligochaeta (10); maximal species number (42) was registered in summer 2007, and minimal – in autumn 2006 and in spring 2007 (19 species).

The average abundance and biomass of the phytophilous invertebrates were 2,12 th. ind/kg and 13,06 g/kg; maximal abundance and biomass were registered in summer 2006 (4,79 th. ind/kg and 24,16 g/kg), minimal abundance – in autumn 2007 (0,51 th. ind/kg) and biomass – in spring 2006 (0,74 g/kg). Corophiidae dominated in terms of abundance (31 % of total), Bivalvia in terms of biomass (55 % of total).

So, totally in the water courses of Kiliya delta 93 species of the phytophilous invertebrates were found, though portions of dominant taxa were different. Common feature for both arms was the considerable amount of mollusks, both Bivalvia and Gastropoda, as well as Crustacea (Corophiidae and Gammaridae), which dominated in certain seasons. In 2007, at low water level, the species richness decreased, especially in the Vostochyi branch.

Phytophilous complex species composition

Over the years 2006–2007 in the investigated ecosystems of the Danube delta 184 species of the phytophilous complex were recorded. Comparison within Romanian part (old delta) and Ukrainian part (young delta) showed equal number of species in both sides: 144.

The most diverse were Chironomidae larvae (42 species, 36 in the old and 30 in the young delta). Considerable number of species were registered also of Gastropoda (21) and Oligochaeta (19). On both sides of the delta the following groups were found: Coleoptera – 13 species; Odonata larvae – 12; Trichoptera larvae – 11, Gammaridae – 11; Hirudinea – 10 species, Heteroptera – 8, Corophiidae – 5, Ceratopogonidae larvae – 4; Bryozoa, Bivalvia, Ephydridae larvae – 3 species each; Isopoda, Mysidacea, Ephemeroptera larvae and Stratiomiidae – 2 species each. Cumacea and Porifera included 1 species each. Other organisms were not determined to the species level.

Comparison of the species composition showed that in the old delta more Trichoptera and Chironomidae larvae were found, whereas in the younger delta Coleoptera and Gammaridae were more frequent.

For the first time in the Ukrainian section of the Danube River the mussel *Dreissena bugensis* Andr. was found attached on *Butomus umbellatus* L., in the mouth section of Vostochnyi branch. Among the phytophilous fauna 9 species occurred with 100% frequency: *Nais barbata* O. F. Muller, *Stylaria lacustris* (Linnaeus), *Pisciola geometra* (Linne), *Ischnura elegans* (van der Linden), *Caenis horaria* (Linne), *Cladotanytarsus mancus* (Walker), *Cricotopus sylvestris* (F.), *Dikerotendipes nervosus* (Staeger*), Psectrocladius sordidellus* (Zetterstedt).

Minimal frequency was recorded for *Hirudo medicinalis* (Linne), which was found only in the Suez channel, *Paramysis intermedia* (Cherniavsky) (Matita lake) and *Pseudocuma cercaroides* G.O.Sars (Small Merhei lake), *Agraylea multipunctata* Curtis and *Cheumatopsyche lepida* Wallengren larvae (Bystryi branch), *Aeschna juncea* (Linne) larvae (Deliukiv lagoon), *Aeschna viridis* (Linne) larvae (Potapiv Kut lagoon), *Cordulia aeneaturfosa* Forster (Merhei lake) and *Sympetrum flaveolum* (Linne) (Lopatna channel).

Comparison of the taxa spectra of the phytophilous complexes (Fig. 2.2.25) showed that Insecta prevailed in terms of species number in all the investigated water ecosystems, though in the arms of the young delta and in Lopatna channel their portion was slightly lower than in other water bodies. In the lakes of the Kiliya delta (Anankin and Deliukiv) portions of Oligochaeta were maximal (respectively 27 and 25%), whereas their minimal portion was found in the Matita lake (17%). Maximal percentage of mollusks species was found in the Vostochnyi branch (22%) and minimal – in the

Anankin lake (only 6%). Crustacea reached considerable portion only in the Bystryi branch (24%) and Suez channel (18%).

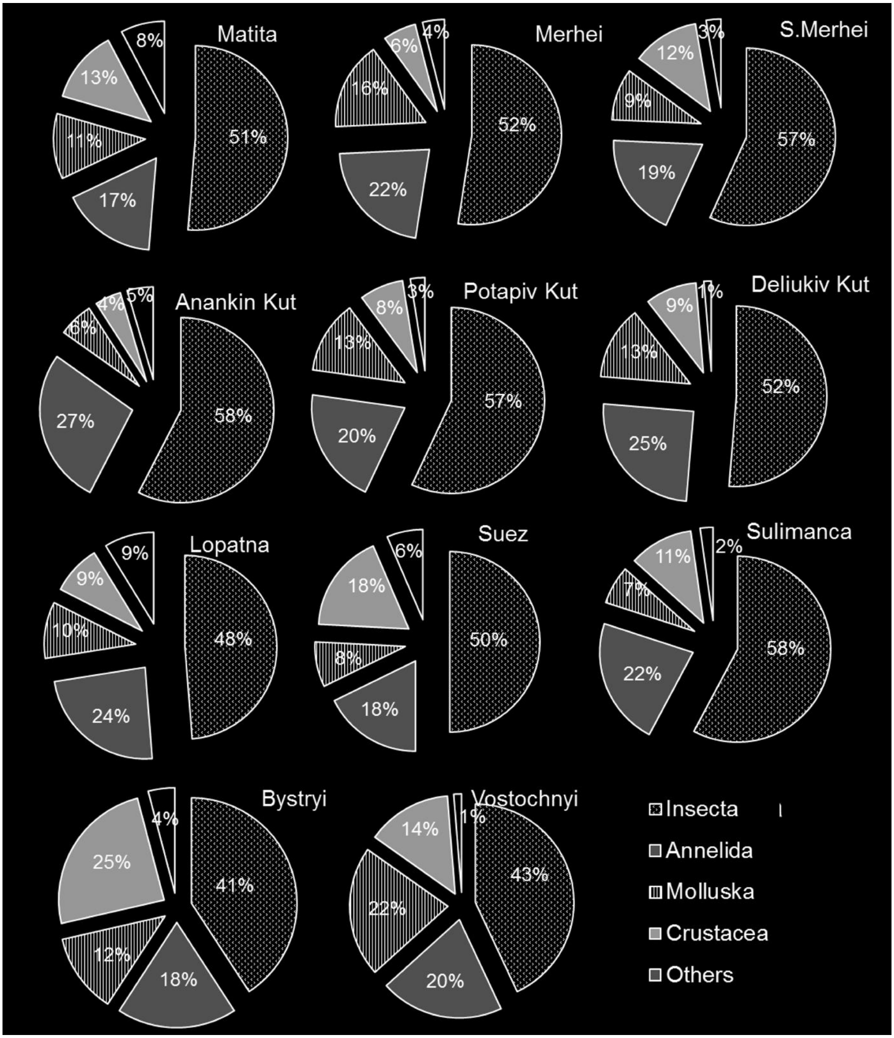

Fig. 2.2.25 Taxonomic composition of the phytophilic fauna of the Danube Delta

So, during the studied period the taxonomic composition of the phytophilous complexes of the old delta were to the smaller degree dependent on the ecosystem's type (there were many common features within channels and lakes), than in the young delta, where higher distinction within the ecosystem types was found.

Quantitative indices.

Maximal average abundance was found in the Lopatna channel (11,69 th. ind/kg) and maximal average biomass – in Bystryi branch (29,09 g/kg); minimal averages of abundance and biomass were registered in the freshwater Anankin Kut lake (0,84 th. ind/kg and 0,82 g/kg) (Fig. 2.2.26, 2.2.27). Generally, the average abundance was lower in the ecosystems of the young delta, than in the old delta. Biomass values varied in more narrow limits than the abundance.

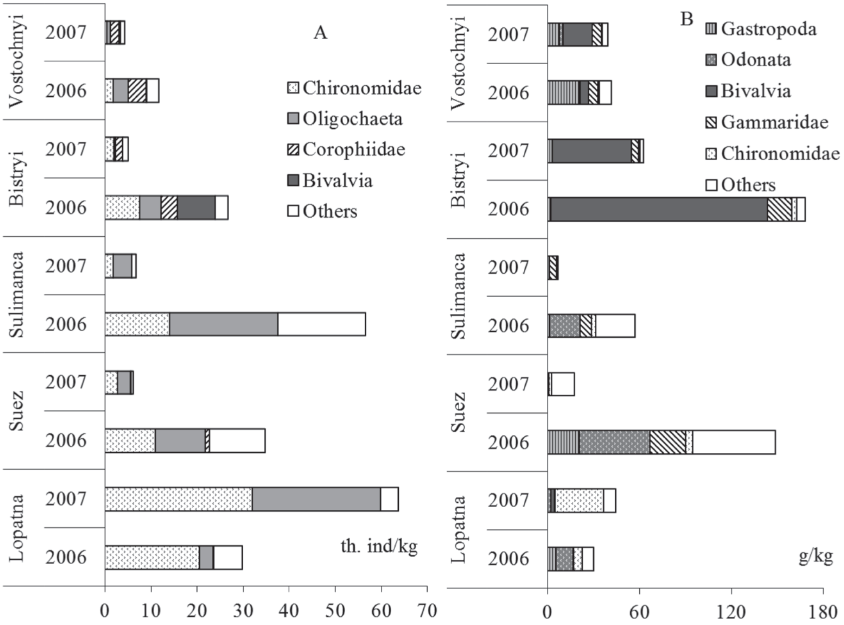

Fig. 2.2.26. Total abundance (A) and biomass (B)
of the phytophilous invertebrates in the investigated water courses

Analysis of the annual averages of abundance and biomass of the phytophilous complexes in the investigated ecosystems showed that in 2006 these indices were higher in almost all of them. (except Lopatna channel). In both years Chironomidae larvae and Oligochaeta dominated in terms of abundance; in Bystryi and Vostochnyi branches, their dominance was shared with Corophiidae also. In terms of biomass, in Kiliya delta arms dominated Gastropoda and Bivalvia, whereas in the ecosystems of the old delta in 2006 dominated Odonata larvae and in 2007 – Gammaridae or Chironomidae larvae.

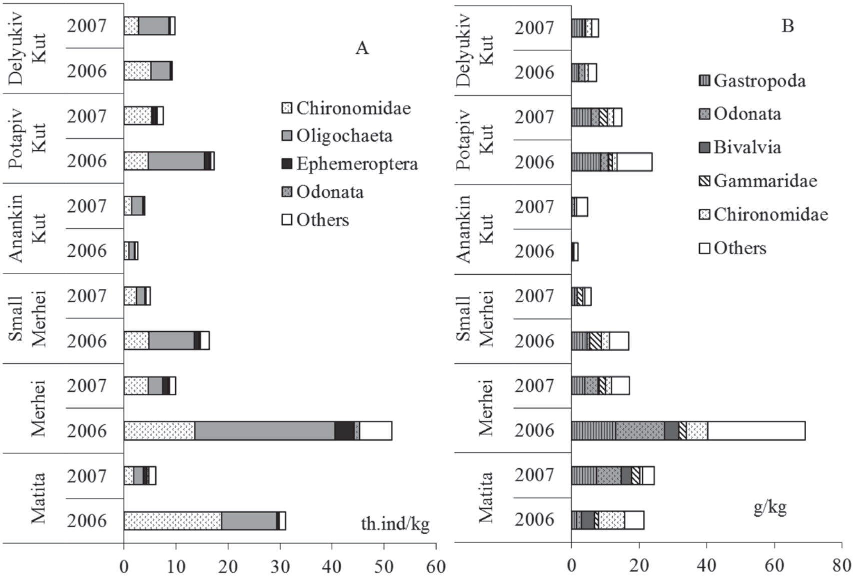

Fig. 2.2.27 Total abundance (A) and biomass (B)
of the phytophilous invertebrates in the investigated water bodies

In the lakes of the Sulina delta and in Potapiv Kut lagoon the annual average abundance of phytophilous invertebrates was higher in 2006 than in 2007 (Fig. 2.2.26); Chironomidae larvae and Oligochaeta were dominant, as in channels. The highest annual average abundance in both years was registered in Merhei lake. In the lakes Merhei, Small Merhei, and Potapiv lagoon the biomass was higher in 2006 than in 2007, as opposed to other ecosystems.

In the water bodies of the Sulina delta, change of the dominant groups occurred in two years of study: in 2006 Chironomidae larvae dominated in Matita lake and Odonata larvae in Merhei lake, in 2007 Gastropoda dominated in both lakes; in Small Merhei, Gastropoda dominated in 2006, while in 2007 they were replaced by Gammaridae.

In the water bodies of the Kiliya delta the dominance was kept for the whole duration of study: e.g. Anankin Kut lake was dominated by Hirudinea, Potapiv Kut and Deliukiv Kut lagoons by Gastropoda.

The highest annual average biomass in 2006 was registered in the Merhei lake, and in 2007 it was recorded in the Matita lake; the lowest annual average was found in the Anankin Kut lake in both years of investigation.

Species diversity of the phytophilous complexes

The Shannon diversity index shows minor variations of species diversity within the different ecosystems (Fig. 2.2.28).

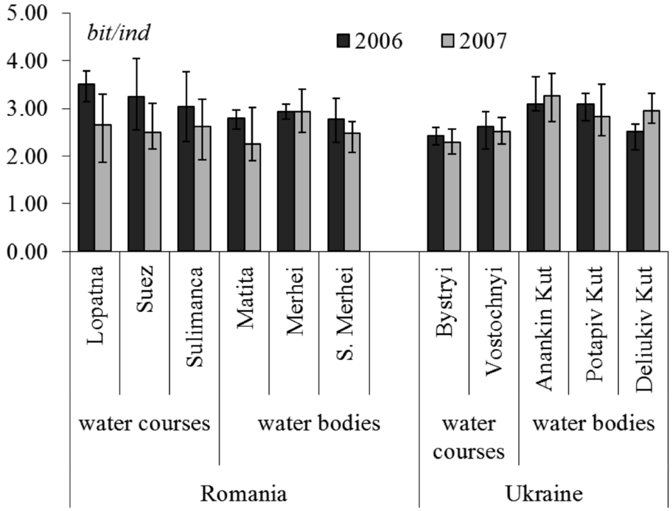

Fig. 2.2.28 The Shannon diversity index of the phytophilous complexes of Danube delta.

Maximal was found in the Anankin Kut lake (3,18 bit/ind) due to its constantly high values during the period of investigation. High diversity of the phytophilous fauna was also registered in the Lopatna channel (3,04 bit/ind), due to the minor variations over the vegetation season in 2006.

Minimal average value of the index calculated in the Bystryi branch, due to the low values recorded in both years (respectively 2,42 and 2,29 bit/ind). The analysis of the Shannon index dynamics showed that species diversity was higher in 2006 in almost all the investigated ecosystems (except Merhei and Anankin Kut lakes and Deliukiv Kut lagoon).

2.2.6. MACROZOOBENTHOS

Lakes of the Sulina delta. During the investigated period 80 species of benthic invertebrates of 18 groups were found: Matita lake – 51, Merhei lake – 54, Small Merhei lake – 31. The most diverse were Chironomidae larvae (28), followed by Oligochaeta (13), Gastropoda (8), Gammaridae (6), Trichoptera (5), Hirudinea (4), Bivalvia (3), Odonata (2) and Ephemeroptera larvae (2). One species of Cumacea, *Pseudocuma cercaroides* (G. O. Sars) and one species of Isopoda, *Asellus aquaticus* L were also found; other groups were not determined to the species level.

In Sulina delta lakes Acariformes and Chironomidae larvae were dominant in terms of abundance; Acariformes abundance ranged within 417–17500 ind/m^2, maximal was registered in autumn 2006 in Small Merhei lake. Chironomidae abundance varied within 750–11583 ind/m^2, maximal was registered in Matita lake in spring. Bivalvia and Gastropoda dominated in 2006 in terms of biomass. Biomass of Bivalvia varied within 1,83–242,50 g/m^2; maximal was reached in Small Merhei lake due to the development of *Dreissena polymorpha* (Pallas). Gastropoda's biomass ranged within 2,33–225,42 g/m^2; maximal was found also in Small Merhei lake due to development of the snail *Viviparus viviparus* (Linne).

In 2007 Chironomidae larvae were dominant in terms of abundance, ranging within 933–10247 ind/m^2; maximal were registered in Matita lake due to the development of *Propsilocerus orielicus* (Thsher.) and *Fleuria lacustris* (Kiffer). Gastropoda were dominant in terms biomass in 2007, ranging within 7,92–313,74 g/m^2; maximal was registered in Matita lake due to the development of the snails *Viviparus viviparus* (Linne).

Water bodies of Kiliya delta. 56 species of benthic invertebrates of 13 groups were identified in the investigated water bodies of Kiliya delta: Potapiv Kut lagoon–- 31, Deliukiv Kut lagoon – 27, Anankin Kut lake – 11. The most diverse were Chironomidae larvae (21 species), followed by Oligochaeta (10), Gastropoda (10), Hirudinea (2), Bivalvia (2), Odonata (2) and Heteroptera (2). One species of Gammaridae (*Pontogammarus robustoides* (Sars) and one species of Corophiidae (*Corophium volutator* (Pallas) were also found; Nematoda, Ceratopogonidae and Coleoptera groups were not determined to the species level.

Oligochaeta and Chironomidae larvae were dominant in terms of abundance during the whole period. In 2006, Oligochaeta abundance ranged within 600–9800 ind/m^2 and in 2007 – within 600–13400 ind/m^2; maximal abundances were registered in Deliukiv Kut and Potapiv Kut lagoons in autumn. The abundance of Chironomidae larvae in 2006 ranged within 100–4800 ind/m^2 and 300–8800 ind/m^2 in 2007; maximal values were recorded in Potapiv Kut lagoon in summer 2006 and in spring 2007. In 2006, Gastropoda dominated in biomass, their values ranging within 19,00–35,70 g/m^2; maximal values were registered in summer in Deliukiv Kut lagoon. In 2007 Bivalvia mussels dominated in terms of biomass, ranging within 14,02–309,80 g/m^2; maximal values were registered in spring in Potapiv Kut lagoon due to the development of the mussel *Anodonta piscinalis* (Nilsson).

Channels of the Sulina delta. 78 species of the benthic invertebrates of 19 groups were found in the channels of the Sulina delta during the investigated period: Sulimanca – 49, Lopatna – 23, Suez – 36. The most diverse were Chironomidae larvae (23 species), followed by Oligochaeta (14), Gastropoda (7), Hirudinea (5), Bivalvia (5), Trichoptera (5), Odonata (3), Mysidacea (1 – *Limnomysis benedeni* Czerniavsky), Cumacea (1 – *Pseudocuma laevis* (G. O. Sars), Isopoda (1 – *Asellus aquaticus* L.), and Ephemeroptera (1 – *Caenis* *horaria* (Linne)). Acariformes, Hydrozoa, Nematoda, Ceratopogonidae, Lepidoptera and Coleoptera were not determined to the species level.

In 2006 Acariformes were dominant in terms of abundance; in Sulimanca channel they reached 46000 ind/m^2, followed by Oligochaeta (250–5750 ind/m^2). Maximal was registered in summer in Sulimanca channel. In 2007 Oligochaeta and Chironomidae larvae were dominant in terms of abundance, their values ranging respectively within 200–29 216 ind/m^2 and 250–9750 ind/m^2; maximal abundance of Oligochaeta was recorded in spring in Suez channel, the highest abundance of Chironomidae was recorded in Sulimanca channel in the same period.

Bivalvia and Gastropoda dominated in terms of biomass; in 2006 the biomass of these groups ranged respectively within 21,23–535,00 g/m^2 and 0,70–355,00 g/m^2, and in 2007 within 510,17–5400,00 g/m^2 and 125,00–500,00 g/m^2. In 2006 maximal values of Bivalvia were registered in summer in Sulimanca channel due to the mussel *D. polymorpha* (Pallas); maximal value of Gastropoda was found in the same period in the Suez channel due to the snail *V. viviparus*. Maximal biomass value of Bivalvia in 2007 was registered in autumn in Sulimanca channel due to the mussel *Unio pictorum* (Linne), and maximal biomass of Gastropoda was recorded in summer in the Suez channel.

Branches of the Kiliya delta. 64 species of the benthic invertebrates of 14 taxonomic groups were found during the investigation period: in Bystryi branch – 42 and in Vostochnyi branch – 47. The most diverse were Chironomidae larvae (14), followed by Gastropoda (13), Oligochaeta (12), Gammaridae (8), Corophiidae (4), Polychaeta (2), Bivalvia (2), Hirudinea (2), Heteroptera (2), Odonata (1), Trichoptera (1) and Isopoda (1); Acariformes and Nematoda were not determined to the species level.

In 2006 the dominant group in abundance was Oligochaeta, ranging within 1000–7900 ind/m^2; maximal was registered in summer in Bystryi channel. Gastropoda and Bivalvia dominated in terms of biomass, ranging respectively within 0,30–28,60 g/m^2 and 8,00–21,00 g/m^2. The highest biomass of both groups was registered in autumn in Bystryi branch.

In 2007 Oligochaeta and Corophiidae were dominant in terms of abundance, the values ranging respectively within 1100–14400 ind/m^2 and 300–16500 ind/m^2; maximal values of both groups were registered in Vostochnyi branch. Gastropoda were dominant in terms of biomass, their values ranging within 11,57–74,83 g/m^2; maximal was reached in summer in the Vostochnyi branch, due to *Fagotia esperi* (Ferussae).

Species composition

Over period of investigation in the considered ecosystems 146 species of benthic invertebrates were recorded (108 in 2006, 100 in 2007). 110 species were found in the ecosystems of Sulina delta: 78 in the channels, 80 in the lakes, whereas in the younger delta 88 species were found: 64 in the arms and 56 in lakes and lagoons.

In 2006 maximal species number was registered in Merhei lake (42), and minimal in Anankin Kut lake (11). In 2007 maximal number of species was registered in Bystryi branch (35), and minimal – in Lopatna channel (4 species).

The presence of the species *Gmelina pusilla* Sars (Crustacea, Amphipoda, Gammaridae) in the lakes of the Sulina delta is considered very important, taking into account the environmental protection, because this species is included in the Red Book of Ukraine.

The presence of the species *Rhynchelmis limnosella* Hoffmeister (Oligochaeta), found only in Suez channel, is also considered important as this species inhabits different types of water bodies (rivers, lakes, springs, wetlands) and prefers shaded places among closed vegetations, on silted soils. Some authors consider this species as glacial relict [CHEKANOVSKAYA 1962].

The following species inhabited only the certain water bodies:

in Sulimanca channel: Hydrozoa, Oligochaeta – *Psammoryctides albicola* (Michaelsen) and *Peloscolex velutinus* (Grube), Cumacea – *Pseudocuma laevis* (G.O. Sars), Gastropoda – *Unio pictorum* (Linne), Chironomidae – *Psectrocladius dilatatus* van der Wulp, Odonata – *Coenagrion pulchellum* (van der Linden), Trichoptera – *Polycentropus flavomaculatus* Pictet, *Hydropsyche ornatula* (Mc. lachlan), Coleoptera, Lepidoptera;

in Lopatna channel: Oligochaeta – *Stylaria lacustris* (Linnaeus), Gastropoda – *Acroloxus lacustris* (L.), Odonata – *Platycnemis pennipes* Pallas;

in Suez channel: Oligochaeta – *Psammoryctides barbatus* (Grube), *Rhynchelmis limnosella* Hoffmeister, *Eiseniella tetraedra* (Savigni), Hirudinea – *Batracobdella paludosa* (Carena) and *Helobdella stagnalis* (L.), Mysidacea – *Limnomysis benedeni* Czerniavsky;

in Matita lake: Oligochaeta – *Nais pseudoptusa* Piguet, *Brachiobdella sp.,* Hirudinea – *Pisciola fasciata* (Linne), Chironomidae – *Psectrocladius zetterstedti* (Zetterstedt), Trichoptera – *Orthotrichia tetensii* Kolbe;

in Merhei lake: Arachnida, Bivalvia – *Anodonta sp*., Trichoptera – *Mystacides longicornis* (Linne), Ephemeroptera – *Caenis robusta* (Eaton), larvae of Diptera Ephidridae sp., Chaoborus sp.;

in Small Merhei lake: Cumacea – *Pseudocuma caercaroides* (G.O. Sars), Gammaridae – *Chaetogammarus ischus* (Stebbing), Trichoptera – *Neureclipsis bicolor* L.;

in Bystryi branch: Gammaridae – *Pontogammarus maeoticus* (Sowinsky), *Pontogammarus obesus* (G. O. Sars), *Stenogammarus macrurus* (G. O. Sars), *Stenogammarus carausui* (Derzhavin et Pjat.), *Stenogammarus similis* (G. O. Sars), Gastropoda – *Physa fontinalis* (Linne), *Valvata pulhella* Studer, Heteroptera – *Sigara falleni* (Fieber);

in Vostochnyi branch: Oligochaeta – *Potamothrix moldaviensis* Vejdovsky et Mrazek, Gastropoda – *Bithynia leachi* (Steppard), *Valvata cristata* (O.F. Muller);

in Potapiv Kut lagoon: Gastropoda – *Anisus vortex* (Linne), *Lymnaea ovata* (Draparnaud), Odonata – *Lestes* sp., Ephemeroptera – *Arthroplea congener* Bengston;

in Deliukiv Kut lagoon: Oligochaeta – *Potamothrix hammoniensis* (Michaelsen), Chironomidae – *Polypedilium scalaenum* (Schrank), Heteroptera – *Ilyocoris cimicoides* (Linne).

In the Anankin Kut lake occurred mainly cosmopolite and ubiquitous species.

The taxonomic composition of the investigated ecosystems comprised 26 groups; maximal number was registered in Sulimanca channel (16), and minimal in Anankin Kut lake (6). Chironomidae larvae and Oligochaeta dominated in almost all the investigated ecosystems (Fig. 2.2.29).

In the investigated ecosystems, only two species were characterized by 100% occurrence frequency: *Tubifex tubifex* (O. F. Muller) and *Chironomus plumosus* (L.).

The following species can be considered as common dominant: *Limnodrilus sp., Limnodrilus hoffmeisteri* (Claparede) (frequency of occurrence 91%), *Nematoda sp.,* (82%), *Valvata piscinalis* (O. F. Muller), *Dreissena polymorpha* (Pallas), *Propsilocerus orielicus* (Thsher.), *Psectrocladius psilopterus* (van der Wulp) (73%), *Bithinia tentaculata* (Linne), *Viviparus viviparus* (Linne), *Parachironomus pararostatus* (Lenz), *Fleuria lacustris* (Kiffer), *Glyptotendipes gripekoveni* (Kieffer), *Polypedilum convictum* (Walker), *Limnodrilus claparedeanus* (Ratzel), *Erpobdella octoculata* (Linne), *Procladius ferrugineus* (Kiffer), *Ceratopogonidae sp.* (64–55%); occurrence frequency of other species was below 50%.

Quantitative indices

Macrozoobenthos quantitative indices of the two sides of the Danube delta varied within wide limits. Maximal annual average abundance and biomass in channels and arms was registered in Sulimanca channel; maximal abundance was found in autumn 2006 (53000 ind/m^2), and maximal biomass – in summer 2006 (1972,75 g/m^2). Minimal for the whole period were registered in Lopatna channel: in spring 2007 (7000 ind/m^2), and in summer 2006 (264,59 g/m^2) (Fig. 2.2.30, 2.2.31).

Seasonal dynamics of the macrozoobenthos quantitative indices in 2006 was similar in almost all the investigated ecosystems, maximal were registered in summer. In 2007 seasonal dynamics was somewhat other: maximum in spring, followed by gradual decrease in summer and autumn.

Maximal quantitative indices in lakes were registered in Small Merhei lake: abundance in autumn 2006 (24000 ind/m^2) and biomass in summer 2006 (391,25 g/m^2), followed by Potapiv lagoon: maximal abundance and biomass were recorded in spring 2007 (18000 ind/m^2 and 391,99 g/m^2). Minimal quantitative indices were found in Anankin Kut lake: maximal abundance was registered in spring 2006 (3133 ind/m^2) and biomass in summer 2007 (6,50 g/m^2) (Fig. 2.2.29).

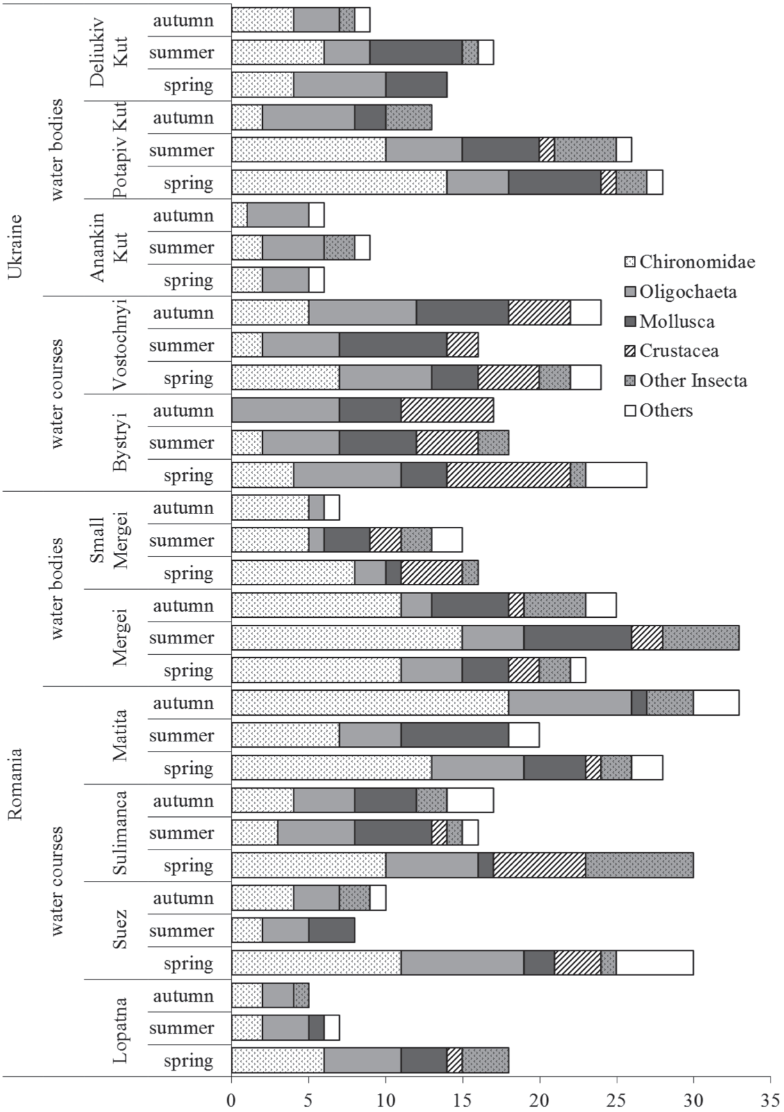

Fig. 2.2.29. Taxonomic composition of macrozoobenthos in the investigated water bodies and watercourses.

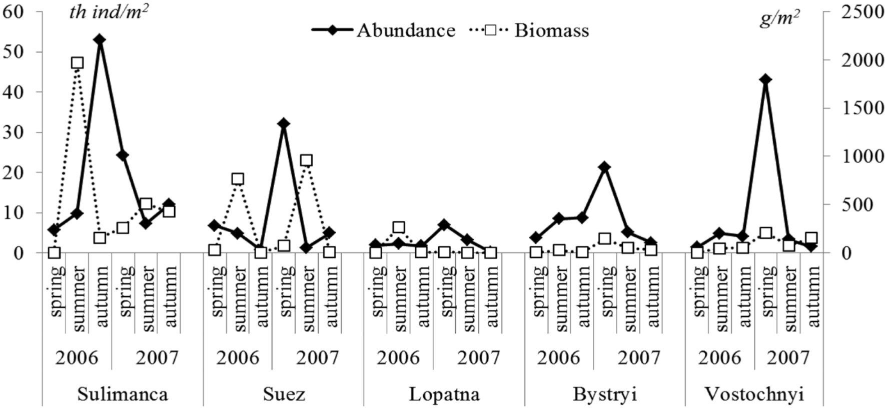

Fig. 2.2.30 Seasonal dynamics of the macrozoobenthos abundance and biomass in the investigated water courses

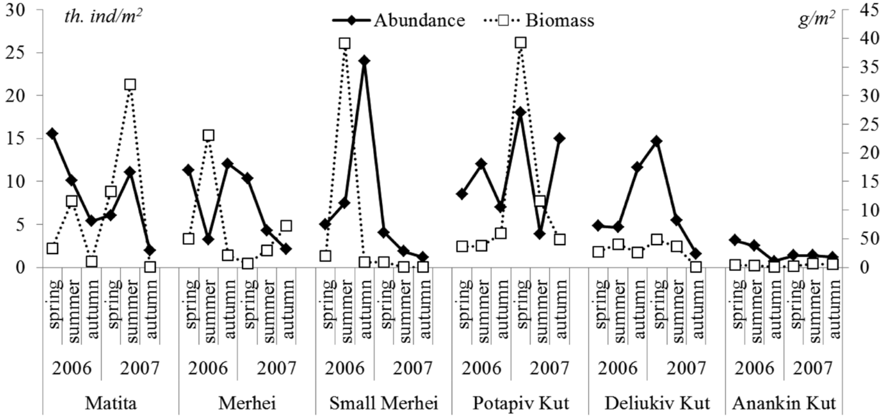

Fig. 2.2.31 Seasonal dynamics of macrozoobenthos abundance and biomass in the investigated water bodies.

Species diversity indices

Similar to other biotic groups, macrozoobenthos diversity was assessed using the Shannon-Wiener index. Maximal value of the Shannon index was registered in spring 2007 in Sulimanca channel (3,77 bit/ind), and the lowest in Bystryi branch in spring 2006. Maximal annual average value of the Shannon index was found in Sulimanca channel (2,71 bit/ind) and the lowest in Small Merhei lake (1,37 bit/ind).

2.3. COMPARATIVE ANALYSIS OF THE DANUBE DELTA AQUATIC ECOSYSTEMS STATUS

2.3.1. Species composition, similarity and distinction.

Total species composition of the found organisms amounts to 895 lowest determined taxa (see Annex "Species list"), among them 745 were registered in the Sulina delta ("old delta"), and 603 – in the Kiliya delta ("young delta") of the Danube river (Fig. 2.3.1). In both parts of the delta total species number was more in the lakes, than in the water courses (channels, arms). In all water bodies' types, as well as in the whole delta, phytoplankton was the richest in species, followed by the macrofauna, something less – zooplankton, and aquatic macrophytes were presented by the least species number. Reducing of the total species number was conditioned by the reducing of the phyto- and zooplankton species number, but not those of the macrofauna.

Structure of the total species richness of the biotic complexes of the studied water bodies is presented in Figure 2.3.2. Maximal species number was registered in the Merhei lake, and minimal in the Bystryi branch On the whole lakes and channels of the Sulina delta were more rich in species than water bodies of the Kiliya delta.

Ratio of the biotic groups in terms of the species richness is presented in the Figure 2.3.3.

Species richness of the both phyto- and zooplankton in all lakes and channels of the Sulina delta was more, than in the arms and lakes of the Kiliya delta. For the macrofauna such dependence was not noted. Lakes

Matita and Merhei were peculiar with the most values of the species richness of all studied biotic complexes. At that in the Matita lake maximal number of the phytoplankton species was registered, and in the Merhei lake – those for zooplankton and macrofauna. Also maximal number of the aquatic macrophytes species (19) was registered in these water bodies. In the water bodies of the Kiliya delta lower values of the species richness were registered, both total and of the separate biotic groups. Minimal number of the macrofauna species was registered in the Anankin Kut lake, of zooplankton – in the Bystryi arm, of phytoplankton – in the Vostochnyi arm. At that in the Sulimanka channel only 3 aquatic macrophytes' species were registered.

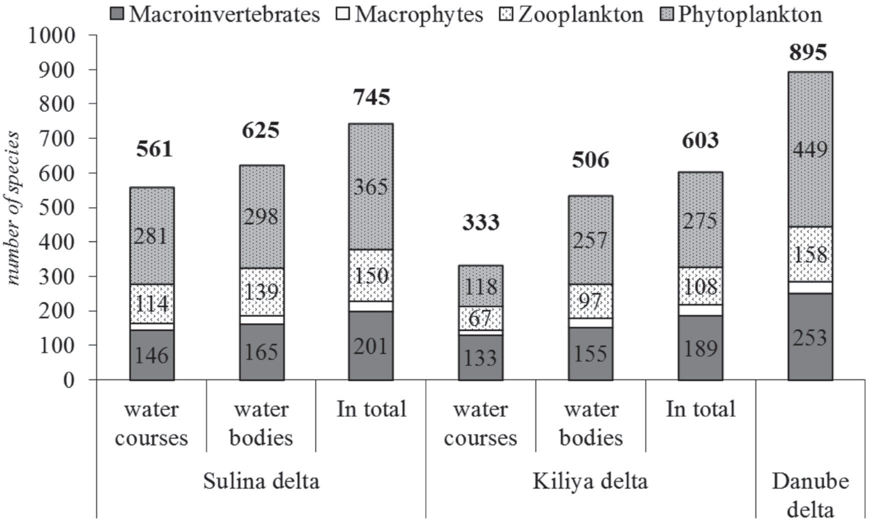

Fig. 2.3.1 Species richness of the different type water bodies of the Danube delta

Relative share of the invertebrate macrofauna was similar in all lakes and channels, at that in the arms it was more, than in the lakes. Ratio of zooplankton and phytoplankton species was similar in all investigated water bodies (1:2), except Anankin Kut lake and Potapiv Kut lagoon where number of phytoplankton species was almost thrice more. Percent shares of the aquatic macrophytes and zooplankton in different water bodies varied in close limits – 1–6% for macrophytes and 17–27% for zooplankton. Such limits of the phytoplankton and invertebrates macrofauna species number were wider (31–53% and 22–44% respectively). Ratio of the biotic groups in terms of species richness in the lakes and channels of the Sulina delta was similar, and in those of the Kiliya delta – different (See Fig. 2.3.1).

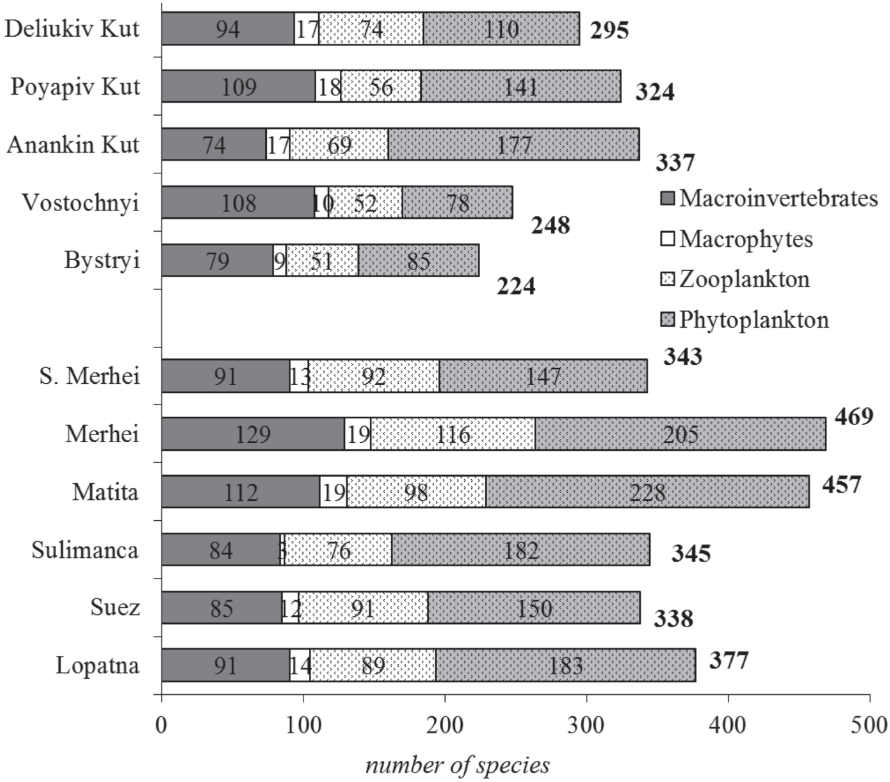

Fig. 2.3.2. Species richness of the water bodies' biotic complexes

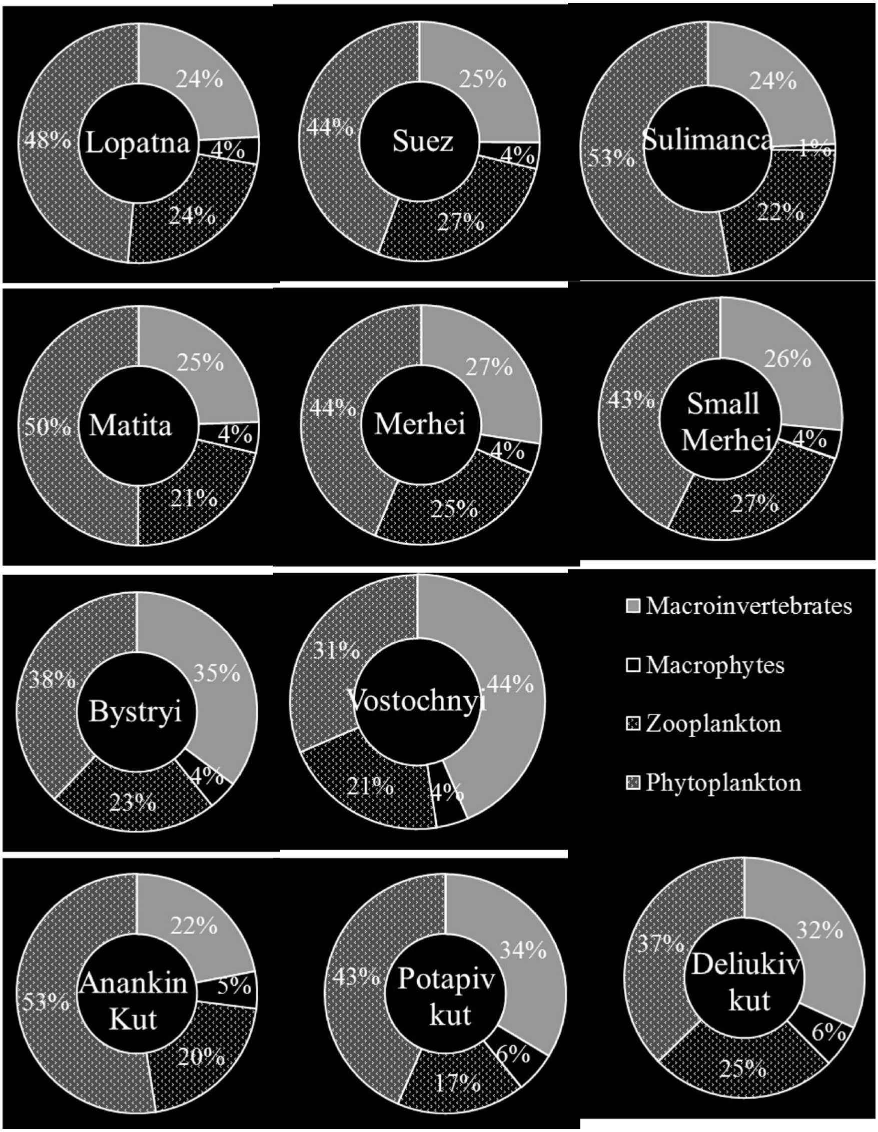

Fig. 2.3.3 Ratio of biotic groups' species richness

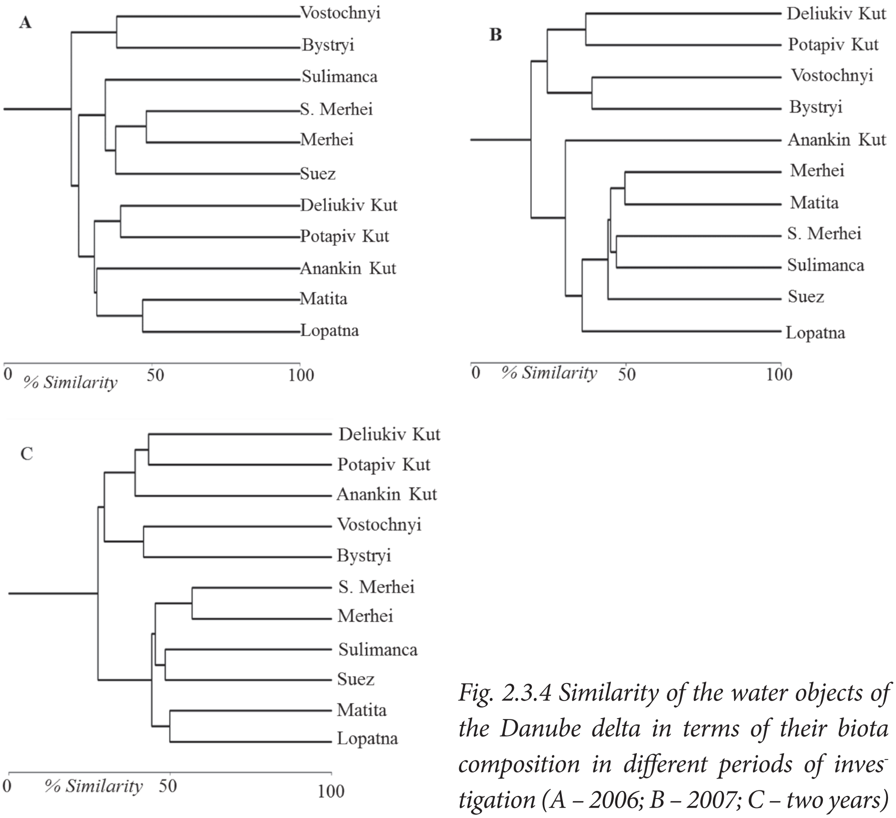

Fig. 2.3.4 Similarity of the water objects of the Danube delta in terms of their biota composition in different periods of investigation (A – 2006; B – 2007; C – two years)

Analysis of the Danube delta water bodies in terms of their biotic complexes' species composition on the base of two-year investigation (Fig. 2.3.4) revealed certain division into the Sulina and Kiliya deltas. Differentiation was noted into types for all water bodies, except the Matita lake and the Lopathna channel. In the similarity analysis for the 2006 and 2007 separately this pattern was not so evident, absolutely clear differentiation of the water objects into two deltas was not noted. Although as a whole similar groups were formed, especially in 2007. Exception was the Anankin Kut lake, which was referred to the Sulina delta group in 2006 and took intermediate posi-

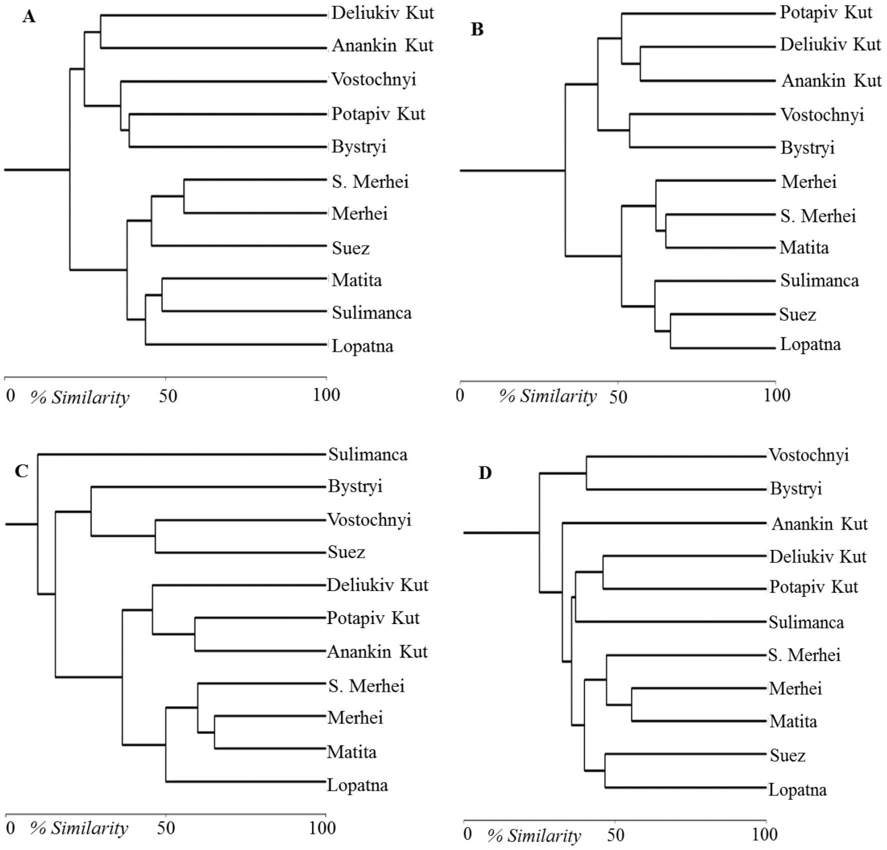

Fig. 2.3.5 Similarity of the water objects of the Danube delta by the species composition of the separate biotic groups (2006–2007). (A – phytoplankton, B – zooplankton, C – macrophytes, D – macrofauna of invertebrates)

tion in 2007. Analysis of the individual biotic groups' species composition over the two-year period revealed significant differences of the plankton communities in two parts of the delta (Fig. 2.3.5). Besides, zooplankton differed in the different types of the water objects. Aquatic macrophytes and invertebrate macrofauna have not such distinctions. At that time distinctions in the species composition in the lakes of the Kiliya and Sulina deltas were noted. Analysis of the invertebrate macrofauna species composition enabled to allot some groups of the water bodies with the high level of similarity: channels of the Sulina delta (Lopatna and Suez); lakes of the Sulina delta (Matita, Merhei and Small Merhei), lagoons of the Kiliya delta (Potapiv Kut and Deliukiv Kut), branches of the Kiliya delta (Bystryi and Vostochnyi). Any logical relations had the Sulimanka channel (which was peculiar at one time with quite rich bottom invertebrate fauna and poor phytophilous fauna) and lake Anankin Kut (which was peculiar with adverse relation – poor bottom invertebrate fauna and rich phytophilous fauna).

2.3.2. QUANTITATIVE PARAMETERS

Comparative analysis of the total abundance of the biotic groups (Fig. 2.3.6) showed certain differences within the Sulina and Kiliya deltas only for the plankton communities (abundance of phyto- and zooplankton in the channels and lakes of the Sulina delta was higher than in the arms and lakes of the Kiliya delta). Abundance of the phytophilous invertebrates and macrozoobenthos varied in closer limits, differences were not significant. Biomass of only zooplankton was notably lesser in the Kiliya delta water bodies comparatively to those of the Sulina delta (fig. 2.3.7).

While analyzing inter-year differences it is worth to note increasing of the abundance and biomass values of phyto- and zooplankton in the Sulina delta in 2007. Other biotic groups revealed no unified dynamics of the quantitative parameters, in some lakes and channels decrease of the phytophilous and bottom invertebrates number was noted, but any decrease of biomass.

Analysis of the ratio of the hydrobionts' quantitative parameters in different water bodies for the two-year period (2006–2007) showed certain differences in the organisms' distribution (Fig. 2.3.8). High level of similarity in the both investigated years was registered in the Vostochnyi and Bystryi branches, Potapiv Kut and Deliukiv Kut lagoons, as well as in the Lopathna channel and the Anankin Kut lake.

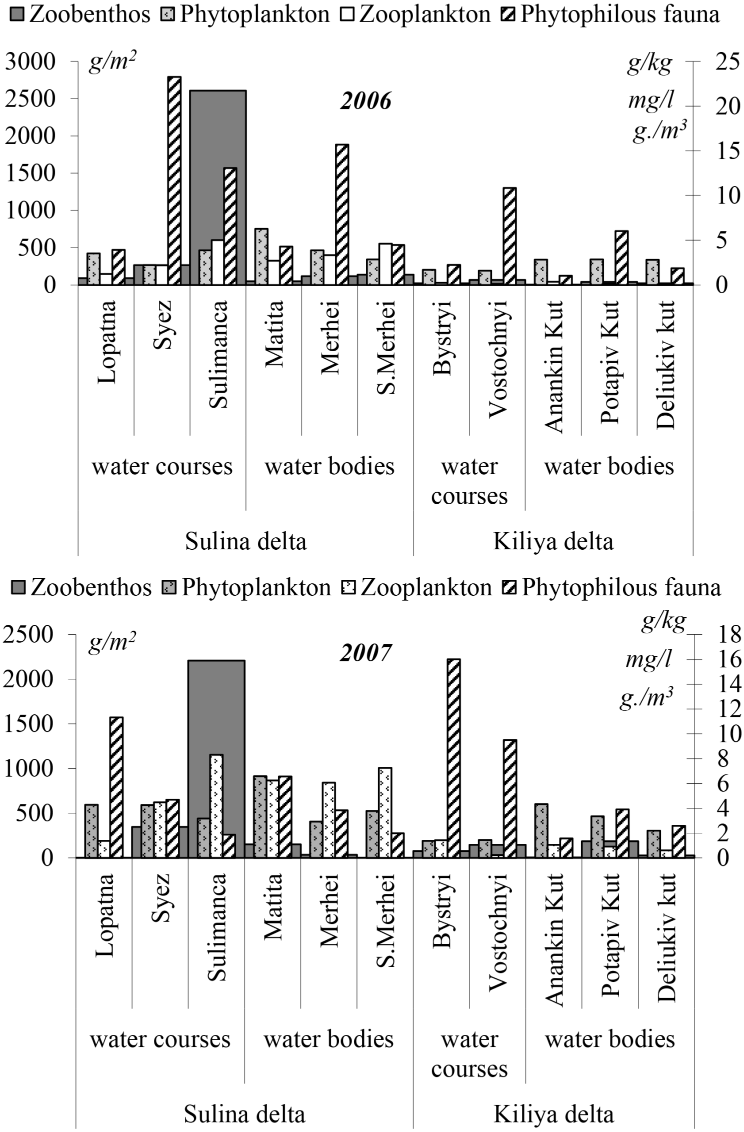

Fig. 2.3.6 Annual average of abundance of the biotic groups.

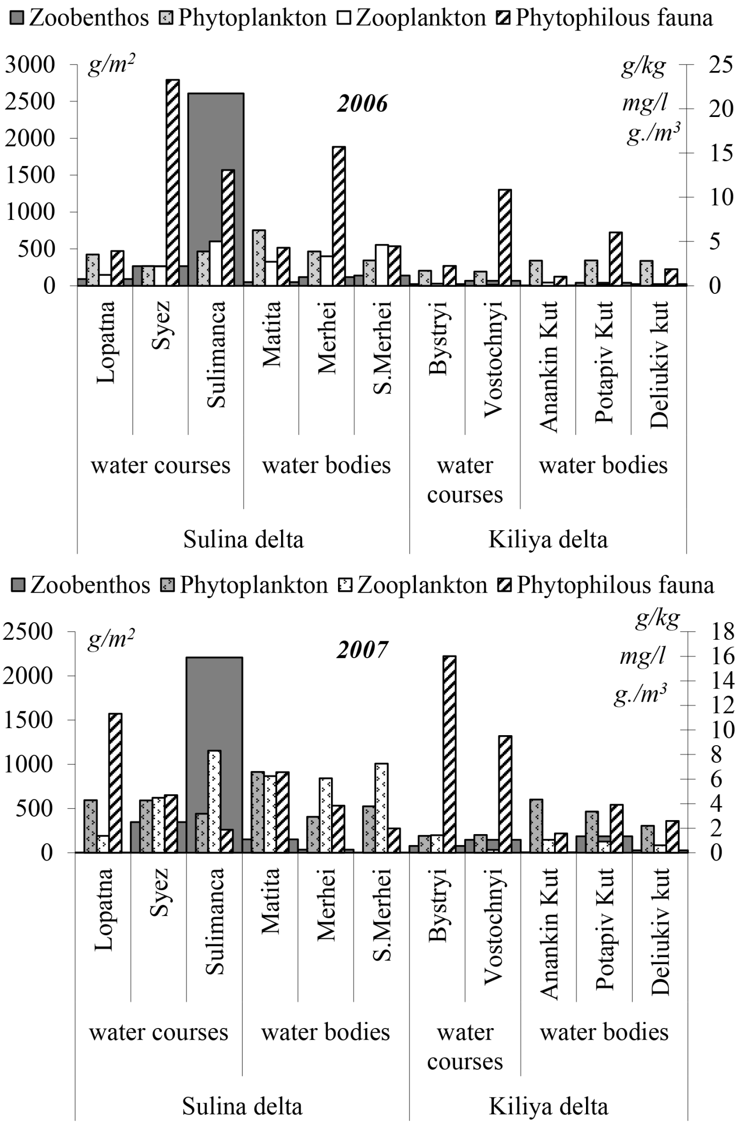

Fig. 2.3.7 Annual average parameters of biomass of the biotic groups

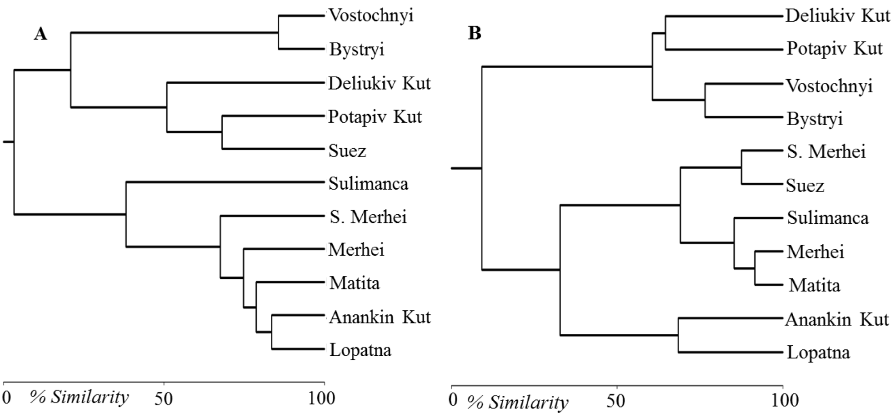

Fig. 2.3.8 Similarity of the water objects by the biota's quantitative parameters (A – 2006; B – 2007).

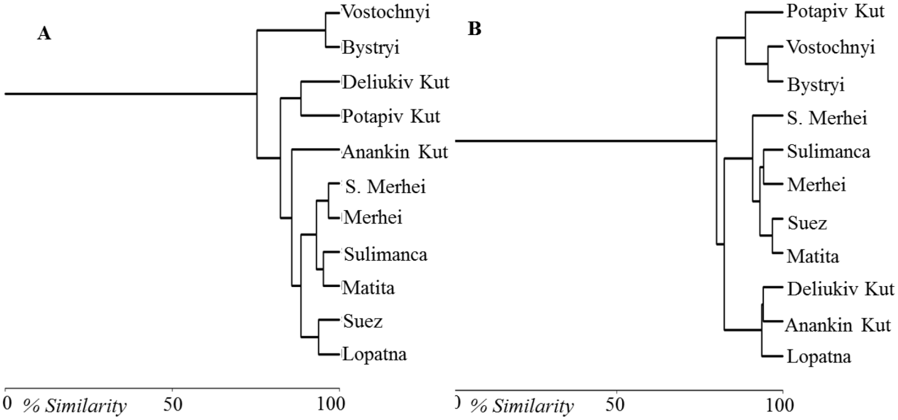

Fig. 2.3.9. Similarity of the water objects by the chemical composition of water (A – 2006; B – 2007).

High level of similarity of the chemical parameters (more than 70%) was registered in all investigated water bodies in 2006, high-water year.

At that similarity for the reservoirs and water courses of the Romanian part of delta was even higher as all of them were united in the unique group without dividing into types (Fig. 2.3.9). Similarity of the Kiliya delta water bodies was lower, but commonness of the chemical parameters was registered within the different water body types (arms, lakes and lagoon).

In the low water 2007 high level of similarity in the Sulina delta (except the Lopathna channel) was registered. Within the Kiliya delta two similar in terms of water chemical composition groups were noted: the Bystryi and Vostochnyi branches and all the water bodies.

2.3.3 ECOLOGICAL CHARACTERISTIC OF THE DANUBE DELTA WATER BODIES

On the whole, according to the average rank index (ARI) water bodies of the Sulina delta were less polluted than water bodies of the Kiliya delta. Increase of pollution level was marked in the low-water 2007; maximal pollution level was registered in the Bystryi arm and the Potapiv lake, minimal – in the lakes Merhei and Small Merhei (Fig. 2.3.10–2.3.14).

Maximal species richness was registered in big lakes of the Sulina delta (Matita and Merhei), minimal – in the arms of the Kiliya delta Bystryi and Vostochnyi (Fig. 2.3.10). In the most of the water bodies increase of the total species number under the growth of the pollution level was noted, except the Bystryi arm, the Lopathna channel and the bay Deliukiv Kut. Similar dynamics was noted for phytoplankton in all water bodies, except the Vostochnyi arm and Deliukiv Kut lagoon. For the invertebrate macrofauna (zoobenthos and phytophilous macrofauna) inverse correlation was registered – decrease of the species richness under the growth of pollution level in all water bodies, except the Bystryi arm and the Deliukiv Kut lagoon. For zooplankton any regularity of the species richness dynamics depending on the water body type or year of investigation was documented.

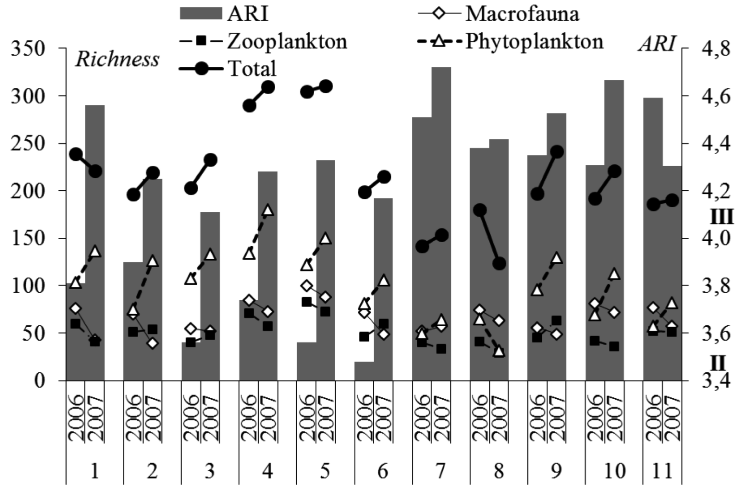

Fig. 2.3.10 Dynamics of the species richness and ARI in the Danube delta water bodies. Here and on the figures 2.3.11–2.3.14: 1 – Lopatna, 2 – Suez, 3 – Sulimanca, 4 – Matita, 5 – Merhei, 6 – Small Merhei, 7 – Bystryi, 8 – Vostochnyi, 9 – Anankin Kut, 10 – Potapiv Kut, 11 – Deliukiv Kut; water quality classes: II – fairy clean, III – slightly polluted, IV – moderately polluted.

In phytoplankton in the most number of the water bodies growth of the Shannon index values under the ARI increase was registered, except the Sulimanka channel, the Vostochnyi arm and the bay Deliukiv Kut (Fig. 2.3.11). In zooplankton reducing of the species diversity under the growth of pollution level was registered only in the Bystryi and Vostochnyi brunches and the Deliukiv Kut lagoon. In the communities of the phytophilous fauna reducing of this parameter was also registered, except the Merhei lake and the Bystryi arm. In the communities of zoobenthos any positive interrelation of the pollution level and species diversity was noted.

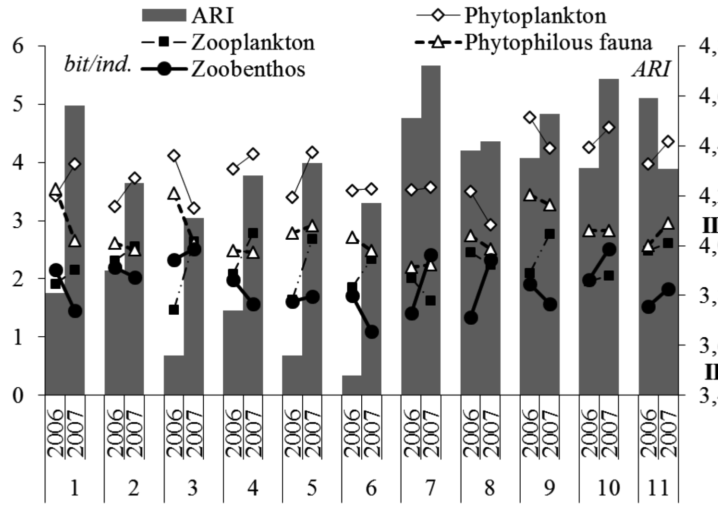

Fig. 2.3.11 Dynamics of the Shannon index and ARI in the Danube delta water bodies

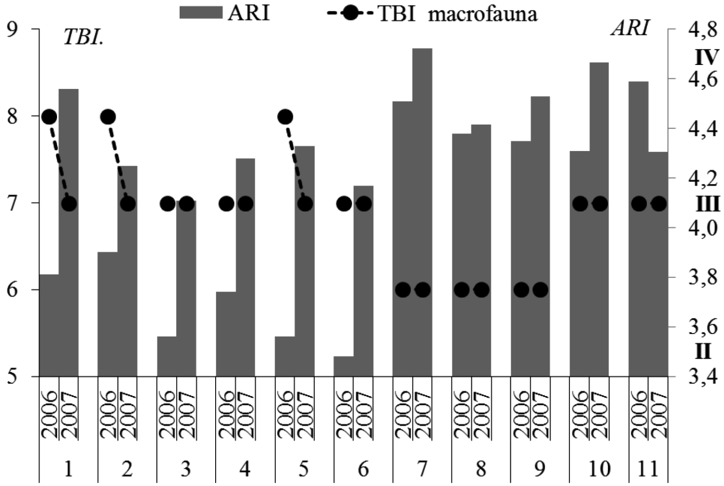

Fig. 2.3.12 Dynamics of TBI and ARI in the Danube delta water bodies.

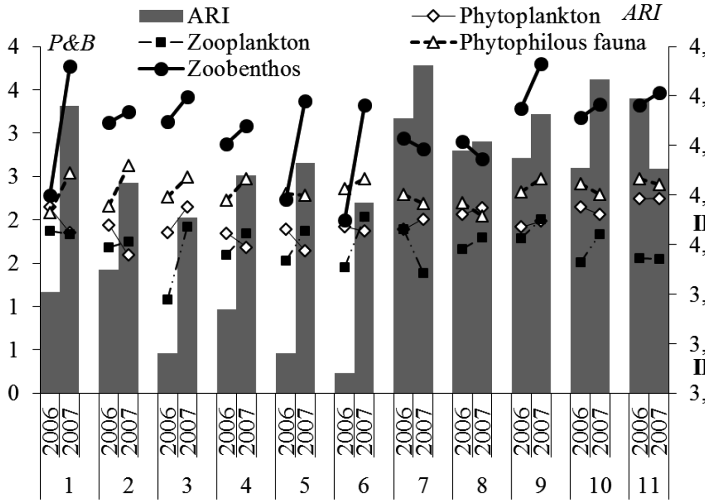

Fig. 2.3.13 Dynamics of the Panthle&Buck index and ARI in the Danube delta water bodies.

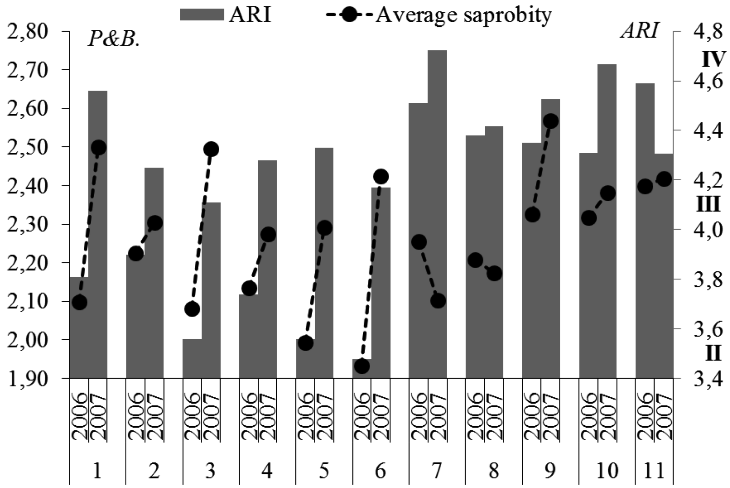

Fig. 2.3.14 Dynamics of the average saprobity by Panthle&Buck index and ARI in the Danube delta water bodies.

According to the Woodiwiss index values [LIASHENKO, ZORINA-SAKHAROVA 2012], all water objects of the Sulina delta and water bodies of the Kiliya delta are considered as «clean–fairly clean» waters, and the Bystryi and Vostochnyi branches and the Anankin Kut lake – as «slightly polluted» (Fig. 2.3.12). Under ARI value growth in the Lopathna and Suez channel, as well as in the Merhei lake, Woodiwiss index decreased. In all other water bodies this parameter remained stable during all period of investigation.

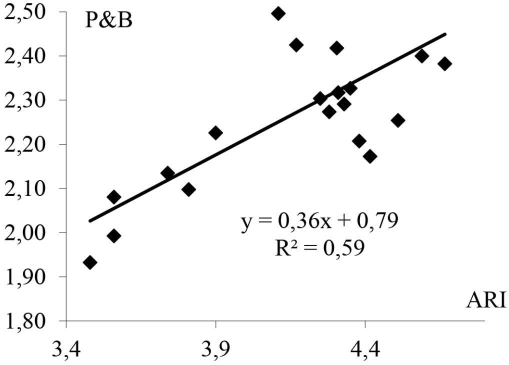

Fig. 2.3.15 Interrelation of the ARI and average saprobity index

Saprobity value, calculated on the indicative species of different biotic groups varied in quite wide limits in all water objects (See Fig. 2.3.13): those calculated on phytoplankton and phytophilous fauna corresponded to β-mesosaprobic zone, those calculated on zooplankton corresponded to α-oligo–β-mesosaprobic zone, and those calculated on zoobenthos to α-mesosaprobic zone. Some differences were marked within years of investigation, up to the change of saprobic zone on zooplankton and zoobenthos. Zoobenthos saprobity index growth under the growth of ARI was registered in all water bodies except the Bystryi and Vostochnyi arms and the Deliukiv Kut lagoon. Similar relation of these parameters was registered also for zooplankton (except the Lopathna channel and the Bystryi arm). Any regularity of these parameters relation was noted for phytoplankton and phytophilous fauna.

According to [UNIFICYROVANIE… 1977] the most reliable assessment of the saprobic characteristic of the water body can be determined taking into account the majority of the biotic groups. Average saprobity index of the water object was calculated on the individual saprobity indices (phytoplankton, zooplankton, zoobenthos). Dynamics of index calculated in such a way is in good agreement with ARI (Fig. 2.3.14). This was confirmed by the regression analysis (Fig. 2.3.15). Exceptions were the Bystryi and Vostochnyi arms and the Deliukiv Kut lagoon, where ARI values growth was associated with decreasing of the average saprobity.

Carried out toxicological investigations indicated, that on the whole content of the oil products in water and bottom sediments of the Kiliya delta was higher than in the Sulina delta (Fig. 2.3.16). Similar dynamics of the oil products content in water and bottom sediments was noted: heightened oil products concentration in water was associated with heightened concentration in the bottom sediments (r=0.82). Regression analysis of these toxicants' content and structural characteristics of the biotic groups indicated only significant decrease of the phytoplankton species richness under the elevated content of the oil products in water (Fig. 2.3.17).

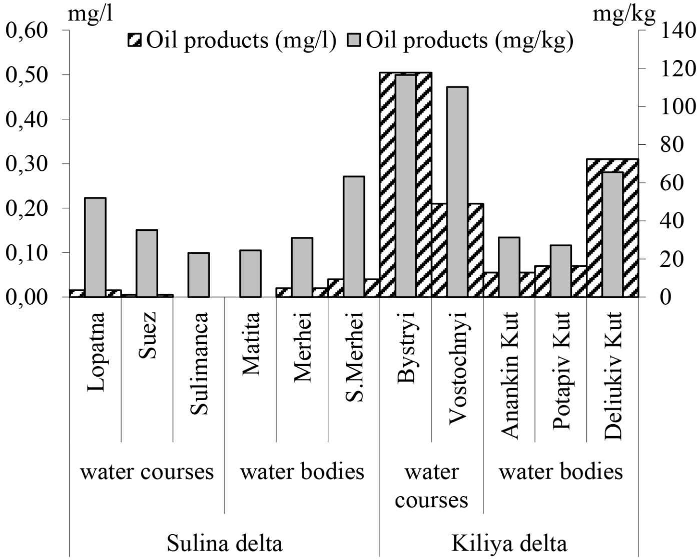

Fig. 2.3.16 Content of the oil products in water and bottom sediments of the Danube delta water bodies

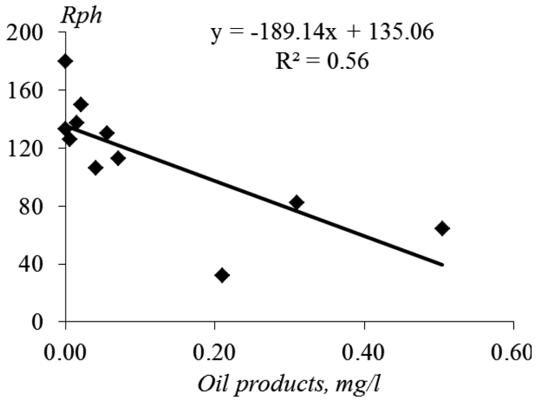

Fig. 2.3.17. Dependence of the phytoplankton species richness on the content of the oil products in water

It is worth to note that maximal oil products content in water was registered in the Bystryi and Vostochnyi arms and the Deliukiv Kut lagoon, MPC for the fishery was exceeded 4–10 times. Just these water objects, as it was shown above, were peculiar with associated dynamics of the species richness, biotic diversity and P&B index with ARI value. Probably, heightened oil products concentration in water caused certain toxic impact, had selective influence on the structural characteristics of the biotic communities, and therefore disturbed regular behavior of some indices, first of all saprobiological.

Summarizing mentioned above data it is worth to note that water objects of the Sulina delta were less polluted than those of the Kiliya delta: Sulina delta – II-III quality class, Kiliya delta – III-IV quality class. Although, dynamics of the biotic indices did not always depend on the water quality. Most of the investigated water objects had similar dynamics of ARI variations and average saprobity, but in the Bystryi and Vostochnyi arms and the Deliukiv Kut lagoon changes of these parameters had inverse directions. It is interesting, that water of these water bodies had the most content of the oil products (exceeding of the fishery MPC by a factor of 4–10), and probably this is the cause of the disturbance of the saprobity index regular behavior.

CHAPTER 3.

JOINT ENVIRONMENTAL MONITORING, ASSESSMENT AND EXCHANGE OF INFORMATION FOR INTEGRATED MANAGEMENT OF THE DANUBE DELTA.

3.1. AQUATIC MACROPHYTES

Aquatic macrophytes are the aquatic plants, despite of their systematic position, well distinguishable without using magnifiers. In fresh waters they include higher aquatic plants (i.e. Bryophyta, Lycopodiophyta, Equisetophyta, Polypodiophyta and Magnoliophyta), algae Charophyta and green filamentous algae [RASPOPOV 1978, JOINT… 2008].

Water Frame Directive [EU… 2006] considers macrophytes as one of the important groups to determine the ecological status of the water bodies. It is connected with the fact that macrophytes are well noticeable, rather easy to be identified without using magnifiers, the ecology of many species is well studied. Moreover, macrophyte communities have environmental and edificator significance. They form vegetations, which allow to get an idea on the whole biogeocoenosis using the boundaries and composition of phytocoenosis. The most often the macrophytes in the shallow water are the main producers of the primary production, underlying most of the energy process in water bodies.

Macrophytes were studied in late September – early November 2011 at 16 stations in the Danube delta: in the main channel (station 2, 3), the first-order arms – Kiliya (station 4–6), Tulcea (station 8); the second-order arms – Sulina (station 9, 10) and St. George (station 11, 12); the third-order arms – Bystryi (station 7), and in the lakes in the territory of Romanian part of the delta (station 13–16). Sulina arm is straightened and has dams along its whole course. This arm serves as navigation channel. Bystryi branch also has an artificial navigation channel. In the arms the studies were along both banks at the shallow-water areas (100 m length). In the lakes we studied 100-m areas in ecologically diverse coastal shallow water sections. In Cuibul cu Lebede lake (station 16) the transect was developed from one bank to another. We studied the species composition (mainly) of the higher aquatic plants [DOBROCHAEVA, KOTOV, PROKUDIN et al. 1987], evaluated their participation in the overgrowing (abundance-coverage) by the European scale. Unfortunately, the late terms of the expedition did not allow to identify the species composition completely and to determine the species representation, which had an impact on the ecological state assessment quality. We studied flora of the semi-aquatic species as an additional criterion (their presence is specified in Table 1 by „+").

The following ecological groups are differentiated in Ukraine among macrophytes [PAPCHENKOV 2003]:

TRUE AQUATIC PLANTS ecotype group

HYDROPHYTE ecotype (true aquatic plants)

1. Macroscopic algae and aquatic mosses.
2. Hydrophytes floating in water (*Ceratophillum, Lemna trisulca, Utricularia*).
3. Rooted submersed hydrophytes (*Myriophyllum, Najas, Vallisneria* and others).
4. Rooted hydrophytes with floating leaves (*Nuphar, Nymphaea, Nymphoides, Potamogeton nodosus* and others).
5. Free-floating hydrophytes (*Lemna minor, Salvinia, Spirodela* and others).

COASTAL AQUATIC PLANTS ecotype group

HELOPHYTES ecotype – aero-aquatic plants

6. Short-grass helophytes – helophytes with average length lower than 1 m (*Butomus, Sagittaria, Sparganium erectum* and others);
7. High-grass helophytes – helophytes with average length of 1 m and higher (*Typha, Phragmites, Scirpus* and others);

HYGROHELOPHYTES ecotype group – species of the low levels of the coastal flood water zone (*Agrostis stolonifera, Bolboschoenus maritimus,* *Carex acuta, Oenanthe aquatica, Ranunculus linqva, Rumex hydrolapatum, Sium latifolium* and others).

Another classification was used in JDS 2 (like as in JDS 1 and MID-CC-project) [JOINT… 2008]:

1. Submersed pleustophytes (**sp**) – species floating in water (*Lemna*, *Utricularia*);
2. Submersed anchored (**sa**) – anchored submersed species (Charophyta, mosses, *Ceratophillum*) and all rooted submersed macrophytes;
3. Rooted plants with floating leaves (**fl**) – rooted species with floating leaves;
4. Acro pleustophytes (**ap**) – species free-floating on the water surface;
5. Amphiophytes (**am**) – species which can grow on the bank like helophytes or in water like submersed (*Sparganium emersum, Oenanthe aquatica, Cicuta viroza* and others)**;**
6. Helophytes (**he**) – all plants on the bank which has close relation with water.

If submersed and above-water parts of the plant are developed approximately similar, it is referred to **am,** if submersed part is prevailing it is referred to **sa,** if above-water part is prevailing it is referred to **he**.

Different characteristics can be used as the factor of the species significance in the plant cover composition: number of individuals (shoots), phytomass, production, participation in the overgrowing (in percentage or in scores).

A five-point scale of species abundance assessment is used in Europe [TRAINING COURSE…, 2011]:

1. – **very rare** – 1 - 5 plants in field of vision;
2. – **rare** – more plants but they occupy less than 5% of area;
3. – **normal** – the species can be found with little effort;
4. – **common**, not massive, covers the regions with large breaks;
5. – **abundant**, dominant species, it covers more than 50% of area.

In addition, in the personal discussions with the Romanian colleagues and during the expedition we found out that some species, such as *Azolla filiculoides* Lam. and *Ceratophyllum demersum* L., are defined more widely in Romania than in Ukraine.

In the large Danube arms with the sharp increase of the depth and high turbidity, the vegetation development depends on the depth, flow rate, water level fluctuations and character of the benthic deposits. *Potamogeton nodosus*, *P. pectinatus*, *P. perfoliatus*, *Ceratophyllum demersum*, *Myriophyllum spicatum*, *Nymphoides peltata*, *Trapa natans* true aquatic plants are usually found in the active arms. They can be individual plants or thin beds located by the narrow strip along the bank up to 0,6-0,7 m depth. The branches lost their hydrological activity gradually become silted. At first the bed strip is widening, then it is completely overgrown by the submersed and free-floating vegetation which is substituted with the communities of the overflow land. This process is faster in the shallow channels. Danube delta water bodies are usually shallow. The vegetation development there depends on the water saltiness, wind - wave actions, external water exchange, character of benthic deposits and water trophicity. There are eurytopic species (of wide ecological range) and stenotopic species which can exist in rather narrow range of factors. The latter are more suitable to evaluate the environment quality. The complexity of assessment will depend on the leveling action of the different factors, ecological flexibility of plants and different stability of the species at the areal borders.

The structural characteristics of the aquatic macrophytes and semi-aquatic plants at the different stations are presented in Anex 2 and Fig. 3.1. At **station 2** (Danube, Reni - 71 mile**)** and **station 3** (Danube, Chatal Izmail – 44 mile) macrophytes were practically absent. Only at **station 2** far from water edge some single undeveloped shoots of *Phragmites australis* were found. The single shoots of the species listed in Table 1 were observed on the bank. Only *Cyperus glomeratus* had a massive development. The height of its shoots (more than 1 m) and the willow roots (mangrove type) tell about the significant water level fluctuations (not less than 4 m), and indicate to the conditions unsuitable for macrophytes development.

Station 4 (Kiliya arm, Izmail – 89,9 km). As for the aquatic plants, a single small bed of *Phragmites australis* was registered on the bank (a few meters to the water edge). The plants were in vegetative stage. Judging by the root form of *Salix* and shoot size of *Cyperus glomeratus,* water level fluctuations are also typical here but their values are lower. Weed species (*Bidens tripartita, Echinochloa crusgali, Erigeron canadensis, Xanthium strumarium*) are prevailing along the bank. It indicates to the anthropogenic load, like the insignificant development of *Potamogeton pectinatus* at shallow-waters.

Station 5 (Kiliya arm, Kiliya – 42 km). Macrophytes are better presented, the aero-aquatic species are developed directly in water. Prevalence of *Potamogeton natans* tells about stream presence, *Ceratophyllum demersum* and weed species on the bank indicate to the anthropogenic load.

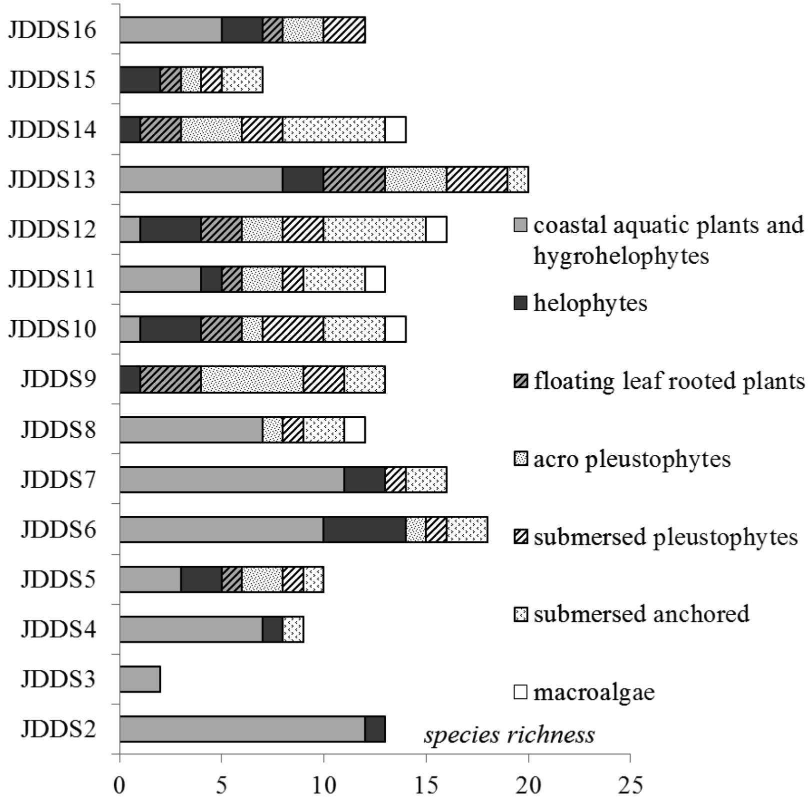

Fig. 3.1 Ecological groups of macrophytes on JDDS stations

Station 6 (Kiliya arm, Vylkove – 21 km). The aero-aquatic vegetation is better developed in the water and on the wet silty bank. Prevalence of the weed species on the bank and species of the wide ecological range also indicate to the anthropogenic load.

Station 7 (Bystryi branch – 1,0 km). Bystryi branch is one of the most active branches of Kiliya delta. It is used as navigable one. The branch bed construction without evident shallow-waters does not facilitate the development of the submersed species. The station is located near the fishermen base. *Ceratophyllum demersum, Potamogeton pectinatus, P. perfoliatus* are developed in water, which can tell about the stream presence and together with the weeds on the bank it indicates to the anthropogenic load.

Station 8 (Tulcea branch, Tulcea – 35 mile). The station is located near the hotel (35 Mile). The banks are argillo-arenaceous with some pebble. The aero-aquatic vegetation does not develop on the bank free from water. There are no semi-aquatic species. The residues of *Potamogeton pectinatus* (submersed plants) and a little of filamentous algae (*Cladophora sp.*) were found at the hotel side. On the opposite bank there are representatives of Salix genus and the species typical for the wet banks (*Gnaphalium uliginosum, Scutellaria galericulata, Cyperus glomeratus*). There are single species of the aquatic plants listed in the table. It is possible that the plants have already finished the vegetation or the set of the conditions does not favor their development.

Station 9 (Sulina arm, Mile 23 – 23 mile). The station is located near the village (23 Mile). The samples were taken in the beds on the bank opposite to the village. The structure of vegetation tells about the stream presence, fresh alluvial deposits and free biogenic elements.

Station 10 (Sulina arm, Sulina – 1,0 mile). It is the offshore zone of Sulina arm with man-made changes. There is dirty sand in the benthic deposits. The aero-aquatic vegetation is developed in the narrow coastal area. The vegetation indicates to the presence of stream and benthic deposits, rich with nutrients. The anthropogenic drain from the bank is possible.

Station 11 (St. George arm, cut meander Uzlina). It is the dead meander, tough silt is prevailing in the benthic deposits. There is very little vegetation, even free-floating. Possible they have finished the vegetation. Prevalence of *Myriophyllum spicatum* and *Ceratophyllum demersum* with filamentous algae tells about biogens presence. Probably, they are the last stages of overgrowing.

Station 12 (St. George arm, St. George – 1,0 mile). The station has the highest amount of the aquatic plant species. There are favorable conditions for the different ecological species growth – presence of stream, possible salt water surges and sufficient amount of the nutrients in water.

Station 13 (Danube Delta Wetlands, Erenciuc lake). It is the floodplain lake in delta surrounded by overflow land canes. There is sufficient amount of biogenic elements in the water. The sampling was performed at three points differed by the external water exchange probably. *Nuphar lutea* and *Trapa natans* are better developed at the areas with the alluvial deposits. The vegetation of the waterlogged areas with the weak water exchange is presented by the communities of *Nymphaea alba* with *Ceratophyllum demersum* and *Hydrocharis morsus-ranae*. More extensive waterlogging is characterized by the development of *Stratiotes aloides, Ceratophyllum demersum* and *Hydrocharis morsus-ranae*.

Station 14 (Danube Delta Wetlands, Uzlina lake). The lake is surrounded by the reed, the water level has significantly reduced. The areas of *Vallisneria spiralis* with *Trapa natans* are located among all reach indicating to the good water exchange and presence of fresh alluvium.

Station 15 (Danube Delta Wetlands, Isak lake). Stations 15 and 16 are characterized by the low development of macrophytes. It can be connected with the unfavorable season of study. The water exchange in Isak lake (station 15) is lower than in Cuibul cu lebede lake (station 16). The lake has sufficient and heavy layer of silts.

Station 16 (Danube Delta Wetlands, Cuibul cu lebede lake). The lake is intensively becoming waterlogged. *Ceratophyllum demersum* and *Stratiotes aloides* are massively developed here. The beds of *Phragmites australis* approach the reach.

Station 12 (sea gate of St. George arm) is the most favorable for macrophytes development in the branches. It is characterized by the highest amount of species. Station 10 (sea gate of Sulina arm) and stations in Kiliya arm of Danube (6, 5 and 7) located near the cities of Vilkove, Kiliya and in the mouth of Bystryi branch are similar to the station 12 (the comparison was conducted using Sørensen index [*WHITTAKER* 1980]).

As for the lakes, station 14 (Uzlina lake) has the highest species richness. Only station 13 (Erenciuc lake) demonstrated the similarity more than 50%. The quality similarity with macrophytes of two other floodplain lakes is about 30% and 40%.

We did not manage to calculate the saprobity of each station as saprobic coefficients are not known for all found species [*UNIFITSIROVANNYIE …* 1977]. Most of the macrophytes species registered in Danube delta are typical for *β*-mesosaprobic area. At station 9 (Sulina arm, Mile 23 – 23 mile) *Salvinia natans*, which prefers *o*-saprobic water and *Nuphar lutea,* which is found both in *β*-mesosaprobic and *o*-saprobic conditions, are well presented together with the mass development of *Ceratophyllum demersum* (typical *β*-mesosaprobic species). *Hydrocharis morsus-ranae* (well developed in *o*-saprobic and *β*-mesosaprobic water) and *Nymphaea alba*, which grows not only in *β*-mesosaprobic but also in cleaner *o*-saprobic conditions, are prevailing at station 13 (Erenciuc lake).

Twenty five species (and one subspecies) of the aquatic vascular hydrophytes and helophytes, 2 species of aquatic ferns (*Azolla filiculoides* Lam., *Salvinia natans* (L.) All.), charophytes and green filamentous algae whose rank was not identified (20 species of vascular hydrophytes and helophytes were detected at two delta stations studied during JDDS 2 project) were revealed at the studied area of Danube delta. As for helophytes, *Phragmites australis* and *Typha angustifolia* are the dominants. Among the hydrophytes (most closely connected with aquatic environment) – *Ceratophyllum demersum* and *Potamogeton pectinatus* (species of wide ecological range) are the dominants. The unfavorable season of study is the reason of detection not all macrophytes common in Danube delta. Most submersed species have already finished their vegetation in September – beginning of October. July – the beginning of August is more favorable season to study summer flora.

Station 12 (St. George arm, St. George – 1,0 mile) and 14 (Danube Delta Wetlands, Uzlina lake) have the highest species richness with the most diverse ecotopes. Almost no aquatic plants were found at stations 2, 3 and 4 due to high fluctuations of water levels. Most macrophytes species registered at the studied stations, characterize the conditions of their growth as β-mesosaprobic.

Joint study of Danube delta by the specialists from Ukraine, Romania and Moldova showed different understanding of the volume (content) of some macrophytes species. Different methods were used to distinguish the ecological group and indicator species and also to determine the environmental quality. From our point of view, the joint trainings of the specialists from Danube countries (at least from the countries located in Danube delta) are required to work out the common vision.

It is preferably to conduct aerial visual survey at the bigger and longer water bodies (floodplain lakes, delta branches) to monitor macrophyte vegetation and evaluate the area of beds (mostly aero-aquatic plants and plants with floating leaves). It is even better to use the large-scale spectrozonal aerophotographs or the space photographs with high-resolution.

1.2. PHYTOBENTHOS

In accordance with the Water Frame Directive of EC 2000/60/EC (WFD) phytobenthos is a biological quality element to determine the ecological state of all river types (WFD, Annex V) [EU 2006]. According to WFD phytobenthos comprises the submerged higher aquatic plants and macroalgae, benthic algae (microphytobenthos) and phytoperiphyton (attached forms). In this study we consider proper phytobenthos – microalgae on the surface of the bottom sediments. According to WFD, for the evaluation of the water body ecological status taxonomic composition and quantitative values (numbers and biomass – abundance) of phytobenthos are used.

Over the JDDS study in benthic samples 130 algal species of 7 groups were identified. Maximal species number belong to Bacillariophyta (81 species, 89 intraspecific taxa) – 61% of total. Chlorophyta comprised 32 species (26%).

Cyanoprokaryota and Euglenophyta were presented significantly less widely – 7 species each. Cryptophyta, Chrysophyta and Xanthophyta were presented with one species each (Anex 3).

The genera *Navicula* (12 species, 14 intraspecific taxa), *Nitzschia* (12 species), *Scenedesmus* (8 species), *Gomphonema* (7 species, 8 intraspecific taxa), *Cymbella* and *Synedra* (6 species each) were presented the most widely. It should be noted, that species of Euglenophyta, Cryptophyta, Chrysophyta and Xanthophyta were met occasionally (by single cells). They did not produce notable abundance or biomass. The extremely low amount of these algae could be explained by the sampling season. Thus, euglenids are rather usual element of phytobenthos of the plain water bodies of the middle latitudes. They are abundant in some seasons in the lakes of Ukrainian delta. Their absence could be conditioned by hydrological and hydrochemical regime of the examined water bodies. Clarification of this matter will require regular seasonal observation during vegetation season.

Bacillariophyta division were unconditional dominant in phytobenthos at all stations. Their portion in numbers and biomass varied from 32,1–91,1 to 86,9–97,4% (Fig. 3.2). The species richness of phytobenthos at different sites varied from 11 to 69.

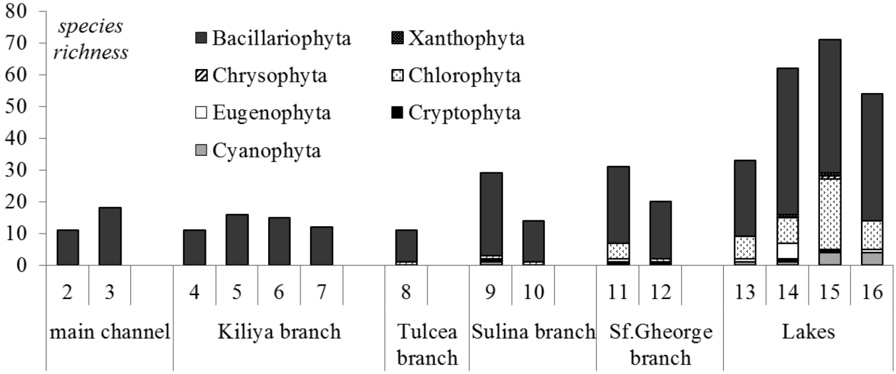

Fig. 3.2. The species richness and taxonomic diversity of phytobenthos at the different stations.

The analysis of the similarity of phytobenthos species composition using Jaccard coefficients and the further cluster analysis allowed to allocate three groups of the stations (clusters) with similar species composition of the benthic algae (Fig. 3.3):

- the stations of the main channel and Kiliya arm (stations 2–7);
- the stations of Tulcea, Sulina and St. George arms (stations 8–12);
- the stations of the delta lakes (stations 13–16).

Phytobenthos species composition of water bodies and water courses was notably different.

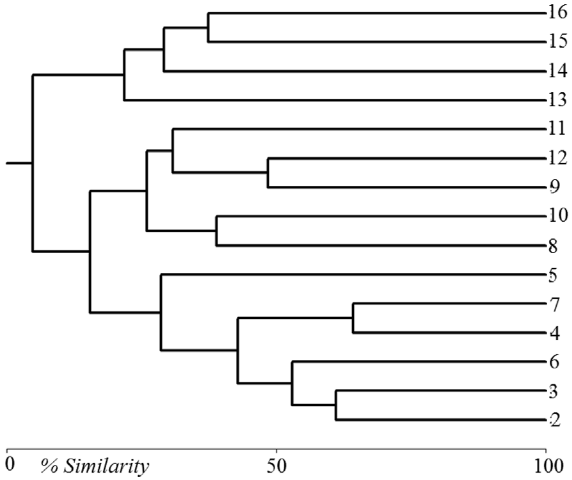

Fig. 3.3 Similarity of phytobenthos species composition of some stations.

Algae abundance and biomass varied within wide limits – from 230,77 to 7637,36 th. cells/10 cm^2 and from 0,224 to 7,738 mg/10 cm^2. The lowest values were recorded at station 8 – Tulcea, the highest – at station 16 Culbul cu Lebede lake. The low quantitative parameters were registered at stations 1–7 (from Reni up to Bystryi), at station 10 – Sulina and at station 12 – St. George (table 3.1.).

The values of species diversity (Shannon indices calculated by abundance and biomass) were rather high – abundance: from 3,10 to 4,61, biomass: from 3,24 to 4,87.

Table 3.1 Characteristics of phytobenthos

№ of station	Species richness	Abundance th. cells/ 10 sm^2	Biomass mg/10 sm^2	Dominantes by abundance	Dominantes by biomass	Saprobity		H/N	H/B
						index	zone		
N 2 – Reni	10	307,69	0,540	*Stephanodiscus subtilis* *Cyclotella sp.*	*Gyrosigma acuminatum* *Didymosphenia geminata*	1,74	b	2,96	2,93
N 3 – Cheatal	18	527,47	1,140	*Synedra actinastroides* *Cyclotella sp.*	*Surirella tenera* *Surirella ovata*	1,88	b	3,80	3,46
N 4 – Izmail	13	329,67	0,657	*Cyclotella sp.* *Stephanodiscus subtilis*	*Synedra ulna* *Gyrosigma acuminatum*	2,00	b	3,49	3,37
N 5 – Kiliia	15	318,68	0,834	*Cyclotella sp.* *Stephanodiscus subtilis* *Melosira granulata*	*Surirella ovata* *Cymbella lanceolata* *Nitzschia sigmoidea*	1,98	b	3,65	3,55
N 6 – Vilkove	16	395,60	0,669	*Synedra actinastroides* *Stephanodiscus hantzschii*	*Gyrosigma acuminatum* *Stephanodiscus hantzschii*	1,90	b	3,70	3,63
N 7 – Bystryi	12	307,69	0,699	*Stephanodiscus subtilis* *Cyclotella sp.*	*Surirella ovata,* *Amphiprora paludosa* *Gyrosigma acuminatum*	1,98	b	3,24	3,07
N 8 – Tulcea	11	230,77	0,224	*Stephanodiscus subtilis* *Cyclotella sp.* *Cocconeis pediculus*	*Cocconeis pediculus* *Stephanodiscus subtilis*	1,90	b	3,10	3,24
N 9 – 23 Mile	29	1351,65	1,546	*Oscillatoria limosa* *Synedra tabulata*	*Cymbella lata* *Gyrosigma acuminatum* *Diatoma vulgare* *Melosira granulata*	2,19	b	4,17	4,05

№ of station	Species richness	Abundance th. cells/ 10 sm^2	Biomass mg/10 sm^2	Dominantes by abundance	Dominantes by biomass	Saprobity		H/N	H/B
						index	zone		
N 10 – Sulina	13	373,63	0,398	*Cocconeis pediculus* *Cyclotella sp.* *Cyclotella glomerata*	*Cocconeis pediculus* *Cocconeis placentula*	1,72	b	3,39	3,34
N 11 – Uzlina	30	1107,69	1,307	*Crucigeniella rectangularis* *Cocconeis placentula*	*Nitzschia sigmoidea* *Surirella ovata* *Diatoma vulgare*	2,05	b	4,48	4,23
N 12 - St George	20	615,38	0,72	*Navicula cryptocephala* *Stephanodiscus subtilis*	*Gyrosigma acuminatum* *Navicula cryptocephala*	2,05	b	4,14	4,01
N 13 – Erinciuc lake	33	6219,78	5,169	*Microcystis aeruginosa* *Melosira granulata*	*Melosira granulata* *Cymbella lanceolata*	1,98	b	3,22	3,30
N 14 – Uzlina lake	61	3208,79	7,024	*Merismopedia minima* *Amphora perpusilla*	*Surirella biseriata* *Cymbella lanceolata*	1,93	-meso	5,45	4,70
N 15 – Isak lake	69	6340,66	4,449	*Merismopedia minima* *Merismopedia punctata*	*Melosira granulata* *Cocconeis pediculus*	1,92	b	4,49	4,87
N 16 – Culbul cu Lebede lake	54	7637,36	7,738	*Merismopedia minima* *Merismopedia punctata*	*Cymbella lanceolata* *Synedra capitata*	1,83	b	4,61	4,68
Total	130								

Stations 2–7 are located along main channel of the Danube and Kiliya arm: species composition and quantitative parameters differed insignificantly: 10–18 species, quantitative parameters varied within 307,69–527,47 th. cell/10 cm^2 and 0,540–1,140 mg/10 cm^2. On the whole, the species composition of these stations was rather uniform with some small differences mainly specified by insignificant quantitative development and calculation errors related to it. Centrophyceae were the background group, they were registered at all stations in the considerable amount: *Stephanodiscus subtilis, Cyclotella sp., Aulacoseira granulata* and other. It should be mentioned that the first species is prevailing in phytoplankton of the lower section of the Danube river in some seasons. These species also were dominant in terms of numbers. The big-cell species of *Surirella, Cymbella lanceolata, Gyrosigma acuminata* genera prevailed in terms biomass.

Special attention should be paid to the presence of *Didymosphenia geminata*, its single cells were found practically in all samples. This genus is not typical for the middle and lower section of the Danube downstream; it was brought by the current from the mountainous sections of the basin. This benthic periphytic species is included into the Global Invasive Species Database. Its extensive development could have unfavorable effect on the water quality. The brackish water species *Amphiprora paludosa* was revealed in phytobenthos of the downstream station 7 (Bystryi branch) in the significant amount, the most probably indicating notable effect of the marine water on this area. Station 3 (Izmail Cheatal) was notable for species richness and quantitative parameters. It can be related to micro-biotope features where phytobenthos sample was taken.

Station 8 – Tulcea: species richness and quantitative parameters were the lowest. Eleven algal species were detected: 10 Bacillariophyta and 1 Chlorophyta. *Stephanodiscus subtilis* (65,9%) and *Cocconeis pediculus* (32,92%) had the highest abundance. It should be mentioned that the first species is abundant in phytoplankton of the downstream of Danube sections in some seasons. The low species richness and abundance of phytobenthos at this station was probably conditioned by the unstable hydrological conditions and high turbidity.

Station 9–23 Mile: phytobenthos comprised 29 taxa of Cyanoprokaryota, Cryptophyta, Chlorophyta (one species) and Bacillariophyta (26 species). The numbers amounted to 1351,65 th. cells/10 cm^2, biomass – 1,546 mg/10 cm^2. Maximal portion of numbers (24,4%) was formed by *Oscillatoria limosa*, the most probably owing to the entry of the waste waters from the settlements located upstream. *Synedra tabulata* also was quite abundant (10,6%). Typical benthic forms *Cymbella lata*, *Gyrosigma acuminatum, Diatoma vulgare* and *Melosira granulata* formed maximal portions of biomass – respectively 16,1, 15,0 and 10,9%, respectively. In addition, rather high portion of species list was formed by periphytic forms – species of the genera *Amphora, Roicosphenia, Cymbella and Gomphonema*.

Station 10 – Sulina: species richness was low – 13 species, 12 of Bacillariophyta and one of Chlorophyta. The quantitative parameters amounted to 373,63 th. cells/10 cm^2 and 0,398 mg/10 cm^2. Dominants in terms of numbers and biomass were similar to those at station 8 – the highest values were registered in *Cocconeis pediculus* (respectively 14.7 and 20.7%). The abundance of *Aulacoseira granulata v. angustissima*, *Cyclotella sp.*, *Cyclotella glomerata* and *Cocconeis placentula* were equal (11.8% each). The latter was subdominant in terms of biomass – 14,4%. Like at station 8, low species number and quantitative parameters were probably stipulated by the high flow rate and turbidity.

Station 11 – Uzlina: species list comprised 30 taxa of four groups – 1 Cryptophyta, 1 Euglenophyta, 5 Chlorophyta and 23 Bacillariophyta. Abundance and biomass amounted to 1107,69 th. cells/10 cm^2 and 1,307 mg/10 cm^2. Only here the green algae *Crucigeniella rectangularis* (Chlorophyta) was dominant in terms of abundance. Though it is considered the planktonic, it was abundant in the bottom water layer (12,7% of total). *Cocconeis placentula* was the second in terms of abundance (8,7%). Dominant complex by biomass included the big-cell Bacillariophyta: *Nitzschia sigmoidea*, *Surirella ovata* and *Cocconeis placentula* (respectively 11,5, 9.2 and 9,6%). It can be assumed that habitat conditions of phytobenthos at this station were more favorable than at the upstream.

Station 12 – St George: species richness comprised 20 taxa: 1 of Cryptophyta, 1 of Chlorophyta and 18 Bacillariophyta. Quantitative parameters amounted to 615,38 th. cells/10 cm^2 and 0,72 mg/10 cm^2. *Navicula cryptocephala* and *Stephanodiscus subtilis* (14,3 and 8,9%) dominated inn terms of abundance, *Gyrosigma acuminatum* and *Navicula cryptocephala* (16,1 and 9,4%) – in terms of biomass.

Station 13 – Erinciuc lake: species richness comprised 33 species: 1 of Cryptophyta and Euglenophyta, 7 of Chlorophyta and 24 of Bacillariophyta. The quantitative parameters were 6219,78 th. cells/10 cm^2 and 5,17 mg/10 cm^2. Dominant complex in terms of biomass included *Microcystis aeruginosa* and *Aulacoseira granulata* (30,0 and 21,2%). *A. granulata* formed maximal portion of biomass (45,5% of total), *Cymbella lanceolata* was subdominant (9,1%).

Station 14 – Uzlina lake: species richness was high – 61 taxa of 6 groups, including 1 of Cyanoprokaryota, Cryptophyta and Xanthophyta, 4 of Euglenophyta, 8 of Chlorophyta and 46 of Bacillariophyta. Quantitative parameters mounted to 3208,79 th. cells/10 cm^2 and 7,024 mg/10 cm^2. Portions of Cyanoprokaryta and Chlorophyta in abundance were almost equal (respectively 11,0 and 13,7%). The small-cell planktonic Cyanoprokaryota Merismopedia minima formed maximal portions of abundance (11,0%), though its portion in biomass did not reach even one-tenth of percent. The highest biomass was formed by the big-cell Surirela biseriata and Cymbella lanceolata (20,4 and 11,8%), though but their portions in abundance did not exceed 0,7%. Algae of Cryptophyta and Xanthophyta were found as single cells.

Station 15 – Isak lake: species richness was the highest among all examined stations – 69 species from 7 divisions. Cryptophyta, Euglenophyta, Chrysophyta and Xanthophyta were presented by 1 species each, 4 – of Cyanoprokaryota. The most diverse were Chlorophyta (22 species), on the contrary to the other stations – it is almost 31,2% of total species composition. 39 species (56,5%) belonged to Bacillariophyta. The quantitative parameters were 6340,66 th. cells/10 cm^2 and 4,449 mg/10 cm^2. Like at the previous station, the small-cell *Merismopedia minima* and *Merismopedia punctata* were the most abundant (27,7 and 8,3%). Total Cyanoprokaryota portion in abundance amounted to 46,8%, whereas their portion in biomass was 0,5%. The portion of Chlorophyta in total abundance was almost 20%, portion of Bacillariophyta – 32,1%. *Melosira granulata* and *Cocconeis pediculus* formed the highest biomass (19,1 and 8,2%).

Station 16 – Cuibul cu Lebede lake: species richness was also rather high – 54 species of 5 groups: 4 Cyanoprokaryota, 1 Euglenophyta, 9 Chlorophyta and 40 Bacillariophyta. At this station quantitative parameters were maximal among all examined – 7637,36 th. cells/10 cm^2 and 7,738 mg/10 cm^2. The small-cell Cyanoprokaryota *Merismopedia minima* and *Merismopedia punctata* were the most abundant (18,4 and 13,8%). Total Cyanoprokaryota's portion was 44,5% of abundance. The large cell Bacillariophyta – *Cymbella lanceolata*, *Epithemia turgida* and *Cocconeis pediculus* formed maximal portions of biomass (12,2; 10,9 and 8,7%).

On the whole, the species composition of phytobenthos in the examined water bodies was quite rich. At the same time, only Bacillariophyta and Cyanoprokaryota had the mass development, with the exception of station 11, where the species of Chlorophyta prevailed. The features of phytobenthos development at stations 13, 14, 15 and 16 consisted in the high values of abundance of the small-cell Cyanoprokaryota. At the same time, their portion in biomass did not exceed one-tenth of percent. Probably, these algae settled in the benthic layers from plankton at the end of vegetation season, when the study was carried out. Benthic forms – large cell Bacillariophyta - prevailed in terms of biomass. Phytobenthos of the examined areas included big portion of the periphytic forms – the species of genera *Cymbella*, *Gomphonema*, *Amphora*, *Roicosphenia*. Centrophycea played an important role at stations 8, 9, 10 and 12. These algae were typical for the plankton of the Danube main channel.

It should be noted that JDS-2 results [JOINT 2008] (we used the study results of the whole channel and of the mouth areas of the tributaries for comparison) demonstrated almost the same number of algae species (without Bacillariophyta) – 52 species of 3 groups versus 49 species of 6 groups, registered in our study. In JDS-2 they mostly included species of Chlorophyta and Cyanoprokaryota, and only 2 species of Rhodophyta (in the upper sections). The differences could be related to the fact that in our studies part of the stations was located in low-flowing water areas, where the conditions for Chlorophyta, Cyanoprokaryota and Euglenophyta development are more favorable than in the main channel. Moreover, Chlorophyta and Cyanoprokaryota found in phytobenthos in our study were mostly plankton forms. The report of JDS-2 mentioned mostly filamentous forms.

The amount of Bacillariophyta species registered in JDS-2 was significantly higher than the amount recorded in our study – 391 taxa versus 89. It is explained by more extended region and biotopes diversity. We consider unreasonable to calculate the frequency of occurrence owing to small amount of stations. Unfortunately, the report on the JDS-2 results does not contain the detailed floristic analysis of phytobenthos – the species abundance by groups and complete list with their locations (or as minimum with the link to Danube region), which complicates the detailed comparison.

In general, the phytobenthos composition at the most studied stations at time of observations can be preliminary evaluated as good – satisfactory. It is confirmed by the high values of the species diversity indices, values of the saprobic index not exceeding -mesosaprobic zone. However, large amount of the small-cell Cyanoprokaryota in phytobenthos (due to plankton settling) at stations 13–16 indicates their mass development in these water bodies and possible unfavorable consequences after their further die-off and decomposition.

1.1. MACROZOOBENTHOS

Significance of the benthic invertebrates as one of the leading biotic component of aquatic ecosystems is well recognized. Bottom dwellers are mostly responsible for the formation of the ecosystem biodiversity. They play an important role in creating the substance and energy flows, the processes of self-purification and bioaccumulation, define the trophic status and productional characteristics of the water bodies and are the reliable indicators of the water saprobity and state of the aquatic ecosystems.

Benthic invertebrate fauna is an integral part of aquatic ecosystem monitoring, as it was established that the structural and functional parameters of the benthic communities appropriately display the general picture of the ecosystem state. They are the important indicators of the aquatic environment quality [AFANASYEV 2002; METCALFE 1989].

Significance of the benthic invertebrates in bioindication of the aquatic ecosystem state is mentioned in the known Directive of European Parliament and Council of Europe establishing a framework for Community action in the field of water policy 2000/60/EC (Water Frame Directive, WFD) [EU…, 2006] – the most competent normative document today regulating the process of determination of the ecological state, organization and conduction of different water bodies monitoring. According to the WFD, macrozoobenthos or benthic invertebrate fauna means the invertebrates, who live at least part of their life cycle at (or in) the benthic substrate of the rivers, lakes, transit or coastal waters. Macrozoobenthos is included into the biocomponents of determination of the ecological state of all rivers [EU 2006 Annex V].

Upon the approval of the European Water Framework Directive EU 60/2000 (WFD), which defined the priority of the biotic component in water management [EU, 2006], bioindication of water contamination and ecosystem conditions is gaining ever more significance in European countries. WFD does not propose concrete approaches being obligatory for implementation in all counties or water basins; moreover, each country, in addition to assessments based upon the WFD principles, is free to use national-based methodologies. The adequacy of results should be reached by virtue of international trainings, intercalibrations, joint projects and expeditions. In this respect, most significant for the Danube are the surveys performed under the aegis of ICPDR: JDS (the Joint Danube Survey) and the JDS2, conducted in 2001 and 2007, as well as our survey – JDDS (the Joint Danube Delta Survey) held in 2011. Pursuant to WDF [EU… 2006], one of the biological elements of ecological condition classification is the composition and spread of bottom-dwelling invertebrates that are characterized (described) on the basis of a set of indexes. In the reports of the aforesaid surveys, to these indexes belong species composition, quantity, biomass and establishing saprobity. The experience of international surveys of the Danube [JDS2, 2008] has demonstrated the differences between sampling and material processing methods, assessment methods that are consistent with WFD principles [JOINT… 2008].

Systemic research of macrozoobenthos of the Lower Danube, the river's delta and the adjacent basins has a lengthy history. The early research conducted in the end of the nineteenth century [BOURGUIGNAT 1870, OSTROUMOV 1897, 1898, ZERNOV 1908, MILASCHEVICH 1908, ANTIPA 1914] was fauna-oriented in nature and presented the general idea about the species composition of invertebrates, the taxonomic structure and the condition of the Ponto-Caspian relict fauna. In the 1920's, German researcher H. Spandl [1926] offered the description of more than 200 species of bottom-dwelling invertebrates of the Danube delta. Further on, until 1960's, fauna research was conducted mainly by Romanian specialists [BACESCO 1934, BORCEA 1924, CARAUSU 1937, MOTAS BACESCO 1937, BOTNARIUC & CANDEA 1953, BOTNARIUC CURE, 1959, ENACEANU 1953, GROSSU, PALADIAN 1956, POPESCU-GORJ, POPESCU, GEORGESCU 1957].

In late 1940's – early 1950's, the specialists of the Institute of Hydrobiology National Academy of Ukraine commenced committed hydrobiological research at the Ukrainian section of the Danube and the large lakes of the river's lower current. Complex generalizing characteristics of the macrozoobenthos of delta and coastal lake waters are provided in the monograph by Yu. M. Markovskyi [1955]. Described for the first time were macrozoobenthos coenoses; quantitative data regarding the development and representation of separate species were furnished. This classic work occupies a unique position to this day, whereas it generalizes the material that can be presently employed for prognostic estimation of water ecosystems condition as a basis for comparison. In 1960's – 1970's the survey of macrozoobenthos in the Ukrainian section of the delta was performed by G. A. Olivari [1961], V. V. Polischuk [1974] and L. N. Zimbalevskaya [1969].

In the Romanian section of the delta, fauna and taxonomic research continued to develop [POPESCU 1963, POPESCU, BOTEA 1962, BREZEANU, PRUNESCUY 1962, GROSSU 1963, POPESCU-MARINESCU, ZINEVICI 1968 (a, b)]. A new approach, including community studies and the assessment of energy flow through some taxonomic groups, was initiated during the middle of the 1970's [TUDORANCEA at al. 1976; DIACONU 1985; BOTNARIUC et al. 1987, VADINEANU et al. 1985, NEACSU, TEODORESCU 1985, RISNOVEANU et al. 1997].

Complex research of macrozoobenthos coenoses, their structural-functional characteristics, the participation of invertebrates in the process of water quality formation was initiated in Ukraine in 1980's–1990's under the leadership of the Ukrainian hydrobiologist Professor T.A. Kharchenko [1993].

Once the Danube Delta became a Natural Reserve, part of the Biosphere, Reserves World heritage 1991, ecological and limnological research embraced a more general ecosystem approach, including aspects of conservation and management [ALEKSANDROV at al. 1999, LIASHENKO, METELETSKAYA 2002, RISNOVEANU et al. 2000, VADINEANU at al. 2001, 2001a, 2003].

Starting the late 20th – early 21st century, research conducted by Ukrainian scientists has been directed at the review of the general biological diversity of macrozoobenthos of the delta, the condition of the populations of rare and disappearing species, and the penetration of invading species [ALEKSANDROV at al. 2007; KORNYUSHIN, LIASHENKO 2004, KHARCHENKO 2005; MAKOVSKIY, LYASHENKO 2011; SON 2007, LIASHENKO at al. 2009, 2010; SANZHAK at al., 2012], phytophilous fauna [ETINGOVA, 2002, AFANASYEV at al. 2008; ZORINA-SAKHAROVA at al. 2008] and epifauna [SANZHAK, LIASHENKO 2009].

Within the last century, upon the publishing of WFD, evaluations of the ecological conditions of Lower Danube water bodies have been undertaken based on macrozoobenthos organisms [LYASHENKO at al. 2006, 2007; ZORINA-SAKHAROVA, LYASHENKO 2008; ROMANENKO at al., 2011], performed in the framework of national and international projects [LYASHENKO, ZORINA-SAKHAROVA 2008, 2009].

Species composition, structural characteristics of macrozoobenthos and the results of bioindication of water quality at each station are provided in Anex 4.

Total taxa (species richness). Totally 115 species of invertebrates were registered. The most species number belonged to Chironomidae (23) and Oligochaeta (21). They were found at each station except station 13 (Erenciuc lake), where Oligochaeta was absent, station 2 (Reni) and station 8 (Tulcea), where Chironomidae were not detected. Also Gastropoda (13 species), Gammaridae (10 species), Bivalvia (9 species) were characterized by notable species richness. There were also registered 6 species of Odonata, 4 species of Hirudinea, Heteroptera and Trichoptera, 3 species of Corophiidae, Ephemeroptera and Coleoptera, 2 species of Bryozoa, Cumacea and Mysidacea. The other taxonomic groups were presented by 1 taxon each.

Diversity. Maximal species number was registered at station 9 (Mila 23) and station 11 (Uzlina) – respectively 32 and 31 (Fig. 3.4). The least species number was registered at station 2 (Reni) – 7 species. It was connected with the soil type (heavy clay), absence of the higher aquatic vegetation and other substrates suitable for the invertebrates' development. Oligochaeta and Gammaridae were widely presented in the water courses, main channel and arms. Chironomidae were widely presented in the most lakes and Oligochaeta prevailed in Isak lake and channels.

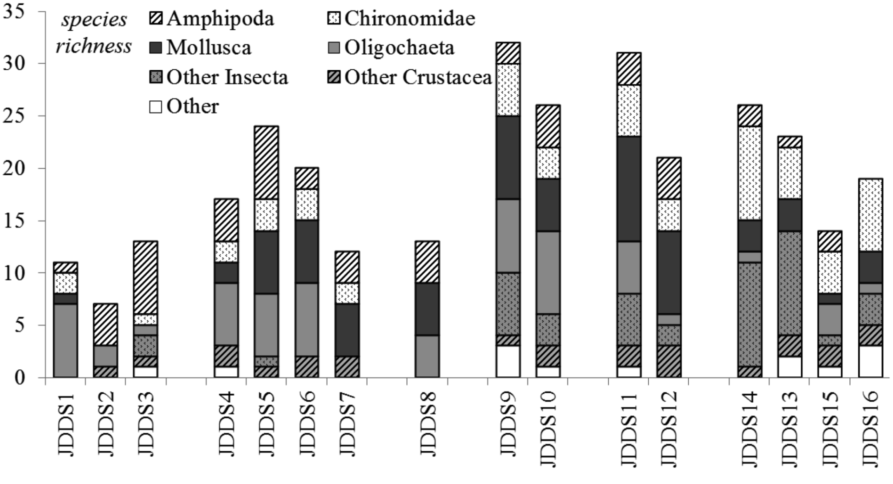

Fig. 3.4. Taxonomic composition of macrozoobenthos (at JDDS stations).

The analysis of the macrozoobenthos similarity using the Jaccard coefficients with the further clustering of the stations showed some logical regularities of macrozoobenthos distribution (Fig. 3.5).

One group includes three of four of the studied delta lakes: station 14 (Uzlina lake), station 16 (Culibul cu lebede lake) and station 13 (Erenciuc lake) and the stations located along St. George arm: station 11 (Uzlina) and station 12 (St. George). No other regularities were detected. It can be related to the high aggregation and pattern structure of benthos distribution in the water courses.

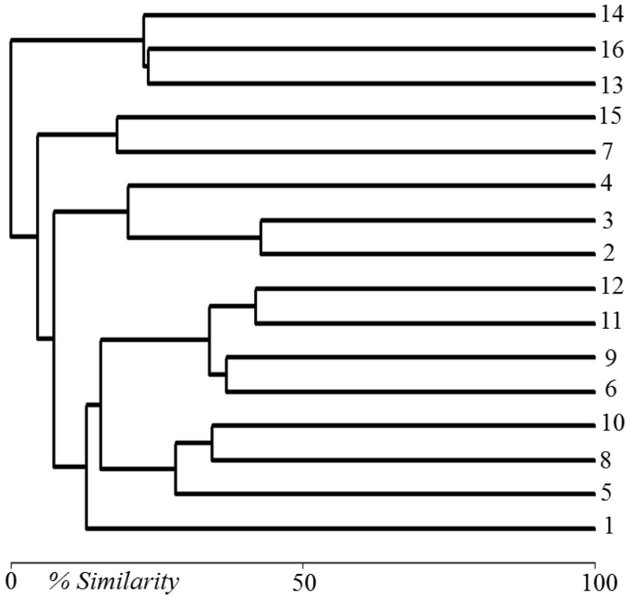

Fig. 3.5. The analysis of the similarity of macrozoobenthos species composition at individual stations (using Jaccard coefficients).

The low similarity values of the benthic invertebrates at the different stations of Kiliya arm also confirm it. They were significantly lower than in Sulina and St. George arms. Sulina and St. George arms have generally high similarity of macrozoobenthos species composition (Table 3.2, Fig. 3.5) –

Jaccard coefficients values for these water courses were maximal. In addition, species composition of the lakes and water courses significantly differed. The Tulcea arm joins the Danube main channel in one group, and Kiliya arm, Sulina and St. George arms compose the separate group. Macrozoobenthos species composition of the Kiliya arm differs from the species composition of Sulina and St. George arms (see Fig. 3.5).

Table 3.2 Similarity Jaccard coefficients
for macrozoobenthos of the main water bodies.

	Kiliya arm	Tulcea arm	Sulina arm	St. George arm	Lakes
Main channel	22	24	23	22	16
Kiliya arm	*	27	34	32	19
Tulcea arm	*	*	25	19	11
Sulina arm	*	*	*	41	30
St. George arm	*	*	*	*	31

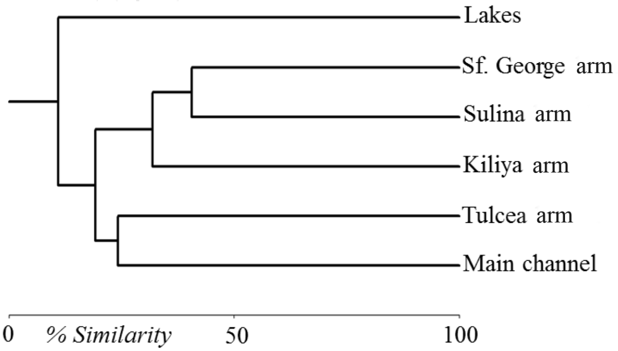

Fig. 3.6. The analysis of the similarity of macrozoobenthos species composition of the water bodies (using Jaccard coefficients)

However, in general the species richness of three arms is characterized by the similar values (Fig. 3.7). 48 species of macrozoobenthos were registered in the Kiliya arm, 47 in the Sulina arm and 43 in St. George arm. Oligochaeta dominated in all arms, where they were presented by 11 species. Only five of them were common for all three arms. The key feature of the Kiliya arm was high diversity of Amphipoda and low of Insecta. In the Sulina arm only two species of Bivalvia were registered, whereas in the Kiliya arm – 5, in the St. George arm – 6. The St. George arm had the lowest species richness of Gastropoda – 5, whereas in the Kiliya and Sulina arm their number was 8.

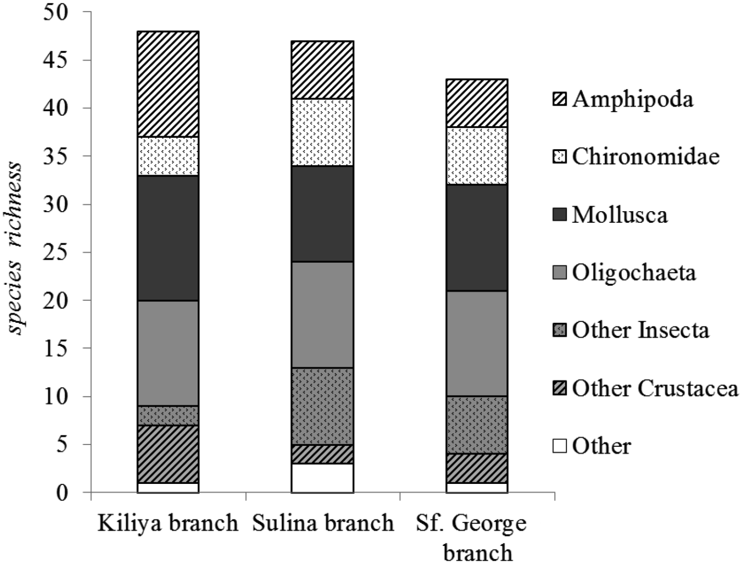

Fig. 3.7. Taxonomic composition of macrozoobenthos in the main branches of Danube delta.

In the water courses, main channel and delta arms 89 species of the benthic invertebrates were registered, and in the lakes – 58 species. Only in the water courses 56 were found and 22 – only in the water bodies. The main difference of macrozoobenthos of the channels and lakes consisted in higher species number of Oligochaeta, Mollusca and Gammaridae. The number of Chironomidae species in arms and lakes was equal (14). The number of species in the delta arms, found using the dredge sampling, was almost similar to the number, identified in the qualitative samples (kick-net) (respectively 5 and 61). However, in the lakes the quantitative samples showed twice lesser species number than the qualitative samples (respectively 20 and 45). In the Erenciuc lake the significant species richness (23 species) in the qualitative samples (weed beds) was accompanied by total absence of the invertebrates in the bottom sediments (detritus and plant residues). Maximal species number in the dredge samples was registered at station 11 (Uzlina), and in kick-net samples – at station 14 (Uzlina lake).

The comparison of the obtained materials with the data of the previous international studies showed that they are quite comparable despite the different methods of sampling (see Fig. 3.8). Over the JDS-1 in the lower section of the Danube River 119 species of macroinvertebrates were registered, and over JDS-2 –153 species. The main differences in the study results are related to the species composition of Diptera (especially Chironomidae). This group was not identified to the species level in JDS-1, but it was paid much attention in JDS-2. We registered half the number of Chironomidae species than it was registered over JDS-2. The same situation was with Oligochaeta. The species richness of Mollusca in the lower section of Danube was 1.5 times higher in JDS-1 than in JDS-2 and JDDS, where respectively 24 and 22 species were registered. The number of Crustacea species was similar in all three studies.

No rare species and species under protection were registered. The relic Ponto-Caspian fauna was widely presented. Over the recent decades its representatives actively expanded their areal and have become invasive in many European ecosystems. At this within their original localities their species richness decreased. 17 species of Ponto-Caspian complex of seven taxonomic groups were registered: *Palludicella articullata, Caspiobdella fadejewi, Jaera sarsi, Echinogammarus ischus, E. warpachowskyi, E. trichiatus, Dikerogammarus haemobaphes, D. villosus, Pontogammarus crassus, P. obesus, Corophium curvispinum, C. nobile, C. robustum, Schizorhynchus scabriusculus, Sch. eudorelloides, Limnomysis benedeni, Paramysis lacustris*. Maximal number of Ponto-Caspian species (8) was identified at station 5 (Kiliya), and minimal – at station 1 (Giurgiulesti) only 1 species and at station 16 (Culibul cu Lebede lake) – 2 species.

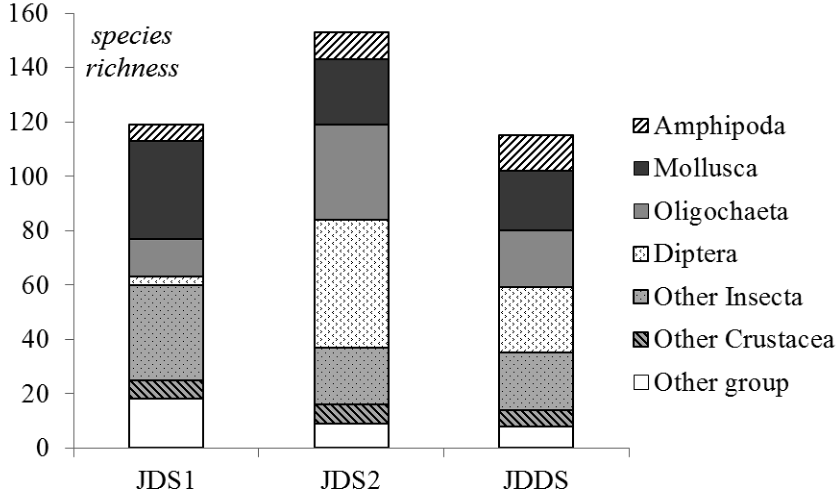

Fig. 3.8 Comparative analysis of the macrozoobenthos species richness at examination of the Danube downstream in JDS1, JDS2 and JDDS (note: the data for Danube downstream area were taken for JDS1 and JDS2).

Four invasive species of the benthic invertebrates were registered: two of Bivalvia – *Corbicula fluminea* and *Sinanodonta woodiana* and two of Gastropoda – *Physella acuta* and *Ferrissia clessiniana*. *Corbicula fluminea* was identified in dredge samples at station 1 (Giurgiulesti) and in the qualitative samples at station 9 (Mila 23). *Sinanodonta woodiana* was found in the arms near the sea gate at station 7 (Bystryi) and at station 12 (St. George). *Physella acuta* was found in the macrophyte beds of Sulina arm (station 9 – Mila 23), and *Ferrissia clessiniana* was registered in the beds of station 14 (Uzlina lake).

Abundance

Macrozoobenthos abundance at different sites significantly differed. Maximal values were registered at station 1 (Giurgiulesti) – 16412 ind/m^2 (Fig. 3.9), which is related to the considerable development of Oligochaeta, particularly *Isochaetides michaelseni*. Minimal values of abundance were recorded at station 2 (Reni) – 96 ind/m^2. The low values of macrozoobenthos abundance were also registered at station 3 (Cheatal) – 182 ind/m^2 and station 7 (Bystryi) – 200 ind/m^2.

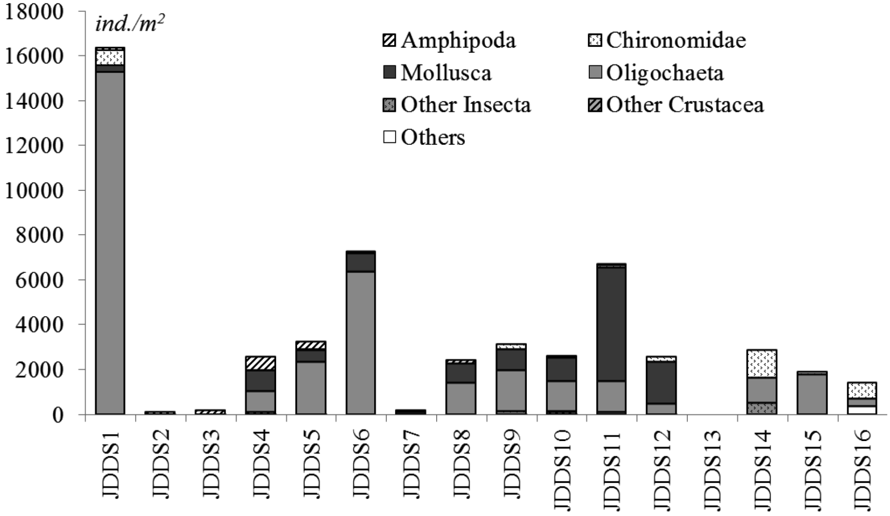

Fig. 3.9 Macrozoobenthos abundance at different stations of Danube delta.

The dominant taxa at the stations of the main channel (station 2 (Reni) and station 3 (Cheatal)) were Gammaridae, presented by the small juvenile individuals, which were impossible to identify to the species level. Oligochaeta prevailed at the stations of the Kiliya, Tulcea, Sulina arms and Isak lake: *Limnodrilus claparedeanus, Limnodrilus hoffmeisteri, Isochaetides newaensis, Tubifex tubifex.* Gastropoda *Lithoglyphus naticoides* prevailed in St. George arm. Chironomidae with the dominant species *Cricotopus sylvestris* and *Cladotanytarsus mancus* were the most abundant in the Uzlina lake and Culibul cu Lebede lake.

Biomass

Similar to abundance, macrozoobenthos biomass significantly differed. Maximal values were formed by the mollusks (both Gastropoda and Bivalvia) (Fig. 3.10), for instance *Esperiana acicularis, Esperiana esperi* and *Viviparus viviparus*, and were recorded at station 9 (Mila 23) – 750,1 g/m^2. The significant biomass was also observed at station 11 (Uzlina), where large bivalve mollusks *Anodonta anatina*, *Unio pictorum* and *Unio tumidus* were found. No mollusks were found in the qualitative samples at station 2 (Reni), station 3 (Cheatal) and in the delta lakes. Therefore, the biomass values were rather low there. In terms of biomass dominated Oligochaeta (stations 2, 14, 15), Chironomidae (station 16) or Gammaridae (station 3). The lowest biomass values were registered at station 2 (Reni) – only 0,04 g/m^2.

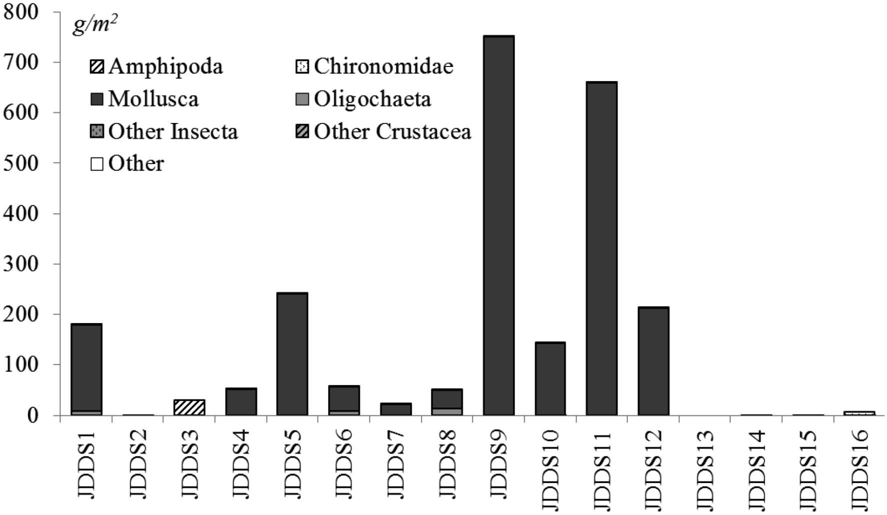

Fig. 3.10 Macrozoobenthos biomass at different stations of Danube delta

Saprobic indices and water quality classes

In order to determine the ecological condition, the Zelinka-Marvan index was employed with the reference value of 2,0 for the Lower Danube [SOMMERHÄUSER et al. 2003). The assessment results (Fig. 3.11) were fluctuating within the boundaries of the II-IV classes of the "Good-Poor" scale; a worsening was noted in the areas of urban influence (Giurgiulesti, Kiliya, Vilkove); and the worst condition among the lakes is established for lake Isak – the largest, least running lake without submersed plants overgrowth. The JDS materials provide no figures for saprobity (JDS, 2001), which complicates the comparative assessment; however, overall, the materials of all surveys yielded the same results.

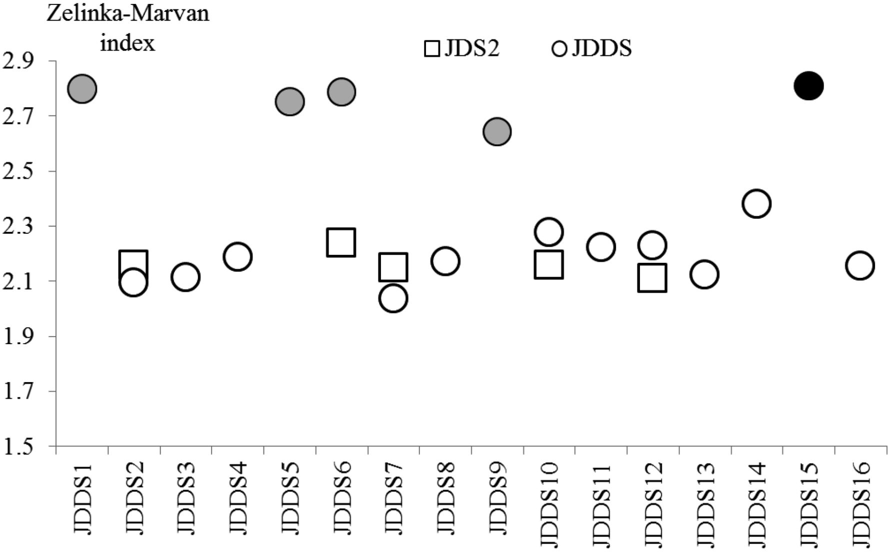

Fig. 3.11 Ecological conditions classification:
white – II-Good, gray – III-Moderate, black – IV–Poor.

The conducted studies demonstrated that Danube delta macrozoobenthos is highly heterogeneous which is connected with the soil type and flow rate. The comparison of the obtained materials with the data of the previous international studies showed that the received results are quite comparable despite the different methods of sampling.

In general, the results of bioindication demonstrate the good ecological state of the most water bodies (II Good). The deterioration was observed at some stations up to III Moderate and lower than IV-V Poor-Bad. It is connected with the use of different assessment methods. Insufficient number of the indicator species of saprobity could have impact on the results accuracy.

CHAPTER 4.

HYDROBIOLOGICAL STUDIES OF MODERN STATE OF SMALL TATARU AND ERMAKOV ISLANDS.

Between 20 and 25 of May 2018, a hydrobiological survey of the Small Tataru and Ermakov islands, located in the Ukrainian part of Danube Delta, was carried out under the auspices of the WWF Kyiv Department.

The main task of the study was to assess the actual state of hydrobiocoenoses in the internal water bodies of the islands (lakes and channels) according to the structural and functional characteristics of macroinvertebrates (zoobenthos and phytophilous fauna) and ichthyofauna (fish larvae and juveniles) to determine degree of their ecosystems rehabilitation after removal of dams and renewal of hydrological connection with the Danube.

The samples were taken at 15 sites of the Small Tataru, Ermakov and Ochakivskyi islands, which were selected to cover the maximum number of available typical water bodies on the islands: internal lakes, flowing and non-drainage channels, reed beds, etc. The general sampling map is shown on Fig. 4.1.

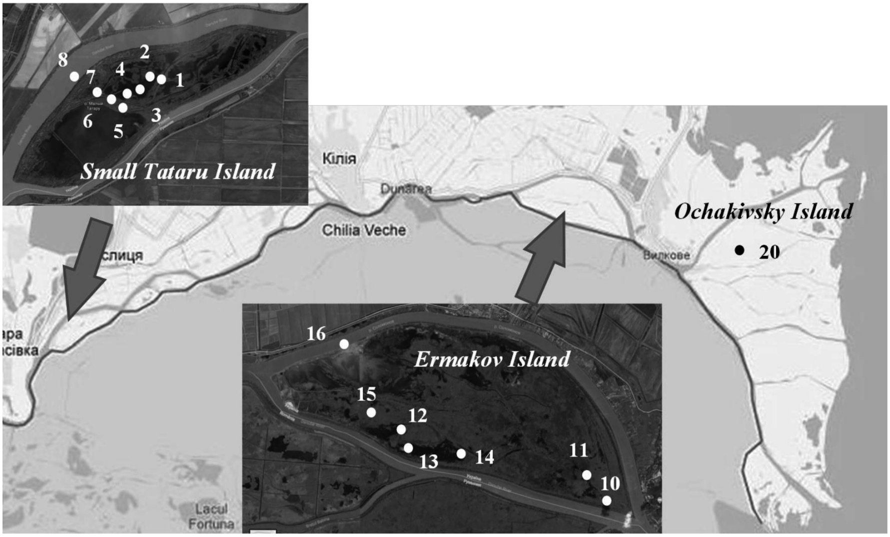

Fig. 4.1. Sketch map of sampling sites.

A series of hydrological and hydrochemical parameters were measured at each sampling site. The temperature, electrical conductivity, total mineralization and NaCl content in water were measured with the conductivity/TDS meter «HANNA HI 9835», the oxygen content was measured with the oxymeter AZHA-101M.

The general information on sampling sites and their hydrological-hydrochemical characteristics are given in Tables 4.1 and 4.2, and Fig. 4.2 shows the nitrogen forms ratio in water at different sites. The hydrological-hydrochemical regime was favorable for water biota development: the water temperature varied within 21–26°C, pH was about neutral (7,12–8,08), the water transparency at all monitoring sites reached the bottom, the depth did not exceed 2,0 m (mainly up to 1,0 m), the bottom sediments were presented by black and gray mud with significant portion of plant residues and detritus. The content of nutrients was relatively low, mostly corresponding to the I–III grade of quality, only in the Small Tataru island the high contents of nitrites (sites N 5 and 8) and nitrates (site N 8) were registered. According to mineralization, water at all stations was fresh and hypohaline, corresponding to I quality class. Such indicators are quite consistent with the period after flood, during which the island water ecosystems are washed by the Danube waters.

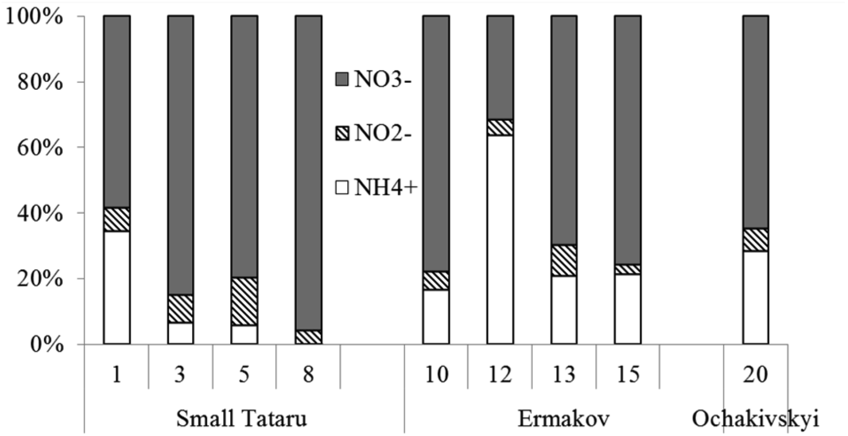

Fig. 4.2. Ratio of nitrogen forms at different sampling sites.

Table 4.1. Results of field measurements at sampling sites in Small Tataru, Ermakov and Ochakivskyi islands

Sampling site			coordinates	Field measurements								
Water body	№	Name of the site		depth, m	soil type	t, °C	vegetation cover, %	salinity, ‰	eH, mS	NaCl, %	pH	O_2, mg/l
Small Tataru island												
Longitudinal channel	1	entrance to the lake	45^{0}21’05,43” 029^{0}00’24,38”	0,70	black mud	21,00	100%	0,28	0,56	1,00	7,56	11,08
Lake	2	eastern peak	45^{0}21’07,97” 029^{0}00’21,39”	1,10	black mud	21,50	100%	0,27	0,55	1,10	–	5.04
	3	middle	45^{0}21’00,63” 029^{0}00’02,10”	2,00	black mud	22,60	100%	0,29	0,58	1,00	7,79	8,34
	4	western peak	45^{0}20’56,52” 028^{0}59’41,62”	1,00	black mud	22,80	70%	0,29	0,56	1,00	–	10,34
Parallel channel	5	middle	45^{0}20’52,25” 028^{0}59’48,40”	1,00	black mud	22,20	90%	0,29	0,58	1,10	7,46	4,17
Cross channel	6	middle	45^{0}20’55,77” 028^{0}59’39,57”	1,50	black mud	24,40	100%	0,28	0,57	1,10	–	6,78
	7	north shore of the island	45^{0}21’08,46” 028^{0}59’22,50”	1,50	black mud	24,20	100%	0,28	0,58	1,10	–	7,51
The Danube River	8	near the island	45^{0}21’12,36” 028^{0}59’17,56”	0,50	grey mud	24,00	0%	0,19	0,38	0,80	8,08	13,4

Sampling site			coordinates	field measurements								
Water body	№	Name of the site		depth, m	soil type	t, °C	vegetation cover, %	salinity, ‰	eH, mS	NaCl, %	pH	O_2, mg/l
Ermakov island												
Lipov-ansky channel	10	outlet	45^{0}24’49,98” 029^{0}32’21,57”	0,70	grey mud	20,50	50%	0,25	0,51	0,90	7,12	10,53
	11	200 m to the outlet	45^{0}25’03,34” 029^{0}32’06,49”	1,00	grey mud	25,00	90%	0,25	0,50	0,90	–	3,15
Lake 1	12	northern part	45^{0}24’49,79” 029^{0}28’27,55”	0,70	black mud	25,00	60%	0,33	0,67	1,40	7,71	4,18
Lake 2	13	beginning from lake 1	45^{0}25’36,22” 029^{0}28’33,39”	1,00	black mud	26,00	80%	0,32	0,63	1,30	7,79	6,35
	14	eastern peak	45^{0}25’25,92” 029^{0}29’38,86”	1,00	black mud	26,00	80%	0,31	0,63	1,20	–	5,44
Cross channel	15	middle	45^{0}25’57,36” 029^{0}27’47,00”	0,50	black mud	22,10	90%	0,29	0,59	1,10	7,17	4,13
The Danube River	16	near the island	45^{0}26’57,06” 029^{0}27’39,33”	0,50	grey mud	23,00	0%	0,18	0,36	0,70	–	12,2
Ochakivskyi island												
Channel	20	within the reed beds	45^{0}23’39,46” 029^{0}37’47,72”	0,50	grey mud	17,70	50%	0,49	0,99	1,90	6,58	5,31

Table 4.2. Values of hydrochemical indicators (based on the results of laboratory tests) and their conformity to the quality classes according to the [METODYKA… 1998].

Indicators		Small Tataru island				Ermakov island				Ochakivskyi island
		sampling sites				sampling sites				sampling sites
		1	3	5	8	10	12	13	15	20
NH_4^+	mg N/dm³	0,040	0,007	0,027	0,007	0,040	0,107	0,013	0,053	0,040
	quality class	I	I	I	I	I	II	I	I	I
NO_2^-	mg N/dm³	0,008	0,009	0,070	0,051	0,013	0,008	0,006	0,007	0,010
	quality class	II	II	IV	IV	III	II	II	II	II
NO_3^-	mg N/dm³	0,068	0,092	0,383	1,329	0,189	0,053	0,044	0,189	0,092
	quality class	I	I	II	IV	I	I	I	I	I
N_{inorg}	mg N/dm³	0,116	0,108	0,480	1,387	0,242	0,168	0,063	0,249	0,142
P_{inorg}	mg P/dm³	0,080	0,093	0,147	0,150	0,005	0,042	0,040	0,055	0,080
	quality class	III	III	III	III	I	II	II	III	III
mineralization (dry residue)	mg/dm³	254	187	241	197	255	251	298	265	409
	quality class	I	I	I	I	I	I	I	I	I
pH	pH	7,23	7,70	7,40	7,90	7,16	7,55	7,59	7,08	7,13
	quality class	I	II	I	II	I	II	II	I	I
Colourity, °Cr-Co-scales		16	20	16	8	19	27	21	26	28

Note: indicators highlighted by grey correspond to the maximum class of water pollution (IV α-mesosaprobic polytrophic waters).

4.1. MACROINVERTEBRATES

Over the research period, totally 108 species of invertebrate macrofauna were registered, the most widely presented were Insecta (59 species), Molluska (18) and Oligochaeta (17). Crustaceans were presented by 6 species only. Maximal species richness was character for the water bodies and water courses of the Small Tataru island – 81. On the Ermakov island 70 species were found and only 22 species – in the reed beds of Ochakivskyi island (Annex, Table 4.3).

Table 4.3. Taxonomic structure of invertebrate macrofauna in hydrobiocoenoses of the Kiliya Danube Delta islands in May 2018

Taxonomic unit	Small Tataru island	Ermakov island	Ochakivskyi island	Total
Bivalvia	4	2	–	4
Gastropoda	9	1-	7	14
Oligochaeta	13	15	2	17
Hirudinea	7	2	1	8
Corophiidae	–	1	–	1
Gammaridae	1	1	2	2
Isopoda	2	1	1	2
Mysidacea	1	1	–	1
Odonata	4	1	1	4
Ephemeroptera	2	1	–	2
Coleoptera	4	6	6	11
Heteroptera	5	4	–	6
Lepidoptera	1	1	–	1
Trichoptera	4	4	–	6
Chironomidae	21	18	2	25
Ceratopogonidae	1	1	–	1
Chaoboridae	1	–	–	1
Ephydridae	–	1	–	1
Psychodidae	1	–	–	1
Total	81	70	22	108

Among all the species of macroinvertebrates, only few were found on all the investigated islands: the mollusks *Gyralus albus* (O. F. Müller), *Planorbarius corneus* (Linne) and *Viviparus contectus* (Millet), the oligochaetes *Nais communis* Piguet and *Stylaria lacustris* (Linnaeus), the isopods *Asellus aquaticus* (Linne), the beetles *Haliplus ruficollis* (De Geer) and the larvae of the buzzer midge *Polypedilum nubeculosum* (Meigen).

The aquatic macrofauna on the islands mostly consisted of the freshwater species (96%). The Ponto-Caspian complex was presented by leeches *Cystobranchus fasciatus* (*Piscicola fasciata*) Kollar and isopods *Jaera sarsi* Valkanov, found in the weedy channels of Small Tataru island, *Chelicorophium curvispinum* (G.O. Sars), found among drifting macroinvertebrates in the mouth of the Lipovansky branch, which runs from Ermakov island into the Danube River (site N 10), and mysids *Limnomysis benedeni* Czerniavsky, found in the channels on both islands. It should be noted that the findings of Ponto-Caspian species (except mysids) were sporadic and occasional. A Sino-Indian species, the mussel *Sinanodonta woodiana* Lea and the oligochaete *Branchiura sowerbyi* Beddard have been recorded respectively in the channels of Small Tataru and Ermakov islands.

<u>Invertebrate macrofauna of the water bodies of Small Tataru island.</u>

In the water bodies of the Small Tataru island 81 invertebrates' species were found (Fig. 4.2), including 59 species of benthic and 55 species of phytophilous fauna (Table 4.4). In general, macrozoobenthos and phytophilous fauna in channels were more abundant than in the lakes due to the higher number of species in each taxonomic group. The overall species richness of macroinvertebrates in the channels was 1.5 times higher than in the lake (see Table 4.4). No larvae of butterflies (Lepidoptera) and Chaoborida were found in the channels, and Gammaridae, Mysidae, Coleoptera and Psychodidae were absent in the samples from the lake.

<u>Mollusks</u> in the island water bodies were presented by bivalves and gastropods. The adult specimens of *S. woodiana* and *Unio pictorum* (Linnaeus) have been found in the channel nearshore areas. The representatives of fam. Sphaeriidae, *Musculium lacustre* (O. F. Müller) and *Pisidium milium* Held have been registered in both channels and lakes. The gastropods were presented

by the pulmonary and branchial forms. Such species as *Gyraulus albus* (O. F. Muller), *Bithynia tentaculata* (Linnaeus) and *Planorbarius corneus* (Linne) occurred the most frequently and massively.

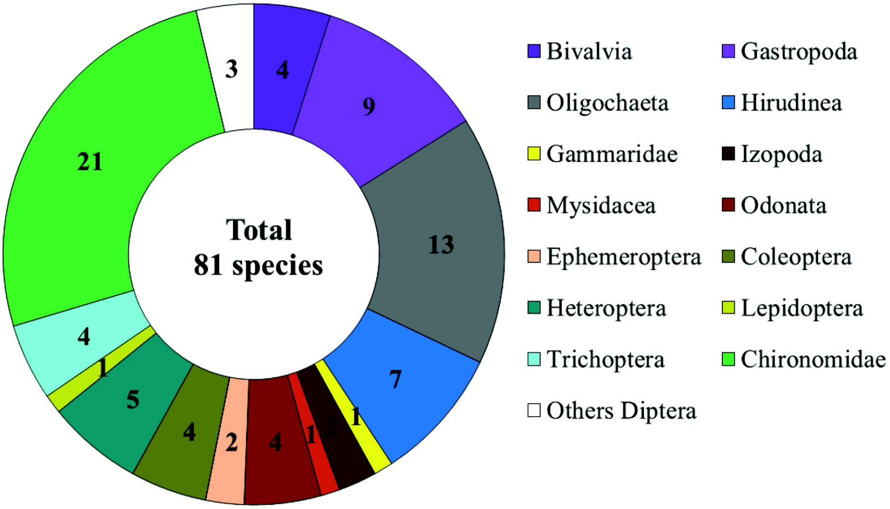

Fig. 4.2 Taxonomic structure of invertebrate macrofauna in water bodies and water courses of the Small Tataru island.

Among <u>Annelida</u> (the segmented worms) the oligochaetes Oligochaeta and leeches Hirudinea were registered in the island hydrobiocenoses. The most widespread and abundant out of 13 Oligochaeta were *Stylaria lacustris* (Linnaeus) and *Ophidonais serpentina* (O. F. Muller) (Naididae) and species of the genus *Limnodrilus* (Tubificidae). The leeches occurred sporadically. In the most swamped areas of the channels, the European medicinal leech *Hirudo medicinalis* Linnaeus has been found.

<u>Crustaceans</u> in the water bodies and water courses of the Small Tataru island were presented by one species of freshwater hoppers, *Niphargus potamophylus* Birstein, two species of isopods, among which *Asellus aquaticus* (Linne) was the most common, while another species *Jaera sarsi* has been

found only once in the phytophilous fauna of the channels. The Mysidae were presented by *Limnomysis benedeni* Czerniavsky, which occurred sporadically in the channels with abundance up to 500 ind/m^2.

Table 4.4. Taxonomic structure of macrozoobenthos and phytophilous fauna in the water bodies and water courses of Small Tataru island (ZB – macrozoobenthos, PF – phytophilous fauna, MF – macrofauna in general).

Taxonomic unit	Channels			Lakes			Total	
	ZB	PF	MF	ZB	PF	MF	ZB	PF
Bivalvia	4	–	4	2	1	2	4	1
Gastropoda	4	6	7	3	6	6	6	8
Oligochaeta	9	4	11	8	5	10	11	6
Hirudinea	3	5	7	1	1	2	4	5
Gammaridae	–	1	1	–	–	–	–	1
Isopoda	1	2	2	–	1	1	1	2
Mysidae	1	–	1	–	–	–	1	–
Odonata	1	3	4	2	1	2	3	3
Ephemeroptera	2	2	2	1	2	2	2	2
Coleoptera	2	3	4	–	–	–	2	3
Heteroptera	2	2	4	–	2	2	2	3
Lepidoptera	–	–	–	1	1	1	1	1
Trichoptera	2	3	4	2	3	3	3	3
Chironomidae	10	12	16	8	10	12	16	16
Ceratopogonidae	1	1	1	1	1	1	1	1
Chaoboridae	–	–	–	1	–	1	1	–
Psychodidae	1	–	1	–	–	–	1	–
Total	**43**	**44**	**69**	**30**	**34**	**45**	**59**	**55**

Insects were diverse both in the island lakes and channels (photo 5). The Chironomidae larvae prevailed by species richness (totally 21 species, respectively 16 species in phytophilous fauna and macrozoobenthos).

Species of gen. *Chironomus* were the most common in this group in benthos, while the phytophilous fauna was dominated by *Cricotopus sylvestris* (F.) and *Parachironomus pararostratus* (Lenz). Among other insects we registered five species of water bugs (Heteroptera); dragonflies (Odonata), beetles (Coleoptera) and caddis flies (Trichoptera) comprised four species each. The representative of the latter, *Leptocerus tineiformes* Curtis, constantly and massively occurred both in macrozoobenthos and phytophilous fauna. The larvae of *Anax imperator* Leach (Emperor dragonfly), the Red Book of Ukraine species has been registered in the most stagnant channel.

The abundance of macrozoobenthos in the water bodies and water courses of the Small Tataru island varied from «high» to «middle» level of development, which respectively corresponded to polytrophic and eutrophic waters (Table 4.5). The biomass varied from «moderate» to «low» level corresponding to eutrophic and mesotrophic waters. The quantitative indexes of macrozoobenthos in the channels were higher than in the lake, while the opposite was observed in phytophilous fauna: its abundance and biomass was higher in the lake than in the channels.

Table 4.5. Characteristics of macroinvertebrate communities in the water bodies and water courses of Small Tataru island.

Indicators	Channels	Lakes	Total
Macrozoobenthos			
Number, th/ ind/m^2	6,00-22,31 10,42	1,30-8,00 3,87	7,61
The level of development (trophity) by abundance	high (polytrophic)	medium (eutrophic)	above medium (eutrophic)
Biomass, g/m^2	26,46-225,76 133,14	3,78-19,28 11,04	80,81
Trophicity level by biomass	medium (eutrophic)	low (mesotrophic)	medium (eutrophic)
Phytophilous fauna			
Abundance, th. ind/kg	1,23-1,55 1,39	1,94-2,91 2,43	1,80
Biomass, g/kg	1,01-5,05 3,00	2,80-12,06 7,43	4,77

In terms of abundance macrozoobenthos in the lake was dominated by oligochaetes, while in the channels dominated Chironomidae larvae (Fig. 4.4*a*). In terms of biomass macrozoobenthos in the lakes was dominated by insect larvae (Chironomidae + Trichoptera), and in the channels dominated mollusks (particularly, Unionidae).

Oligochaetes prevailed in terms of abundance in the phytophilous fauna of both channels and lake, while mollusks dominated by biomass in the lake, and in the channels prevailed the Trichoptera larvae (Fig. 4.4b).

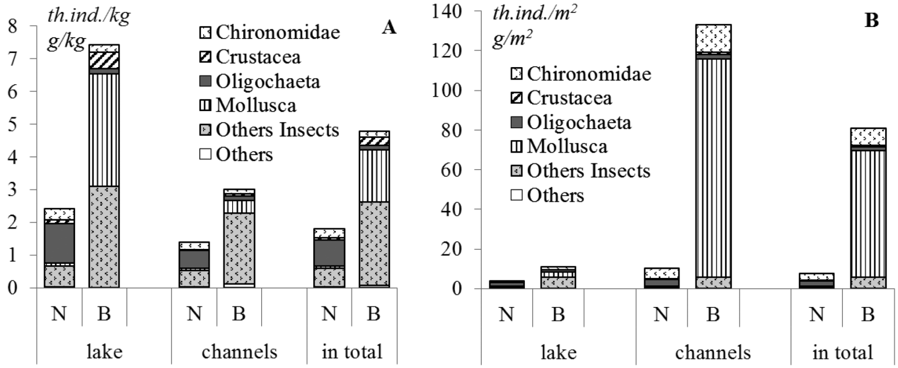

Fig. 4.4 Taxonomic structure of macrozoobenthos (a) and phytophilous fauna (b) in terms of abundance (N) and biomass (B) on Small Tataru island

<u>Invertebrate macrofauna in the water bodies and water courses of the Ermakov island.</u>

The macrofauna of Ermakov island was presented by 70 species of invertebrates, of which 46 in macrozoobenthos, 42 in phytophilous fauna and 21 in drift samples, collected at the inflow of the Lipovansky branch into the Danube river (site N 10) (Fig. 4.5, Table 4.6).

The species richness of phytophilous fauna and benthic macroinvertebrates in the lakes was higher than in the channels. There were no Hirudinea, Gammaridae, Mysidae, Odonata and Lepidoptera larvae, whereas in the lakes beetles Coleoptera and flies Ephydridae have not been registered.

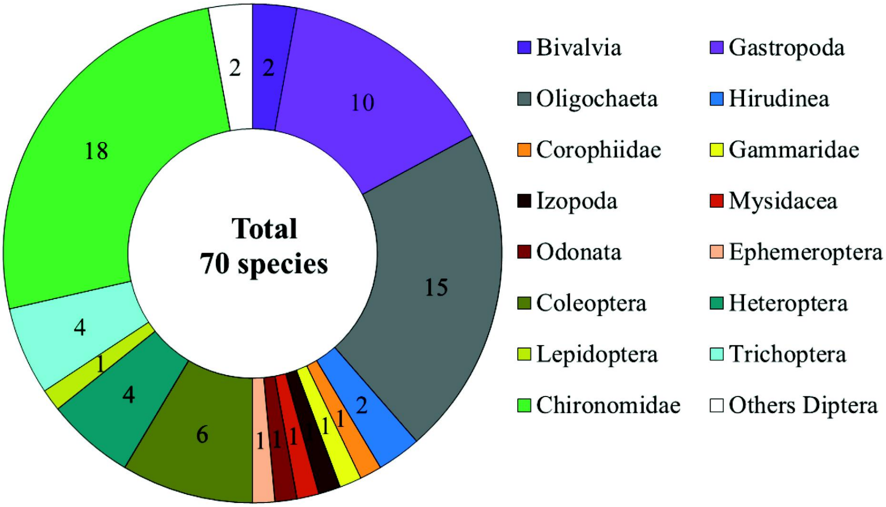

Fig. 4.5 Taxonomic structure of invertebrate macrofauna in water bodies and water courses of Ermakov island.

The drifting macroinvertebrates (site N 10) were mostly presented by insect larvae, mainly the Coleoptera larvae and Chironomidae larvae, besides four species of pulmonary gastropods has been registered as well. It is important to mention that six species, namely *Lymnaea auricularia* (Linne), *Cheliocorophium curvispinum*, Driops and *Enochrus* beetles, *Sigara falleni* (Fieber) and *Cladotanytarsus mancus* (Walker) larvae have been found only in the drift and were not registered in other macroinvertebrate communities of the island.

Mollusks in Ermakov island were presented by 12 species. Compared to the Small Tataru island, the Unionidae were absent, whereas same Spheriidae have been found: *Musculium lacustre* and *Pisidium milium*. Among 10 species of gastropods, *Gyralus albus*, *Bithynia tentaculata*, *Planorbarius corneus* and *Planorbis planorbis* (Linne) were the most frequent in all types of the water bodies, and *Valvata pulchela* Studer was present in the benthic communities of both channels and lakes.

Table 4.6. Taxonomic structure of macrozoobenthos and phytophilous fauna in the water bodies and water courses of the Ermakov island (ZB – macrozoobenthos, PF – phytophilous fauna, MF – macrofauna in general)

Taxonomic unit	Channels			Lakes			Total		
	ZB	PF	MF	ZB	PF	MF	ZB	PF	Drift
Bivalvia	2	–	2	1	–	1	2	–	–
Gastropoda	6	4	6	5	7	8	7	7	4
Oligochaeta	8	4	1–	8	5	10	12	6	3
Hirudinea	–	–	–	1	2	2	1	2	–
Corophiidae	–	–	–	–	–	–	–	–	1
Gammaridae	–	–	–	–	1	1	–	1	–
Isopoda	1	1	1	1	1	1	1	1	–
Mysidacea	–	–	–	1	–	1	1	–	–
Odonata	–	–	–	–	1	1	–	1	–
Ephemeroptera	–	1	1	1	1	1	1	1	1
Coleoptera	1	4	4	–	–	–	1	4	4
Heteroptera	–	2	2	–	2	2	–	3	3
Lepidoptera	–	–	–	1	1	1	1	1	–
Trichoptera	–	1	1	3	4	4	3	4	–
Chironomidae	9	6	10	10	9	15	14	10	5
Ceratopogonidae	1	1	1	1	1	1	1	1	–
Ephydridae	1	–	1	–	–	–	1	–	–
Total	**29**	**24**	**39**	**33**	**35**	**49**	**46**	**42**	**21**

Annelida included 15 species of Oligochaeta and 2 species of Hirudinea. The oligochaetes *Stylaria lacustris* and *Ophidonais serpentina* (O. F. Muller) have been recorded in all biotopes of the island, and in some cases their number reached 35 th. ind/kg in the plant thickets and 6 th. ind/m^2 in the bottom communities. Among Oligochaeta in macrozoobenthos prevailed Tubificidae (*Limnodrilus sp.*, *Tubifex tubifex* (OF Muller)). Besides, *Branchiura sowerbyi* has been found in benthos of the Lipovansky branch. This is a species of the alien Sino-Indian fauna, that has been living in the Danube Delta for a long time (reliably known from the 1940-ies [FINOGENOVA 1968]).

The leeches *Glossiphonia complanata* (Linne) and *Glossiphonia heteroclita* (Linne) were registered both in the bottom communities and within plant thickets of the studied lakes.

Crustaceans were presented by amphipods *Cheliocorophium curvispinum* in the drift and juvenile Gammaridae. *Asellus aquaticus* was also widespread on the island, and mysid *Limnomysis benedeni* Czerniavsky has been found in macrozobenthos in the channels.

Insects were the most diversely presented group of macrofauna both in channels and lakes of the Ermakov island – totally 37 species were registered, maximal belonged to Chironomidae larvae, among which the most widespread and dominant were species of the gen. *Chironomus* and *Parachironomus varus* (Goetghebuer). There were also six species of beetles, two of which, *Driops sp*. and *Enochrus sp*., have been registered only in the drift samples; *Acilius sulcatus* (L.) and *Cybister lateralimarginalis* (Deg.) were found in the phytophilous fauna; *Hydrophilus piceus* Linnaeus and *Haliplus ruficollis* (De Geer) occurred among vegetation and macrozoobenthos in the channels. The most frequently occurring Hemiptera within the phytophilous fauna were *Plea minutissima* Leach and *Corixa punctata* (Illiger). Trichoptera larvae *Ecnomus tenellus* (Rambur), *Leptocerus tineiformes* Curtis and *Tricholeiochiton fagesii* (Guinard) were the typical in the benthic and phytophilous communities.

Abundance of the benthic macroinvertebrates in the lakes was higher than in the channels, and corresponded to «very high» (hypertrophic waters) and «high» (polytrophic waters) levels of macrozoobenthos development. The biomass varied from «below medium» (in the lakes) to «above medium» (in the channels) development level, which corresponded to eutrophic and mesotrophic waters (Table 4.7). Oligochaetes prevailed in terms of abundance in benthos of all the water bodies, while the mollusks, particularly the gastropods, prevailed in terms of biomass (Fig. 4.6, *a*).

Table 4.7 Characteristics of macroinvertebrate communities in water bodies and water courses of the Ermakov island.

Indicators	Channels	Lakes	Total
Macrozoobenthos			
Number, th. ind/m^2	3,40-22,30 10,55	3,76-63,70 22.85	15,94
The level of development (trophity) by number	high (polytrophic)	very high (hypertrophic)	high (polytrophic)
Biomass, g/m^2	12,48-358,28 157,32	7,05-79,26 35,15	104,96
The level of development (trophicity) by biomass	above the medium (eutrophic)	below the medium (mesotrophic)	medium (eutrophic)
Phytophilous fauna			
Number, th. ind/kg	8,83-46,92 27,59	5,26-41,68 28,28	28,01
Biomass, g/kg	16,16-41,42 26,20	14,89-49,36 32,13	28,57

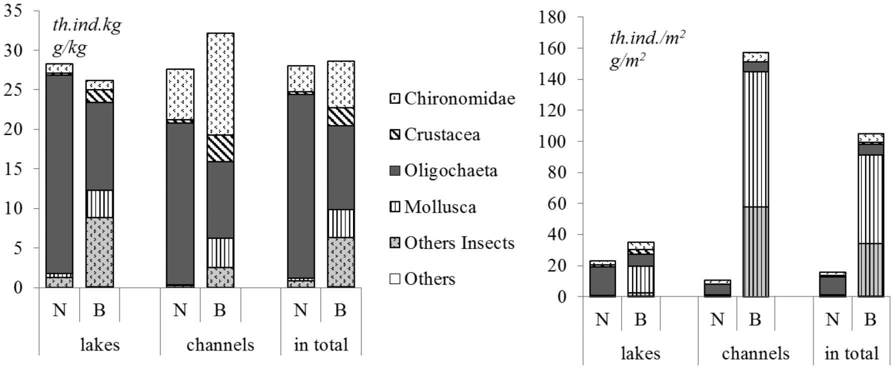

Fig. 4.6 Taxonomic structure of macrozoobenthos (a) and phytophilous fauna (b) by abundance (N) and biomass (B) on the Ermakov island.

The abundance and biomass of the phytophilous fauna in the lakes and channels did not significantly differ (Table 7). As in the benthos, Oligochaetes prevailed in terms of abundance in the vegetation, they also dominated in terms biomass in the lakes, while the Chironomidae larvae prevailed in the channels (Fig. 4.6, b).

Macrofauna of the channel in the reed beds of the Ochakivskyi island.

In a channel (duct) in the reed beds of the Ochakivskyi island 22 species of macroinvertebrates were found (Fig. 4.7). The most diverse were Gastropoda (7 species), among which dominated Pulmonata *Physella acuta* Draparnaud, *Planorbarius corneus* (O. F. Muller), *Planorbis planorbis* (Linne), *Acroloxis lacustris* (Linne) and *Gyraulus albus*. Of Pectinibranchia were registered *Bithynia troschelii* (Paasch) and *Viviparus contectus* (Millet).

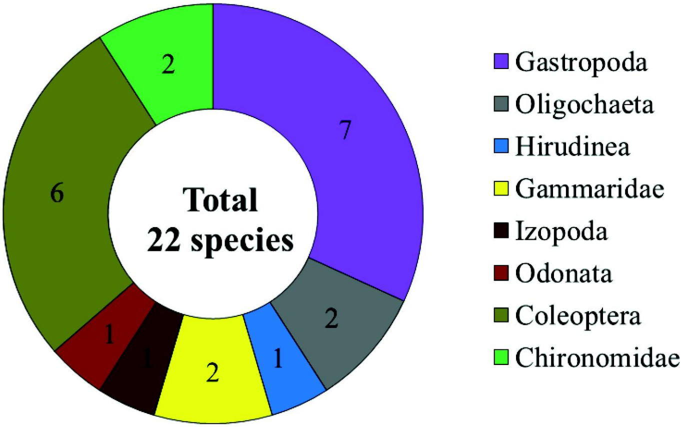

Fig. 4. 7. The taxonomic structure of invertebrate macrofauna in the channel in the reed beds of the Ochakivskyi island.

Annelida were presented by two widespread species of Oligochaeta (*Stylaria lacustris* and *Nais communis*) and Hirudinea *Haementeria costata* (Muller).

Crustacea were presented by *Niphargus potamophylus* Birstein, juvenile Gammaridae and *Asellus aquaticus*.

Insects were characterised by considerable diversity of Coleoptera (6 species). Besides, larvae of two Chironomidae species (*Einfeldia longipes* (Staeger) and *Polypedilum nubeculosum* (Meigen) and Odonata *Anax imperator* have also been found.

Gastropods dominated in benthos in terms of both abundance and biomass. The total values (2,7 th. ind/m^2 and 391,56 g/m^2) reached respectively the «medium» and «high» level of development, which corresponded to eutrophic and polytrophic waters in terms of number and biomass.

Comparative characteristics of macrofauna.

The state of macrofauna was analyzed by comparison of the hydrobiocoenoses characteristics of the Small Tataru and Ermakov islands, as well as with other similar Danube Delta water bodies in current period, and also with retrospective materials.

Comparison of the species richness of macroinvertebrates in the islands showed that the macrofauna on the Small Tataru Island is more diverse than that on the Ermakov island (81 species vs. 70) (Table 4.8).

The Small Tataru had more number of Bivalvia, Hirudinea, Isopoda, Odonata, Ephemeroptera, Heteroptera and Chironomidae species, whereas on the Ermakov island more species of Gastropoda, Oligochaeta and Coleoptera were registered. The Sørensen similarity index amounted to 0,64; 48 species, that is 47% of the total species composition (103 species) were common to both islands. Maximal number of common species was registered in three biggest groups: Gastropoda – 7 species of 12 (58%); Oligochaeta – 11 species of 16 (65%); and Chironomidae, 14 species of 25 (56%).

More than one third of the macrofauna species of each island (22 on Ermakov and 31 on the Small Tataru) was not registered on the other one. Maximal number of these species was presented by Coleoptera (5 species), Oligochaeta and Chironomidae (4 species each) on Ermakov, and Chironomidae (7 species), Hirudinea (5 species) and Odonata (4 species) on the Small Tataru.

Comparison of the species composition in each type of the water body showed that the species richness in the lakes of both islands was generally close (45 and 49 species (see Table 4.8), whereas in the channels on the

Small Tataru island it was 1,4 times richer than on Ermakov (69 vs. 49). The Sørensen index (Table 4.9) showed similarity of the species composition in these water bodies, which was maximal in the lakes (0,66) due to significant number of common species (31), which accounts for 49% of total species richness in the lakes (63).

Table 4.8. Taxonomic structure of macrofauna of Small Tataru and Ermakov islands.

Taxonomic unit	Small Tataru island			Ermakov island		
	channels	lakes	total	channels	lakes	total
Bivalvia	4	2	4	2	1	2
Gastropoda	7	6	9	6	8	10
Oligochaeta	11	10	13	10	10	15
Hirudinea	7	2	7	–	2	2
Corophiidae	–	–	–	–	–	1
Gammaridae	1	–	1	–	1	1
Isopoda	2	1	2	1	1	1
Mysidacea	1	–	1	–	1	1
Odonata	4	2	4	–	1	1
Ephemeroptera	2	2	2	1	1	1
Coleoptera	4	–	4	4	–	6
Heteroptera	4	2	5	2	2	4
Lepidoptera	–	1	1	–	1	1
Trichoptera	4	3	4	1	4	4
Chironomidae	16	12	21	10	15	18
Ceratopogonidae	1	1	1	1	1	1
Chaoboridae	–	1	1	–	–	–
Ephydridae	–	–	–	1	–	1
Psychodidae	1	–	1	–	–	–
Total:	**69**	**45**	**81**	**39**	**49**	**70**

Table 4.9. Similarity of macrofauna species composition (by the Sørensen index) of the hydrobiocoenoses of the Delta islands.

Type of water body	Ermakov island, channels	Small Tataru island, channels	Ermakov island, lakes	Small Tataru island, lakes
Ochakivskyi island, channels	0,36	0,22	0,23	0,15
Ochakivskyi island, channel	*	**0,54**	**0,55**	0,50
Small Tataru island, channels	*	*	**0,55**	**0,58**
Ermakov island, lakes	*	*	*	**0,66**

In turn, though the level of similarity for channels was quite high (0,55), but lower than that of lakes. The number of common species was only 29, which amounted to 37% of total species number in the channels (79), while 41 distinct species (60% of total species number in the island channels) were found in the macrofauna of Small Tataru channels, and only 10 peculiar species were found in the macrofauna of Ermakov channels (25% of total species number on the island).

The species composition of macroinvertebrates in the channel among the reed beds of Ochakivskyi island was of quite low similarity to the macrofauna of other islands (Sorensen coefficients 0,15-0,36), it was most similar (0,36) to the channels of Ermakov island. The structure of macroinvertebrate complexes on Ochakivskyi island can be an example of what happens to a hydroecosystem after islands transform into the reed beds: the species richness significantly decreases, the structural transformation takes place with the change of dominant groups up to their vanishing, particularly crustaceans, insects, bivalve mollusks (see Fig. 4.7, Table. 4.3). It should be noted that the processes of gradual conversion of lake ecosystems into marshes, swamps and dry land are natural for a river delta.

Only one publication «Hydrofauna of the Danube lower reaches within the boundaries of Ukraine» [POLISCHUK 1974] is available among the retrospective studies of fauna in the water bodies of the Danube Delta islands. A small section in this book is devoted to these water objects. Unfortunately, it is unknown which islands and at what scale, were investigated. It is to point out that according to this monograph, the macrofauna of invertebrates on the delta islands was presented by 44 species. The most studied by V.V. Polischuk [1974] was the fauna of beetles (the aquatic and those inhabiting wetlands) and mollusks. It is important to note that the study of beetles requires special capturing methods that we did not use, and the information on this group in our samples is therefore quite limited. The difference in the collected material (21 species in V. V. Polishchuk [1974] versus 9 in our collections) could be the evidence of insufficient study of this group in the island water bodies. Among 12 species of gastropods listed by V. V. Polischuk [1974], we have registered 11 (except *Lymnaea truncatula*). The representatives of other macroinvertebrate groups (the oligochaetes *Stylaria lacustris* (Linnaeus), leeches, bugs), which are mentioned in the species list of island hydrofauna dated on the 1960-ies, were presented in our samples in almost complete range.

We have also compared the species composition of invertebrate macrofauna on the Small Tataru and Ermakov islands with the hydrobiocoenoses of other water bodies of the Danube Delta that we have investigated in the recent period. We selected water bodies and water courses which have certain similarity by the hydromorphological characteristics. For example, in May 2017 we investigated the internal delta lakes Babina and Merhei located in the Sulina delta, have similar type of overgrowing (the submerged vegetation), similar depths, and are preserved in their natural state. There were no similar freshwater lakes in the list of the water bodies within the Ukrainian part of the Danube Delta. The close morphometric features and some other indicators are characteristic for the Anankin Kut lake, a water body that has separated from the sea about 50 years ago, is heavily overgrown with floating-leaf plants (European caltrop and European white water lily), and is connected with the Danube arms by some small narrow channel (Anankin Kut channel). To some extent, these channels can be considered as similar to the channels of the Small Tataru and Ermakov islands. The materials of investigation of Anankin Kut lake and Anankin Kut channel, which were carried out in June 2017, have been taken for comparison. The taxonomic structure of invertebrate macrofauna in Merhei, Babina and Anankin Kut lakes and a duct connecting the latter with the Vostochnyi branch, are given in Table 4.10.

Table 4.10. Taxonomic structure of invertebrate macrofauna in lakes Merhei, Babina, Anankin Kut and Anankin Kut channel.

Taxonomic unit	Merhei lake	Babina lake	Anankin Kut lake	Anankin Kut channel
Bivalvia	1	1	–	3
Gastropoda	7	7	2	9
Oligochaeta	10	15	11	11
Hirudinea	1	–	5	7
Corophiidae	–	–	–	3
Gammaridae	1	1	1	2
Izopoda	–	–	1	1
Cumacea	–	–	–	1
Mysidacea	1	–	1	–
Odonata	1	–	1	2
Ephemeroptera	1	1	2	2
Coleoptera	–	–	1	5
Heteroptera	–	–	4	6
Lepidoptera	–	1	–	1
Trichoptera	4	3	1	3
Chironomidae	14	19	18	20
Ceratopogonidae	1	1	1	1
Ephydridae	–	–	1	1
Total	**42**	**49**	**50**	**78**

The general level of species richness (42–49 species) and the taxonomic structure in all the lakes were quite similar and comparable with those of the Small Tataru and Ermakov lakes (45–49 species) (see Table 4.8, 4.10). The species richness of channel coming out of the Anankin Kut lake was higher than in the channels of the Small Tataru island and especially Ermakov island (2 times higher than in the latter) (see Table 4.8, 4.10).

The Sørensen coefficient analysis has shown that the highest similarity of macroinvertebrates species composition is characteristic for the lakes of the Small Tataru and the non-island water bodies, as well as for the channels of Small Tataru island and the Anankin Kut channel (Table 4.11). The highest percentage of common species was recorded in macrofauna of the island lakes and Babina lake: respectively 28 species (42%) and 26 species (36%) on Small Tataru and Ermakov, whereas macrofauna of Small Tataru channels had a highest number and percentage of common species with the Anankin Kut channel (39 species, 36%). The similarity of macrofauna species composition in various water bodies was caused by the high percentage of common insects and oligochaetes species.

Table 4.11. Species composition similarity (according to the Sorensen index) of macrofauna in the island and non-island lakes and channels.

Water body type	Merhei lake	Babina lake	Anankin Kut lake	Anankin Kut channel
Ochakivskyi island, channel	0,09	0,14	0,11	0,16
Ermakov island, channels	0,40	0,47	0,45	0,44
Small Tataru island, channels	0,45	0,44	**0,51**	**0,53**
Ermakov island, lakes	**0,51**	**0,53**	0,48	0,49
Small Tataru island, lakes	**0,57**	**0,59**	0,46	**0,54**

The generalized dendrogram of the species composition similarity and the species number of the invertebrate communities are shown in Figure 4.8. The identified clusters, in our opinion, are quite logical and understandable, there are a few of them. There are three with maximal degree of the species composition similarity (marked by blue), namely: the lakes of Small Tataru and Ermakov islands; the system of the Anankin Kut lake and Anankin channel; and lakes Merhei and Babina of the Sulina Delta. The separate cluster is formed by the channels and lakes of the Ukrainian islands (light green). High similarity was determined for the Sulina delta lakes and Anankin Kut lake with Anankin channel (pale yellow). All these water bodies form the general pool with high similarity of the macrofauna species composition, about 50% and above. Only the channel in the reed beds of the Ochakivskyi island stands apart from the pool (we consider it as an object for comparison, a model of a drying island water body, analogous to the situation at the time of the islands being embanked). It was also characterized by the lowest species richness, while the species number in all other hydrobiocoenoses was much higher.

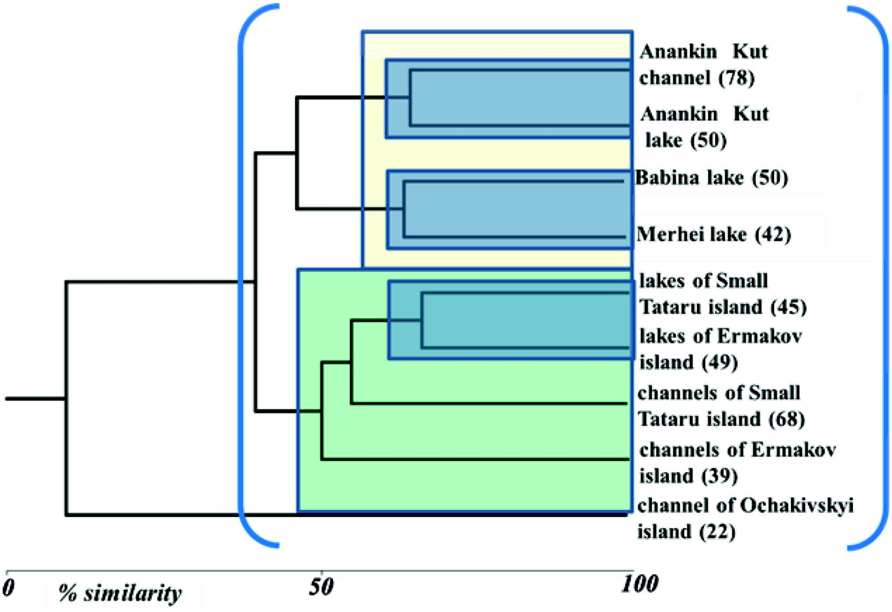

Fig. 4.8. Similarity dendrogram of the species composition and species richness of invertebrate macrofauna.

The quantitative indices of macrozoobenthos and the corresponding trophity levels according to the [METODY… 2006] are given in Table 4.12. The macrozoobenthos abundance and biomass in the non-island lakes corresponded to the meso-eutrophic waters, and in the Anankin Kut lake and its channel the abundance reached the level corresponding to the hypertrophic waters, whereas the biomass corresponded to mesotrophic (Table 4.12).

Table 4.12. Quantitative indices and the trophic levels of macrozoobenthos

Water bodies		Abundance		Biomass	
		th. ind/m^2	development level (trophity)	g/m^2	development level (trophity)
Small Tataru island	lakes	3,87	medium (eutrophic)	11,04	low (mesotrophic)
	channels	10,42	high (polytrophic)	133,14	medium (eutrophic)
Ermakov island	lakes	22,85	very high (hypertrophic)	35,15	below the medium (mesotrophic)
	channels	10,55	high (polytrophic)	157,32	above the medium (eutrophic)
Channel of Ochakivskyi island		2,70	middle (eutrophic)	391,56	high (polytrophic)
Lake Merhei		2,00	below the medium (mesotrophic)	50,39	middle (eutrophic)
Lake Babina		8,06	above the medium (eutrophic)	13,33	low (mesotrophic)
Lake Anankin Kut		25,29	very high (hypertrophic)	15,13	below the medium (mesotrophic)
Channel Anankin Kut		29,02	very high (hypertrophic)	31,80	below the medium (mesotrophic)

Summarizing the above-mentioned material, it should be stated that the rich and diverse aquatic invertebrate macrofauna has been recorded on the Small Tataru and Ermakov islands (respectively 81 and 70 species), which were generally characterized by high similarity of the species composition. The species richness of macroinvertebrates on the Small Tataru island was higher than on the Ermakov island due to higher species number in the island channels. Species richness and the species structure of macroinvertebrate complexes in the island water bodies were quite comparable to those recorded in other hydrobiocoenoses of the Danube Delta (except the channel of the Ochakivskyi island). The channels of the Small Tataru island were characterized by somewhat lesser species number than the non-island the Anankin Kut channel and rather high similarity of species composition, no concern regarding the condition of the investigated invertebrate communities is needed. The Ermakov island channels were characterized by significant overgrowth and slow flow, sometimes resembling the dead branches with standing water. Given that the water levels during our studies were relatively high, the stagnant phenomena with high deficiency of oxygen, which can cause asphyxia of the aquatic organisms, could be even more probable in the drought period. So, in our opinion, it is important to ensure further intensive washing of the islands by the Danube water. On the whole, the materials obtained indicate the «natural» current state of the water bodies on the Small Tataru and Ermakov islands according to the invertebrate macrofauna indices in spring period, that is the achievement of the goals set by breaching the dikes.

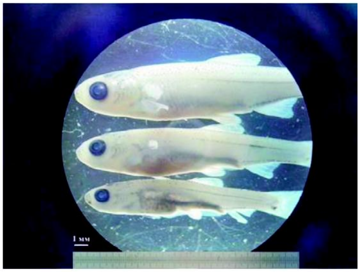

Photo 4.1 Larvae and juveniles of ide Idus idus (L.) from the Danube River near Small Tataru island

4.2. Ichthyofauna

Small Tataru island. The larvae and juveniles of 12 fish species of four families were found in the island water bodies and water courses. The species composition in the considered biotopes was significantly different (Table 4.13). The general list comprises 13 species, of which the ide *Idus idus* (L.) was found in the Danube arm adjacent to the northern side of the island, but did not occur

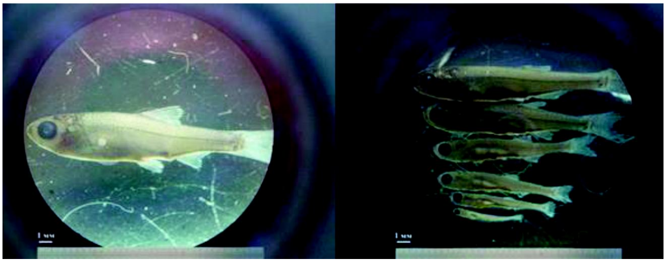

Photo 4.2 Dominant species of Small Tataru Island water bodies: roach Rutilus rutilus (left), sunbleak Leucaspius delineatus (right)

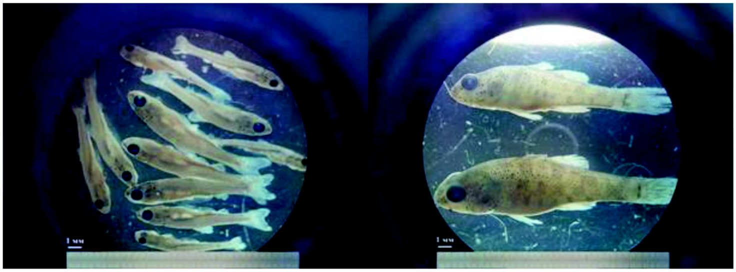

Photo 4.3 Alien species: stone moroko Pseudorasbora parva (left), chinese sleeper Perccottus glenii (right)

in its inland water bodies (photo 4.1).The most common species in all the internal water bodies and water courses of the island were roach, common rudd, sunbleak, silver bream and common bream. Their relative numbers varied depending on the habitat: for example, roach (photo 4.2) prevailed in the lakes, sunbleak prevailed in the overgrown shallows covered by duckweed. The invasive Far-East species, stone moroko and shinese sleeper (photo 4.3), also prevailed there. The early juveniles of European bitterling were abundant in the channels (photo 4.4). In view of the spawning substrate this species is ostracophilous: it lays eggs in the mantle cavity of bivalve mollusks, which also occurred in the channel. It means that there is no stagnation in the bottom layer of water and bottom sediments of the channels, at least in spring, and the oxygen regime is favorable for the development of invertebrates and ichthyofauna. The early juvenile European asp is rheophilous, it was found in the channels only, which indicates that during the spring flood these water courses get good flowage that facilitates spawning of the riverine fishes. The asp juveniles

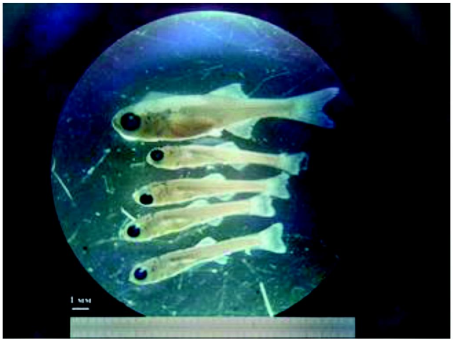

Photo 4.4 Ostracophile species: European bitterling Rhodeus amarus

were also caught in the Danube arm adjacent to the northern side of the island. The young specimens in the arm were mainly presented by roach and ide – typical riverine species, which juveniles were not registered in the internal island waters. In the Danube we have not found limnophilous (lacustrine and lacustrine-riverine) species such as rudd, sunbleak, bitterling etc., which were widespread in the island water bodies.

Table 4.13 Species composition of the early juvenile fish in the waters of the Small Tataru island

№	Taxonomic unit	Relative number, %			
		Channels	Lakes	Overgrown shallows	The Danube
	Cyprinidae				
1.	*Idus idus* L. – Ide	-	-	-	15,8
2.	*Rutilus rutilus* L. – Roach	12,8	47,8	0,2	77,2
3.	*Scardinius erythrophthalmus* L. – Common rudd	0,7	11,3	0,1	-
4.	*Alburnus alburnus* L. – Bleak	0,2	2,6	-	-
5.	*Leucaspius delineatus* Heckel – Sunbleak	61,8	26,1	94,1	-
6.	*Blicca bjoerkna* L. – Silver bream	8,9	4,3	2,0	0,6
7.	*Abramis brama* L. – Common bream	1,2	1,7	0,2	2,9
8.	*Aspius aspius* L. – European asp	1,6	-	-	3,5
9.	*Rhodeus amarus* Bloch – European bitterling	10,0	-	0,1	-
10	*Pseudorasbora parva* Temminck et Schlegel – Stone moroko	-	-	3,2	-
	Percidae				
11	*Perca fluviatilis* L. – European perch	2,6	3,5	-	-
	Odontobutidae				
12	*Perccottus glenii* Dybowski – Chinese sleeper	-	-	0,1	-
	Gobiidae				
13	*Proterorhinus semilunaris* Heckel – Western tubenose goby	0,2	2,6	-	-

According to the local fishermen, during the spring flood many fish species enter the island waters to spawn, particularly carp Cyprinus carpio L., catfish *Silurus glanis* L., pikeperch *Sander lucioperca* L.; several fishes permanently occur and reproduce on the island: pike Esox lucius L., crucian and Prussian carps *Carassius sp.*, tench *Tinca tinca* L. Sometimes the Pontic shad *Alosa pontica* Eichwald enters the island waters, but was not observed to spawn here. Thus, the list of fishes that use the island waters as spawning area comprises at least 19 species, many of which are the permanent inhabitants of the island hydroecosystems. In summer during the drought, strong drop in water level and rapid decrease in spawning areas usually happen. This can lead to suffocation of fingerlings and adult specimens and their predation by birds, as a result of facilitating the access to prey and reducing the opportunities for fish to shelter. That is why in order to ensure the fish survival, it is necessary to maintain flowage of the island channels even over the drought periods.

Ermakov island. In the water bodies and water courses of the Ermakov island, larvae and juveniles of 15 fish species of five families were identified (Table 4.14). Similar to the Small Tataru island, this value can be considered quite indicator, given such short term of the research. For comparison, we identified only 7 fish species in the lakes and water courses within the Sulina delta (lakes Babina, Matita, Puiu and the adjacent channels) in May 2017, using just the same methods.

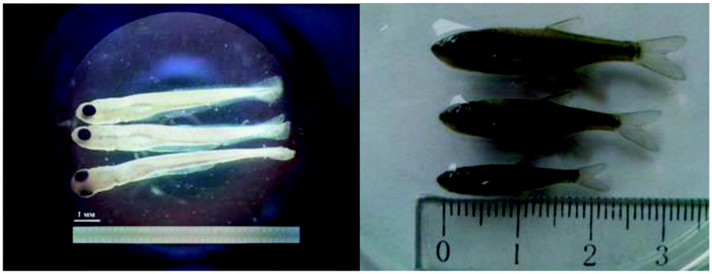

Photo 4.5 Reophilic species: European chub Squalius cephalus (left), asp Aspius aspius (right)

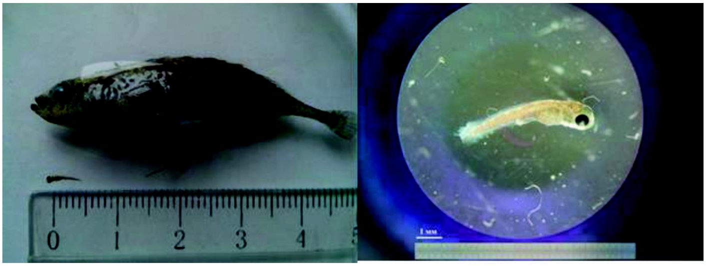

Photo 4.6 Ukrainian stickleback Pungitius platygaster and its larvae from a Ermakov inland lake

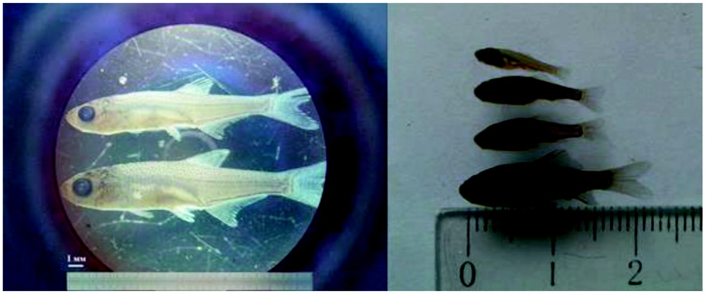

Photo 4.7 Commercial species: common bream Abramis brama (left), Prussian and crucian carps Carassius sp. (right)

Maximal relative number was character for roach, which prevailed in the flowing sections, and sunbleak, that formed the basis of the early juveniles fish communities in the lacustrine biotopes. The riverine and riverine-lacustrine species such as chub, common bream and European asp were noted in the flowing areas only, though their number was rather low (photo 4.5).

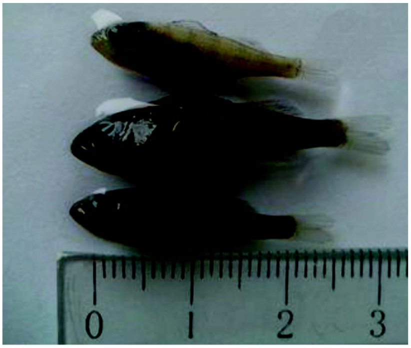

Photo 4.8 European perch Perca fluviatilis, a predator of the island water bodies.

In particular, the single individuals of chub occurred only at inflow of the Lipovansky arm into Danube (sampling site N 10): some individuals were found in the sandy shallows, one larva was also caught with a planktonic net at the confluence of the Lipovansky arm with the Danube River. Other species were found both in the channels and lakes (European rudd, crucian and Prussian carps, perch, Chinese sleeper), some species were caught in the lakes only, namely bitterling, stone moroko, Ukrainian stickleback (photo 4.6), western tubenose goby.

The occurrence and relative number of the early juvenile common breams were lower than on the Small Tataru, while larvae and fry of another commercially valuable species the Prussian carp (photo 4.7) were abundant on Ermakov. Portion of the juvenile perch (photo 4.8) in catches was lower compared to the Small Tataru, though it should be noted that the schools of its juveniles counting 10–15 individuals which actively avoided the sampling equipment, were visually observed in the flowing areas of the island. The relative number of bitterling larvae was significantly lower than on the Small Tataru, which was probably connected with lesser number of bivalve mollusks – its spawning substrate.

Table 4.14 Species composition of the early young fish in Ermakov island waters.

	Taxonomic unit	Relative number, %		
		Channels	Lakes	The Danube
	Cyprinidae			
1.	*Squalius cephalus* (L.) – European chub	0,8	–	8,0
2.	*Rutilus rutilus* (L.) – Roach	89,7	0,5	8,0
3.	*Scardinius erythrophthalmus* (L.) – Common rudd	3,8	4,9	–
4.	*Alburnus alburnus* (L.) – Bleak	–	0,2	76,0
5.	*Leucaspius delineatus* (Heckel) – Sunbleak	1,3	91,5	4,0
6.	*Blicca bjoerkna* (L.) – Silver bream	–	1,1	–
7.	*Abramis brama* (L.) – Common bream	0,5	–	–
8.	*Aspius aspius* L. – European asp	0,5	–	
9.	*Rhodeus amarus* (Bloch) – European bitterling	–	0,6	4,0

	Taxonomic unit	Relative number, %		
		Channels	Lakes	The Danube
10.	*Pseudorasbora parva* (Temminck et Schlegel) – Stone moroko	–	0,2	–
11.	*Carassius sp.* – Crucian and Prussian carp	2,5	0,4	–
	Gasterosteidae			
12.	*Pungitius platygaster* (Kessler) – Ukrainian stickleback	–	0,1	–
	Percidae			
13.	*Perca fluviatilis* L. – Eoropean perch	0,3	0,1	–
	Odontobutidae			
14.	*Perccottus glenii* Dybowski – Chinese sleeper	0,8	0,3	–
	Gobiidae			
15.	*Proterorhinus semilunaris* (Heckel) – Western tubenose goby	–	0,2	–

The channels were strongly overgrown (mainly by the water soldier *Stratiotes aloides*), in some places this aquatic plant vegetated so intensively that even obstructed moving of the boat. Such a situation can be harmful for feeding conditions of the reophilous species in summer. Ensuring the appropriate hydrological regime, which will guarantee the inflow of the Danube waters both over the flood and drought periods, will improve the conditions for their development in the island water bodies. In addition, they will be able to freely migrate into the Danube only if the sufficient capacity of passages in the dikes is maintained.

Besides these species, the local fishermen reported on high abundance of pike *Esox lucius* in the lakes of the Ermakov Island. Moreover, according to their information, the island water bodies in spring serve as spawning areas for common carp *Cyprinus carpio*, which migrates to the island from the Danube. In addition, according to the results of the previous research (Report about the Ermakov island provided by the WWF), the island is also inhabited by pumpkinseed *Lepomis gibbosus* (L.) and tench *Tinca tinca*, also ide *Idus idus* L. occasionally occurs. Therefore, taking into account these data, the current list of fishes which use the flooded island as spawning area includes at least 20 species. If the natural regime of the island is further restored and the appropriate seasonal flowage provided, it is likely that the riverine and riverine-lacustrine fish species (ide, chub, bream, asp, carp) will become more abundant.

Abundance of the early juvenile fishes. The aggregations of fish larvae and juveniles were observed in the coastal zone or near the vegetation thickets, located both near shores and on the «islands» in the middle of lakes. The calculated specific number of larvae and fry (individuals per m^2 of area) in locations of their concentration significantly varied in different biotopes, and their distribution in the littoral zone was extremely uneven (Table 4.15). The early juveniles number depended not only on the habitat characteristics, but also on the dominant species occurring there at different development stages. For example, the aggregations in which the sunbleak early larvae prevailed, amounted to 2260 ± 463 ind/m^2 (the overgrown shallows on the Small Tataru island). In the communities dominated by roach, which was mostly presented by juveniles, the specific number was significantly lower, 333±116 ind/m^2 (the channels on the Ermakov island). The significant errors in average values illustrated large difference in numbers of the collected samples, and therefore uneven distribution of juvenile fishes.

The fact that juvenile fishes concentrate predominantly in the coastal biotopes was confirmed by ichthyoplankton sampling of the lake pelagic zone. For instance, the numbers of larvae and juveniles in the pelagic zone of the lake on the Small Tataru island amounted to 9,6 ind/100 m^3 of water (75% of sunbleak and 25% of bleak), and only one bleak larva has been caught in similar way in central zone of the main channel. The early juveniles numbers in the pelagic zone of the lake on the Ermakov island was significantly higher – 47 ind/100 m^3. The species composition was also more diverse, including 5 species: sunbleak (79,5%), crucian carp (2,6%), Chinese sleeper (7,7%), western tubenose goby (7,7%) and Ukrainian stickleback (2,6%). Probably, owing to the shallowness and the presence of the submerged vegetation in most of the lake water area, some larvae leave the littoral zone and disperse over the lake. Furthermore, some breeders of these fishes can use the open spawning areas, after which their larvae could feed and grow in the same open areas where they have hatched. But still, the majority of juveniles concentrate in the coastal zone.

Table 4.15. The specific numbers of fish larvae and juveniles in localities of their aggregation

Island	Specific number, ind/m^2			
	Channels	Lakes	Overgrown shallows	The Danube
Small Tataru	414 ± 152 240–717	142 ± 6 137–148	2260 ± 463 1797–2723	570*
Ermakov	333 ± 116 103–463	1164 ± 193 720–1627	–	42*

Notes: above the line - the mean numbers with error (N ± n); below the line – the numbers range (min-max); «» – single sample; «–» – no data.*

Species diversity and structure of the aquatic organisms' communities, including the juvenile fishes, is closely connected with the effects of various environmental factors, both natural and anthropogenic. The latter, which include the river flow regulation, embanking, channel straightening, pollution, eutrophication etc., lead to sharp change in the conditions and, in most cases, cause decrease of species diversity. The species number is reduced, the domination of certain species, which are characterized by short life cycles, increases, the early maturation takes place, the biomass and production indices rise. Under eutrophication and pollution of the water bodies, the eurybiontic species with *r*-strategy take advantage, whereas under oligotrophic conditions of unpolluted waters, where the diversity is high and the species domination is less pronounced, the stenobiontic species with long development cycles and *K*-strategy are more represented [ODUM 1986, SHITIKOV 2003]. In order to obtain the indirect information about the state of the island hydroecosystems, the indices of species diversity and dominance of the juvenile fishes communities were calculated (Table 4.16).

Table 4.16. Species diversity indices of juvenile fish communities.

Island	Shannon Index (*H*)			
	Channels	Lakes	Overgrown shallows	The Danube
Small Tataru	1,85	2,11	0,42	1,07
Ermakov	0,74	0,61	–	1,26

The species diversity indices on the Small Tataru island were rather high, except the overgrown shallows, characterized by small number of species and strongly expressed dominance of one short-cycle limnophilous species (sunbleak), which reached the dominance index of 0,96. The second position by domination (only in this biotope) was occupied by the stone moroco (dominance index 0,17), this species is a rather harmful invader, resistant to unfavorable impact and very adaptive to the spawning temperature and substrate, a food competitor to juveniles of valuable native fish species. The stone moroco was not detected in other island biotopes, and the dominance of sunbleak was not so strong (from 0,24 in lakes to 0,45 in channels). At the same time, the lacustrine-riverine, riverine-lacustrine and riverine, medium- and long-cycle fishes, many of which are commercially valuable, were of much greater coenotic value in the lakes and channels. For example, the dominance indices of roach, asp, common bream, silver bream and perch in the island channels were respectively equal to 0,62, 0,12, 0,10, 0,10 and 0,15. The dominance indexes of roach and perch in the lakes amounted respectively to 0,84 and 0,19. In the Danube River beside roach (0,82), dominated ide (0,46), asp (0,30) and common bream (0,15).

The obtained results showed the obvious positive impact of breaching the dikes and flushing of the island over the flood, which provides high diversity of fishes and creates conditions for reproduction of the commercial species. In view of further restoration of natural regime on the island, we should expect the gradual decrease of the functional role of the short-cycle low-value and invasive species in the ichthyocoenoses (sunbleak, stone moroko, Chinese sleeper), which clearly confirms to the measures that have been carried out to rehabilitate the island.

Despite the higher species richness of the fish juveniles compared to the Small Tataru, Ermakov Island was characterized by lower indices of species diversity, owing to inequality of the communities, where the large species numbers was leveled out by strong dominance of one or two species. For example, in the Ermakov channels the dominance indices of roach and sunbleak were respectively equal to 0,94 and 0,19. Indices of all other species were below 0,1. The lakes were dominated by sunbleak and common rudd, which dominance indices were respectively equal to 0,91 and 0,25; the indices of other nine species were below 0,1. The species number in the Danube adjacent channel was lower than in the island waters, but the indices of each species were quite high, which indicated their more even contribution to the structure of the communities and higher stability of the ecosystem. The lower indices of the species diversity compared to the Small Tataru were probably conditioned by the fact that the natural regime of the Ermakov island was restored much later, so its ichthyocoenoses actually are at the recovery stage. The large number of minor species in the island waters probably indicate the first stages of increasing the ichthyofauna biodiversity after restoration of the natural hydrological regime on the island. Those species which are secondary now, can later be consolidated in the ecosystem and «balance» the communities, reducing the role of the short-cycle limnophilous species. Among these minor species on the island there are several medium- and long-cycle commercial species, such as crucian and Prussian carp, common bream, asp, European chub and others. In our opinion, given the subsequent annual flooding and flushing of the island during the spring flood, we should expect increase of these species portion in the ichthyocoenoses.

4.3. MODERN STATE OF HYDROBIOCOENOSES OF SMALL TATARU AND ERMAKOV ISLANDS.

The carried out studies showed that according to the hydrochemical parameters, the characteristics of invertebrate macrofauna and early young fishes the hydrobiocenoses of the Danube Delta islands Small

Tataru and Ermakov in spring fully corresponded to those in similar non-island water bodies of the delta, which suggests their «naturalness» and significant restoration of the ecological state as compared with the embanking period, when the flooding process was practically suspended and the aquatic ecosystems on the islands were destroyed. The hydrological-hydrochemical regime during the research period was favorable for the development of the aquatic biota.

During the research, 108 species of the macroinvertebrates were registered, the most widely presented were insects (59 species), mollusks (18 species) and oligochaetes (17 species). Crustaceans included only six species. Maximal species number (81) was registered in the water bodies and water courses of the Small Tataru island, on the Ermakov island – 70 species, and 22 species in the reedbed channel of the Ochakivskyi island.

The structure of macroinvertebrate complexes in the channel of Ochakivskyi island has been studied for comparison, as an example of what happens to hydroecosystems of islands after they convert to the reed beds: we noted the decrease of species richness and extinction of crustaceans, insects and bivalve mollusks.

One of the most interesting findings in the invertebrate macrofauna communities of the Small Tataru and Ermakov islands was the Red Book species *Anax imperator* Leach, 1815 and the European medicinal leech *Hirudo medicinalis* Linnaeus, 1758 [CHERVONA 2009]. Though these species are mostly scarce in the natural habitats and vulnerable to pollution, they occur quite often in the Danube Delta. The medicinal leech has been included into the world's conservation lists, such as Annex 2 of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES, Washington Convention), Annex 3 of the Convention on the Conservation of European Wildlife and Natural Habitats (Bern Convention) and Annex V of the Habitats Directive [UTEVSKY, ZAGMAJSTER, TRONTELJ 2014].

One of the biggest aquatic beetles in Ukraine, the great silver water beetle *Hydrophilus piceus* (Linnaeus, 1758), and the biggest water bug, the water stick insect *Ranatra linearis* (Linnaeus), which are typical inhabitants of the Danube Delta, have been found in the channels of the Ermakov island.

The water stick insect is sensitive to the water pollution by the oil products and lubricants, spread on the water surface, blocking the insects' breathing through the respiratory tubes. The numbers of *Ranatra linearis* has been decreasing over the recent years, that is why this species has been included in regional conservation lists [ROMANENKO, AFANASYEV, PETUCHOV 2003].

On the other hand, an interesting and unusual fact for the Delta hydrobiocoenoses is rather low representation of the Ponto-Caspian fauna; only four species were registered on the islands, namely *Cystobranchus fasciatu*s (*Piscicola fasciata*), *Jaera sarsi*, *Chelicorophium curvispinum* and *Limnomysis benedeni*. A species of Sino-Indian fauna, *Branchiura sowerbyi* and *Sinanodonta woodiana*, also were registered.

Comparison of the species composition in each type of the water bodies showed that the species richness in the island lakes was close (45 and 49 species), and species number of the channels of Small Tataru island were 1.4 times higher of the Ermakov island (69 vs. 49), probably owing to greater degree of overgrowth and weaker flowage.

The similarity analysis of the species composition of the lakes of the Small Tataru and Ermakov islands with the non-island lakes Merhei and Babina (Sulina Delta) and the Anankin Kut lake and Anankin Kut channel (Kiliya Delta) showed that the mentioned water bodies form the common pool with high similarity level – 50% and above. Only the reed bed channel of the Ochakivskyi Island was separated as it was characterized by minimal species richness. Thus, the species richness and species composition of macroinvertebrates' complexes in the water bodies of the islands are quite comparable to those in other hydrobiocoenoses of the Danube Delta (except the channel on the Ochakivskyi Island).

The studies of the fish larvae and juveniles on the considered islands and the adjacent areas of the Danube River have registered 16 fish species of five families. The most abundant was Cyprinidae, including 12 species. The Gasterosteidae, Percidae, Odontobutidae and Gobiidae were presented by single species each. 13 fish species of four families have been identified in the waters of Small Tataru and 15 species of five families – on the Ermakov waters. Taking into account the short research period, this can be generally considered as a high values.

The significant coenotic diversity of ichthyofauna was observed: the lakustrine-riverine, riverine-lakustrine and riverine, medium- and long-cycle fishes, many of which are commercially valuable. The distribution of European bitterling, a fish that deposits eggs inside the freshwater oxyphilous bivalve mollusks, indicated that at least in spring the stagnant processes in the bottom water layer of the channels are absent, and the oxygen regime is favorable for the development of invertebrates and ichthyofauna. The asp juveniles were registered only in the channels, the presence of this rheophilous species indicates good flowage over the spring flood, favorable for spawning of the riverine fishes.

It can be assert that the impact of dozing was obviously positive. This has ensured the access of the Danube waters to the island water bodies over the spring flood, their life-giving flushing, favorable conditions for their development and reproduction and, as a consequence, high diversity of invertebrate macrofauna and fishes including valuable species. Provided that the natural water regime on the islands is maintained, gradual decrease of the functional role of the short-cycle, low-value and invasive species (sunbleak, stone moroko, Chinese sleeper) in fish communities should be expected. Simultaneously, the riverine and riverine-lakustrine valuable fish species (ide, chub, bream, asp, carp) can become more numerous.

At the same time, we can not but highlight a series of negative phenomena that we and other researchers observed. For instance, in summer, over the drought period, strong drop in water levels and reduction in the island water areas are probable. In the shallow areas the water temperature rapidly rises, the oxygen concentration decreases, hypoxia can occur, which can cause death of juvenile and adult fishes, as well as their eating out by birds, due to the easier access to prey and less opportunities for fish to shelter. The decrease of water level also affects many other aquatic organisms, that is why it is necessary to maintain the flowage of the island water bodies for the entire vegetation season, especially over the drought period to ensure their survival.

We also noted strong vegetal invasion of the channels, especially on the Ermakov Island. If such a situation happens over the long period in summer, it can also affect the successful feeding of rheophilous fishes and normal development of other aquatic organisms. Provision of the appropriate hydrological regime will improve the conditions for their development in the island water bodies and ensure the inflow of Danube water over both flood and drought period. Moreover, maintaining the required capacity of passages in the dikes is essential for free fishes' migration in the Danube.

Nevertheless, the situations with lack of oxygen, overgrowing and drying of the water bodies, as well as catastrophic floods, are quite natural. The transformation of the water bodies and water courses, which are now isolated, into oxbows and dead channels like the studied one on the Ochakivskyi island, and their subsequent transformation into dry land, are all the stages of natural succession.

But we have already intervened the island ecosystems and thus assumed the responsibility for their future destiny, so perhaps we must determine what do we prefer them to look like. What regime of using the islands to choose, whether cattle grazing, or environment-oriented, recreational and touristy, or all of them simultaneously. At the moment, we are interested in maintaining the high biotopical and biological diversity, typical for the early stages of succession. The real management tools to control the biotic processes on the islands could be: maintenance of the appropriate hydrological regime, provision of good flowage and oxygen dynamics, prevention of silting and loss of depth, swamping, stagnation processes, oxygen deficit, etc. That is elimination of dikes, which opens the way for the Danube water to the islands' inland waters.

Certain concern is caused by the fact that the dissolved load will come along with the Danube water, and the excessive quantity of alluvia and its accumulation will again contribute to the above-mentioned negative phenomena. That is why the suspended matter from the Danube should not only come in, but also come out of island hydroecosystems, or be artificially removed. Realizing that establishing of the appropriate hydrological regime and maintaining the steady morphometric indices of the water bodies on the islands is significantly beyond our competence, we have to note that during the organization of hydroecological monitoring, the specialists on hydrobiology are able to predict the adverse periods in hydrobiocoenoses, deterioration of the ecological situation and need for the appropriate measures. Under limited funding and institutional capacity, the efficiency of monitoring should be achieved with the help of limited and substantiated set of parameters and their regular control.

The development of the specific algorithm for hydroecological monitoring is probably essential for the water bodies of each island, though this was not the subject of this work. We should only note that, in our opinion, the monitoring site located on the outlet of Lipovansky arm from the Ermakov island to Danube (our sampling site N10) may be effective in terms of obtaining the comprehensive information on the state of internal island hydrobiocoenoses. By installing the drift trap (traps) at the channel mouth, it is possible to control the quantitative and qualitative indicators of properly planktonic organisms (phyto-, zoo- and ichthyoplankton). Their structural characteristics will change over the year, and based on their dynamics it is possible to determine the state of internal island hydrobiocoenoses and the way they change. An atypical increase in portions of the benthic, periphytic organisms, fishes and other nekton organisms, along with other signs, could signalize on the situation worsening.

Summarizing the carried out research, we can state the high degree of «naturalness» of hydroecosystems on the studied islands and the need for further elimination of dikes and urgent need for environmental monitoring.

CHAPTER 5.

REFERENCE PARAMETERS OF THE KILIYA DANUBE DELTA WATER BODIES

Characteristic, given above is significant and important component of the actual ecological status of the water bodies comprehending, but it does not enable assessment of their ecological status according to the principles of the EC Water Framework Directive [EU… 2006]. The background WFD's conception is that for the ecological status of the water bodies determination it is necessary to evaluate level of its ecosystem's disturbance comparatively to the certain conditional natural status. Assessment of the ecological status (state) in fact consists in classification of the water bodies (or their sections) on the background of the comparison of data obtained in the field investigation with the reference (etalon) parameters of the given water bodies' type. The next stage is establishment of the etalon, reference conditions (that is those, occurred before human impact or other disturbances) for the every type of the water bodies. Annex V of the WFD clearly indicates elements to be used for the classification of the water bodies' ecological status (state): 1) composition, abundance and biomass of phytoplankton, 2) composition and abundance of other aquatic flora; 2) composition and abundance of benthic invertebrate fauna; 3) composition, abundance and age structure of fish fauna.

Within each element as indicative parameters can serve, for example, individual species, groups, populations or communities of the aquatic organisms, characteristics of which according to the changes of the aquatic environment quality, considered as biotope, caused first of all by the human load. As characteristics (descriptors) both individual parameters of the species (saprobic index, indicative value) or population (informational diversity of the size and weight groups, sexual structure) and different biotic indices, which take into account presence of the of the indicative groups in the communities, or simple ratio of the species number in the communities of the aquatic organisms. Any negative impact disturbs communities' structure, changes species composition of the biotic complexes, quantitative ratio of the certain groups. That's why presence of the rare and endangered species can indicate originality of the certain water body, its peculiarity, and high species richness can indicate lack of the disturbance of the habitats. Characteristics' deviations toward more or less values comparatively to the reference, is an evidence of the negative processes, though sometimes the assessment is not so single valued.

Reference conditions are the benchmark for the further activities, comparison for the actual parameters and, as a result, assessment of the actual status of the separate elements and ecosystem on the whole. On the background of the material of the given project, our previous investigation [ALEKSANDROV at al. 2007; KORNYUSHIN, LIASHENKO 2004, MAKOVSKIY, LYASHENKO 2011, SANZHAK at al. 2012, AFANASIEV at al. 2008; ZORINA-SAKHAROVA at al. 2008, SANZHAK, LIASHENKO 2009, LYASHENKO at al. 2006, 2007, 2009, 2010, 2012, 2013; ZORINA-SAKHAROVA, LYASHENKO 2008; ROMANENKO at al., 2011, LYASHENKO, ZORINA-SAKHAROVA 2008, 2009, 2012, 2014, 2015] and the well-known literary data [MARKOVSKIY 1955, OLIVARI 1961, POLISCHUK 1974, ZIMBALEVSKAYA 1969] we have made the first attempt for the determination of the reference conditions for the some water body types of the Kiliya Danube delta (Table 5.1.).

Proposed table is a background for the assessment of the actual state (status) of the water bodies, this is the first attempt to create starting point for the comparison. Surely, many parameters need specification, may be completion by other descriptors. Ideally, every kind of pressure have to be associated with the certain descriptor. Probably, it is appropriate to include into the biological blocks organisms of the higher trophic levels, because they integrate characteristic of status, as well as rare and Red Lists' fish and bird species, because they indicate high value of the ecosystems capable of maintaining their occurring. Certainly, such assessment needs big volume of additional information for all blocks of the Table. This will be a subject for the further investigation

Table. 5.1. Reference characteristic of the Kiliya Danube delta water bodies

Hydrobiological parameters		Objects of classification of the Kiliya delta (August)		
		Arms and branches	Reservoirs of delta	
			In-delta lakes	Brackish bays
Block 1 – Water quality				
Invertebrate macrofauna biotic index		7	8	8
Saprobity, phytoplankton		β-mesosaprobic	β-mesosaprobic	β-mesosaprobic
Saprobity, zooplankton		β-mesosaprobic	β-mesosaprobic	β-mesosaprobic
Saprobity, zoobenthos		β-mesosaprobic	β-mesosaprobic	β-mesosaprobic
Saprobity, phytophilous fauna		β-mesosaprobic	β-mesosaprobic	β-mesosaprobic
Trophity		mesotrophic	mesotrophic	mesotrophic
Block 2 – Communities' structure (*Indicative and significant for the reference conditions groups in the main communities*)				
Species richness	zoobenthos	15	20	25
	phytophilous fauna	20	30	30
Number of invertebrates species		Ephemeroptera – 4 Trichoptera – 6 Odonata – 6 Bivalvia – 4	Ephemeroptera – 3 Trichoptera – 6 Odonata – 6 Bivalvia – 3	Ephemeroptera – 3 Trichoptera – 5 Odonata – 6
Number of the aquatic macrophytes in the indicative groups		Rheophilous – 3, Limnophilous – 1	Rheophilous – 1 Limnophilous – 3 Swamp – 3	Rheophilous – 2 Limnophilous – 3 Swamp – 1
Number of the aquatic macrophytes belts		1	3	3
Block 3 - Biodiversity (*Indicative and significant for the reference conditions species*, as well as endemics and protected species)				
Indicative and significant for the reference conditions invertebrates species		*Anax imperator, Astacus leptodactilus, Ecdyorynus venosus, Palyngenya eucaudata, Hirudo medicinalis, Oligoneureula renana, Ranatra linearis*	*Corophium sp., Dikerogammarus sp., Donacia sp., Hirudo medicinalis, Astacus leptodactilus, Ranatra linearis*	*Amathelina cristata, Mysidacea, Cumacea, Unio pictorum, U. crassus, Anodonta cignea, Hirudo medicinalis Astacus leptodactilus, Ranatra linearis*

Hydrobiological parameters	Objects of classification of the Kiliya delta (August)		
	Arms and branches	Reservoirs of delta	
		In-delta lakes	Brackish bays
Indicative and significant for the reference conditions aquatic macrophytes species (plants of the Red book of Ukraine and endangered species – in **Bold**)	*Typha latifolia, T. angustifolia, Phragmites australis, Glyceria maxima, Sparganium emersum, Potamogeton pectinatus, P. perfoliatus*, absence of the plants with floating leaves	Presence of the submerged plants, not more than 3 species of the plants with floating leaves, *Nymphaea alba*	*Sparganium emersum, Trapa natans, Potamogeton pectinatus, P. perfoliatus*,
Indicative and significant for the reference conditions fish species			
Numerical density phytophilous fauna, thousand ind/kg	4,5	3,5	1,5
	0,5	1,5	
Biomass phytophilous fauna, g/kg	10	15	5
	8,0	10,0	
Block 4 - Biotopes (*ratio of the main biotopes indicative for the reference conditions)*			
Rate of the overgrowth	1	100	25
Average depth	7	1,5	2
Prevailing substratum type	sand, gray loamy silt	gray silt, black silt	gray silt, silted sand

CHAPTER 6.

PROPOSAL FOR THE MONITORING SCHEME OF THE DANUBE DELTA

The worldwide decline of biodiversity as a consequence of habitat alteration, along with new concepts brought by the sustainable development, aiming to assure the safe environment for the next generations, lead to the increasing concern towards the ecological status of the ecosystems.

Consequently, an important conceptual shift occurred in the last decades in the assessment of water quality and aquatic ecosystems status: transition from the mainly chemical control of water quality, considered as "human resource", to the investigation of the ecological status, considering the aquatic ecosystem as environment for the aquatic biocenoses. Nowadays many scientists associate the term "good" or "high" status with "not disturbed", "reference" or "natural" status of the ecosystem [AFANASIEV, 2001, DE PAUW, HAWKES 1993, SCHOFIELD, DAVIES 1996], defining for example "health of a river as level of similarity with etalon river of the same type" [SCHOFIELD, DAVIES 1996].

The adoption and implementation of Water Framework Directive (2000/60/EC), which introduced unified EU-wide approach to the water management by river basins, aiming to ensure "good ecological status" of the aquatic ecosystems, was a step forward in the monitoring of the surface waters due to its holistic approach. For the first time the aquatic ecosystem was considered as an entity, its ecological integrity being assessed as interaction of biological, hydromorphological, chemical and physical parameters.

For such a wide area as Danube River Basin, common assessment strategy is a must in order to assure a proper ecological quality of its aquatic ecosystems. The second river in Europe, Danube has the most international river basin as it comprises the territories of 19 countries, covering a surface of more than 800,000 km^2. Based on the provisions of Danube River Protection Convention, in 1996 the common monitoring program was launched by the International Convention for Protection of Danube River, the TransNational

Monitoring Programme (TNMN), with the main aim to provide an overall view of pollution and long-term trends in water quality of the major rivers in the Danube River Basin.

According to TNMN criteria, water quality can be classified in 5 classes, the limits of class II being considered as target values and the limits of class I as reference conditions. Class III–V is considered as in non-compliance with WFD; the TNMN limits for surface water classification are presented in Annex 1. Among the 37 monitored parameters, only 1, the saprobiological index, takes into consideration the biological communities (being calculated based on benthic invertebrates); other two microbiological parameters were added recently: fecal and total coliforms), but still, these criteria can not indicate the ecological status of the aquatic ecosystem. Consequently, in 2006 the TNMN was revised to ensure full compliance with the provisions of the EU-WFD.

Both countries, Romania and Ukraine, have committed to apply the requirements of WFD in order to achieve the good ecological status of waterbodies by 2015, implementing new assessment measures in their legislation.

Romania has aligned her legislation to WFD compliances adopting the M.O. 161/16.02.2006 for the "Classification of surface waters quality in order to establish the ecological status of waterbodies", where biological, hydromorphological and physico-chemical criteria are considered. The biological criteria comprise the evaluation of phytoplankton (species richness, abundance, biomass), phytobenthos and macrophytes (species richness, abundance), macroinvertebrates (species richness, abundance), icthyofauna (species richness, abundance, structure of age classes). The hydromorphological criteria comprise the river discharge, flow, the connectivity with underground layer, river/lake depth, retention time for lakes, river width and continuity, substrata and banks structure. The physico-chemical criteria comprise transparency, temperature, dissolved oxygen, the content of organic matter, mineralization, pH, nutrients, priority substances or other substances discharged in the river/lake. The saprobic index in rivers is calculated based on plankton, benthic algae and benthic macroinvertebrates, while for lakes, the trophic status is assessed based on total phosphorus, mineral nitrogen, phytoplankton biomass and chlorophyll-a.

In Ukraine, the “Methodology for ecological assessment of surface waters and estuaries” was adopted in 1998 by the Ministry of Environmental Protection as national guidance for the ecological assessment of surface waters quality. The annex 2 of this document, “Ecological assessment of the surface waters and estuaries by trophic-saprobiological (ecological and sanitary) criteria” – contains 18 parameters, one third referring to biological communities (phytoplankton biomass, self-purification index, bacterioplankton abundance, saprophytic bacteria abundance, saprobic index according Pantle-Buck and Goodnight-Whitley), but this assessment does not offer information about the biodiversity and bioresources of the aquatic ecosystem.

The different systems of water quality assessment have higher impact when dealing with transboundary waterbodies as different tools had always lead to different conclusions about the ecosystems status. Therefore, we consider as necessary the adoption of the common evaluation system in the whole Danube River Basin, in order to obtain reliable results regarding its ecological state.

According to the WFD, the information regarding phytoplankton, phytobenthos, aquatic vegetation, macroinvertebrates and fish communities is the first step in the ecological assessment of an aquatic ecosystem. The anthropogenic impact can affect the aquatic ecosystems in many ways, leading to changes in the structural and functional parameters of its communities. Thus, species richness, abundance and biomass, saprobic index (calculated based on presence/absence of some indicator species), size and weight of the populations (evaluated for example by Shannon index) or other biotic indices (e.g. TBI) can be used as reliable indicators.

An important step is the establishment of threshold values, i.e. critical values, which indicate the deterioration of the ecological status. For instance, the «Rapid Bioassessment Protocols» (RBPs), approved by the US Enviromental Protection Agency in 1989 and improved in 1990, is based on the ecological variability assessment. If the characteristics are increasing or decreasing by more than 25%, following the variation of anthropogenic load, it indicates the worsening of ecological conditions.

In the European Union, the transition towards higher water classes shows the worsening of water quality (from class I – very good to V – bad), but the effects on biological communities are evaluated considering mainly the saprobic indices in rivers or trophic status in lakes.

Since 2005, in the framework of SCOPES project and of the intercademic cooperation, the Institute of Biology Bucharest, Romanian Academy and the Institute of Hydrobiology Kiev, NAS of Ukraine have carried out joint hydroecological investigations in Danube Delta. Within 2006–2007, 11 aquatic ecosystems from the Romanian and Ukrainian parts of the delta were investigated, aiming at assessment the actual ecological status of these ecosystems using the common methodology, in compliance with WFD. Both institutes have carried research projects in the Danube Delta since the 1950ies, the long term investigations allowing the observation of gradual changes occurred in delta's aquatic ecosystems under the anthropogenic impact. Also, the Institute of Hydrobiology is involved in the integrated ecological monitoring of the project concerning renewing and exploitation of the deep-water navigation channel in Bystryi arm.

Based on the conceptual principles mentioned above and on the previous experiences, the joint proposal for monitoring and assessment of ecological status of the aquatic ecosystems in the Danube Delta is presented, aiming to provide useful tools to the decision makers for the biodiversity conservation and the sustainable use of its resources. Some characteristic ecosystems were chosen for monitoring (Table 6.1), aiming to assess both biodiversity and anthropogenic influence, in order to mitigate the environmental impact, but this network can be extended according to further needs and possibilities.

Table 6.1. Sites proposed for monitoring in Danube Delta (both Ro+Ukr sides)

Code*	Kiliya Delta (UA)	Code*	Sulina Delta (RO)
UA-R01	Danube, 2 km upstream Reni	**RO- R01**	**Danube – Izmail Chatal, Tulcea arm, 1 km downstream the bifurcation**
UA-R02	Danube, 1 km downstream Reni	RO-R02	Tulcea arm, 1 km upstream Tulcea
UA-R03	**Danube – Izmail Chatal, upstream bifurcation in Tulcea and Kiliya arms**	RO-R03	Tulcea arm, 2 km downstream Tulcea
UA-R04	Kiliya arm, 2 km upstream Izmail	**RO-R04**	**Tulcea arm, 1 km upstream bifurcation at Saint George Chatal**
UA-R05	Kiliya arm, 1 km downstream Izmail	RO-R05	Sulina arm, 2 km upstream Maliuc

Code*	Kiliya Delta (UA)	Code*	Sulina Delta (RO)
UA-R06	Kiliya arm, 2 km upstream Kiliya	RO-R06	Sulina arm, 1 km downstream Maliuc
UA-R07	Kiliya arm, 1 km downstream Kiliya	RO-R07	Sulina arm - Old Danube meander – 1 km from the bifurcation
UA-R08	Kiliya arm, 1 km upstream Vilkove	RO-R08	Sulina arm – Old Danube meander – 1 km before the confluence with main arm
UA-R09	**Ochakivskyi branch, 1 km downstream Vilkove**	RO-R09	Sulina arm, 1 km upstream Crisan
UA-R10	Ochakivskyi branch, 1 km upstream bifurcation in Prorva and Potapiv branches	RO-R10	Sulina arm – 1 km downstream Crisan
UA-R11	Prorva branch, outlet to sea	RO-R11	Sulina arm, 1 km upstream Sulina town
UA-R12	Potapiv branch, outlet to sea	**RO-R12**	**Sulina arm, outlet to the sea**
UA-R13	Starostambulskyi branch, upstream bifurcation to Bystryi branch	RO-R13	Saint George arm, 1 km upstream Mahmudia
UA-R14	Starostambulskyi branch, outlet to sea	RO-R14	Saint George arm – old meander, 1 km from the inflow
UA-R15	**Bystryi branch – 1 km from the inflow**	RO-R15	Saint George arm – old meander, Uzlina village
UA-R16	**Bystryi branch, outlet to sea**	RO-R16	Saint George arm – old meander, 1 km before the confluence
UA-R17	**Vostochnyi branch, 1 km from the inflow**	RO-R17	Saint George arm - 1 km upstream Dunavat
UA-R18	**Vostochnyi branch, outlet to sea**	RO-R18	Saint George arm, 2 km downstream Ivancea
UA-R19	Rybachyi branch - entrance to the Anankin Kut lake	**RO-R19**	**Saint George arm – outlet to the sea**
UA-R20	Limba branch	**RO-L20**	**Rosu lake**
UA-R21	Misura branch	**RO-L21**	**Erenciuc lake**
UA-R22	**Solonyi branch**	**RO-L22**	**Uzlina lake**
UA-R23	Shabash Kut	**RO-L23**	**Isac lake**
UA-L24	Potapiv Kut	**RO-L24**	**Gorgova lake**
UA-L25	Deliukiv Kut	**RO-L25**	**Matita lake**
UA-L26	Ptichiy Kut	**RO-L26**	**Merhei lake**
UA-L27	Lebiazhiye melkovodiye	**RO-L27**	**Furtuna lake**
UA-L28	Lake Lazorkin Kut	**RO-L28**	**Tataru lake**
UA-L29	**Lake Anankin Kut**	RO-C29	Lopatna channel

Note: * R – arm and branches, L – lake, C – channel; the ecosystems in bold are considered as mandatory to be monitored.

The list of physical, chemical and biological parameters selected for monitoring is suggested in Table 6.2; as most of the pollutants accumulate at the bottom of the aquatic ecosystem, we considered necessary to include a list of parameters which should be monitored also in the sediment. Diversity indices based on the structure of different trophic levels may be calculated (Shannon, TBI) in order to compare the different ecosystems.

Besides these analyses, a screening to track the sub-lethal effects of pollution should be done in the areas with the highest anthropogenic impact as the current monitoring strategy has been proven to be unable to detect such effects [KOEHLER et al 2005; SANDU et al 2008]. Such analyses should include biomarkers in fish (e.g. hsp 70, CyP 450, EROD activity) [KOEHLER et al, 2007] and bioaccumulation of pollutants in fish tissues. According to the results, the monitoring strategy can be adequately adapted by adding/cancelling some of the parameters.

Table 6.2. List of the parameters and observation frequency recommended for the hydroecological monitoring of the Danube Delta (both Ro+Ukr sides without transitional waters)

Parameters	Measurement unit	Minimum sampling frequency*	Location
A. **Physico-chemical parameters**			
Water column			
Temperature	°C	Every two months	All
Transparency	m	Every two months	All
pH	-	Every two months	All
Conductivity	µS/cm	Every two months	All
Salinity	‰	Every two months	Outlets to the sea, lagoons
Suspended matter	mg/l	Every two months	All
Dissolved oxygen	mg O_2/l	Every two months	All
Biochemical oxygen demand ($BOD_{5)}$	mg O_2/l	Every two months	All
Chemical oxygen demand (COD-Cr)	mg O_2/l	Every two months	All
Ammonium (N-NH_4^+)	mg N/l	Every two months	All
Nitrites (N-NO_2^-)	mg N/l	Every two months	All
Nitrates (N-NO_3^-)	mg N/l	Every two months	All
Dissolved inorganic nitrogen (DIN)	mg N/l	Every two months	All

Parameters	Measurement unit	Minimum sampling frequency*	Location
Total nitrogen	mg N/l	Every two months	All
Ortho-phosphates (P-PO_4^{3-})	mg P/l	Every two months	All
Total phosphorus (TP)	mg P/l	Every two months	All
Chlorophyll-a	µg/l	Every two months	All
Chlorides (Cl^-)	mg/l	Every two months	Outlets to the sea, lagoons
Sulphates (SO_4^{2-})	mg/l	Every two months	Outlets to the sea, lagoons
Calcium (Ca^{2+})	mg/l	Every two months	Outlets to the sea, lagoons
Magnesium (Mg^{2+})	mg/l	Every two months	Outlets to the sea, lagoons
Sodium (Na^+)	mg/l	Every two months	Outlets to the sea, lagoons
Total chromium (Cr^{3+}+ Cr^{6+})	µg/l	Every two months	Arms, channels
Copper (Cu^{2+})	µg/l	Every two months	Arms, channels
Zinc (Zn^{2+})	µg/l	Every two months	Arms, channels
Arsen (As^{3+})	µg/l	Every two months	Arms, channels
Barium (Ba^{2+})	µg/l	Every two months	Arms, channels
Selenium (Se^{4+})	µg/l	Every two months	Arms, channels
Cobalt (Co^{3+})	µg/l	Every two months	Arms, channels
Lead (Pb)	µg/l	Every two months	Arms, channels
Cadmium (Cd)	µg/l	Every two months	Arms, channels
Mercury (Hg)	µg/l	Every two months	Arms, channels
Nickel (Ni)	µg/l	Every two months	Arms, channels
Total iron (Fe^{2+}+ Fe^{3+})	mg/l	Every two months	Arms, channels
Total manganese (Mn^{2+}+ Mn^{7+})	mg/l	Every two months	Arms, channels
Phenolic index	µg/l	Every two months	All
ANA Detergents	µg/l	Every two months	Arms, channels
Absorbable organically bound halogens (AOX)	µg/l	Every two months	Arms, channels
Polyaromatic hydrocarbons ($\sum$ PAH)	µg/l	Every two months	Arms, channels
Polychlorinated biphenyls ($\sum$ PCB)	µg/l	Every two months	Arms, channels
Pesticides	µg/l	Every two months	All
Oil products	µg/l	Every two months	All
Sediment			
Organic matter	%	seasonal	All
Total nitrogen	mg N/kg	seasonal	All
Total phosphorus	mg P/kg	seasonal	All

Parameters	Measurement unit	Minimum sampling frequency*	Location
Arsenic (As^{3+})	mg/kg	seasonal	Arms, channels
Cadmium (Cd)	mg/kg	seasonal	Arms, channels
Total chromium (Cr^{3+}+ Cr^{6+})	mg/kg	seasonal	Arms, channels
Copper (Cu^{2+})	mg/kg	seasonal	Arms, channels
Lead (Pb)	mg/kg	seasonal	Arms, channels
Mercury (Hg)	mg/kg	seasonal	Arms, channels
Nickel (Ni)	mg/kg	seasonal	Arms, channels
Zinc (Zn^{2+})	mg/kg	seasonal	Arms, channels
Polyaromatic hydrocarbons ($\sum$ PAH)	mg/kg	seasonal	Arms, channels
Polychlorinated biphenyls ($\sum$ PCB)	mg/kg	seasonal	Arms, channels
Pesticides	mg/kg	seasonal	All
Oil products	mg/kg	seasonal	All
Phenols	mg/kg	seasonal	All
B. Biological parameters			
Microbiological parameters		seasonal	
Abundance	no/l		All
Biomass	µg C/l		All
Faecal coliforms	no/100 ml		Arms, channels
Total coliforms	n/100 ml		Arms, channels
Faecal streptococci	n/100 ml		Arms, channels
Phytoplankton		seasonal	
Species richness	n, species list		All
Number of families	n		All
Abundance	ind/l		All
Biomass	mg/l		All
Biomass, according Chlorophyll-a	mg/l		All
Phytobenthos		seasonal	
Species richness	n, species list		All
Number of families	n		All
Abundance	ind/m^2		All
Biomass	mg/m^2		All
Macrophytes		seasonal	
Species richness	n, species list		All
Number of families	n		All

Parameters	Measurement unit	Minimum sampling frequency*	Location
Number of belts	n		All
Coverage of water surface	%		All
Frequency of occurrence of invasive species	%		All
Coverage of invasive species	%		All
Zooplankton		seasonal	
Species richness	n, species list		All
Abundance	ind/l		All
Biomass	mg/l		All
Macroinvertebrates		seasonal	
Species richness	n, species list		All
Number of indicative groups	n, groups list		All
Abundance	ind/m^2		All
Biomass	mg/m^2		All
Dominant species	n, species list		All
Species of special protection	n, species list		All
Threatened species	n, species		All
Invasive species	n, species		All
Ichthyofauna		not less 1 times/ year	
Species richness	n, species list		All
Species of special protection	n, species list		All
Frequency of catching of invasive species	%		All
Number of fry emigration	n		Arms, channels
Abundance	n		All
Age/sex structure	n		All
C. Saprobic index			Arms, channels
Phytoplankton		seasonal	
Oligosaprobic indicators	n/l		All
β-mesosaprobic indicators	n/l		All
α-mesosaprobic indicators	n/l		All
Polysaprobic indicators	n/l		All
Saprobic index fpk			All
Zooplankton		seasonal	

Parameters	Measurement unit	Minimum sampling frequency*	Location
Oligosaprobic indicators	n/l		All
β-mesosaprobic indicators	n/l		All
α-mesosaprobic indicators	n/l		All
Polysaprobic indicators	n/l		All
Saprobic index zpk			All
Benthic algae		seasonal	
Oligosaprobic indicators	n/l		All
β-mesosaprobic indicators	n/l		All
α-mesosaprobic indicators	n/l		All
Polysaprobic indicators	n/l		All
Saprobic index bnalg			All
Benthic macroinvertebrates		seasonal	
Oligosaprobic indicators	n/l		All
β-mesosaprobic indicators	n/l		All
α-mesosaprobic indicators	n/l		All
Polysaprobic indicators	n/l		All
Saprobic index zbn			All
D. Evaluation of trophic status		seasonal	Lakes
Total phosphorus	mg P/l		All
Inorganic nitrogen	mgN/l		All
Phytoplankton biomass	mg/l		All
Chlorophyll-a	µg/l		All
E. Presence of protected/ endangered species**			
Ichthyofauna		seasonal	All
Amphibians + reptiles		seasonal	All
Birds species		seasonal	All
Mammals		seasonal	All
F. Presence of invasive species			
Macroinvertebrates		seasonal	All
Ichtyofauna		seasonal	All

*The ideal strategy should include monthly investigations; as this is difficult to achieve mainly due to economical reasons, a minimum number of investigations was considered. In the first year of monitoring the physical and chemical parameters will be monitored more frequent in order to establish dynamics and levels of contamination; where the concentration is below the detection limit for the whole year and no pollution source is located in the area, since the second year the parameter can be monitored twice per year.

**In order to stop the biodiversity decline, these species will receive special attention; the list will include species, nomber of individuals observed/caught, location, category of protection (e.g. Bern convention, IUCN, etc.). Whenever possible, their habitats should be strictly protected as habitat alteration has been proven to be the main cause for species loss.

The assessment of ecological status should take into consideration also the hydromorphological characteristics of the aquatic ecosystem; thus, the following parameters should be evaluated (Table 6.3).

As this list of parameters represent a compilation of national and international standards in compliance with WFD, we consider this monitoring scheme as a guidance for further development of national monitoring strategies in order to achieve the common ecological evaluation system in the Danube River Basin. The cooperation with local experts can be very helpful in finding the best solution for its adaptation to the specific conditions of the Danube Delta.

Tab. 6.3 Hydromorphological parameters considered for the assessment of ecological status of rivers and lakes (M.O. 161/2006)

Rivers	Lakes
Water flow and discharge	Amount of water
Connectivity with underground layer	Retention time
Depth	Connectivity with underground layer
Width variation	Depth
River continuity	Amount and structure of substrata
Substrata structure	Banks structure

Afterword

The book is a summary of one more stage of investigations of the Danube delta – the European second biggest delta (after the Volga delta) formed by single river. The Danube is an international river, its basin covers territory of 18 states, and delta itself is shared by two – Ukraine and Romania. Lower Danube and delta are not only of European, but of global significance. So, in the book the main attention was paid to the results of joint international studies.

Danube is one of the world biggest rivers and has its own peculiarity – downstream the Iron Gate dam for about 1000 km it runs in the relatively natural riverbed with minor embankment, and thus river waters become highly turbid owing to significant amount of suspended matters. Their annual average content for the prolong period amounted to 170–200 g/m^3 with maximal values up to 2300 g/m^3, the annual volume of alluvia can reach 100 mil tons. Significant concentration of the suspended matters conditions development of the branched secondary, or marine, delta, which constantly advances into the sea.

The Danube delta begins nearby the Izmail Cheatal by bifurcation of the main channel into two arms – the Tulcea (Romanian) and Kiliya, which serves as a boundary between Ukraine and Romania. The Tulcea arm is quite short (14 km), downstream the town of Tulcha it divides into the Sulina and St. George arms. Hydrobiological characteristics of different arms have their peculiarities, which was confirmed by our investigations. Sometimes specialists consider deltas of individual arms – delta of the Kiliya arm, delta of the Sulina and St. George arms, as they historically developed in different way and experienced different anthropogenic intrusion.

The secondary Kiliya arm's delta is the youngest. It is located downstream the town of Vylkove, process of its forming started about 300 years ago and still continues. It is conditioned by several hydrophysical processes, as turbulent mixing of the water masses, sedimentation of suspended matters, forming of bottom sediments, mixture of the fresh and saline waters, flooding of vast territories, etc. At the flow velocity deceleration close of the

Danube River fall into the Black Sea, the suspended particles settle, form coastal spits, desalinated bays («kut»), intra-delta lakes and islands. Active part of the Kiliya delta, or expansion zone, is hydraulically connected with the river flow and sea. The islands are covered by the lacustrine and swamp vegetation (wetlands). The wetlands are rich in the unique biotopes, which provides occurrence of both common widely distributed species and rare, endemic and relic species as well, plants and animals, remained from the past geological epochs.

To the certain degree similar processes take place in the front marine part of the St. George arm delta, however significantly less intensive. The Sulina arm has no advanced delta, it was significantly modified – straightened for navigation purposes, and in the lowest section, at falling into the sea it is limited by dikes at both sides, for more than 10 km to provide transport of the suspended material from the coastal shallow areas to the more distant sea sections.

Actually, under redistribution of the water flow, preservation of the biological diversity of the delta, restoration and rehabilitation of its unique ecosystems needs special concern of scientists, administrations, non-governmental organizations, local communities. Presented material one more time showed both high importance of the delta hydroecosystems on the whole, conditioned by exclusive species richness and diversity, and peculiarities of its individual water bodies, which, in fact, form general unique characteristics.

Investigations of the lower Danube and delta by the Romanian and Ukrainian hydrobiologists have been started more than a century ago, since studies of G. P. Bourgugnat [1870], A. A. Ostroumov [1897; 1898]. S. O. Zernov [1908], K. O. Milashevych [1908] and G. Antipa [1914] in the late XIX – early XX cent., G. Shpandl [1926], Yu. M. Markovskiy [1955], A. M. Almazov, K. S. Vladimirova, K. K. Zerov, G. A. Olivari, Ya. V. Roll, Ya. Ya. Tseeb [DUNAY… 1961], V. V. Polishchuk [1974], O. I. Ivanov [1987], T. A. Kharchenko [KHARCHENKO 1993, KHARCHENKO, LYASHENKO 1998, KHARCHENKO, LYASHENKO, BASHMAKOVA 2000, 2001] in the middle and late XX cent., to the studies of the last decades – by Ukrainian scientists S. O. Afanasyev [2008], A. V. Liashenko and K. Ye. Zorina-Sakharova

[2002–2017], T. M. Dyachenko [2006, 2011] and by Romanian researchers [DANUBE…2006].

Modern period of hydroecological investigations of the Danube River is characterized not only by integral studies of the aquatic ecosystems, biotic communities and populations of the aquatic organisms, but by profound analysis of the intra-waterbody processes, particularly under the impact of the anthropogenic and climatogenic factors. More than 60 years of regular investigations of the institute of hydrobiology NAS of Ukraine, started just after the WWII, enabled to create original bank of hydrobiological data, to establish certain regularities of the biodiversity forming, functioning of the aquatic coenoses, to evaluate production potential and water quality of the Romano-Ukrainian river stretch and its delta. Over the years 2005–2012 the Institute of hydrobiology along with other institutions of the National Academy of sciences of Ukraine participated in the National program of integral ecological monitoring at restoration and operation of the deep navigational channel «Danube – Black Sea», where it was responsible for the block of hydroecological issues of the freshwater part of the Kiliya delta. In fact, the chapter «Suggestions to development of the monitoring scheme of the water bodies of the Danube delta» includes results of this work.

Implementation of the joint international monitoring in the lower Danube and delta over the last years has become urgent. The main problem was and still is implementation in Ukraine of the Directive 2000/60/EC principles. In the EU-member states of the Danube basin monitoring of the water bodies status on the basis of comparison of the reference characteristics with the actual, obtained in the field surveys, characteristics of biological and supportive hydromorphological and physico-chemical quality elements is obligatory. After ratification of the Danube convention Ukraine in fact has undertaken obligations to present data of the Danube River monitoring as it is prescribed by Directive 2000/60/EC already in 2002, however only after signing of EU-Ukraine Association Agreement this approach was finally approved in the Ukrainian legislation. Adoption of the Cabinet of Ministers Decree of September 19, 2018 N 758 «On approval of Procedure of the state monitoring of waters», which was prepared with participation of the specialists of the Institute of hydrobiology, became a final step towards harmonization of the EU and Ukrainian legislation in the field of evaluation of the ecological state of the surface water bodies.

It should be stressed, that the presented monograph has the advantage even of the most comprehensive publications of the last years because it contains maximum complete species lists of the main groups of the aquatic organisms, moreover, they are arranged separately for different investigation periods and for individual sites in different types of the water bodies. This is essential in view of realization of the Directive 2000/60/EU approaches regarding establishing of the reference parameters and in further assessment of the ecological state of the surface water bodies of the lower Danube and the Danube delta.

On the whole it should be stated that hydroecological studies of the Danube River entered a new phase, which is characterized by international integration and cooperation on the principles of application of common approaches and attraction of the international teams for solution of both purely scientific, fundamental tasks and applied, water management issues and problems.

Післямова

Підведено підсумок ще одного етапу досліджень дельти Дунаю, другої після Волги дельти Європи, створеною стоком однієї річки. Дунай – міжнародна річка, її басейн охоплює території 18 країн, а саму дельту поділяють дві з них – Україна та Румунія. Пониззя та дельта Дунаю мають не тільки європейське, а й загальнопланетарне значення. Тому в роботі зроблено акценти саме на результатах спільних міжнародних досліджень.

Дунай належить до найбільших річок світу і має характерну особливість: протікаючи за Джердапською греблею на ділянці майже 1000 км у відносно природному, мало одамбованому руслі, води річки набувають високої каламутності, зумовленої значною кількістю зважених наносів. Їхній середньорічний вміст за багаторічний період спостережень становить 170–200 г/м^3 з максимальними величинами до 2,3 кг/м^3, річний обсяг наносів може сягати до 100 млн тонн на рік. Велика концентрація зважених часток зумовлює розвиток розгалуженої вторинної, або морської дельти, яка постійно розширюється в бік моря.

Дельта починається в районі Ізмаїльського Чаталу біфуркацією основного русла Дунаю на два рукави: Тульчинський (румунський) та Кілійський, по якому проходить україно-румунський кордон. Тульчинський рукав доволі короткий (14 кілометрів), нижче м. Тульча він розгалужується на Сулинський та Свято-Георгіївський рукави. Гідробіологічні характеристики різних рукавів мають свої особливості, що підтвердили й наші дослідження. Іноді говорять про дельти окремих рукавів: дельта Кілійського рукава, Свято-Георгіївського та Сулинського. Вони історично розвивалися по-різному та зазнали різного антропогенного втручання.

Наймолодшою є вторинна дельта Кілійського рукава, що розташована нижче м. Вилкове, процес її утворення почався близько 300 років тому і продовжується у наш час. Він зумовлений такими гідрофізичними процесами, як турбулентне перемішування водних мас, седиментація зважених часток, формування донних ґрунтів, змішування прісних і солоних вод, затоплення великих територій тощо. За впадіння Дунаю у море та зниженні швидкості течії завислі частки осідають, утворюються прибережні коси, опріснені затоки (кути), внутрішньодельтові озера і острови. Активна частина Кілійської дельти, або зона висунення, гідравлічно пов'язана з річковим стоком і морем. Острови покриті озерно-болотною рослинністю (плавнями). Неповторні водно-територіальні комплекси рясніють унікальними біотопами, які забезпечують можливість існування не тільки звичайних, широко поширених, але й рідкісних ендемічних і реліктових видів, представників тваринного і рослинного світу, що збереглися з часів минулих геологічних епох.

Певною мірою схожі процеси відбуваються у передній, морській частині дельти Свято-Георгіївського рукава, але у значно менших масштабах. Сулинський рукав не має дельти висунення, він зазнав суттєвого антропогенного впливу, був спрямлений для зручності судноплавства, а в кінцевій частині, при впадінні у море, затиснутий з двох боків дамбами завдовжки понад 10 км для забезпечення виносу зважених часток із зони прибережної мілини подалі у море на ділянку звалу глибин.

Збереження біологічного різноманіття дельти, відтворення та розвитку її унікальних екосистем на сьогодні, в умовах перерозподілу водного стоку та інших антропогенних впливів потребує особливої уваги широкого загалу як вчених, можновладців, так і пересічних небайдужих громадян. Представлені у роботі матеріали ще раз показали як високу природну цінність гідроекосистем дельти загалом, зумовлену надзвичайним видовим багатством та різноманіттям, так і особливості її окремих водних об'єктів, з яких, власне, й складаються унікальні загальні показники.

Вивчення пониззя та дельти Дунаю українськими та румунськими гідробіологами має вже понад сторічну історію, від досліджень Дж. Р. Боургугната [BOURGUIGNAT 1870], А. А. Остроумова [OSTROUMOV 1897, 1898], С. О. Зернова [ZERNOV 1908], К. О. Мілашевича [MILASHEVICH 1908] та Г. Антипи [ANTIPA 1914] кінця позаминулого –

початку минулого сторіччя, Г. Шпандля [SPANDL 1926], Ю. М. Марковського [MARKOVSKYI 1955], А. М. Алмазова, К. С. Владимирової, К. К. Зерова, Г. А. Оливари, Я. В. Ролла, Я. Я. Цееба [DUNAY…1961], В. В. Поліщука [POLISCHUK 1974], О. І. Іванова [IVANOV 1987], Т. А. Харченка [KHARCHENKO 1993, KHARCHENKO, LYASHENKO 1998, KHARCHENKO, LYASHENKO, BASHMAKOVA 2000, 2001] – середини та кінця минулого століття, до робіт дослідників останніх десятиліть – українських науковців С. О. Афанасьєва [AFANASYEV et al. 2008], А. В. Ляшенка та Зоріної-Сахарової [LIASHENKO, ZORINA-SAKHAROVA 2002–2017], Т. М. Дьяченко [2006, 2011] та румунських дослідників [DANUBE…2006].

Сучасний період гідроекологічних досліджень річки характеризується не тільки комплексним вивченням водних екосистем, біотичних угруповань та окремих популяцій гідробіонтів, але й глибоким аналізом внутрішньоводойменних процесів, що в них відбуваються, зокрема під впливом антропогенних та кліматогенних факторів. Систематичні, понад 60-річні дослідження Інституту гідробіології НАН України, розпочаті одразу після війни, дозволили створити оригінальний банк гідробіологічних даних, встановити певні закономірності формування біорізноманіття, функціонування водних ценозів, виконати оцінки біопродукційного потенціалу і якості вод українсько-румунської ділянки річки та її дельти. З 2005 по 2012 роки Інститут гідробіології разом з іншими установами НАН України брав участь у державній програмі Комплексного екологічного моніторингу довкілля при відновленні та експлуатації глибоководного суднового ходу Дунай – Чорне море, де відповідав за блок гідроекологічних проблем прісноводної частини Кілійської дельти. Власне до розділу “Пропозиції до розробки схеми моніторингу водних об’єктів дельти Дунаю” увійшли напрацювання за результатами цієї роботи.

Питання втілення в пониззі та дельті Дунаю спільного міжнародного моніторингу в останні роки стало нагальним. Основною проблемою було й залишається впровадження в Україні положень Директиви 2000/60/ЄС. У придунайських країнах членах ЄС проведення моніторингу та класифікації водних об’єктів на основі порівняння референційних показників з актуальними, отриманими в ході натурних досліджень біологічних та підтримуючих гідроморфологічних та фізико-хімічних показників, є обов’язковим. Україна, ратифікувавши Дунайську конвенцію, фактично зобов’язалася надавати дані моніторингу Дунаю у форматі Директиви 2000/60/ЄС ще в 2002 році, але тільки після підписання Угоди про Асоціацію Україна/ЄС такий підхід отримав остаточне визнання в Законах і підзаконних актах та національних нормативно-правових документах. Прийняття Постанови Кабінету Міністрів України від 19 вересня 2018 р. № 758 «Про затвердження Порядку здійснення державного моніторингу вод», у підготовці проекту якого брали участь науковці Інституту гідробіології, стала остаточним кроком у напрямку гармонізації законодавства України та ЄС у галузі оцінки екологічного стану масивів поверхневих вод за європейськими правилами.

Зауважимо, що представлена монографія вигідно відрізняється навіть від найбільш вагомих публікацій останніх років тим, що містить максимально повні переліки видів основних груп гідробіонтів, до того ж складених окремо за конкретними типами масивів поверхневих вод та по різним станціям спостережень. Це важливо в плані реалізації підходів Директиви 2000/60/ЄС як для визначення значень референсних показників, так і для подальшої оцінки екологічного стану масивів поверхневих вод пониззя та дельти Дунаю.

Загалом можна констатувати, що гідроекологічні дослідження на Дунаї на сьогодні вступили в нову фазу, що характеризується міжнародною інтеграцією та співробітництвом на засадах використання спільних підходів та залучення інтернаціональних команд для вирішення як суто наукових, фундаментальних, так і прикладних, водогосподарських та управлінських питань та проблем.

Concluzii

Este alcătuit rezumatul încă unei etape de cercetare a Deltei Dunării, a doua după Volga, deltă din Europa, creată prin scurgerea unui fluviu. Dunărea este un fluviu internațional, bazinul său acoperă teritoriile din 18 țări, iar delta însăși este împărțită între două state – Ucraina și România. Sectoarele inferioare și delta Dunării nu au doar o semnificație europeană, ci și o semnificație planetară. Prin urmare, în lucrare este făcut accent anume pe rezultatele cercetărilor internaționale comune.

Dunărea unul dintre cele mai mari fluvii din lume și are o trăsătură distinctivă: curgând după defileul Đerdap într-un sector de aproape 1000 km, într-o albie cu diguri naturale relativ puține, apa fluviului devine foarte tulbură datorită unei cantități mari de aluviuni în suspensie. Cantitatea medie anuală a acestora pe parcursul observațiilor timp de mai mulți ani este de 170-200 g/m^3, cu valori maxime de până la 2,3 kg/m^3, volumul anual de aluviuni poate fi de până la 100 mln. tone pe an. Concentrația mare de particule în suspensie determină dezvoltarea deltei ramificate sau maritime secundare, care este în continuă extindere spre mare.

Delta se începe în bifurcatia în zona Ceatalului Izmail prin bifurcația albiei principale a Dunării în două brațe: Tulcea (român) și Chilia, care concomitent alcătuiește hotarul ucrainean-român. Brațul Tulcea este destul de scurt (14 kilometri), în amonte de Tulcea acesta se ramifică în brațul Sulina și brațul Sfântu Gheorghe. Caracteristicile hidrobiologice ale diferitelor brațuri au propriile sale particularități, confirmate de studiul nostru, uneori, vorbim despre deltele unor brațe separate: delta brațului Chilia, delta brațului Sfântu Gheorghe și delta brațului Sulina. Acestea au evoluat istoric în diferite moduri și au fost expuse unor diverse interferențe antropice.

Cea mai tânără este delta secundară a brațului Chilia, situată sub orașul Vilcovo, procesul de formare a acesteia a început aproximativ 300 de ani în urmă și continuă până în prezent. Acesta este cauzat de astfel de procese hidrofizice, cum ar fi amestecarea turbulentă a masei de apă, sedimentarea particulelor aluviale, formarea solurilor de fund, amestecarea apelor dulci și sărate, inundarea teritoriilor mari etc. La vărsarea Dunării în mare și reducerea vitezei curentului, particulele în suspensie se sedimentează, se formează limbe de coastă, golfuri desalinizate (colțuri), lacuri și insule în interiorul deltei. Partea activă a deltei Chilia sau zona de avansare este legată hidraulic cu debitul fluviului și marea. Insulele sunt acoperite cu vegetație lacustră (baltă). Complexele incomparabile de apă și terenuri sunt bogate în habitate unice, care oferă posibilitatea existenței nu numai a unor specii obișnuite, răspândite, dar și celor rare, endemice și relicve, reprezentând lumea animală și vegetală, care s-a păstrat din epocile geologice trecute.

Într-o oarecare măsură, procese similare au loc și în sectorul anterior în partea de mare a deltei Sfântu Gheorghe, dar într-o proporție mult mai mică. Brațul Sulina nu are o deltă de extindere, acesta a suferit un impact semnificativ antropogen, a fost îndreptat pentru confortul navigației și în final, la vărsarea în mare este înconjurat din ambele părți de baraje pe o distanță mai mare de 10 km pentru a asigura îndepărtarea particulelor în suspensie din zona bancului de coastă spre mare în zona pantei continentale.

Conservarea diversității biologice a deltei, reproducerea și dezvoltarea ecosistemelor sale unice, în prezent, în condițiile redistribuirii debitului de apă și a altor impacte antropogene, necesită o atenție deosebită a publicului larg, atât din partea savanților, autorităților, cât și din partea cetățenilor obișnuiți, neindiferenți. Materialele prezentate în lucrare au demonstrat încă o dată valoarea naturală înaltă a sistemelor hidroecologice ale deltei în general, datorită bogăției și diversității extraordinare a florei și faunei, precum și particularităților obiectelor acvatice individuale, care, de fapt, constituie indicatori generali unici.

Studiul teritoriului pe cursul inferior al apei și a deltei Dunării de către hidrobiologii ucraineni și români numără mai mult de un secol, începând de la cercetările lui J.R.Bourgugnat [BOURGUIGNAT 1870], A.A.Ostroumov [OSTROUMOV 1897; 1898] S.O.Zernov [ZERNOV 1908], K.O.Milașevici [MILASHEVICH 1908], G.Antipa [ANTIPA 1914] de la sfârșitul secolului precedent celui trecut – începutul secolului trecut, G.Șpandlea [SPANDL 1926], Iu.M.Marcovschii [MARKOVSKYI 1955], A.M.Almazov, K.S.Vladimirov, K.K.Zerov, G.A.Olivar, Ia.V.Rolla, Ia.Ia. Țeeba [DUNAY…1961], V.V.Polișciuc [POLISCHUK 1974], O.I.Ivanov [IVANOV 1987], T.A.Harcenco

[KHARCHENKO 1993, KHARCHENKO, LYASHENKO 1998, KHARCHENKO, LYASHENKO, BASHMAKOVA 2000, 2001] – jumătatea și sfârșitul secolului trecut, până la lucrările savanților contemporani S.O.Afanasiev [AFANASYEV et al. 2008], A.V.Liașenco și Zorina-Saharova [LIASHENKO, ZORINA-SAKHAROVA 2002-2017], T.M.Diacenco [2006, 2011] și cercetători români [DANUBE…2006].

Perioada modernă de cercetări hidroecologice a fluviului este caracterizată nu numai prin studiul complex al ecosistemelor acvatice, grupurilor biotice și a populațiilor separate de hidrobionți, dar și prin analiza aprofundată a proceselor din interiorul acvariului, care apar în special sub influența factorilor antropogeni și climatogeni. Studiile sistematice, efectuate timp de peste 60 de ani de Institutul de Hidrobiologie de pe lângă Academia Națională de Științe din Ucraina, s-au început imediat după război, au contribuit la crearea băncii originale de date hidrobiologice, la stabilirea unor legități a formării biodiversității, a funcționării cenozei acvatice, la evaluarea potențialului de bio-producție și a calității apei în secțiunea ucrainean-român a fluviului și a deltei acestuia. Din anul 2005 până în anul 2012, Institutul de Hidrobiologie, împreună cu alte instituții din cadrul Academiei Naționali de Științe din Ucraina a participat la programul de stat de monitorizare complexă a mediului ecologic în timpul restabilirii și exploatării șenalului navigabil adânc Dunărea-Marea Neagră, unde a fost responsabil de analiza problemelor legate de sectorul cu apă dulce din delta Chilia. De fapt, capitolul ”Propuneri pentru elaborarea schemelor de monitorizare a obiectelor acvatice din delta Dunării“ conține date, obținute în rezultatul acestei lucrări.

Problema implementării în teritoriul pe cursul inferior al apei și în delta Dunării a monitorizării internaționale comune a devenit urgent în ultimii ani. Principala problemă a fost implimentarea a dispozițiilor Directivei 2000/60/CE în Ucraina. În țările dunărene, membre UE, monitorizarea și clasificarea obiectele acvatice în baza comparație indicatorilor referențiali cu cei reali, obținuți în timpul studiilor de teren ale indicatorilor biologici și de suport hidromorfologici și fizico-chimici, sunt obligatorii. Ucraina, ratificând Convenția Dunării, s-a angajat, de altfel, să furnizeze datele de monitorizare a Dunării sub forma Directivei 2000/60/CE încă din anul 2002, însă numai după semnarea Acordului de asociere Ucraina/UE această abordare a fost recunoscută în final în Legile și actele legislative și actele normative naționale. Adoptarea Rezoluției Cabinetului de Miniștri al Ucrainei din 19 septembrie 2018 nr. 758 „Cu privire la aprobarea procedurii de implementare a monitorizării de stat a apelor", în elaborarea căreia au participat cercetători ai Institutului de Hidrobiologie, a devenit ultimul pas spre armonizarea legislației Ucrainei și UE în domeniul evaluării stării ecologice a obiectelor acvatice de suprafață conform regulilor europene.

Reținem că monografia prezentată se distinge favorabil chiar și de cele mai importante publicații din ultimii ani, prin faptul că conține cele mai complete liste de specii din principalele grupe de hidrobionți, pe lângă acestea, alcătuite separat în funcție de tipurile de obiecte acvatice de suprafață și diferite stații de monitorizare, ceea ce est important în ceea ce privește implimentarea abordării din Directiva 2000/60/CE, atât pentru definirea valorilor de referință, cât și pentru evaluarea ulterioară a stării de mediu a apelor de suprafață din teritoriul pe cursul inferior al apei și din delta Dunării.

În general, se poate afirma că în prezent studiile hidroecologice a fluviului Dunărea au intrat într-o nouă fază, caracterizată prin integrarea și cooperarea internațională pe baza utilizării unor abordări comune și a implicării echipelor internaționale în rezolvarea aspectelor și problemelor pur științifice, fundamentale și aplicate din domeniul gospodării și gestionării apelor.

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Anex 1.Species list of hydrobionts Danube delta delta (2006-2007).

№	Taxon	Part of delta																
		Sulina delta								Romania	Kiliya delta							Ukraine
		water courses				water bodies					water courses			water bodies				
		Lopatna	Suez	Sulimanca	total	Matita	Merhei	Small Merhei	total		Bystryi	Vostochnyi	total	Anankin Kut	Potapiv Kut	Deliukiv Kut	total	
		Macrophytes																
	Macroalgae																	
1.	Filamentous alga					+	+		+	+				+	+	+	+	+
2.	Chara sp.						+		+	+					+		+	+
	Bryophyta																	
3.	Fontinalis sp.		+		+					+	+		+					+
	Spermatophyta submerged Rhizophytes																	
4.	Elodea canadensis Michx. HCY	+			+	+			+	+					+		+	+
5.	Myriophyllum spicatum L. HAL			+	+		+	+	+	+				+	+		+	+
6.	Najas marina L. NAJ						+		+	+		+	+					+
7.	Potamogeton crispus L. POT	+			+	+	+	+	+	+				+	+		+	+
8.	P. pectinatus L. POT	+	+		+	+	+	+	+	+	+	+	+	+	+	+	+	+
9.	P. pusillus L. POT					+			+	+								
10.	P. perfoliatus L. POT		+		+	+	+		+	+	+		+			+	+	+
11.	Vallisneria spiralis L. HCY						+		+	+								

№	Taxon	Part of delta																
		Sulina delta								Romania	Kiliya delta							Ukraine
		water courses				water bodies					water courses			water bodies				
		Lopatna	Suez	Sulimanca	total	Matita	Merhei	Small Merhei	total		Bystryi	Vostochnyi	total	Anankin Kut	Potapiv Kut	Deliukiv Kut	total	
	Spermatophyta, free floating and floating leafed plants																	
12.	Ceratophyllum demersum L. CTR	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
13.	Stratiotes aloides L.HCY	+			+	+	+		+	+				+		+	+	+
14.	Lemna trisulca L. LMN					+		+	+	+				+	+		+	+
15.	Lemna minor L. LMN					+	+	+	+	+	+		+	+	+	+	+	+
16.	Spirodela polirhiza (L.) SCHLEIDEN LMN					+	+	+	+	+				+	+	+	+	+
17.	Hydrocharis morsus-ranae L. HCY	+			+	+	+	+	+	+				+	+	+	+	+
18.	Salvinia natans L.SLI	+			+					+		+	+	+	+	+	+	+
19.	Azolla caroliniana Wild. AZO														+		+	+
20.	P. natans L. POT														+	+	+	+
21.	Nuphar lutea (L.) Smith. NYM	+	+		+	+	+	+	+	+						+	+	+
22.	Nymphaea alba L. NYM	+			+	+	+	+	+	+				+			+	+
23.	Nymphaea candida J. et C.Pres.NYM													+			+	+
24.	Nyphoides peltata (S.G. Gmel.) O. Kuntze NYM													+			+	+
25.	Trapa natans L.s.l. TRA	+			+	+	+		+	+				+	+	+	+	+
	Spermatophyta, Helophytes																	
26.	Sagittaria sagittifolia L. ALI					+			+	+	+		+			+	+	+

№	Taxon	Part of delta																
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		water courses				water bodies					water courses			water bodies				
		Lopatna	Suez	Sulimanca	total	Matita	Merhei	Small Merhei	total		Bystryi	Vostochnyi	total	Anankin Kut	Potapiv Kut	Deliukiv Kut	total	
27.	Alisma gramineum LEJEUNE ALI		+		+					+								
28.	Scirpus sylvaticus L.CYP		+		+					+								
29.	Sparganium erectum L. SPG		+		+					+		+	+			+	+	+
30.	Butomus umbellatus L. BOT											+	+			+	+	+
31.	Glyceria maxima (C. Hartm.) Holmberg POA	+	+		+					+		+	+					+
32.	Phragmites australis (Cav.) Trin. ex Steud. POA	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
33.	Schoenoplectus lacustris (L.) Palla POA										+		+		+		+	+
34.	Typha angustifolia L. TYP	+	+		+	+	+	+	+	+	+	+	+	+	+	+	+	+
35.	Typha latifolia L. TYP	+	+		+	+	+	+	+	+		+	+					+
		Phytoplankton																
	Cyanoprokaryota																	
36.	Dactylococcopsis acicularis Lemm.			+	+	+	+	+	+	+								
37.	Dactylococcopsis elenkinii Roll						+		+	+								
38.	Dactylococcopsis linearis Geitl.		+		+		+	+	+	+								
39.	Dactylococcopsis rhaphidioides Hansg.			+	+	+			+	+								
40.	Synechococcus elongatus Näg.		+	+	+	+	+	+	+	+								

№	Taxon	Part of delta																
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		water courses				water bodies					water courses			water bodies				
		Lopatna	Suez	Sulimanca	total	Matita	Merhei	Small Merhei	total		Bystryi	Vostochnyi	total	Anankin Kut	Potapiv Kut	Deliukiv Kut	total	
41.	Synechococcus major Schröt.		+		+					+								
42.	Synechocystis sp.			+	+					+								
43.	Synechocystis minuscula Woronich.		+		+					+								
44.	Merismopedia glauca (Ehr.) Näg.			+	+	+	+	+	+	+	+		+		+		+	+
45.	Merismopedia minima G. Beck	+	+	+	+	+	+	+	+	+	+		+	+	+	+	+	+
46.	Merismopedia punctata Meyen	+	+	+	+	+	+	+	+	+					+		+	+
47.	Merismopedia elegans A. Br.	+			+					+								
48.	Merismopedia tenuissima Lemm.		+	+	+	+	+	+	+	+	+		+		+		+	+
49.	Pseudoholopedia convoluta (Bréb.) Elenk.		+		+		+	+	+	+								
50.	Microcystis aeruginosa Kütz. emend Elenk.	+	+	+	+	+	+	+	+	+				+			+	+
51.	Microcystis pulverea (Wood) Forti emend. Elenk.	+		+	+	+	+	+	+	+	+	+	+	+			+	+
52.	Microcystis pulverea f.inserta (Lemm.) Elenk.	+	+	+	+	+	+	+	+	+				+			+	+
53.	Eucapsis minuta F.E. Fritsch															+	+	+
54.	Aphanothece stagnina (Spreng.) B.-Peters. et Geitl. emend.		+		+					+								
55.	Coelosphaerium kuetzingianum Näg.		+	+	+	+	+	+	+	+								
56.	Gomphosphaeria aponina Kütz.		+		+					+								

№	Taxon	Part of delta																
		Sulina delta								Romania	Kiliya delta							Ukraine
		water courses				water bodies					water courses			water bodies				
		Lopatna	Suez	Sulimanca	total	Matita	Merhei	Small Merhei	total		Bystryi	Vostochnyi	total	Anankin Kut	Potapiv Kut	Deliukiv Kut	total	
57.	Gomphosphaeria lacustris Chod.	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
58.	Gomphosphaeria lacustris v. compacta (Lemm.) Elenk.	+	+	+	+	+	+	+	+	+				+	+		+	+
59.	Gloeocapsa magma (Breb.) Kütz. emend. Hollerb.						+	+	+	+								
60.	Gloeocapsa turgida (Kütz.) Hollerb.		+	+	+	+	+	+	+	+				+			+	+
61.	Marsoniella elegans Lemm.	+	+	+	+	+	+	+	+	+	+	+	+	+			+	+
62.	Rhabdoderma lineare Scmidle et Laut. emend. Hollerb					+			+	+								
63.	Anabaena sp.	+	+		+	+	+	+	+	+				+			+	+
64.	Anabaena scheremetievi Elenk.						+		+	+				+			+	+
65.	Anabaena spiroides Kleb.	+	+	+	+	+	+		+	+				+			+	+
66.	Aphanizomenon issatschenkoi (Ussatsch.) Pr.-Lavr.	+	+	+	+	+	+	+	+	+				+			+	+
67.	Aphanizomenon flos-aquae (L.) Ralfs	+	+	+	+	+	+	+	+	+				+	+		+	+
68.	Oscillatoria chalybea (Mert.) Gom.											+	+	+			+	+
69.	Oscillatoria planctonica Wolosz.	+	+	+	+	+	+	+	+	+	+	+	+		+	+	+	+
70.	Oscillatoria lacustris (Kleb.) Geitl.						+		+	+		+	+					+
71.	Oscillatoria limosa Ag.	+			+	+	+		+	+						+	+	+
72.	Spirulina major Kütz.							+	+	+								

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		Sulina delta								Romania	Kiliya delta							Ukraine
		water courses				water bodies					water courses			water bodies				
		Lopatna	Suez	Sulimanca	total	Matita	Merhei	Small Merhei	total		Bystryi	Vostochnyi	total	Anankin Kut	Potapiv Kut	Deliukiv Kut	total	
73.	Spirulina minima Kütz.		+	+	+		+		+	+								
74.	Spirulina raphidioides Geitl.		+		+	+	+	+	+	+								
75.	Romeria elegans (Wolosch.) Koszhw.		+		+	+	+	+	+	+								
76.	Romeria leopoliensis (Racib.) Koszhw.		+	+	+	+	+	+	+	+								
77.	Lyngbya circumcreta G.S. West		+	+	+	+	+	+	+	+								
78.	Lyngbya limnetica Lemm.	+	+	+	+	+	+	+	+	+								
79.	Phormidium sp.	+			+					+								
80.	Phormidium molle (Kütz.) Gom.		+		+			+	+	+								
81.	Phormidium mucicola Hub.-Pestalozzi	+	+	+	+		+		+	+								
82.	Cylindrospermum sp.						+		+	+								
	Dinophyta																	
83.	Katodinium sp.			+	+					+								
84.	Glenodinium sp.					+			+	+				+			+	+
85.	Glenodinium berolinense (Lemm.) Lind.			+	+	+		+	+	+								
86.	Glenodinium quadridens (Stein) Schiller	+	+	+	+	+	+	+	+	+								
87.	Gymnodinium sp.	+		+	+	+	+	+	+	+	+		+	+			+	+
88.	Peridinium aciculiferum Lemm.						+	+	+	+								
89.	Peridinium sp.	+	+		+	+	+		+	+								

№	Taxon	Part of delta																
		Sulina delta								Romania	Kiliya delta							Ukraine
		water courses				water bodies					water courses			water bodies				
		Lopatna	Suez	Sulimanca	total	Matita	Merhei	Small Merhei	total		Bystryi	Vostochnyi	total	Anankin Kut	Potapiv Kut	Deliukiv Kut	total	
	Cryptophyta																	
90.	Cryptomonas sp.	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
91.	Cryptomonas erosa Ehr.	+	+	+	+	+	+	+	+	+								
92.	Cryptomonas anas Javorn.							+	+	+								
93.	Cryptomonas nasuta Pasch.			+	+	+	+		+	+								
94.	Cryptomonas ovata Ehr.						+		+	+								
95.	Rhodomonas pusilla (Bachm.)	+	+	+	+	+		+	+	+								
	Euglenophyta																	
96.	Trachelomonas armata (Ehr.) Stein											+	+					+
97.	Trachelomonas hispida (Perty) emend. Defl.	+			+	+	+		+	+	+		+	+		+	+	+
98.	Trachelomons intermedia Dang.															+	+	+
99.	Trachelomonas lemmermanii Wolosz.													+			+	+
100.	Trachelomonas planctonica Swir.													+		+	+	+
101.	Trachelomonas rugulosa Stein						+		+	+	+		+					+
102.	Trachelomonas volvocina Ehr.	+			+	+	+	+	+	+	+		+	+	+	+	+	+
103.	Strombomonas acuminata (Schmarda) Defl.	+			+	+			+	+								

№	Taxon	Part of delta																
		Sulina delta								Romania	Kiliya delta							Ukraine
		water courses				water bodies					water courses			water bodies				
		Lopatna	Suez	Sulimanca	total	Matita	Merhei	Small Merhei	total		Bystryi	Vostochnyi	total	Anankin Kut	Potapiv Kut	Deliukiv Kut	total	
104.	Strombomonas urceolata (Stokes) Defl.	+			+	+			+	+				+			+	+
105.	Euglena acus Ehr.	+			+	+	+		+	+				+	+	+	+	+
106.	Euglena bucharica I. Kissel.	+	+	+	+	+	+	+	+	+					+	+	+	+
107.	Euglena granulata (Klebs) Schmitz	+	+	+	+	+	+		+	+				+	+	+	+	+
108.	Euglena limnophila Lemm.													+			+	+
109.	Euglena obtusa Schmitz		+	+	+		+		+	+				+			+	+
110.	Euglena oxyuris Schmarda	+			+					+	+		+	+			+	+
111.	Euglena pasheri Swir.						+		+	+								
112.	Euglena spirogyra Ehr.													+			+	+
113.	Euglena vagans Defl.	+	+		+	+	+		+	+				+	+		+	+
114.	Euglena viridis Ehr.					+			+	+					+		+	+
115.	Euglena sp.	+	+		+	+	+	+	+	+				+	+	+	+	+
116.	Lepocinclis fusiformis (Carter) Lemm.	+		+	+		+		+	+	+		+	+	+	+	+	+
117.	Lepocinclis globula Perty			+	+	+			+	+								
118.	Lepocinclis ovum (Ehr.) Lemm.	+			+	+	+		+	+				+	+		+	+
119.	Lepocinclis steinii Lemm.													+			+	+
120.	Phacus agilis Skuja															+	+	+
121.	Phacus anaceolus Stokes													+			+	+

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		water courses				water bodies					water courses			water bodies				
		Lopatna	Suez	Sulimanca	total	Matita	Merhei	Small Merhei	total		Bystryi	Vostochnyi	total	Anankin Kut	Potapiv Kut	Deliukiv Kut	total	
122.	Phacus curvicauda Swir.					+			+	+					+	+	+	+
123.	Phacus longicauda (Ehr.) Duj.															+	+	+
124.	Phacus longicauda v. tortus Lemm.													+			+	+
125.	Phacus megalopsis Pochm.	+	+		+	+			+	+								
126.	Phacus megapirenoides Roll	+			+	+			+	+				+	+		+	+
127.	Phacus mirabilis Pochm.	+	+	+	+		+	+	+	+				+			+	+
128.	Phacus monilatus Stokes													+			+	+
129.	Phacus monilatus v. suecicus Lemm.													+	+		+	+
130.	Phacus onyx Pochm.						+		+	+								
131.	Phacus orbicularis Hübner														+	+	+	+
132.	Phacus parvulus Klebs													+			+	+
133.	Phacus pleuronectes (Ehr.) Duj.										+		+					+
134.	Phacus polytrophos Pochm.						+		+	+								
135.	Phacus pyrum (Ehr.) Stein															+	+	+
136.	Phacus setosus France	+	+	+	+	+	+	+	+	+				+			+	+
137.	Phacus striatus France	+			+					+								
138.	Phacus triquetrus (Ehr.) Duj.			+	+					+								

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		water courses				water bodies					water courses			water bodies				
		Lopatna	Suez	Sulimanca	total	Matita	Merhei	Small Merhei	total		Bystryi	Vostochnyi	total	Anankin Kut	Potapiv Kut	Deliukiv Kut	total	
139.	Astasia curvata Klebs			+	+					+								
140.	Cryptoglena pigra Ehr.	+		+	+	+	+	+	+	+				+	+	+	+	+
141.	Gyropaigne intermedia Asaul		+		+					+								
	Chlorophyta																	
142.	Chlamydomonas sp.	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
143.	Chlamydomonas monadina Stein	+																
144.	Chlamydomonas mucosa (Korsch.)						+		+	+								
145.	Chlamydomonas reinhardtii Dang.	+	+	+	+	+	+	+	+	+		+	+	+	+	+	+	+
146.	Chlamydomonas zebra Korsch.						+		+	+								
147.	Carteria radiosa Korsch.	+			+					+								
148.	Lobomonas ampla Pasch.						+	+	+	+								
149.	Lobomonas stellata Chod.						+	+	+	+								
150.	Phacotus coccifer Korsch.	+	+	+	+	+	+	+	+	+	+		+		+		+	+
151.	Phacotus pallidus Korsch.													+			+	+
152.	Pteromonas angulosa Lemm.													+			+	+
153.	Pyramomonas sp.					+	+	+	+	+						+	+	+
154.	Pedinopera robusta Matv.	+	+	+	+	+			+	+								

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		water courses				water bodies					water courses			water bodies				
		Lopatna	Suez	Sulimanca	total	Matita	Merhei	Small Merhei	total		Bystryi	Vostochnyi	total	Anankin Kut	Potapiv Kut	Deliukiv Kut	total	
155.	Volvulina steinii Playf.						+	+	+	+								
156.	Gonium pectorale Müll.						+		+	+								
157.	Pandorina charkoviensis Korsch.													+			+	+
158.	Pandorina morum (Müll.) Bory	+			+	+	+	+	+	+					+	+	+	+
159.	Eudorina elegans Ehr.	+			+	+	+		+	+								
160.	Golenkinia radiata Chod.		+	+	+	+	+	+	+	+	+		+		+		+	+
161.	Golenkiniopsis longispina (Korsch.) Korsch.			+	+		+	+	+	+								
162.	Golenkiniopsis parvula (Woronich). Korsch					+			+	+								
163.	Ankyra judayi (G.M. Smith) Fott	+		+	+	+			+	+								
164.	Characium pluriococcum Korsch.										+		+					+
165.	Polyedriopsis spinulosa (Schmidle) Schmidle	+	+	+	+					+								
166.	Siderocelis ornata (Fott) Fott	+			+	+			+	+								
167.	Treubaria euryacantha (Schmidle) Korsch.			+	+	+			+	+								
168.	Treubaria planctonica (G.M. Smith) Korsch.	+			+					+								
169.	Treubaria setigera (Arch.) G.M. Smith					+			+	+				+			+	+
170.	Treubaria triappendiculata Bern.	+	+	+	+	+		+	+	+								

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		Lopatna	Suez	Sulimanca	total	Matita	Merhei	Small Merhei	total		Bystryi	Vostochnyi	total	Anankin Kut	Potapiv Kut	Deliukiv Kut	total	
171.	Dicellula planctonica Swir.		+	+	+	+		+	+	+								
172.	Schroederia setigera (Schröd.) Lemm.	+	+	+	+	+	+	+	+	+		+	+	+	+		+	+
173.	Schroederia spiralis (Printz) Korsch.	+	+	+	+	+	+	+	+	+					+		+	+
174.	Pediastrum boryanum (Türp.) Men.	+	+	+	+	+	+	+	+	+								
175.	Pediastrum duplex Meyen		+		+	+	+	+	+	+					+		+	+
176.	Pediastrum duplex v.gracillimum W. et. G.S. West	+	+	+	+	+	+	+	+	+								
177.	Pediastrum kawraiskyi Schmidle			+	+	+	+	+	+	+								
178.	Pediastrum simplex Meyen		+	+	+	+	+		+	+	+		+					+
179.	Pediastrum tetras (Ehrenb.) Ralfs	+	+	+	+	+	+	+	+	+					+	+	+	+
180.	Franceia tenuispina Korsch.	+	+	+	+	+	+	+	+	+				+			+	+
181.	Coenochloris pyrenoidosa Korsch.					+			+	+								
182.	Lagerheimia ciliata (Lagerh.) Chod.	+		+	+	+	+		+	+	+		+					+
183.	Lagerhemia genevensis (chod.) Chod.	+	+	+	+	+	+	+	+	+					+		+	+
184.	Lagerchemia marssonii Lemm.													+			+	+
185.	Lagerhemia wratislawiensis Schröd.					+	+	+	+	+				+			+	+
186.	Oocystis borgei Snow	+	+	+	+	+	+	+	+	+	+		+	+			+	+
187.	Oocystis lacustris Chod.					+			+	+					+		+	+

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		Sulina delta								Romania	Kiliya delta							Ukraine
		water courses				water bodies					water courses			water bodies				
		Lopatna	Suez	Sulimanca	total	Matita	Merhei	Small Merhei	total		Bystryi	Vostochnyi	total	Anankin Kut	Potapiv Kut	Deliukiv Kut	total	
188.	Oocystis submarina Lagerh.			+	+	+	+	+	+	+	+		+		+		+	+
189.	Dimorphococcus lunatus A. Br.							+	+	+								
190.	Tetraedron caudatum (Corda) Hansg.	+	+	+	+	+	+	+	+	+				+			+	+
191.	Tetraedron incus (Teil.) G.M. Smith	+		+	+	+	+	+	+	+				+		+	+	+
192.	Tetraedron minimum (A. Br.) Hansg.			+	+	+	+	+	+	+								
193.	Tetraedron triangulare Korsch.		+		+		+		+	+				+			+	+
194.	Monoraphidium arcuatum (Korsch.) Hind.	+	+	+	+	+	+	+	+	+	+	+	+	+	+		+	+
195.	Monoraphidium contortum (Thur.) Kom.-Legn.	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
196.	Monoraphidium irregulare (G.M. Smith) Kom.-Legn.			+	+	+	+	+	+	+								
197.	Monoraphidium minutum (Näg.) Kom.-Legn.	+	+	+	+	+	+	+	+	+	+		+	+	+	+	+	+
198.	Monoraphidium tortile (W. et G.S. West) Kom.-Legn.					+			+	+								
199.	Closteriopsis acicularis (G.M. Smith) Belcher et Swale	+		+	+	+	+	+	+	+		+	+	+		+	+	+
200.	Ankistrodesmus fusiformis Corda ex Korsch.	+		+	+	+	+	+	+	+	+		+	+	+		+	+
201.	Closteriopsis longissima (Lemm.) Lemm.											+	+					+

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		water courses				water bodies					water courses			water bodies				
		Lopatna	Suez	Sulimanca	total	Matita	Merhei	Small Merhei	total		Bystryi	Vostochnyi	total	Anankin Kut	Potapiv Kut	Deliukiv Kut	total	
202.	Monoraphidium griffithii (Berk.) Kom.-Legn.	+			+		+		+	+				+			+	+
203.	Closteriopsis acicularis (G.M. Smith) Belcher et Swale		+		+			+	+	+				+			+	+
204.	Nephrochlamys allantoidea Korsch.					+	+		+	+	+		+	+	+		+	+
205.	Nephrochlamys subsolitaria (G.S. West.) Korsch.					+			+	+								
206.	Micractinium bornhemiense (Corn.) Korsch.	+	+	+	+	+			+	+	+		+	+			+	+
207.	Micractinium crassisetum Hortob.					+			+	+								
208.	Micractinium pusillum Fres.	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
209.	Micractinium quadrisetum (Lemm.) G.M. Smith	+			+					+								
210.	Kirchneriella aperta Teil.					+			+	+								
211.	Kirchneriella lunaris (Kirchn.) Mob.		+	+	+	+	+		+	+		+	+	+		+	+	+
212.	Kirchneriella obesa (W.West) Schmidle	+		+	+			+	+	+								
213.	Quadrigula korschikoffii Kom.													+			+	+
214.	Raphidocelis sigmoidea Hind.					+			+	+								
215.	Selenastrum bibraianum Reinsch.											+	+					+
216.	Selenastrum gracile Reinsch.					+			+	+								
217.	Dictyosphaerium anomalum Korsch.		+	+	+		+	+	+	+								

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218.	Dictyosphaerium pulchellum Wood.	+		+	+					+								
219.	Dictyosphaerium subsolitaria von Goor			+	+					+								
220.	Dictyosphaerium tetrachotomum Printz	+	+	+	+	+	+	+	+	+	+		+	+			+	+
221.	Coelastrum astroideum De-Not	+	+	+	+	+	+	+	+	+		+	+					+
222.	Coelastrum microporum Näg.	+			+	+			+	+				+			+	+
223.	Coelastrum sphaericum Näg.	+			+	+	+		+	+		+	+			+	+	+
224.	Crucigeniella apiculata (Lemm.) Kom.		+	+	+	+	+	+	+	+				+			+	+
225.	Crucigenia fenestrata (Schmidle) Schmidle					+			+	+								
226.	Crucigenia lauterbornei (Schmidle) Schmidle						+	+	+	+								
227.	Crucigenia guadrata Morr.	+			+	+	+		+	+		+	+	+			+	+
228.	Crucigeniella rectangularis (Näg.) Kom.	+			+			+	+	+								
229.	Crucigenia tetrapedia (Kirchn.) W. et G.S. West	+	+	+	+	+	+		+	+		+	+	+	+		+	+
230.	Tetrachlorella alternans (G.M. Smith) Korsch.		+	+	+	+			+	+					+		+	+
231.	Tetrastrum elegans Playf.		+	+	+			+	+	+				+			+	+
232.	Tetrastrum heteracanthum (Nordst.) Chod.					+			+	+				+			+	+
233.	Tetrastrum komarekii Hind.							+	+	+								

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234.	Tetrastrum staurogeniaeforme (Schröd.) Lemm.	+	+	+	+	+	+	+	+	+		+	+	+	+		+	+
235.	Tetrastrum triangulare (Chod.) Kom.	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
236.	Actinastrum fluviatile (Schröd.) Fott		+	+	+	+	+		+	+		+	+			+	+	+
237.	Actinastrum hantzschii Lagerh.	+		+	+	+	+	+	+	+	+	+	+	+	+		+	+
238.	Didymogenes anomala (G.M. Smith) Hind.			+	+					+								
239.	Tetradesmus wisconsinense G.M. Smith		+	+	+	+	+	+	+	+								
240.	Scenedesmus acuminatus (Lag.) Chod.			+	+	+	+		+	+				+			+	+
241.	Scenedesmus acuminatus v. tortuosus Skuja		+		+					+								
242.	Scenedesmus acuminatus v. elongatus G.M. Smith	+	+	+	+	+	+		+	+				+			+	+
243.	Scenedesmus acutus Meyen					+	+		+	+				+			+	+
244.	Scenedesmus arcuatus (Lemm.) Lemm.					+			+	+								
245.	Scenedesmus bicaudatus Deduss.	+	+	+	+	+	+		+	+	+		+	+	+	+	+	+
246.	Scenedesmus caudato-aculeolatum Chod.		+		+	+			+	+					+		+	+
247.	Scenedesmus denticulatus Lagerh.	+	+	+	+	+	+		+	+		+	+	+	+		+	+
248.	Scenedesmus disciformis (Chod.) Fott et Kom.					+			+	+								

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249.	Scenedesmus falcatus Chod.	+	+	+	+		+	+	+	+	+	+	+		+		+	+
250.	Scenedesmus granulatus W. et G.S. West					+			+	+								
251.	Scenedesmus hystrix Lagerh.					+			+	+				+			+	+
252.	Scenedesmus intermedius Chod.	+	+	+	+	+	+	+	+	+	+	+	+	+	+		+	+
253.	Scenedesmus intermedius v.bicaudatus Hortob.		+	+	+					+								
254.	Scenedesmus lefevrii Defl.		+		+	+	+		+	+								
255.	Scenedesmus obliquus (Turp.) Kütz.	+	+	+	+		+		+	+	+	+	+		+	+	+	+
256.	Scenedesmus obtusus Meyen	+	+	+	+	+	+	+	+	+				+	+		+	+
257.	Scenedesmus opoliensis P. Richt	+	+	+	+	+	+	+	+	+	+		+	+	+		+	+
258.	Scenedesmus polyglobulus Hortob.						+		+	+								
259.	Scenedesmus quadricauda (Turp.) Breb.	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
260.	Scenedesmus spicatus W. et G.S. West	+		+	+	+			+	+		+	+	+	+	+	+	+
261.	Scenedesmus spinosus Chod.		+	+	+	+	+	+	+	+					+		+	+
262.	Didymocystis inconspicua Korsch.			+	+					+								
263.	Didymocystis inermis (Fott) Fott					+			+	+								
264.	Didymocystis planctonica Korsch.	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+

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265.	Granulocystis verrucosa (Roll) Hind.	+		+	+	+	+	+	+	+	+		+	+			+	+
266.	Closterium aciculare (Tuff.) West					+	+		+	+				+			+	+
267.	Closterium acerosum (Schrank) Ehr.		+		+	+			+	+				+		+	+	+
268.	Closterium acutum (Lyngb.) Bréb.					+	+		+	+								
269.	Closterium exiguum W. et G.S. West					+			+	+								
270.	Closterium gracile Bréb.					+	+		+	+								
271.	Closterium peracerosum Gay											+	+					+
272.	Closterium setaceum Ehr.														+		+	+
273.	Closterium venus Kütz.					+			+	+								
274.	Cosmarium orbiculatum Ralfs			+	+					+								
275.	Cosmarium ovale Ralfs							+	+	+								
276.	Cosmarium reniforme (Ralfs) Arch.														+		+	+
277.	Cosmarium sp.					+	+	+	+	+						+	+	+
278.	Cosmoastrum polytrichum (Perty) Pal.-Mordv.	+			+		+	+	+	+								
279.	Xanthidium sp.						+	+	+	+								
280.	Desmidium aptogonum Bréb.		+		+			+	+	+								
281.	Desmidium aptogonum v. acutius Nordst.		+		+		+	+	+	+								

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282.	Staurodesmus cuspidatus (Bréb.) Teil.					+			+	+								
283.	Staurastrum boreale W. et G.S. West	+			+					+								
284.	Staurastrum cingulum (W. et G.S. West.) G.M. Smith		+	+	+	+	+	+	+	+								
285.	Staurastrum inconspicuum Nordst.					+			+	+								
286.	Staurastrum paradoxum Meyen			+	+					+								
287.	Staurastrum sebaldii Reinsch.			+	+					+								
288.	Sraurastrum tetracerum Ralfs			+	+	+		+	+	+								
289.	Staurastrum sp.					+	+		+	+						+	+	+
	Chrysophyta																	
290.	Stenokalyx densata Schmid	+			+					+					+		+	+
291.	Stenokalyx incostans Schmid													+			+	+
292.	Stenokalyx monilifera Schmid			+	+	+	+	+	+	+				+			+	+
293.	Stenocalyx parvula Schmid	+	+	+	+	+	+	+	+	+				+			+	+
294.	Kephyrion cupuliforme Conr.			+	+					+								
295.	Kephyrion rubri-claustri Conr.	+	+	+	+					+				+	+		+	+
296.	Kephyrion ovum Pasch.										+		+					+
297.	Ochromonas sp.	+		+	+			+	+	+				+		+	+	+

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298.	Ochromonas nana Dofl.						+		+	+								
299.	Synochromonas gracilis Korsch.														+		+	+
300.	Dinobryon acuminatum Ruttn.															+	+	+
301.	Dinobryon bavaricum Imhof	+			+	+	+		+	+								
302.	Dinobryon divergens Imhof	+		+	+	+	+	+	+	+				+	+		+	+
303.	Dinobryon korschikofii Matv.													+			+	+
304.	Dinobryon korschikofii f. glabra (Korsch.) Matv.	+	+		+	+	+	+	+	+				+			+	+
305.	Dinobryon sertularia Ehr.	+		+	+	+			+	+								
306.	Dinobryon spirale Iwan.													+			+	+
307.	Pseudokephirion cinctum (Schill.) Schmid			+	+					+								
308.	Pseudokephyrion ovum (Pasch. et Ruttn.	+		+	+		+	+	+	+		+	+	+	+		+	+
309.	Pseudokephyrion pilidium Schill.																	
310.	Pseudokephirion poculum Conr.													+			+	+
311.	Pseudokephirion rutthneri (Schill.) Schmid.	+			+					+								
312.	Pseudokephyrion schilleri Conr.	+		+	+			+	+	+				+			+	+
313.	Pseudokephyrion undulatum (Klebs) Pasch.							+	+	+								

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314.	Pseudokephyrion sp.			+	+					+								
315.	Mallomonas sp.																	
316.	Mallomonas acaroides Perty		+	+	+	+			+	+				+			+	+
317.	Mallomonas curta (Playf.) Conr.	+			+					+								
318.	Mallomonas tonsurata Teil.	+			+					+								
	Xanthophyta																	
319.	Pseudostaurastrum enorme (Ralfs) Chod.					+			+	+								
320.	Pseudostaurastrum hastatum (Reinsch) Chod.		+		+	+			+	+								
321.	Goniochloris fallax Fott			+	+	+	+		+	+								
322.	Goniochloris laevis Pasch.	+	+	+	+	+	+	+	+	+				+		+	+	+
323.	Goniochloris spinosa Pasch.	+	+	+	+	+	+		+	+								
324.	Goniochloris tripus Pasch.						+		+	+				+		+	+	+
325.	Goniochloris mutica (A. Br.) Fott					+			+	+								
326.	Centritractus africanus Fritsch et Rich		+		+		+		+	+								
327.	Centritractus belenophorus Lemm.	+			+	+	+		+	+				+			+	+
328.	Centritractus globulosus Pasch.					+			+	+				+			+	+
329.	Ophiocytium arbuscula (A.Br.) Rabenh.	+			+					+								

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330.	Ophiocytium parvulum A. Br.						+		+	+								
331.	Pseudopolyedriopsis sp.			+	+					+								
332.	Tetraplektron acutum (Pasch.) Fott					+			+	+								
333.	Tetraplektron tribulus (Pasch.) Fott	+		+	+	+			+	+								
334.	Tetraedriella acuta Pasch.						+		+	+								
335.	Tetraedriella impressa Pasch.		+		+	+			+	+								
336.	Tetraedriella spinigera Skuja	+		+	+		+	+	+	+				+			+	+
	Bacillariophyta																	
337.	Melosira ambigua (Grun.) O. Müll.	+			+					+								
338.	Melosira binderana Kütz.					+			+	+				+		+	+	+
339.	Melosira distans (Ehr.) Kütz.													+			+	+
340.	Melosira granulata (Ehr.) Ralfs	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
341.	Melosira granulata v. angustissima (O. Müll.) Hust.	+	+	+	+	+	+	+	+	+	+	+	+	+	+		+	+
342.	Melosira italica (Ehr.) Kütz.					+			+	+								
343.	Cyclotella sp.	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
344.	Cyclotella bodanica Eulenst.	+			+	+			+	+	+	+	+	+	+	+	+	+
345.	Cyclotella kuentzingiana Thw.										+		+	+	+		+	+

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346.	Cyclotella melosiroides (Kirchn.) Lemm.													+		+	+	+
347.	Cyclotella meneghiniana Kütz.	+	+		+	+	+	+	+	+	+	+	+	+	+	+	+	+
348.	Cyclotella quadrijuncta (Schröter) Hust.	+			+	+			+	+	+	+	+					+
349.	Stephanodiscus astraea (Ehr.) Grun.	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
350.	Stephanodiscus dubius (Fricke) Hust.	+			+					+	+	+	+	+	+	+	+	+
351.	Stephanodiscus hantzschii Grun.	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
352.	Stephanodiscus subtilis (Van Goor) A. Cl.			+	+					+	+	+	+	+	+	+	+	+
353.	Coscinodiscus lacustris Grun.											+	+			+	+	+
354.	Rhizosolenia eriensis H. L. Sm.			+	+	+			+	+								
355.	Attheya zachariasii Brun	+			+	+			+	+								
356.	Diatoma elongatum (Lyngb.) Ag.			+	+					+		+	+	+	+		+	+
357.	Diatoma vulgare Bory										+	+	+					+
358.	Fragilaria capucina Desm.					+			+	+						+	+	+
359.	Fragilaria construens (Ehr.) Grun.			+	+					+				+			+	+
360.	Fragilaria construens v. binodis (Ehr.) Grun.		+		+		+		+	+								
361.	Fragilaria inflata (Heid.) Hust.			+	+	+	+	+	+	+								
362.	Fragilaria pinnata Ehr.		+	+	+	+	+		+	+								

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363.	Fragilaria virescens Ralfs	+	+	+	+	+	+	+	+	+				+	+		+	+
364.	Fragilaria virescens v. mesolepta Schönf.			+	+					+								
365.	Synedra actinastroides Lemm.	+	+	+	+	+	+		+	+	+	+	+		+		+	+
366.	Synedra acus Kütz.	+		+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
367.	Synedra capitata Ehr.					+	+	+	+	+								
368.	Synedra minuscula Grun.	+		+	+	+	+		+	+		+	+	+	+	+	+	+
369.	Synedra montana Krasske		+	+	+	+	+	+	+	+								
370.	Synedra pulchella (Ralfs) Kütz.			+	+					+								
371.	Synedra tabulata (Ag.) Kütz.	+	+	+	+	+	+	+	+	+	+		+	+		+	+	+
372.	Synedra tenera W. Sm.	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
373.	Synedra ulna (Nitzsch) Ehr.	+		+	+	+			+	+	+	+	+	+	+	+	+	+
374.	Synedra vauscheriae Kütz.			+	+					+								
375.	Asterionella formosa Hass.			+	+					+	+	+	+	+	+		+	+
376.	Cocconeis pediculus Ehr.	+			+		+		+	+				+		+	+	+
377.	Cocconeis placentula Ehr.	+	+	+	+	+	+	+	+	+	+	+	+		+	+	+	+
378.	Achnanthes minutissima Kütz.	+	+		+		+		+	+						+	+	+
379.	Neidium iridis (Ehr.) Cl.					+		+	+	+								

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		water courses				water bodies					water courses			water bodies				
		Lopatna	Suez	Sulimanca	total	Matita	Merhei	Small Merhei	total		Bystryi	Vostochnyi	total	Anankin Kut	Potapiv Kut	Deliukiv Kut	total	
380.	Navicula atomus (Näg.) Grun.	+		+	+	+	+	+	+	+		+	+	+	+	+	+	+
381.	Navicula cryptocephala Kütz.	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
382.	Navicula cryptocephala v. veneta (Kütz.) Grun.	+	+		+					+				+		+	+	+
383.	Navicula dicephala (Ehr.) W. Sm.		+		+					+					+		+	+
384.	Navicula exigua (Greg.) O. Müll.														+	+	+	+
385.	Navicula gracilis Ehr.														+		+	+
386.	Navicula gregaria Donk.														+		+	+
387.	Navicula hungarica Grun.															+	+	+
388.	Navicula hungarica v capitata (Ehr.) Cl.	+	+	+	+	+	+		+	+				+	+	+	+	+
389.	Navicula laterostrata Hust.										+		+		+		+	+
390.	Navicula menisculus Schum.														+		+	+
391.	Navicula mutica Kütz.			+	+					+								
392.	Navicula placentula (Ehr.) Grun.	+			+	+			+	+				+	+	+	+	+
393.	Navicula pupula Kütz.		+	+	+	+	+		+	+		+	+		+		+	+
394.	Navicula pupula v. rostrata Hust.														+		+	+
395.	Navicula radiosa Kütz.	+	+		+	+	+		+	+				+	+	+	+	+
396.	Navicula rhynchocephala Kütz.	+		+	+		+		+	+		+	+	+	+		+	+
397.	Navicula roteana (Rabenh.) Grun.															+	+	+

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398.	Navicula salinarum Grun.													+	+		+	+
399.	Navicula semen Ehr.													+			+	+
400.	Navicula tuscula (Ehr.) Grun.															+	+	+
401.	Navicula viridula Kütz.	+	+		+		+	+	+	+	+	+	+	+	+	+	+	+
402.	Navicula vulpina Kütz.					+			+	+					+		+	+
403.	Pinnularia gibba Ehr.					+			+	+								
404.	Pinnularia interrupta W. Sm.					+			+	+				+			+	+
405.	Pinnularia rangoonensis Grun.					+			+	+								
406.	Pinnularia subsolaris (Grun.)Cl.	+			+					+					+	+	+	+
407.	Caloneis amphisbaena (Bory) Cl.											+	+		+	+	+	+
408.	Caloneis bacillum (Grun.) Cl.	+			+					+								
409.	Caloneis permagna (Bail.) Cl.														+		+	+
410.	Gyrosigma acuminatum (Kütz.) Rabenh.													+		+	+	+
411.	Gyrosigma attenuatum (Kütz.) Rabenh.															+	+	+
412.	Gyrosigma distortum (W.Sm.) Cl.	+			+					+				+	+		+	+
413.	Gyrosigma spenceri (W. Sm.) Cl.											+	+	+		+	+	+
414.	Stauroneis anceps Ehr.		+		+					+								

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		water courses				water bodies				Romania	water courses			water bodies				Ukraine
		Lopatna	Suez	Sulimanca	total	Matita	Merhei	Small Merhei	total		Bystryi	Vostochnyi	total	Anankin Kut	Potapiv Kut	Deliukiv Kut	total	
415.	Stauroneis anceps v.gracilis (Ehr.) Cl.													+			+	+
416.	Amphora coffeaeformis Ag.	+			+					+								
417.	Amphora ovalis Kütz.	+	+	+	+	+	+	+	+	+				+	+	+	+	+
418.	Amphora perpusilla Grun.													+			+	+
419.	Amphora veneta Kütz.	+	+	+	+	+	+	+	+	+		+	+	+	+	+	+	+
420.	Cymbella cistula (Hemp.) Grun.			+	+					+					+	+	+	+
421.	Cymbella ehrenbergii Kütz.										+		+					+
422.	Cymbella lata Grun.							+	+	+						+	+	+
423.	Cymbella lanceolata (Ehr.) V.H.	+	+		+	+	+	+	+	+	+	+	+		+	+	+	+
424.	Cymbella pusilla Grun.	+	+	+	+	+			+	+				+		+	+	+
425.	Cymbella ventricosa Kütz.	+	+	+	+	+	+	+	+	+	+	+	+	+	+		+	+
426.	Cymbella sp.	+		+	+					+								
427.	Gomphonema acuminatum Ehr.	+			+					+	+		+		+		+	+
428.	Gomphonema acuminatum v. coronatum (Ehr.) W. Sm.													+			+	+
429.	Gomphonema augur Ehr.	+			+		+		+	+	+		+			+	+	+
430.	Gophonema constrictum Ehr.	+		+	+	+	+	+	+	+								
431.	Gomphonema constrictum v. capitatum (Ehr.) Cl.	+	+		+	+			+	+								

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432.	Gomphonema longiceps Ehr.	+			+					+	+	+	+		+		+	+
433.	Gomphonema longiceps v. subclavatum Grun.	+			+					+								
434.	Gomphonema tergestinum (Grun.) Fricke													+	+	+	+	+
435.	Gomphonema olivaceum (Lyngb.) Kütz.	+			+	+	+		+	+	+		+		+	+	+	+
436.	Gomphonema parvulum (Kütz.) Grun.															+	+	+
437.	Rhoicosphaenia abbreviata (Ag.) L.-B.					+	+		+	+	+		+	+	+		+	+
438.	Amphiprora paludosa W. Sm.														+		+	+
439.	Eunotia gracilis (Ehr.) Rabenh.	+			+					+								
440.	Epithemia intermedia Fricke													+	+		+	+
441.	Eunotia lunaris (Ehr.) Grun.	+	+		+	+			+	+	+		+					+
442.	Epithemia ocellata Kütz.			+	+		+		+	+				+			+	+
443.	Epithemia sorex Kütz.	+			+					+								
444.	Epithemia turgida (Ehr.) Kütz.			+	+	+	+	+	+	+				+	+	+	+	+
445.	Epitheima zebra (Ehr.) Kütz.		+	+	+	+	+		+	+					+		+	+
446.	Epithemia zebra v. parcellus (Kütz.) Grun.	+	+	+	+	+	+	+	+	+				+	+		+	+
447.	Rhopalodia gibba (Ehr.) O. Müll.	+		+	+	+	+	+	+	+				+	+	+	+	+

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448.	Rhopalodia musculus (Kütz.) O. Müll.	+	+		+		+		+	+								
449.	Bacillaria paradoxa Gmelin													+	+		+	+
450.	Nitzschia acicularis W.Sm.	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
451.	Nitzschia acuminata (W. Sm.) Grun.		+		+					+								
452.	Nitzschia amphibia Grun.	+			+					+								
453.	Nitzschia angustata (W. Sm.) Grun.		+		+					+								
454.	Nitzschia closterium (Ehr.) W. Sm.						+		+	+								
455.	Nitzschia communis Rabenh.										+		+		+		+	+
456.	Nitzschia dissipata (Kütz.) Grun.	+	+	+	+		+		+	+		+	+	+	+	+	+	+
457.	Nitzschia dubia W. Sm.											+	+					+
458.	Nitzschia gracilis Hantzsch	+		+	+	+			+	+	+	+	+	+	+	+	+	+
459.	Nitzschia fonticola Grun.						+	+	+	+	+		+					+
460.	Nitzschia hantzschiana Rabenh.													+			+	+
461.	Nitzschia kuetzingiana Hilse													+				
462.	Nitzschia linearis W. Sm.											+	+		+	+	+	+
463.	Nitzschia longissima (Breb.) Ralfs			+	+	+	+		+	+					+	+	+	+
464.	Nitzschia longissima v. reversa W. Sm.										+		+	+	+	+	+	+

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465.	Nitzschia palea (Kütz.) W. Sm.	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
466.	Nitzschia paleaceae Grun.	+			+	+	+		+	+	+	+	+		+	+	+	+
467.	Nitzschia recta Hantzsch	+		+	+	+	+		+	+	+	+	+	+	+		+	+
468.	Nitszhia scalaris (Ehr.) W. Sm.					+`			+	+								
469.	Natzschia sigmoidea (Ehr.) W. Sm.										+		+		+	+	+	+
470.	Nitzschia stagnorum Rabenh.													+			+	+
471.	Nitzschia subtilis (Kütz.) Grun.		+	+	+		+		+	+		+	+	+	+	+	+	+
472.	Nitzschia tryblionella Hantzsch													+			+	+
473.	Nitzschia vermicularis (Kütz.) Grun.											+	+	+		+	+	+
474.	Nitzcshia vitrea Norman	+			+					+								
475.	Cymatopleura elliptica (Breb.) Cl.															+	+	+
476.	Cymatopleura solea (Breb.)W. Sm.		+		+					+	+		+		+	+	+	+
477.	Cymatopleura solea v. gracilis Grun.	+			+	+			+	+				+	+		+	+
478.	Surirela biseriata Breb.	+			+	+			+	+				+	+		+	+
479.	Surirella elegans Ehr.										+	+	+		+		+	+
480.	Surirella delicatissima Lewis														+		+	+
481.	Surirella linearis W. Sm.	+			+					+								
482.	Surirella ovata Kütz.					+			+	+	+	+	+		+	+	+	+

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483.	Surirella robusta Ehr.					+			+	+					+		+	+
484.	Surirella robusta v.splendida (Ehr.) V.H.															+	+	+
		Zooplankton																
	ROTATORIA																	
485.	Notommata sp.		+	+	+			+	+	+	+		+			+	+	+
486.	Cephalodella sp.	+	+	+	+	+	+	+	+	+		+	+	+	+		+	+
487.	Trichocerca (D.) tigris Müller					+			+	+								
488.	T. (D.) intermedia Stenroos			+	+					+								
489.	T. (D.) similis (Wierzejski)	+	+	+	+	+	+	+	+	+				+	+	+	+	+
490.	T. (s. str.) bicristata Gosse	+	+		+					+								
491.	T. (s. str.) elongata (Gosse)		+		+	+	+	+	+	+								
492.	T. (s. str.) rattus (Müller)	+	+		+					+								
493.	T. (s. str.) cylindrica (Imhof)	+	+	+	+	+	+	+	+	+	+		+					+
494.	T. (s. str.) capucina (Wierz. et Zacharias)	+	+	+	+	+	+	+	+	+						+	+	+
495.	T. (s. str.) longiseta (Schrank)		+		+	+	+	+	+	+						+	+	+
496.	Trichocerca sp.	+	+		+	+	+	+	+	+					+		+	+
497.	Gastropus stylifer Imhof.		+	+	+	+	+		+	+					+	+	+	+

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498.	Ascomorpha agilis Zacharias						+		+	+								
499.	Synchaeta sp.	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
500.	Polyarthra vulgaris Carlin	+	+	+	+	+	+	+	+	+				+		+	+	+
501.	P. dolychoptera Idelson		+	+	+	+	+	+	+	+								
502.	P. minor Voigt	+	+	+	+	+	+	+	+	+				+			+	+
503.	P. remata Skorikov	+	+	+	+	+	+	+	+	+	+	+	+	+		+	+	+
504.	Polyarthra sp.	+		+	+	+	+		+	+								
505.	Bipalpus hudsoni (Imhof.)						+		+	+						+	+	+
506.	Asplanchna herricki Guerne	+	+	+	+	+	+	+	+	+								
507.	A. priodonta Gosse	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
508.	A. sieboldi (Leydig)	+	+	+	+			+	+	+	+		+					+
509.	Asplanchnopus multiceps (Schr.)	+	+	+	+	+	+	+	+	+								
510.	A. hyalinus Harr.																	
511.	A. pelagica Gosse						+		+	+								
512.	Lecane (s. str.) luna (Müller)	+	+	+	+	+	+	+	+	+	+		+	+	+	+	+	+
513.	L. (s. str.) flexilis (Gosse)					+	+		+	+						+	+	+
514.	L. (s. str.) ungulata (Gosse)	+	+		+		+		+	+					+		+	+
515.	L. (s. str.) stokesii (Pell)					+			+	+								

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516.	L. (s. str.) ludwigii (Eckst)					+			+	+								
517.	L. (M.) pyriformis Daday			+	+					+								
518.	L. (M.) arcuata (Bryce)	+	+	+	+	+	+	+	+	+				+			+	+
519.	L. (M.) decipiens (Murray)					+			+	+								
520.	L. (M.) psammophila Wiszniewski						+		+	+								
521.	L. (M.) quadridentata (Ehrenberg)	+	+	+	+	+	+	+	+	+								
522.	L. (M.) crenata (Harr)					+			+	+								
523.	L. (M.) lunaris (Ehrenberg)	+	+	+	+		+		+	+				+	+		+	+
524.	L. (M.) bulla (Gosse)	+	+	+	+	+	+	+	+	+				+		+	+	+
525.	Lecane sp.	+	+	+	+	+	+	+	+	+						+	+	+
526.	Epiphanes pelagica Jennings	+		+	+													
527.	Epiphanes macroura (Barrois et Daday)			+	+			+	+	+								
528.	Epiphanes clavulata Ehrenberg					+			+	+								
529.	T. pocillum (Müller)	+	+	+	+	+	+	+	+	+				+	+	+	+	+
530.	Mytilina mucronata (Müller)	+	+	+	+	+	+	+	+	+		+	+	+		+	+	+
531.	M. trigona (Gosse)															+	+	+
532.	M. ventralis (Ehrenberg)	+		+	+	+	+		+	+	+		+	+	+	+	+	+

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533.	C. colurus (Müller)	+		+	+		+		+	+	+		+	+	+	+	+	+
534.	Lepadella quadridentata (Stenroos)						+		+	+								
535.	L. ovalis (Müller)	+			+									+			+	+
536.	L. patella (Müller)		+	+	+	+			+	+		+	+		+		+	+
537.	Lepadella sp.	+			+	+	+	+	+	+				+			+	+
538.	Euchlanis incisa Carlin						+		+	+					+		+	+
539.	E. dilatata Ehrenberg	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
540.	E. deflexa Gosse						+	+	+	+					+	+	+	+
541.	E. pyriformis Gosse	+			+					+								
542.	E. triquetra Ehrenberg	+			+		+		+	+						+	+	+
543.	Brachionus quadridentatus Hempel	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
544.	B. leydigii Cohn	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
545.	B. leydigi rotundus Rousselet	+			+					+								
546.	B. falcatus Zacharias					+	+	+	+	+								
547.	B. budapestinensis Daday	+	+	+	+	+	+	+	+	+				+			+	+
548.	B. вennini Leissling						+		+	+					+		+	+
549.	B. diversicornis (Daday)	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+

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550.	B. forficula Wierz.	+	+	+	+	+	+	+	+	+								
551.	B. calyciflorus Pallas	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
552.	B. c. amphiceros Pallas	+		+	+			+	+	+	+		+					+
553.	B. angularis Gosse	+	+	+	+	+	+	+	+	+		+	+	+	+	+	+	+
554.	Platyias quadricornis(Ehrenberg)	+	+	+	+		+	+	+	+		+	+	+	+	+	+	+
555.	P. patulus (Müller)	+	+		+		+		+	+		+	+	+	+		+	+
556.	Keratella cruciformis Thompson					+			+	+								
557.	K. cochlearis (Gosse)	+	+	+	+	+	+	+	+	+	+	+	+	+	+		+	+
558.	K. ticinensis Callerio	+	+	+	+	+	+	+	+	+								
559.	K. paludosa Lucks	+	+	+	+	+	+	+	+	+								
560.	K. quadrata Müller	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
561.	Notholca acuminata (Ehrenberg)	+			+	+	+		+	+		+	+					
562.	Anuraeopsis fissa (Gosse)	+	+	+	+	+	+	+	+	+				+	+	+	+	+
563.	Conochilus unicornis Rousselet		+	+	+					+								
564.	Testudinella patina (Hermann)	+	+	+	+		+	+	+	+		+	+	+	+	+	+	+
565.	Pompholyx complanata Gosse	+	+	+	+	+	+	+	+	+								
566.	P. sulcata Hudson	+	+	+	+	+	+	+	+	+								

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		Sulina delta									Kiliya delta							Ukraine
		water courses				water bodies				Romania	water courses			water bodies				
		Lopatna	Suez	Sulimanca	total	Matita	Merhei	Small Merhei	total		Bystryi	Vostochnyi	total	Anankin Kut	Potapiv Kut	Deliukiv Kut	total	
567.	Filinia longiseta (Ehrenberg)					+			+	+	+	+	+	+		+	+	+
568.	F. terminalis (Plate)	+	+	+	+	+	+	+	+	+								
569.	F. longiseta limnetica (Zacharias)	+	+	+	+	+	+	+	+	+				+			+	+
570.	Filinia sp.		+		+					+								
571.	Rotaria rotatoria Pallas															+	+	+
572.	Bdelloidea gen. sp.	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
573.	Illoricata indet.	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
	CLADOCERA																	
574.	Sida crystallina (O.F. Müller)					+	+	+	+	+	+		+					+
575.	Diaphanosoma brachyurum (Lievin)	+	+	+	+	+	+	+	+	+	+	+	+	+	+		+	+
576.	Daphnia longispina O.F. Müller		+		+	+	+		+	+	+	+	+	+		+	+	+
577.	D. pulex Leydig										+	+	+	+			+	+
578.	D. cucullata Sars		+		+	+	+		+	+	+		+					+
579.	Simocephalus vetulus (O.F. Müller)	+			+	+	+	+	+	+		+	+	+	+	+	+	+
580.	S. serrulatus (Koch)															+	+	+
581.	Moina micrura Hellich	+	+	+	+	+	+	+	+	+	+		+	+	+	+	+	+
582.	M. macrocopa (Straus)	+	+		+	+			+	+								

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		water courses				water bodies					water courses			water bodies				
		Lopatna	Suez	Sulimanca	total	Matita	Merhei	Small Merhei	total		Bystryi	Vostochnyi	total	Anankin Kut	Potapiv Kut	Deliukiv Kut	total	
583.	Ceriodaphnia quadrangula (O.F. Müller)					+	+	+	+	+	+	+	+					+
584.	C. affinis Lilljeborg		+		+	+	+	+	+	+		+	+					+
585.	C. pulchella Sars	+	+	+	+	+	+	+	+	+								
586.	Scapholeberis mucronata (O.F. Müller)	+	+		+					+				+		+	+	+
587.	Macrothrix hirsuticornis Norman et Brody							+	+	+				+			+	+
588.	Ilyocryptus sordidus (Lievin)			+	+	+		+	+	+					+		+	+
589.	I. agilis Kurz							+	+	+				+			+	+
590.	Eurycercus lamellatus (O.F. Müller)			+	+	+	+	+	+	+								
591.	E. glasialis Lilljrborg	+	+		+		+		+	+								
592.	Acroperus harpae (Baird)	+			+	+	+		+	+		+	+	+		+	+	+
593.	Peracantha truncata Sars						+		+	+				+		+	+	+
594.	Monospilus dispar (O.F. Müller)	+			+		+		+	+					+	+	+	+
595.	Graptoleberis testudinaria (Fischer)	+	+		+		+		+	+		+	+			+	+	+
596.	Leydigia leydigii (Leydig)		+		+		+		+	+						+	+	+
597.	L. acanthocercoides (Fischer)						+		+	+								
598.	Alonopsis elongata Sars						+	+	+	+		+	+		+	+	+	+
599.	Chydorus sphaericus (O.F. Müller)	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+

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		water courses				water bodies					water courses			water bodies				
		Lopatna	Suez	Sulimanca	total	Matita	Merhei	Small Merhei	total		Bystryi	Vostochnyi	total	Anankin Kut	Potapiv Kut	Deliukiv Kut	total	
600.	Ch. globosus Baird		+		+					+						+	+	+
601.	Disparalona rostrata (Koch)						+	+	+	+	+	+	+	+		+	+	+
602.	Pleuroxus aduncus (Jurine)	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
603.	P. uncinatus (Baird)		+		+	+			+	+								
604.	P. trigonellus O.F. Müller						+	+	+	+		+	+	+		+	+	+
605.	P. striatus Schoedler						+		+	+								
606.	Alona affinis (Leydig)		+		+		+	+	+	+				+	+	+	+	+
607.	A. quadrangularis (O.F. Müller)		+		+		+	+	+	+	+		+	+		+	+	+
608.	A. costata Sars		+	+	+	+	+	+	+	+						+	+	+
609.	A. guttata Sars	+	+	+	+	+	+	+	+	+				+	+	+	+	+
610.	A. rectangula Sars	+	+		+	+	+	+	+	+	+	+	+	+	+	+	+	+
611.	Alonella nana (Baird)						+	+	+	+				+			+	+
612.	A. exigua (Lilljeborg)						+		+	+								
613.	Oxyurella tenuicaudis (Sars)						+		+	+								
614.	Bosmina longirostris O.F. Müller	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
615.	B. coregoni Baird					+			+	+	+		+					+
616.	Polyphemus pediculus (Linné)	+			+					+		+	+					+

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		water courses				water bodies					water courses			water bodies				
		Lopatna	Suez	Sulimanca	total	Matita	Merhei	Small Merhei	total		Bystryi	Vostochnyi	total	Anankin Kut	Potapiv Kut	Deliukiv Kut	total	
617.	Leptodora kindtii (Focke)	+	+	+	+	+	+	+	+	+								
618.	Cladocera juv.	+	+		+	+		+	+	+	+	+	+	+	+		+	+
	COPEPODA																	
619.	Nauplii Copepoda	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
620.	Cyclopoida juv.	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
621.	Macrocyclops fuscus (Jurine)	+			+		+		+	+								
622.	M. albidus (Jurine)					+	+	+	+	+					+	+	+	+
623.	Eucyclops serrulatus (Fischer)	+			+	+	+	+	+	+	+	+	+	+	+	+	+	+
624.	E. macruroides (Lilljeborg)	+	+		+		+		+	+								
625.	E. macrurus (Sars)					+	+		+	+								
626.	Paracyclops fimbriatus (Fischer)					+	+	+	+	+								
627.	Cyclops strenuus Fischer											+	+					+
628.	C. vicinus Uljanin	+	+		+		+		+	+	+	+	+			+	+	+
629.	Acanthocyclops vernalis (Fischer)	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
630.	A. viridis (Jurine)	+	+		+	+		+	+	+	+		+	+		+	+	+
631.	Diacyclops bicuspidatus (Claus)					+	+	+	+	+	+		+		+	+	+	+
632.	Microcyclops varicans Sars						+	+	+	+				+		+	+	+

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633.	M. bicolor Sars		+		+	+			+	+						+	+	+
634.	Mesocyclops leuckarti (Claus)					+	+		+	+	+	+	+	+	+	+	+	+
635.	Thermocyclops oithonoides (Sars)	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
636.	T. crassus (Fischer)	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
637.	Calanoida juv.	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
638.	Eurytemora velox (Lilljeborg)	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
639.	Eudiaptomus gracilis Sars			+	+			+	+	+	+	+	+					+
640.	E. graciloides (Lilljeborg)		+	+	+	+	+	+	+	+	+		+	+			+	+
641.	Harpacticoida gen. sp.	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
	Mollusca																	
642.	Veliger Dreissena	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
		Macrofauna																
	Porifera																	
643.	Spongilla lacustris Linnaeus	+			+					+								
644.	**Hydrozoa**	+	+	+	+	+		+	+	+	+		+	+	+		+	+
	Nematoda																	
645.	Nematoda sp.	+	+	+	+	+	+		+	+	+		+	+	+	+	+	+
	Oligochaeta																	

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646.	Stylaria lacustris (Linnaeus)	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
647.	Chaetogaster diaphanus (Gruith.)	+	+		+	+	+	+	+	+	+	+	+		+	+	+	+
648.	Chaetogaster diastrophus (Gruith.)	+		+	+	+	+	+	+	+		+	+	+	+	+	+	+
649.	Dero digitata (O.F.Muller)	+	+	+	+	+	+	+	+	+		+	+	+	+	+	+	+
650.	Dero obtusa d'Udekem	+			+		+		+	+				+	+	+	+	+
651.	Ophidonais serpentina (O.F.Muller)	+	+		+	+	+	+	+	+	+		+	+		+	+	+
652.	Pristina equiseta Bourne		+		+		+		+	+	+		+	+	+	+	+	+
653.	Pristina bilobata (Bretscher)						+		+	+								
654.	Pristina longiseta Ehrenberg			+	+		+		+	+		+	+	+		+	+	+
655.	Nais sp.	+			+	+			+	+								
656.	Nais communis Piguet	+		+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
657.	Nais elenguis O.F.Muller			+	+	+	+		+	+					+		+	+
658.	Nais barbata O.F.Muller	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
659.	Nais pseudoptusa Piguet	+	+		+	+	+	+	+	+	+	+	+	+	+	+	+	+
660.	Nais simplex Piguet			+	+					+				+		+	+	+
661.	Brachiobdella sp.					+			+	+								
662.	Peloscolex velutinus (Grube)			+	+					+								

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663.	Branchiura sowerbyi Beddard	+			+					+		+	+	+	+		+	+
664.	Psammoryctides barbatus (Grube)		+		+					+								
665.	Psammoryctides albicola (Michaelsen)			+	+					+					+	+	+	+
666.	Potamothrix hammoniensis (Michaelsen)					+	+		+	+								
667.	Limnodrilus sp.	+	+	+	+	+	+		+	+	+	+	+	+	+	+	+	+
668.	Limnodrilus hoffmeisteri (Claparede)	+	+	+	+	+	+		+	+	+	+	+	+	+	+	+	+
669.	Limnodrilus claparedeanus (Ratzel)		+	+	+	+			+	+	+	+	+		+		+	+
670.	Limnodrilus udekemianus (Claparede)					+			+	+	+		+	+	+	+	+	+
671.	Limnodrilus helveticus Piguet										+		+		+		+	+
672.	Lumbriculus variegatus Grube											+	+		+		+	+
673.	Isochaetides michaelseni (Lastockin)										+	+	+					+
674.	Isochaetides newaensis (Michaelsen)										+	+	+					+
675.	Tubifex tubifex (O. F. Muller)	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
676.	Potamothrix hammoniensis (Michaelsen)															+	+	+
677.	Potamothrix moldaviensis Vejdovsky et Mrazek											+	+					+
678.	Psammoryctides albicola (Michaelsen)										+		+			+	+	+

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679.	Rhynchelmis sp.						+		+	+								
680.	Rhynchelmis limnosella Hoffmeister		+		+					+								
681.	Eiseniella tetraedra (Savigni)		+		+					+								
682.	Enchytraeidea sp.					+	+		+	+								
	Polychaeta																	
683.	Hypaniola kowalewskii (Grimm)										+	+	+					+
684.	Hypania invalida (Grube)										+	+	+					+
	Hirudinea																	
685.	Erpobdella octoculata (Linne)	+	+	+	+	+	+	+	+	+		+	+	+	+	+	+	+
686.	Batracobdella paludosa (Carena)	+	+		+		+		+	+								
687.	Helobdella stagnalis (L.)	+	+		+					+				+			+	+
688.	Hemiclepsis marginata (O.F.Muller)						+	+	+	+		+	+		+		+	+
689.	Hirudo medicinalis (Linne)		+		+					+								
690.	Piscicola fasciata (Linne)			+	+	+			+	+								
691.	Piscicola geometra (L.)	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
692.	Protoclepsis tessulata (O.F.Muller)															+	+	+
693.	Glossiphonia complanata (Linne)	+			+	+	+	+	+	+		+	+	+	+	+	+	+
694.	Glossiphonia heteroclita (L.)	+	+		+	+	+		+	+		+	+	+	+		+	+

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	Gammaridae																	
695.	Dikerogammarus haemobaphes (Ehrenberg)		+	+	+			+	+	+	+	+	+		+		+	+
696.	Dikerogammarus villosus Sowinsky	+	+	+	+	+		+	+	+	+	+	+			+	+	+
697.	Chaetogammarus ischus (Stebbing)							+	+	+	+	+	+					+
698.	Pontogammarus maeoticus (Sowinsky)										+		+					+
699.	Pontogammarus crassus (G.O. Sars)		+	+	+	+	+	+	+	+	+	+	+		+	+	+	+
700.	Pontogammarus robustoides (Sars)			+	+	+	+	+	+	+	+		+		+		+	+
701.	Pontogammarus obesus (G.O. Sars)	+	+		+	+	+		+	+	+		+					+
702.	Niphargus valachicus Dobreanu et Manolache	+	+	+	+		+	+	+	+		+	+			+	+	+
703.	Gammaridae sp.		+		+	+	+	+	+	+	+	+	+					+
704.	Gmelina pusilla Sars			+	+	+		+	+	+								
705.	Gmelina costata Sars										+	+	+					+
706.	Chaetogammarus warpachowskyi (Sars.)						+	+	+	+								
707.	Stenogammarus macrurus (Sars)					+			+	+	+		+		+		+	+
708.	Stenogammarus carausui (Derzhavin et Pjat.)										+		+					+
709.	Stenogammarus similis (G.O. Sars)						+	+	+	+	+		+		+		+	+

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	Corophiida																	
710.	Corophium chelicorne Sars		+		+	+			+	+	+	+	+	+		+	+	+
711.	Corophium nobile (G.O. Sars)	+	+		+					+	+	+	+					+
712.	Corophium robustum Sars			+	+					+	+	+	+	+		+	+	+
713.	Corophium volutator (Pallas)										+	+	+		+		+	+
714.	Corophium curvispinum Sars	+	+	+	+					+	+	+	+			+	+	+
	Isopoda																	
715.	Asellus aquaticus L.	+	+	+	+	+	+		+	+				+	+	+	+	+
716.	Jaera sarsi (Valkanov)										+	+	+					+
	Mysidacea																	
717.	Limnomysis benedeni Czerniavsky	+	+		+	+		+	+	+		+	+					+
718.	Paramysis intermedia (Cherniavsky)					+			+	+								
	Cumacea																	
719.	Pseudocuma laevis (Sars)			+	+					+								
720.	Pseudocuma caercaroides (Sars)							+	+	+								
	Insecta																	
	Odonata																	

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721.	Aeschna juncea (Linne)															+	+	+
722.	Aeschna viridis (Linne)														+		+	+
723.	Agrion vigro (L.)										+	+	+					+
724.	Crocothemis erythraea (Brulle)						+		+	+								
725.	Coenagrion puella L.					+	+	+	+	+	+		+		+		+	+
726.	Coenagrion pulchellum (van der Linden)	+	+	+	+		+	+	+	+				+	+		+	+
727.	Coenagrion vernale (Hagen)	+	+	+	+	+	+	+	+	+		+	+	+	+	+	+	+
728.	Cordulia aeneaturfosa Forster						+		+	+								
729.	Erythroma najas (Hansemann)		+		+	+	+		+	+								
730.	Gomphus flavipes (Charpentier)										+	+	+					+
731.	Lestes sp.														+		+	+
732.	Lestes barbara (Fabricius)			+	+					+					+		+	+
733.	Ischnura pumilo (Charpentier)	+		+	+	+	+	+	+	+				+	+	+	+	+
734.	Ischnura elegans (van der Linden)	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
735.	Platycnemis pennipes Pallas	+			+					+								
736.	Sympetrum flaveolum (Linne)	+			+					+								
	Ephemeroptera																	

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737.	Arthroplea congener Bengston														+		+	+
738.	Caenis robusta (Eaton)						+		+	+								
739.	Caenis horaria (Linne)	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
740.	Cloen dipterum (Linne)	+	+	+	+	+	+	+	+	+				+	+	+	+	+
	Heteroptera																	
741.	Ilyocoris cimicoides (Linne)		+		+	+		+	+	+	+		+		+	+	+	+
742.	Sigara sp.										+	+	+		+		+	+
743.	Sigara falleni (Fieber)										+		+					+
744.	Corixidae sp.										+		+		+		+	+
745.	Gerris argentatus Schummel		+		+					+								
746.	Hebrus ruficeps Thomson										+	+	+	+	+	+	+	+
747.	Mesovelia furcata Mulsant et Rey	+	+	+	+	+		+	+	+				+	+	+	+	+
748.	Nepa cinerea Linne											+	+					+
749.	Plea minutissima Leach	+			+	+	+		+	+		+	+		+	+	+	+
750.	Vellia affinis Kolenati											+	+	+			+	+
	Trichoptera																	
751.	Agraylea multipunctata										+		+					+
752.	Agrypnia pagetana Curtis							+	+	+								

№	Taxon	Part of delta																
		Sulina delta								Romania	Kiliya delta							Ukraine
		water courses				water bodies					water courses			water bodies				
		Lopatna	Suez	Sulimanca	total	Matita	Merhei	Small Merhei	total		Bystryi	Vostochnyi	total	Anankin Kut	Potapiv Kut	Deliukiv Kut	total	
753.	Cheumatopsyche lepida Wallengren										+		+					+
754.	Neureclipsis bicolor L.							+	+	+								
755.	Neureclipsis bimaculata (Linne)			+	+					+		+	+					+
756.	Mystacides longicornis (Linne)						+	+	+	+					+		+	+
757.	Leptocerus tineiformes Curtis	+	+	+	+	+	+	+	+	+		+	+		+		+	+
758.	Limnephilus coenosus Curtis							+	+	+								
759.	Polycentropus flavomaculatus Pictet			+	+					+								
760.	Oecetis furva (Rambur)					+	+	+	+	+								
761.	Orthotrichia tetensii Kolbe	+	+	+	+	+	+	+	+	+	+		+		+	+	+	+
762.	Ecnomus tenellus (Rambur)	+	+	+	+	+	+	+	+	+	+	+	+		+	+	+	+
763.	Hydropsyche ornatula (Mc lachlan)			+	+					+								
764.	Triaenoides bicolor (Curtis)						+	+	+	+								
765.	Tricholeiochitom fagesii (Guinard)					+	+		+	+								
	Lepidoptera																	
766.	Lepidoptera sp.	+		+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
	Coleoptera																	
767.	Chrysomelidae sp.														+		+	+

№	Taxon	Part of delta																
		Sulina delta								Romania	Kiliya delta							Ukraine
		water courses				water bodies					water courses			water bodies				
		Lopatna	Suez	Sulimanca	total	Matita	Merhei	Small Merhei	total		Bystryi	Vostochnyi	total	Anankin Kut	Potapiv Kut	Deliukiv Kut	total	
768.	Curculionidae sp.							+	+	+					+	+	+	+
769.	Cybister sp.		+		+					+								
770.	Donacia sp.														+	+	+	+
771.	Dytiscus sp.						+	+	+	+				+			+	+
772.	Gyrinus sp.										+		+	+			+	+
773.	Haliplus ruficollis (De Geer)	+	+	+	+	+	+		+	+		+	+		+	+	+	+
774.	Helodidae sp.											+	+					+
775.	Helophorus aquaticus Fabricius													+	+		+	+
776.	Hydrobia tarta (Herbst.)														+		+	+
777.	Hydrochus sp.															+	+	+
778.	Peltodytes caesus Hbst.	+			+					+		+	+					+
779.	Acilius sp.			+	+					+								
780.	Driopidae sp.	+			+	+	+		+	+				+		+	+	+
	Diptera																	
	Limoniidae																	
781.	Limoniidae sp.						+		+	+				+			+	+
	Chironomidae																	

№	Taxon	Part of delta																
		Sulina delta								Romania	Kiliya delta							Ukraine
		water courses				water bodies					water courses			water bodies				
		Lopatna	Suez	Sulimanca	total	Matita	Merhei	Small Merhei	total		Bystryi	Vostochnyi	total	Anankin Kut	Potapiv Kut	Deliukiv Kut	total	
782.	Ablabesmia monilis (Linne)	+	+	+	+	+	+	+	+	+		+	+	+	+	+	+	+
783.	Ablabesmia lentiginosa (Fries)						+	+	+	+								
784.	Anatopynia plumipes (Fries)	+			+	+	+	+	+	+					+		+	+
785.	Brillia flavifrons Johansen													+				
786.	Camptochironomus pallidivitatus (Maloch)	+			+	+	+		+	+						+	+	+
787.	Chironomus plumosus (L.)	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
788.	Chironomus sp.	+			+		+		+	+						+	+	+
789.	Parachironomus pararostatus (Lenz)	+		+	+	+	+	+	+	+		+	+		+		+	+
790.	Cladotanytarsus mancus Walker	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
791.	Corynonevra scutellata Winnertz	+	+	+	+	+	+	+	+	+		+	+	+	+	+	+	+
792.	Cricotopus cylindraceus Kieffer						+	+	+	+	+	+	+	+		+	+	+
793.	Cryptochironomus viridulus (Fabricius)		+	+	+	+			+	+								
794.	Cryptochironomus defectus (Kiffer)			+	+					+		+	+		+		+	+
795.	Cryptochironomus conjungens Kieffer		+		+	+		+	+	+								
796.	Cricotopus silvestris (F.)	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
797.	Cricotopus algarum (Kiffer)						+	+	+	+	+	+	+					+
798.	Dikrotendipes nervosus (Staeger)	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+

№	Taxon	Part of delta																
		Sulina delta								Romania	Kiliya delta							Ukraine
		water courses				water bodies					water courses			water bodies				
		Lopatna	Suez	Sulimanca	total	Matita	Merhei	Small Merhei	total		Bystryi	Vostochnyi	total	Anankin Kut	Potapiv Kut	Deliukiv Kut	total	
799.	Limnochironomus tritomus (Kieffer)		+		+					+		+	+					+
800.	Microtendipes chloris Meigen			+	+		+		+	+								
801.	Fleuria lacustris (Kiffer)	+	+	+	+	+	+	+	+	+		+	+		+		+	+
802.	Einfeldia carbonaria Meigen						+		+	+								
803.	Einfeldia longipes (Staeger)						+		+	+				+			+	+
804.	Endochironomus albipennis (Meigen)	+	+	+	+	+	+	+	+	+		+	+	+			+	+
805.	Endochironomus tendens (F.)						+		+	+		+	+	+	+	+	+	+
806.	Endochironomus impar (Walker)	+		+	+	+			+	+				+			+	+
807.	Endochironomus stackelbergi Goetghebuer		+		+	+	+	+	+	+				+			+	+
808.	Eukiefferiella sp.	+			+			+	+	+								
809.	Glyptotendipes caulicola (Kieffer)					+			+	+								
810.	Glyptotendipes gripekoveni (Kieffer)	+	+	+	+	+	+	+	+	+		+	+	+	+	+	+	+
811.	Glyptotendipes barbipes (Staeger)		+	+	+	+	+		+	+		+	+					+
812.	Leptochironomus tener (Kieffer)	+	+	+	+	+	+	+	+	+				+	+		+	+
813.	Orthocladius clarki Soponis		+		+					+	+	+	+		+	+	+	+
814.	Paratanytarsus austriacus (Kieffer)	+		+	+	+	+		+	+		+	+	+			+	+
815.	Paratendipes albimanus Meigen											+	+			+	+	+
816.	Pentapedilum sordens (wan der Wulp)	+	+	+	+	+	+	+	+	+				+			+	+

№	Taxon	Part of delta																
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		water courses				water bodies					water courses			water bodies				
		Lopatna	Suez	Sulimanca	total	Matita	Merhei	Small Merhei	total		Bystryi	Vostochnyi	total	Anankin Kut	Potapiv Kut	Deliukiv Kut	total	
817.	Propsilocerus orielicus (Thsher.)		+	+	+	+	+	+	+	+				+	+	+	+	+
818.	Procladius choreus Meigen					+	+	+	+	+						+	+	+
819.	Procladius ferrugineus (Kiffer)		+	+	+	+	+	+	+	+					+		+	+
820.	Tanypus craatzi (Kieffer)					+			+	+					+		+	+
821.	Tanypus vilipennis (K.)					+	+		+	+		+	+		+		+	+
822.	Tanypus punctipennis (Meigen)						+		+	+					+	+	+	+
823.	Tanytarsus gr.gregarius Kieffer		+		+	+	+		+	+					+		+	+
824.	Psectrocladius delatotis Zelentzov											+	+					+
825.	Psectrocladius ferratilies Linevitch		+		+	+			+	+								
826.	Psectrocladius simulans (Johansen)			+	+	+			+	+								
827.	Psectrocladius socolovae Zelentzov et Makarchenko						+		+	+								
828.	Psectrocladius sordidellus (Zetterstedt)	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
829.	Stictochironomus clossiforceps (Kieffer)	+			+	+			+	+								
830.	Tanytarsus excavatus Edwards	+			+	+	+	+	+	+		+	+	+			+	+
831.	Telopelopia okoboji Walley						+		+	+								
832.	Psectrocladius zetterstedti (Zetterstedt)					+			+	+								
833.	Psectrocladius dilatatus van der Wulp			+	+					+								

№	Taxon	Part of delta																
		Sulina delta								Romania	Kiliya delta							Ukraine
		water courses				water bodies					water courses			water bodies				
		Lopatna	Suez	Sulimanca	total	Matita	Merhei	Small Merhei	total		Bystryi	Vostochnyi	total	Ananki Kut	Potapiv Kut	Deliukiv Kut	total	
834.	Psectrocladius psilopterus (van der Wulp)	+	+		+	+	+	+	+	+	+	+	+		+		+	+
835.	Paratanytarsus lauterborni (Kiffer)					+	+	+	+	+								
836.	Polypedilum nubeculosum Meigen	+		+	+		+		+	+					+		+	+
837.	Polypedilum exectum (Keffer)		+		+			+	+	+		+	+		+		+	+
838.	Polypedilum bicrenatum (Kieffer)			+	+					+					+	+	+	+
839.	Polypedilum convictum (Walker)	+	+		+		+	+	+	+	+		+		+	+	+	+
840.	Polypedilum nubifer (Skuse)							+	+	+		+	+		+		+	+
841.	Polypedilium scalaenum (Schrank)						+	+	+	+		+	+		+	+	+	+
	Chaoboridae																	
842.	Chaoborus sp.						+		+	+								
	Culicidae																	
843.	Culex sp.	+			+					+				+		+	+	+
	Ceratopogonidae																	
844.	Bezzia xantocephala Goetghebuer	+			+	+	+	+	+	+		+	+	+	+	+	+	+
845.	Culicoides sp.	+			+	+	+	+	+	+	+		+	+		+	+	+
846.	Palpomia tibialis (Meigen)		+		+	+	+		+	+					+		+	+
847.	Ceratopogonidae sp.	+	+	+	+		+	+	+	+				+	+	+	+	+

№	Taxon	Part of delta																
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		water courses				water bodies					water courses			water bodies				
		Lopatna	Suez	Sulimanca	total	Matita	Merhei	Small Merhei	total		Bystryi	Vostochnyi	total	Anankin Kut	Potapiv Kut	Deliukiv Kut	total	
	Psychodidae																	
848.	Psychodidae sp.											+	+	+		+	+	+
	Stratiomyidae																	
849.	Odontomya ornata (Meigen)													+			+	+
850.	Stratiomyidae sp.														+	+	+	+
	Syrphidae																	
851.	Syrphidae sp.													+			+	+
	Ephydridae																	
852.	Ephydridae sp.	+	+		+	+	+		+	+					+	+	+	+
853.	Hydrellia sp.	+			+					+								
854.	Setacera aurata (Stenhamar)						+		+	+								
	Muscidae																	
855.	Muscidae sp.															+	+	+
856.	**Aranea**	+	+		+	+	+	+	+	+	+	+	+	+	+	+	+	+
	Acariformes																	
857.	Acarina sp.	+		+	+	+	+	+	+	+	+		+	+			+	+
	Gastropoda																	
858.	Acroloxus lacustris (L.)	+	+	+	+	+	+	+	+	+	+	+	+	+		+	+	+

№	Taxon	Part of delta																
		Sulina delta								Romania	Kiliya delta							Ukraine
		water courses				water bodies					water courses			water bodies				
		Lopatna	Suez	Sulimanca	total	Matita	Merhei	Small Merhei	total		Bystryi	Vostochnyi	total	Anankin Kut	Potapiv Kut	Deliukiv Kut	total	
859.	Anisus acronicus (Ferussac)			+	+		+	+	+	+		+	+			+	+	+
860.	Anisus albus (O.F.Muller)	+			+	+	+	+	+	+		+	+	+		+	+	+
861.	Anisus vortex (Linne)	+			+					+		+	+		+	+	+	+
862.	Armiger crista (Linne)	+			+	+			+	+				+			+	+
863.	Fagotia esperi (Ferussae)			+	+	+			+	+	+	+	+		+	+	+	+
864.	Bithinia tentaculata (Linne)	+	+	+	+	+	+	+	+	+		+	+		+	+	+	+
865.	Borysthenia naticina (Menke)	+			+					+								
866.	Fagotia acicularis (Ferussac)											+	+					+
867.	Bithynia leachi (Steppard)											+	+					+
868.	Planorbis carinatus (O. F. Muller)											+	+			+	+	+
869.	Planorbarius (Coretus) corneus (Linne)						+		+	+		+	+			+	+	+
870.	Planorbis planorbis (Linne)											+	+					+
871.	Physa fontinalis (Linne)										+	+	+		+		+	+
872.	Lithoglyphus naticoides C. Pfeiffer			+	+	+	+		+	+	+	+	+					+
873.	Lymnaea lagotis (Schrank)																	
874.	Lymnaea auricularia (L.)		+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
875.	Lymnaea danubialis (Schranck)						+		+	+								

№	Taxon	Part of delta																
		Sulina delta								Romania	Kiliya delta							Ukraine
		water courses				water bodies					water courses			water bodies				
		Lopatna	Suez	Sulimanca	total	Matita	Merhei	Small Merhei	total		Bystryi	Vostochnyi	total	Anankin Kut	Potapiv Kut	Deliukiv Kut	total	
876.	Lymnaea palustris (O.F.Muller)					+	+		+	+					+	+	+	+
877.	Lymnaea ovata (Draparnaud)														+		+	+
878.	Lymnaea stagnalis (Linne)					+	+		+	+	+	+	+		+	+	+	+
879.	Segmentina montagozoniana Bourguignat						+		+	+		+	+			+	+	+
880.	Theodoxus fluviatilis (Linne)			+	+	+	+		+	+	+	+	+			+	+	+
881.	Valvata sp.						+		+	+					+		+	+
882.	Valvata cristata (O.F.Muller)						+		+	+		+	+					+
883.	Valvata piscinalis (O. F. Muller)	+			+	+	+	+	+	+	+	+	+		+	+	+	+
884.	Valvata pulhella Studer						+	+	+	+	+	+	+		+		+	+
885.	Viviparus viviparus (Linne)	+	+	+	+	+	+	+	+	+		+	+		+		+	+
	Bivalvia																	
886.	Corbicula fluminea (O. F. Muller)			+	+					+	+		+					+
887.	Musculum sp.		+		+	+	+		+	+								
888.	Dreissena polymorpha (Pallas)	+	+		+	+	+	+	+	+	+	+	+		+	+	+	+
889.	Dreissena bugensis Andr.											+	+					+
890.	Anodonta sp.						+		+	+								
891.	Anodonta piscinalis (Nilsson)		+	+	+					+					+	+	+	+

№	Taxon	Part of delta																
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		water courses				water bodies					water courses			water bodies				
		Lopatna	Suez	Sulimanca	total	Matita	Merhei	Small Merhei	total		Bystryi	Vostochnyi	total	Anankin Kut	Potapiv Kut	Deliukiv Kut	total	
892.	Unio pictorum (Linne)			+	+					+								
	Briozoa																	
893.	Polydicella articulata Ehrenberg	+	+		+	+	+		+	+								
894.	Plumatella emarginata Allman	+	+		+	+	+		+	+								
895.	Plumatella fungosa Pallas	+			+	+			+	+								
		377	338	345	561	457	469	343	625	745	224	248	333	337	324	295	536	603

Annex 2 Structural characteristics of the aquatic macrophytes and semi-aquatic plants

Species/stations	Ecotype	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
		Reni	Cheatal	Izmail	Kiliya	Vilkove	Bystryi	Tulcea	Mila 23	Sulina	Uzlina	St. Gheorge	Erenciuc lake	Uzlina lake	Isak lake	Culibul cu lebede lake
COASTAL AQUATIC PLANTS and HYGROHELOPHYTES																
Salix alba L.		+	+	+			+	+		+	+					
S. cinerea L.								+				+	+			+
S. triandra L.		+						+			+					
Populus alba L.		+						+			+					
P. tremula L.		+									+					
Amorpha fruticosa L.		+		+	+	+	+									
Rhamnus catharticus L.																
Alopecurus aequalis Sobol.	he	+		+												
Bidens cernua L.	he												+			
B. tripartita L.	he			+		+	+									
Calystegia sepium (R.)Br							+						+			
Cyperus fuscus L.	he	+														
C. glomeratus L.	he	+	+					+								
Echinochloa crusgali (L.) Beauv.	he			+		+										
Epilobium palustre L.	he												+			+
Erigeron canadensis L				+	+	+	+									
Gnaphalium uliginosum L.	he	+						+								
Humulus lupulus L.							+									
Juncus bufonius L.	he	+														
Lycopus europaeus L	he												+			+
Lythrum salicaria L.	he					+										+
Petasites spurious (Retz.) Reichenb.	he						+									
Plantago major L.						+	+									
Polygonum aviculare L.						+										
P. hydropiper L.		+				+							+			
Rorippa amphibian (L.) Bess.	he	+														

Species/stations	Ecotype	2 Reni	3 Cheatal	4 Izmail	5 Kiliya	6 Vilkove	7 Bystryi	8 Tulcea	9 Mila 23	10 Sulina	11 Uzlina	12 St. Gheorge	13 Erenciuc lake	14 Uzlina lake	15 Isak lake	16 Culibul cu lebede lake
Rumex hydrolapatum Huds.	he												+			
Scutellaria galericulata L.								+								
Solanum dulcamara L.	he				+								+			+
Tripolium vulgare Nees	he						+									
Tussilago farfara L.						+										
Urtica dioica L.							+									
Xanthium strumarium L.	he			+		+	+									
HELOPHYTES																
Phragmites australis (Cav.) Trin. ex Steud.	he	1		3	3	3	4			2 3	2	2 3	5 5 5	5	5 5	5 5
Typha angustifolia L.	he				3	3	2			1 2		3 2	2 2 2		1 3	3 1
Glyceria maxima (Hartm.) Holmb.	he					2										
Butomus umbellatus L.	he					1						2 3				
Sparganium erectum L.	he									1 1						
Sagittaria sagittifolia L.	he								2							
ROOTED PLANTS WITH FLOATING LEAVES																
Nymphaea alba L.	fl												5			
Nuphar lutea (L.)Smith	fl								3				3		4	3
Trapa natans s.l. L.	fl								2		1	2	2 3	4		
Trapa natans. subsp. *muzzanensis* (Jäggi) Schinz	fl								2					1		
Potamogeton nodosus Poir.	fl									1						
P. natans L.	fl				3					3 3		3				
ACRO PLEUSTOPHYTES																
Azolla filiculoides Lam.	ap								1							

Species/stations	Ecotype	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
		Reni	Cheatal	Izmail	Kiliya	Vilkove	Bystryi	Tulcea	Mila 23	Sulina	Uzlina	St. Gheorge	Erenciuc lake	Uzlina lake	Isak lake	Culibul cu lebede lake
Hydrocharis morsus-ranae L.	ap								1			1 1	5 3 5			1
Lemna minor L.	ap								1		1		1 2 1	1	1	
Salvinia natans (L.) All.	ap				1	2			5	1		1		1		1
Spirodela polyrhiza (L.) Schleid.	ap				1			1	1		1		1	1		
SUBMERSED PLEUSTOPHYTES																
Ceratophyllum demersum L.	sa				1	3	2	1	4	2 2	2	1	3 3 3	3	2 3	5 5
C. submersum L.	sa									1		1				
Lemna trisulca L.	sa								1				1 1	1		
Stratiotes aloides L.	sa									1 1			2 2			2 4
SUBMERSED ANCHORED																
Elodea nuttallii (Planch.) H. St. John	sa										1			1		
Myriophyllum spicatum L.	sa							2	1		2	4	1	1		
M. verticillatum L.	sa								1							
Najas marina L.	sa									1 1		1				
Potamogeton crispus L.	sa										1				1 1	
P. pectinatus L.	sa			2		3	2	1		1 2		1 1		1	1	
P. perfoliatus L.	sa				1	3	2			1		1 2		1		
Vallisneria spiralis L.	sa											3		3		
MACROALGAE																
Chara sp.	sa									1						
Cladophora sp.	sa							1			2	3		2		
Total species hygrophytes and helophytes		1	0	2	7	8	5	5	13	13	9	15	12	14	7	7

Note: ‘+’ for hygrohelophytes and semi-aquatic species indicates to their presence at the station; 1–5 – significance for hydrophytes and helophytes by [Training course…, 2011]; two (three) columns of numbers at one station correspond to the species significance at the left and right banks in the branches or at the ecological heterogeneous areas of shallow-water in the lakes.

Anex 3 The list of the species of phytomicrobenthos (at JDDS stations).

Species/Varieties	Sampling sites														
	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
	Reni	Cheatal	Izmail	Kiliya	Vilkove	Bystryi	Tulcea	Mila 23	Sulina	Uzlina	St. Gheorge	Erenciuc lake	Uzlina lake	Isak lake	Culibul cu lebede lake
Cyanoprokaryota															
Merismopedia minima G. Beck													+	+	+
Merismopedia punctata Meyen														+	+
Microcystis aeruginosa Kütz. emend. Elenk.												+			+
Marsoniella elegans Lemm.														+	
Oscillatoria planctonica Wolosz.														+	
Oscillatoria limnetica Lemm.															+
Oscillatoria limosa Ag.								+							
Cryptophyta															
Cryptomonas sp.								+		+	+		+	+	
Eugenophyta															
Trachelomonas volvocina Ehr.										+					
Euglena granulata (Klebs) Schmitz													+		
Euglena limnophila Lemm.													+		
Euglena obtusa Schmitz													+		
Euglena sp.												+			
Phacus mirabilis Pochman													+		+
Cryptoglena pigra Ehr.													+		
Chlorophyta															
Chlamydomonas sp.										+					
Phacotus coccifer Korsch.									+				+	+	
Pediastrum duplex Meyen												+		+	
Pediastrum boryanum (Thurp.) Menegh.														+	
Pediastrum simplex Meyen												+		+	

Species/Varieties	Sampling sites														
	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
	Reni	Cheatal	Izmail	Kiliya	Vilkove	Bystryi	Tulcea	Mila 23	Sulina	Uzlina	St. Gheorge	Erenciuc lake	Uzlina lake	Isak lake	Culibul cu lebede lake
Pediastrum tetras (Ehr.) Ralfs													+		+
Schroederia spiralis (Printz.) Korsch.														+	
Franceia tenuispina Korsch.												+		+	+
Monoraphidium arcuatum (Korsch.) Hind.													+		
Monoraphidium contortum (Thur.) Kom.-Legn.													+		
Oocystis submarina Lagerh.										+		+			
Tetraedron caudatum (Corda) Hansg.														+	
Tetraedron incus (Teil.) G.M. Smith														+	
Ankistrodesmus fusiformis Corda														+	
Coelastrum sphaericum Näg.													+		
Crucigeniella rectangularis (Näg.) Kom.										+					
Tetrastrum elegans Playf.														+	
Scenedesmus denticulatus Lagerh.								+		+			+		
Scenedesmus intermedius Chod.														+	
Scenedesmus quadricauda (Turp.) Breb. sensu Chod.							+			+	+	+	+	+	+
Scenedesmus disciformis (Chod.) Fott et Kom.														+	
Scenedesmus acuminatus (Lagerh.) Chod.														+	+
Scenedesmus opoliensis P. Richt.												+		+	+
Scenedesmus obliquus (Turp.) Kütz.												+			+
Scenedesmus falcatus Chod.														+	+
Selenastrum gracile Reinsch														+	
Didymocystis planctonica Korsch.													+		
Tetraedron triangulare Korsch.														+	+
Closterium sp.														+	

Species/Varieties	Sampling sites														
	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
	Reni	Cheatal	Izmail	Kiliya	Vilkove	Bystryi	Tulcea	Mila 23	Sulina	Uzlina	St. Gheorge	Erenciuc lake	Uzlina lake	Isak lake	Culibul cu lebede lake
Cosmarium sp.														+	+
Staurastrum tetracerum Ralfs ex Ralfs														+	
Staurastrum cingulum (W. et G.S. West) G. Sm.														+	
Chrysophyta															
Mallomonas tonsurata Teiling														+	
Xanthophyta															
Tetraedriella acuta Pasch.													+	+	
Bacillariophyta															
Aulacoseira granulata (Ehr.) Sim.	+	+	+	+	+	+		+	+	+	+	+	+	+	+
Aulacoseira granulata v. angustissima (O. Müll) Sim.	+	+		+					+			+		+	
Cyclotella glomerata Bachmann									+						
Cyclotella sp.	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Cyclotella bodanica Grun.	+	+	+	+	+	+	+	+	+	+	+	+	+	+	
Stephanodiscus astraea (Ehr.) Grun.		+			+		+	+			+		+		+
Stephanodiscus hantzschii Grun.				+	+									+	
Stephanodiscus subtilis (Goor) A. Cleve	+	+	+	+	+	+	+	+			+				
Diatoma vulgare Bory		+			+			+		+	+	+	+	+	
Fragilaria virescens Ralfs															+
Synedra actinastroides Lemm.	+	+			+	+									
Synedra acus Kütz.														+	
Synedra tenera W. Sm.								+					+		
Synedra tabulata (Agardh.) Kütz.								+		+		+	+	+	+
Synedra ulna (Nitzsch.) Ehr.			+		+	+		+	+			+	+	+	+
Synedra capitata Ehr.												+		+	+

Species/Varieties	Sampling sites														
	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
	Reni	Cheatal	Izmail	Kiliya	Vilkove	Bystryi	Tulcea	Mila 23	Sulina	Uzlina	St. Gheorge	Erenciuc lake	Uzlina lake	Isak lake	Culibul cu lebede lake
Navicula binodis Ehr.										+					
Navicula capitata Ehr.	+	+	+	+	+	+	+	+	+	+	+		+	+	+
Navicula cryptocephala Kütz.										+					
Navicula cryptocephala v. veneta (Kütz.) Rabenh.											+				
Navicula dicephala Ehr.														+	
Navicula hungarica Grun.									+	+		+		+	+
Navicula scutum Schumann														+	
Navicula placentula (Ehr.) Grun.		+	+		+		+	+	+	+	+				
Navicula semen Ehr.											+				+
Navicula pupula Kütz.		+		+										+	+
Navicula radiosa Kütz.													+	+	+
Navicula pupula v. rostrata Hust.								+							
Navicula rhynchocephala Kütz.													+		
Navicula viridula (Kütz.) Ehr.	+	+		+	+		+	+		+	+	+	+	+	
Pinnularia maior (Kütz.) Rabenh.															+
Pinnularia viridis (Nitzsch) Ehr.													+		+
Pinnularia subsolaris (Grun.) Cl.															+
Neidium dubium (Ehr.) Cl.														+	
Neidium productum (W. Sm.) Cl.														+	
Caloneis silicula (Ehr.) Cl.													+		
Gyrosigma acuminatum (Kütz.) Rabenh.	+	+	+		+	+		+			+	+	+	+	
Gyrosigma spenceri (Quek.) Grif. et Henf.													+		
Cocconeis pediculus Ehr.		+	+			+	+	+	+	+	+	+	+	+	+
Cocconeis placentula Ehr.							+	+	+	+		+	+	+	+
Achnanthes minutissima Kütz.												+			

Species/Varieties	Sampling sites														
	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
	Reni	Cheatal	Izmail	Kiliya	Vilkove	Bystryi	Tulcea	Mila 23	Sulina	Uzlina	St. Gheorge	Erenciuc lake	Uzlina lake	Isak lake	Culibul cu lebede lake
Amphora ovalis (Kütz.) Kütz.		+										+	+	+	+
Amphora perpusilla Grun.								+			+		+	+	+
Amphora veneta Kütz.								+		+			+	+	
Cymbella lanceolata (Ehr.) Kirch.				+								+	+	+	+
Cymbella parva (W. Sm.) Cl.												+	+		+
Cymbella tumidula (Breb.) V. H.													+		
Cymbella turgida (Ehr.) Hass.													+	+	
Cymbella ventricosa (Agard.) Agard.											+			+	+
Cymbella lata Grun. in Cl.								+				+	+		
Gomphonema acuminatum Ehr.														+	
Gomphonema acuminatum v. coronatum (Ehr.) Rabenh.													+	+	+
Gomphonema augur Ehr.														+	
Gomphonema angustatum (Kütz.) Rabenh.													+		
Gomphonema constrictum v. capitatum (Ehr.) Grun.												+	+	+	+
Gomphonema longiceps Ehr.								+					+	+	+
Gomphonema olivaceum (Horn.) Breb.										+			+		
Gomphonema parvulum (Kütz.) Kütz.								+		+	+		+		+
Rhoicosphenia abbreviata (Ag.) L.-B.					+			+	+	+	+		+	+	+
Eunotia paralella Ehr.															+
Eunotia pectinalis v. ventralis (Ehr.) Hust.												+			
Epithemia zebra (Ehr.) Kütz.												+	+	+	+
Epithemia sorex Kütz.														+	+

Species/Varieties	Sampling sites														
	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
	Reni	Cheatal	Izmail	Kiliya	Vilkove	Bystryi	Tulcea	Mila 23	Sulina	Uzlina	St. Gheorge	Erenciuc lake	Uzlina lake	Isak lake	Culibul cu lebede lake
Epithemia turgida (Ehr.) Kütz.				+								+		+	+
Rhopalodia gibba (Ehr.) O. Müll.														+	+
Rhopalodia gibba v. ventricosa (Kütz.) H. Peragallo et M. Peragallo															+
Didymosphenia geminata (Lyngb.) M. Schm.	+	+	+	+											
Bacillaria paradoxa Gmel.													+		
Nitzschia acicularis (Kütz.) W. Sm.													+	+	+
Nitzschia angustata Grun.										+					
Nitzschia dissipata (Kütz.) Grun.								+		+			+		
Nitzschia gracilis Hant.							+	+	+	+			+		
Nitzschia frustulum (Kütz.) Grun. in Cl. et Grun.								+			+		+		+
Nitzschia linearis (Ag.) W. Sm.														+	+
Nitzschia longissima (Breb.) Ralfs.								+					+		
Nitzschia longissima v. reversa W. Sm.		+													
Nitzschia recta Hant. in Rabenh.			+			+						+			+
Nitzschia sigmoidea (Nitzsch) W. Sm.				+		+				+			+		
Nitzschia subtilis (Kütz.) Grun. in Cl. et Grun.													+		
Nitzschia tryblionella Hantzsch				+						+					
Nitzschia vermicularis (Kütz.) Hant. in Rabenh.				+						+					
Cymatopleura solea v. elegans Virieux												+			
Cymatopleura solea (Breb.) W. Sm.													+	+	
Cymatopleura solea v. gracilis Grun.															+
Surirela biseriata Breb. in Breb. et God.													+		+
Surirella ovata Kütz.	+	+		+	+	+				+			+	+	
Surirella tenera Greg.													+		+

Annex IV The list of the species and structural characteristics of macrozoobenthos (at JDDS stations).

	Number of station	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
	Name of station	Giurgiulesti	Reni	Cheatal	Izmail	Kiliya	Vilkove	Bystryi	Tulcea	Mila 23	Sulina	Uzlina	St. Gheorge	Erenciuc lake	Uzlina lake	Isak lake	Culibul cu lebede lake
	Nematoda																
1.	Nematoda sp.									X	X						X
	Oligochaeta																
2.	Aelosoma hemprichi Ehr.												X				
3.	Branchiura sowerbyi Beddard	X					X			X	X	X					
4.	Eiseniella tetraedra (Savigni)										X						
5.	Isochaetides michaelseni (Lastockin)	X											X				
6.	Isochaetides newaensis (Michaelsen)	X				X			X		X	X	X		X		
7.	Limnodrillus claparedeanus Ratzel				X	X	X			X	X	X	X		X		
8.	Limnodrilus helveticus Piguet																
9.	Limnodrillus hoffmeisteri Claparede						X			X	X		X		X		X
10.	Limnodrilus sp.	X	X	X	X	X	X		X	X	X	X	X		X		
11.	Limnodrilus udekemianus (Claparede)					X	X										
12.	Nais barbata O.F.Muller												X		X	X	
13.	Nais communis Piguet	X														X	
14.	Nais elenguis O.F.Muller	X								X			X				
15.	Nais simplex Piguet		X														
16.	Nais sp.														X		
17.	Ophidonais serpentina (O.F.Muller)														X		
18.	Potamothrix hammoniensis (Michaelsen)				X	X	X			X							
19.	Potamothrix moldaviensis Vejdovsky et Mrazek				X				X		X				X		

	Number of station	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
	Name of station	Giurgiulesti	Reni	Cheatal	Izmail	Kiliya	Vilkove	Bystryi	Tulcea	Mila 23	Sulina	Uzlina	St. Gheorge	Erenciuc lake	Uzlina lake	Isak lake	Culibul cu lebede lake
20.	Stylaria lacustris (Linnaeus)				X								X		X		
21.	Uncinais uncinata (Oersted)				X												
22.	Tubifex tubifex (O. F. Muller)	X				X	X		X	X	X	X	X		X	X	
	Hirudinea																
23.	Caspiobdella fadejewi (Epstein)									X							
24.	Erpobdella octocullata (Linne)																X
25.	Glossiphonia complanata (Linne)									X							
26.	Pisciola geometra (Linne)											X					X
	Gastropoda																
27.	Esperiana acicularis Fer						X			X		X	X				
28.	Esperiana esperi (Ferussac)					X	X	X		X	X	X	X				
29.	Ferrissia clessiniana Tryon														X		
30.	Lithoglyphus naticoides C. Pfeiffer				X	X	X		X	X	X	X	X				
31.	Lymnaea auricularia (Linne)									X				X	X		
32.	Lymnaea stagnalis (Linne)																X
33.	Physella acuta Drp.									X							
34.	Planorbis planorbis (Linne)													X			X
35.	Theodoxus danubialis C.Pf.						X	X	X	X	X	X	X				
36.	Theodoxus fluviatilis (Linne)					X			X		X						
37.	Valvata cristata (O.F.Muller)				X												
38.	Viviparus contectus (Millet)					X											
39.	Viviparus viviparus (Linne)						X			X		X	X	X	X		X
	Bivalvia																
40.	Anodonta cygnea (L.)					X											

	Number of station	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
	Name of station	Giurgiulesti	Reni	Cheatal	Izmail	Kiliya	Vilkove	Bystryi	Tulcea	Mila 23	Sulina	Uzlina	St. Gheorge	Erenciuc lake	Uzlina lake	Isak lake	Culibul cu lebede lake
41.	Anodonta piscinalis (Nilsson)											X					
42.	Corbicula fluminea (O. F. Muller)	X								X							
43.	Dreissena bugensis Andr.							X									
44.	Dreissena polymorpha (Pallas)						X	X	X		X	X	X			X	
45.	Pseudoanodonta anatina (Linne)											X					
46.	Sinanodonta woodiana (Lea)							X					X				
47.	Unio pictorum (Linne)											X					
48.	Unio tumidus (Filipsson)					X			X			X	X				
	Acarina																
49.	Acarina sp.			X	X									X			
	Izopoda																
50.	Jaera sarsi Valkanov					X											
	Gammaridae																
51.	Chaetogammarus ischus (Stebbing)					X											
52.	Chaetogammarus warpachowskyi (Sars)						X										
53.	Dikerogammarus haemobaphes (Eichwald)		X	X		X					X	X	X	X		X	
54.	Dikerogammarus villosus Sowinsky		X	X		X			X	X	X		X		X		
55.	Echinogammarus trichiatus Martyn.										X	X	X				
56.	Gammaridae sp.		X	X	X				X								
57.	Niphargus sp.											X					
58.	Stenogammarus sp.				X												
59.	Pontogammarus crassus (Sars)			X				X									
60.	Pontogammarus obesus (Sars)					X											
	Corophiidae																

	Number of station	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
	Name of station	Giurgiulesti	Reni	Cheatal	Izmail	Kiliya	Vilkove	Bystryi	Tulcea	Mila 23	Sulina	Uzlina	St. Gheorge	Erenciuc lake	Uzlina lake	Isak lake	Culibul cu lebede lake
61.	Corophium curvispinum Sars	X	X	X	X	X	X	X	X	X	X		X		X	X	
62.	Corophium nobile Sars			X	X	X											
63.	Corophium robustum Sars			X		X		X	X								
	Cumacea																
64.	Schizorhynchus scabriusculus (Sars.)				X												
65.	Schizorhynchus eudorelloides (Sars.)										X		X				
	Myzidacea																
66.	Limnomysis benedeni Czerniavsky		X	X	X		X			X	X	X	X	X	X	X	X
67.	Paramysis lacustris (Mart.)						X	X				X	X	X		X	X
	Decapoda																
68.	Palaemon elegans Rathke							X									
	Odonata																
69.	Aeschna cyanea (O.F.Muller)													X			
70.	Coenagrion armatum (Charpentier)													X			
71.	Calopterix spendens (Harris)			X													
72.	Erythroma najas (Hansemann)														X		
73.	Ischnura elegans (van der Linden)									X	X			X	X		X
74.	Ischnura pumilo (Charpentier)													X	X		
	Ephemeroptera																
75.	Caenis horaria (Linne)									X		X			X		X
76.	Caenis robusta Eth.									X		X		X	X		
77.	Cloen dipterum (Linne)														X		
	Coleoptera																
78.	Curculionidae sp.													X			

	Number of station	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
	Name of station	Giurgiulesti	Reni	Cheatal	Izmail	Kiliya	Vilkove	Bystryi	Tulcea	Mila 23	Sulina	Uzlina	St. Gheorge	Erenciuc lake	Uzlina lake	Isak lake	Culibul cu lebede lake
79.	Dytiscus marginalis Linne			X													
80.	Haliplus ruficollis (De Geer)									X							
	Heteroptera																
81.	Mesovelia furcata Mulsant et Rey													X	X		
82.	Micronecta griseola Kirkaldy												X				
83.	Nepa cinerea Linne.													X			
84.	Vellia affinis Kolenati													X			
	Lepidoptera																
85.	Acentria ephemerella										X						
	Trichoptera																
86.	Cheumatopsyche lepida Wallengren					X											
87.	Ecnomus tenellus (Rambur)									X		X	X		X	X	
88.	Leptocerus tineiformes Curtis											X			X		X
89.	Orthotrichia tetensii Kolbe									X				X	X		
	Ceratopogonidae																
90.	Dasyhelea sp.										X	X					
	Chironomidae																
91.	Ablabesmya monilis (L.)														X		
92.	Anatopynia plumipes (Fries)											X					
93.	Chironomus sp.	X										X			X		X
94.	Cladotanytarsus mancus (Walker)	X								X		X			X		X
95.	Corynoneura scutellata Winnertz													X	X		
96.	Cricotopus sylvestris (F.)				X	X	X	X		X	X	X	X	X	X	X	X
97.	Criptocladopelma viridula (Fabricius)														X		

	Number of station	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
	Name of station	Giurgiulesti	Reni	Cheatal	Izmail	Kiliya	Vilkove	Bystryi	Tulcea	Mila 23	Sulina	Uzlina	St. Gheorge	Erenciuc lake	Uzlina lake	Isak lake	Culibul cu lebede lake
98.	Dikrotendipes nervosus (Staeger)									X		X	X			X	
99.	Endochironomus albipennis Meigen													X			X
100.	Endochironomus stackelbergi Goetghebuer										X						
101.	Glyptotendipes gripekoveni (Kieffer)												X	X			
102.	Harnnischia burganadzeae (Tshernovskij)				X												
103.	Hydrobaenus lugubris (Fries)														X		
104.	Hydrobaenus pilipes (Malloch)														X	X	
105.	Leptochironomus tener (Kieffer)									X				X	X	X	X
106.	Parakiefferiella gracillima																X
107.	Pentapedilum sordens (van der Wulp)									X							
108.	Polypedilum bicrenatum Kieffer					X	X										
109.	Polypedilium convictum (Walker)					X	X										
110.	Polypedilum nubeculosum Meigen							X									
111.	Polypedilium scalaenum (Schrank)										X						
112.	Psectrocladius litofilus Akhrorov			X													
113.	Tanytarsus excavatus Edwards																X
	Bryozoa																
114.	Plumatella fungosa Pallas															X	
115.	Polydicella articulata Ehrenberg													X			
	Total species richness	11	7	13	17	24	20	12	13	32	26	31	30	23	35	14	19
	Shannon, bit/ind	2,09	0,89	2,00	2,66	2,58	2,49	1,00	1,90	3,50	2,81	1,61	2,26	–	3,81	0,32	2,29
	Abundance, th.ind/m^2	16412	96	182	2562	3250	7294	200	2420	3146	2596	6710	2574	–	2860	1892	1408
	Biomass, g/m^2	179,3	0,1	30,1	52,1	242,0	57,1	21,1	50,3	750,1	143,2	659,1	212,1	–	2,1	1,9	6,2
	Zelinka-Marvan index	2,80	2,10	2,11	2,19	2,75	2,79	2,04	2,17	2,64	2,28	2,22	2,23	2,12	2,38	2,81	2,16

Anex 5. List of macroinvertebrates species of water bodies and water courses of Danube delta islands (may, 2018).

№	Species	Small Tataru island			Ermakov island				Ochakivskyi island
		channels	lakes	total	channels	lakes	drift	total	channel
	Bivalvia								
1.	Sinanodonta woodiana Lea.	+		+					
2.	Pisidium milium Held	+	+	+	+			+	
3.	Musculium lacustre (O. F. Müller)	+	+	+	+	+		+	
4.	Unio pictorum (Linne)	+		+					
	Gastropoda								
5.	Acroloxis lacustris (Linne)		+	+					+
6.	Gyraulus albus (O.F.Muller)	+	+	+	+	+		+	+
7.	Bithynia tentaculata (Linne)	+	+	+	+	+		+	
8.	Bithynia troschelii (Paasch)								+
9.	Lymnaea auricularia (Linne)						+	+	
10.	Lymnaea ovata (Draparnaud)	+	+	+		+		+	
11.	Lymnaea stagnalis (Linne)	+		+					
12.	Physa fontinalis (Linne)	+	+	+		+	+	+	
13.	Physella acuta Draparnaud.								+
14.	Planorbarius corneus (Linne)	+		+	+	+	+	+	+
15.	Planorbis planorbis (Linne)				+	+	+	+	+
16.	Valvata piscinalis (O.F.Muller)		+	+		+		+	
17.	Valvata pulchela Studer				+	+		+	
18.	Viviparus contectus (Millet)	+		+	+			+	+
	Oligochaeta								

№	Species	Small Tataru island			Ermakov island				Ochakivskyi island
		channels	lakes	total	channels	lakes	drift	total	channel
19.	Branchiura sowerbyi Beddard				+			+	
20.	Chaetogaster diaphanus (Gruith.)	+	+	+		+		+	
21.	Dero digitata (O.F.Muller)				+	+		+	
22.	Dero dorsalis Ferroniere	+	+	+	+			+	
23.	Limnodrilus claparedeanus Ratzel	+		+	+			+	
24.	Limnodrilus sp.	+	+	+	+	+		+	
25.	Nais barbata O.F.Muller		+	+					
26.	Nais communis Piguet	+	+	+	+	+	+	+	+
27.	Nais elenguis O.F.Muller	+	+	+		+		+	
28.	Nais pseudobtusa Piguet	+		+					
29.	Nais simplex Piguet					+		+	
30.	Ophidonais serpentina (O.F.Muller)	+	+	+	+	+	+	+	
31.	Potamothrix haemmoniensis (Mich.)	+		+		+		+	
32.	Psammorichtides albicola (Michaelsen)		+	+	+			+	
33.	Sperosperma ferox (Eisen)					+		+	
34.	Stylaria lacustris (Linnaeus)	+	+	+	+	+	+	+	+
35.	Tubifex tubifex (O. F. Muller)	+	+	+	+			+	
	Hirudinea								
36.	Erpobdella octocullata (Linne)	+		+					
37.	Glossiphonia complanata (Linne)	+	+	+		+		+	
38.	Glossiphonia heteroclita (Linne)	+	+	+		+		+	
39.	Haementeria costata (Muller)								+

№	Species	Small Tataru island			Ermakov island				Ochakivskyi island
		channels	lakes	total	channels	lakes	drift	total	channel
40.	Haemopis sanguisuga (L.)	+		+					
41.	Hirudo medicinalis Linnaeus	+		+					
42.	Cystobranchus fasciatus Kollar.	+		+					
43.	Piscicola geometra (Linne)	+		+					
	Corophiidae								
44.	Corophium curvispinum Sars						+	+	
	Gammaridae								
45.	Niphargus potamophilus Birstein	+		+					+
46.	Gammaridae sp.					+		+	+
	Isopoda								
47.	Asellus aquaticus (Linne)	+	+	+	+	+		+	+
48.	Jaera sarsi Valkonov	+		+					
	Mysida								
49.	Limnomysis benedeni Czerniavsky	+		+		+		+	
	Odonata								
50.	Anax imperator	+		+					+
51.	Coenagrion puella L.	+	+	+					
52.	Ischnura elegans (van der Linden)	+	+	+		+		+	
53.	Libellula vulgata Linnaeus	+		+					
	Ephemeroptera								
54.	Caenis horaria (Linne)	+	+	+	+	+	+	+	
55.	Cloen dipterum (Linne)	+	+	+					
	Coleoptera								
56.	Acilius sulcatus (L.)				+			+	+

№	Species	Small Tataru island			Ermakov island				Ochakivskyi island
		channels	lakes	total	channels	lakes	drift	total	channel
57.	Cybister lateralimarginalis (Deg.)				+		+	+	
58.	Driops sp.						+	+	+
59.	Enochrus sp.						+	+	
60.	Gaurodites sp.	+		+					
61.	Haliplus ruficollis (De Geer)	+		+	+		+	+	+
62.	Heterocerus sp.								+
63.	Hydrophilus piceus Linnaeus				+			+	+
64.	Hyphydrus ovatus (Linnaeus, 1761)	+		+					
65.	Ilibius sp.	+		+					
66.	Laccobius sp.								+
	Heteroptera								
67.	Corixa linnaei (Fieber)	+		+					
68.	Corixa punctata (Illiger)					+	+	+	
69.	Ilyocoris cimicoides (Linne)		+	+					
70.	Plea minutissima Leach	+	+	+	+	+	+	+	
71.	Ranatra linearis Linne	+		+	+			+	
72.	Sigara falleni (Fieber)	+		+			+	+	
	Lepidoptera								
73.	Lepidoptera sp.		+	+		+		+	
	Trichoptera								
74.	Agraylea multipunctata Curtis					+		+	
75.	Ecnomus tenellus (Rambur)	+	+	+		+		+	
76.	Leptocerus tineiformes Curtis	+	+	+	+	+		+	

№	Species	Small Tataru island			Ermakov island				Ochakivskyi island
		channels	lakes	total	channels	lakes	drift	total	channel
77.	Oecetis lacusris (Pictet)	+		+					
78.	Orthotrichia tetensii Kolbe	+	+	+					
79.	Tricholeiochitom fagesii (Guinard)					+		+	
	Chironomidae								
80.	Ablabesmya monilis (L.)	+	+	+	+	+		+	
81.	Chironomus sp.	+	+	+	+	+	+	+	
82.	Cladotanytarsus mancus (Walker)						+	+	
83.	Cladopelma lateralis (Goetghebuer)					+		+	
84.	Corynoneura scutellata, Winnertz	+	+	+		+		+	
85.	Cricotopus algarum (Kieffer)		+	+					
86.	Cricotopus sylvestris (F.)	+	+	+		+		+	
87.	Criptochironomus obreptans Kieffer					+		+	
88.	Dikrotendipes nervosus (Staeger)	+	+	+	+	+	+	+	
89.	Einfeldia longipes (Staeger)					+		+	+
90.	Endochironomus albipennis Meigen		+	+		+		+	
91.	Endochironomus tendens (F.)	+		+					
92.	Glyptotendipes gripekoveni (Kieffer)	+		+	+	+		+	
93.	Hydrobaenus lugubris (Fries)	+		+					
94.	Hydrobaenus pilipes (Malloch)	+		+					
95.	Parachironomus pararostatus (Lenz)	+	+	+	+	+		+	
96.	Paratanytarsus lauterborni (Kiffer)	+	+	+					

№	Species	Small Tataru island			Ermakov island				Ochakivskyi island
		channels	lakes	total	channels	lakes	drift	total	channel
97.	Polypedilum convictum (Walker)		+	+					
98.	Polypedilum exectum (Keffer)	+		+	+			+	
99.	Polypedilum nubeculosum Meigen	+		+	+			+	+
100.	Polypedilum sordens (van der Wulp)	+		+					
101.	Procladius choreus Meigen	+		+	+	+		+	
102.	Psectrocladius sordidellus (Zetterstedt)		+	+		+	+	+	
103.	Tanypus vilipennis (K.)	+		+	+	+	+	+	
104.	Tanytarsus excavatus Edwards		+	+	+	+		+	
	Ceratopogonidae								
105.	Ceratopogonidae sp.	+	+	+	+	+		+	
	Chaoboridae								
106.	Chaoborus sp.		+	+					
	Ephydridae								
107.	Ephydridae sp.				+			+	
	Psychodidae								
108.	Psychodidae sp.	+		+					
	In total	**69**	**45**	**81**	**39**	**49**	**21**	**70**	**22**

Contents.

Наукове видання

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(англійською мовою)

Монографія

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