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THE SEVENTIETH ANNIVERSARY OF THE INSTITUTE IN DUBROVNIK

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EDITORS
Professor Nenad Jasprica
Mirna Batistić, PhD

REVIEWERS
Academician Mladen Juračić
Academician Frano Kršinić
Academician Mirko Orlić

PUBLISHER
University of Dubrovnik

FOR THE PUBLISHER
Professor Nikša Burum

LANGUAGE EDITING
Graham McMaster, PhD

DESIGN
Katarina Banović

COVER PHOTO
Klaudio Pozniak

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THE SEVENTIETH ANNIVERSARY OF THE INSTITUTE IN DUBROVNIK

A Monograph

Dubrovnik, 2024.

FROM THE EDITORS

Dear Readers,

It is our pleasure to present a monograph prepared on the occasion of the seventieth anniversary of the foundation of the Institute in Dubrovnik, which we celebrated in April 2019.

The Croatian people have grown and anchored themselves in the Mediterranean, thus establishing connections with the whole world, most of all through the people of Dubrovnik. We sailed and fell in love with the sea like few other nations; we embraced its beauty and greatness. Without the sea, Croatian history and culture, life itself, would not be the way it is today. The sea is a teacher and defender; it is life for both Adriatic and inland Croatia.

We are a country with sovereign rights over approximately 54,000 km2 of seabed and about 57,000 km2 of land territory. Today, we have the opportunity to make full use of the sea and all its advantages. In order to be able to manage the sea and hand its natural resources down to those who come after us, it is necessary to understand the processes that take place within it. Today, we know that the decision of the then Yugoslav Academy of Sciences and Arts (Zagreb) in 1949 to establish a scientific institution on the southern coast of the Adriatic, in Dubrovnik, to study the natural features of the coast and sea, was necessary and justified.

As is usually the case, the beginnings were difficult. Despite frequent changes in internal organisation, names, or even headquarters, the Institute in Dubrovnik has remained recognized as one of the few centres in the Mediterranean where plankton is comprehensively researched from the earliest period to the present day. Planktonic organisms are the foundation of life in the sea as they have an impact on the functioning of the whole of the Earth's hydrosphere.

Before you is a monograph in which we present the Institute in Dubrovnik from its establishment to the present day and its role in the scientific community and society in general. Considering that the Adriatic Sea, especially the open sea of the southern Adriatic, is an ecosystem that significantly affects its remaining part and is insufficiently researched in Croatia, there is still much work ahead for us and future generations. The need for such research is particularly emphasised in the context of climate and other changes, which are largely the result of human activity. The use of the resources of the Adriatic is a Croatian economic priority and also a strategic national scientific research priority.

Dubrovnik, April 20, 2024

Nenad Jasprica

Mirna Batistić

Employees of the Institute for Marine and Coastal Research during the celebration of the 70th anniversary of its founding (2019) at the Dubrovnik Aquarium. From left to right: Nenad Antolović, Božo Grmoljez, Jakša Bolotin, Igor Brautović, Nenad Jasprica, Mirna Batistić, Davor Lučić, Valter Kožul, Barbara Gangai Zovko, Katija Dolina, Marijana Hure, Svjetlana Bobanović-Ćolić, Jele Martinović, Iris Dupčić Radić, Nikša Glavić, Nenad Gledić (Photo by T. Plazibat/Cropix).

CONTENTS

THE HISTORY OF THE INSTITUTION FOR MARINE AND COASTAL RESEARCH IN DUBROVNIK

Damir Viličić, Nenad Jasprica

Abbreviations:

BZIOR – Biological Station of the Institute of Oceanography and Fisheries
HHI – Croatian Hydrographic Institute
IRB – Ruđer Bošković Institute
JAZU – Yugoslav Academy of Sciences and Arts
PMF – Faculty of Science, University of Zagreb

In this chronological overview, we analyse the development of marine research in Dubrovnik, as well as of the botanical and ornithological research conducted within an institution that has changed its name and location multiple times in Dubrovnik over the past 70 years. Alongside the research scientists mentioned in the text, we cite their most important works that define these individuals within the described timeframe.

Marine research on the eastern coast of the Adriatic Sea before World War II

The history of research in the Adriatic Sea has been addressed by Zavodnik (2002), Casellato (2008), Orlić (2011), Dulčić and Kršinić (2012), and Viličić (2015). Research on the Adriatic Sea began in the 15th and 16th centuries, during the economic dominance of Venice, with significant contributions from the Dubrovnik Republic in the 16th and 17th centuries. Maritime transport and naval warfare required data on the physical properties of the sea and atmosphere, as well as nautical cartography. Consequently, in 1684, the *Accademia degli cosmographica degli argonauti* was established in Venice to study cartography, marine currents, and changes in the sea.

Serious research into the Adriatic Sea began in the northern Adriatic under the administration of Italy and the Austro-Hungarian

Viličić, D., Jasprica, N., 2021: The history of the institution for marine and coastal research in Dubrovnik. The Seventieth Anniversary of the Institute in Dubrovnik (eds. Jasprica, N., Batistić, M.). University of Dubrovnik, Dubrovnik.

Monarchy in the 19th century. The opening of a railway line to Rijeka in 1873 contributed to the development of maritime transport and the economy. Following the establishment of the Zoological Station in Trieste in 1875, naturalists from various European countries began research in the northern Adriatic. Oceanographic observations in the Adriatic began after the launch of the world's first oceanographic expedition aboard the research vessel *Challenger* from 1872 to 1876. Research along the eastern coast of the Adriatic was associated with several expeditions under the Italian-German and the Hungarian administrations from 1872 to 1933, some of which extended to the southern Adriatic. During this time, research was primarily qualitative and focused on understanding the composition of benthic and planktonic organisms. Croatian naturalists also operated in this environment. The first Croatian scientific research on the Adriatic Sea was conducted aboard the ship *Zvonimir* in 1893, with Lazar Car being the lead researcher on that journey (Orlić 1997). In 1894, the malacologist Spiridion Brusina, the first professor of zoology at the University of Zagreb, organised the second scientific research expedition in the Adriatic Sea aboard the ship *Margita*. Brusina promoted Darwin's evolutionary ideas and established numerous museum collections.

The oldest institution for marine research on the eastern Adriatic coast was established in Rovinj as the Zoological Station of the Berlin Aquarium (*Zoologische Station des Berliner Aquarium*) in 1891. In 1918, the institution came under Italian administration (*Stazione Zoologica,* later *Istituto di Biologia Marina per l'Adriatico-Rovigno*), and from 1937 to 1940, it was jointly administered by Italy and Germany (*Deutsch-Italienisches Institut für Meeresbiologie zu Rovigno,* or *Istituto Italo-Germanico di Biologia Marina di Rovigno d'Istria*). After World War II, from 1948 onward, the institution in Rovinj operated under the authority of the Ministry for Science and Culture of the People's Republic of Yugoslavia and administratively became a department of the Institute of Oceanography and Fisheries in Split (Institute for Fisheries Ecology). From 1951 to 1968, the Institute became part of the Yugoslav Academy of Sciences and Arts under the name Institute of Marine Biology.

Following the establishment of the Kingdom of Serbs, Croats, and Slovenes, later renamed the Kingdom of Yugoslavia, the Institute of Oceanography and Fisheries was established in Split in 1930. The first director of the Institute was Professor Hjalmar

Broch from Oslo, who, drawing on Norwegian experiences in oceanography, organised scientific research at the Institute. Ante Ercegović returned from France and introduced a method for quantitative research into phytoplankton using a microscope.

Research in Dubrovnik prior to World War II

The Dubrovnik area and the southern Adriatic were relatively remote and excluded from marine research during the 19th and the first half of the 20th century. However, as early as 1894, Croatian naturalist Spiridion Brusina proposed the establishment of a research station in the southern Adriatic.

Research in Dubrovnik from the Second World War to the Croatian War of Independence

Station in Gruž

In 1946, the Ministry of Fisheries of the then People's Republic of Croatia established the Fisheries Station in Dubrovnik (Figure 1). The first research was conducted by Kirinčić and Lepetić. More intensive marine research in Dubrovnik was initiated by Tomo Gamulin, who came to the Station from Rovinj in 1951. The Station was abolished in 1956, and Tomo Gamulin moved to the University of Zagreb, while the academies in Zagreb and Belgrade redirected the fisheries activities to the Institute in Split. In Dubrovnik, the Natural History Museum

Figure 1. Fisheries Station in Gruž opened in 1946 (Photo Archive of the Institute).

existed, founded in 1872 as the Dubrovnik Patriotic Museum, which preserved collections of prominent Dubrovnik residents, pharmacists, and shipowners such as Antun Drobac and drawing teacher Baldo Kosić. In 1949, the Yugoslav Academy of Sciences and Arts (JAZU) initiated the successful establishment of the Biological Institute in Dubrovnik in 1950 after the government provided land and a building on the southern shore of the Gruž port (JAZU 1952). The Institute was organised by Stanko Karaman, who began research on underground fauna.

The Institute of JAZU in Fort St. John

The president of JAZU, Andrija Štampar, negotiated in 1957 with the municipality of Dubrovnik the relocation of the Biological Institute from Gruž to the island of Lokrum (the whole of Lokrum, including its buildings, was allocated to the Institute at that time). Thanks to the efforts of the artisan Krstić, a marine aquarium was established in Fort St. John in 1953. Cultural and educational institutions, namely the Natural History Museum and the Aquarium, were assigned to the Biological Institute of JAZU, creating a unique institution. Tomo Gamulin was appointed as the director of the Institute, and he embraced Andrija Štampar's idea, conceptualising scientific activities on Lokrum Island by organising the Botanical Garden and botanical research. Tomo Gamulin, during his tenure at the Oceanographic Institute in Split, had already been involved in zooplankton studies. He participated in the Hvar expedition organised by the Institute from 1948 to 1949, where he comprehensively studied zooplankton, correlating the spawning of pelagic fish, especially sardines, with their diet. He continued his zooplankton research after his arrival in Dubrovnik, and together with Jure Hure linked zooplankton with sardine spawning in the Adriatic Sea (Gamulin and Hure 1955).

In 1960, JAZU consolidated its institutions in Rovinj, Trsteno, and Dubrovnik under the leadership of Tomo Gamulin with headquarters in Rovinj. However, this structure was abandoned in 1963 when the institutions in Rovinj and Trsteno were divided into distinct units (Kršinić 1989). With initial funding from JAZU, director Tomo Gamulin gradually succeeded in organising the aquarium and financing research largely through the revenue generated by the aquarium. In 1961, he acquired a ship - a small wooden cutter named *Baldo Kosić*, and in 1965, he set up laboratories on the ground floor of Fort St. John.

Figure 2. Tomo Gamulin in 1979 (Photo Archive of the Institute).

After obtaining their doctorates in 1965, Jure Hure and Tomo Gamulin laid the groundwork for more serious research on zooplankton in Dubrovnik (Figure 3). The director of the Institute, Tomo Gamulin, collaborated with colleagues from France (*Observatoire Océanologique de Villefranche-sur-Mer*), Italy (*Stazione Zoologica di Napoli*, *Università degli Studi di Trieste*), and Austria (*Universität Wien*). Even during his time in Rovinj, Tomo Gamulin collaborated with Rupert Riedl, a professor of zoology at the University of Vienna, for whom research in the Adriatic was largely the basis for the publication of the first edition of the manual on the fauna and flora of the Adriatic and later the Mediterranean Sea (Riedl 1983). Gamulin organised collaboration with Pietro Dohrn, the director of the Zoological Station in Naples, and initiated comparative research on zooplankton in the southern Adriatic and the Gulf of Naples (Gamulin et al. 1968).

Figure 3. Jure Hure and Tomo Gamulin at the 1st Symposium of Yugoslav Oceanographers in Split, 1962. From left to right (top row): Tamara Vučetić, Jure Hure, Otmar Karlovac; bottom row: Ante Škrivanić, Stefan Gelineo, Šime Županović, Tomo Gamulin (Photo by M. Alajbeg).

Figure 4. Student fieldwork on the islet of Bobara in 1982. The students are led by their professor, Milan Meštrov, and the botanist Stipe Hećimović (Photo by D. Viličić).

Tomo Gamulin used the collaboration with the Faculty of Science, University of Zagreb (PMF), to bring in young professionals, thus laying the groundwork for the future organised scientific institution starting from 1967. Fourth-year Biology students from the PMF spent about ten days on fieldwork in Dubrovnik, and were accommodated in the former Benedictine monastery on Lokrum Island (Figure 4). After the Dubrovnik earthquake in 1979, fieldwork on Lokrum was discontinued.

Director Tomo Gamulin encouraged the discipline and interest in the sea among young assistants and emphasised the importance of publishing research results in high-quality scientific journals. Discussions at the Institute regularly covered research methodology, equipment needs, presentation of results at conferences, and publication of papers. Gamulin involved assistants in projects and collaborations with other national and foreign institutions from the beginning. Jure Hure specialised in planktonic copepods (Hure et al. 1980), while Adam Benović directed his research towards jellyfish (Benović 1973, Benović et al. 1987) and the biomass of net zooplankton (Benović et al. 1984). Tomo Gamulin devised the first research project on microzooplankton in the Adriatic, which Frano Kršinić took over in 1972, standardising the sampling methodology using a Van Dorn bottle (Kršinić 1980); he later developed a new sampling tool, the Adriatic net (Kršinić 1990). Kršinić furthered his expertise in Germany, at the *Biologische Anstalt Helgoland, Litoralstation List/*

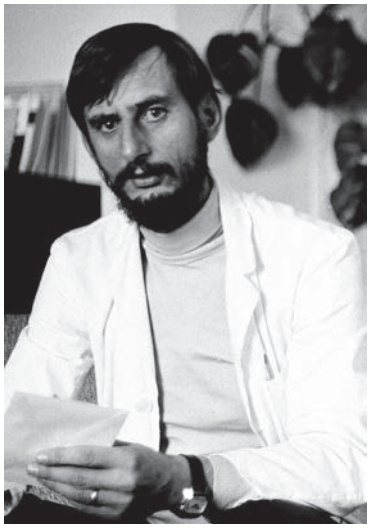

Figure 5. Adam Benović in 1978 (Photo by D. Viličić).

Figure 6. Researchers on the deck of the *Baldo Kosić* in 1979. From left to right: Frano Kršinić, Damir Mušin, Vladimir Onofri, Radimir Balenović, and the seaman Mirko Udženija (Photo by D. Viličić).

Sylt, and applied his experience in the International Pollution Monitoring Project in the Mediterranean (UNEP MED POL projects), in which the Institute participated from 1978 to 1989 in collaboration with the Ruđer Bošković Institute (IRB) in Zagreb. The acquisition of an inverted microscope triggered research on phytoplankton. At that time, only temperature and salinity were monitored, with the use of Nansen bottles (Viličić and Balenović 1982). The assistants at the Institute changed over time, as evidenced by the list of personnel published in this book.

Within the Botanical Garden on the island of Lokrum, Lav Rajevski initiated botanical research in 1960 (Rajevski 1969), focusing on the adaptation and introduction of foreign plant species to the Dubrovnik area, and also establishing a collection of eucalyptus and cacti (see Figure 7). Research on the flora and vegetation of the Dubrovnik area was continued by Vladimir Birač (Birač 1973). After his departure in 1977, Marija Hećimović and Stipe Hećimović took over (Hećimović M. 1981, Hećimović S. 1982), and following their departure in 1990, professional associates remained to care for the Botanical Garden. More information about the Garden is provided in this monograph, Dolina (2024). From 1951 to 1985, ornithologist Ivan Tutman was active at the Institute and within the Museum (see Figure 8).

Figure 7. The collection of cacti by Lav Rajevski in the greenhouse (gardener Mirko Šiljeg and Frano Kršinić in 1979) (Photo by D. Viličić).

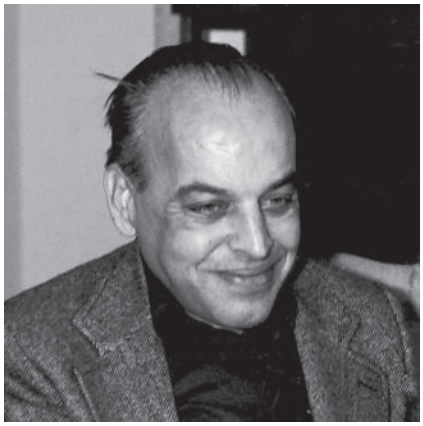

Figure 8. Ornithologist Ivan Tutman in 1979 (Photo by D. Viličić).

Biological Station of the Institute of Oceanography and Fisheries

In 1976, the Biological Institute in Dubrovnik became the Department (Croatian: Zavod) of the Institute of Oceanography and Fisheries (BZIOR) with administrative oversight in Split. After Tomo Gamulin retired, Adam Benović became the head of the Dubrovnik unit. The connection with the Institute's headquarters in Split was mainly administrative. The Institute in Split was occupied with numerous commercial projects in which Dubrovnik's scientists were mostly not involved. Despite the fact that at the time fewer references were needed for advancement in research positions than today, Dubrovnik's researchers were focused on scientific investigations and publishing in reputable scientific journals. In Dubrovnik, assistants obtained their master's and doctoral degrees relatively quickly, leading to an increase in the number of researchers with scientific titles. This was one of the reasons why the institution in Dubrovnik was welcomed as part of the Institute of Oceanography and Fisheries.

During the period from 1965 to the Croatian War of Independence (Homeland War) in 1990, plankton research was conducted in the coastal and open waters of the southern Adriatic Sea (Figures 9, 10, 11). A new and larger ship of the same name (*Baldo Kosić*) was built in 1987 (Figure 12). An interesting one-year comparative study of the taxonomic composition and ecological properties of plankton in 11 bays along the eastern coast of the Adriatic Sea (sampling once a month) was organised using a car and private fishing boats (Kršinić 1987, Viličić 1989a, Viličić et al. 1995a). Plankton and shellfish research was conducted in Mali Ston Bay (Kršinić 1987, Viličić et al. 1994a, Lučić and Kršinić 1998). In the lakes of Mljet, the seasonal and fine vertical distribution of microzooplankton was determined (Kršinić and Lučić 1994).

Figure 9. Plankton nets for collecting mesozooplankton on the deck of the *Baldo Kosić* in 1979; Vladimir Onofri and Damir Mušin (Photo by D. Viličić).

Figure 10. Working with a probe in Župa Bay in 1983; Davor Lučić and Damir Mušin (Photo by D. Viličić).

Figure 11. Cutting the plankton net at the Institute in Dubrovnik – Frano Edl in 1986 (Photo by D. Viličić).

Figure 12. The *Baldo Kosić* – departure ceremony in 1987 (Photo by D. Viličić).

Zooplankton researchers from Dubrovnik participated in studies of the northern Adriatic (Kršinić 1995, Benović and Lučić 1996). Oceanographic measurements and plankton research in the open sea of the Adriatic were conducted between 1974 and 1990 using the hydrographic vessel of the Yugoslav Navy, *Andrija Mohorovičić*, the only vessel suitable for such work (Figures 13, 14, 15). Researchers from Dubrovnik participated in all cruises along the transverse profiles (transects) of the Adriatic and monitored all size-fractions and taxonomic groups of plankton (Kršinić 1998, Viličić et al. 1989b, 1994b, 1995b). The first results on copepods from these cruises were published by Jure Hure and colleagues from Naples (Hure et al. 1980).

Figure 13. Sampling of mesozooplankton with a closing net (ø250 μm) in 1985 (Photo by D. Viličić).

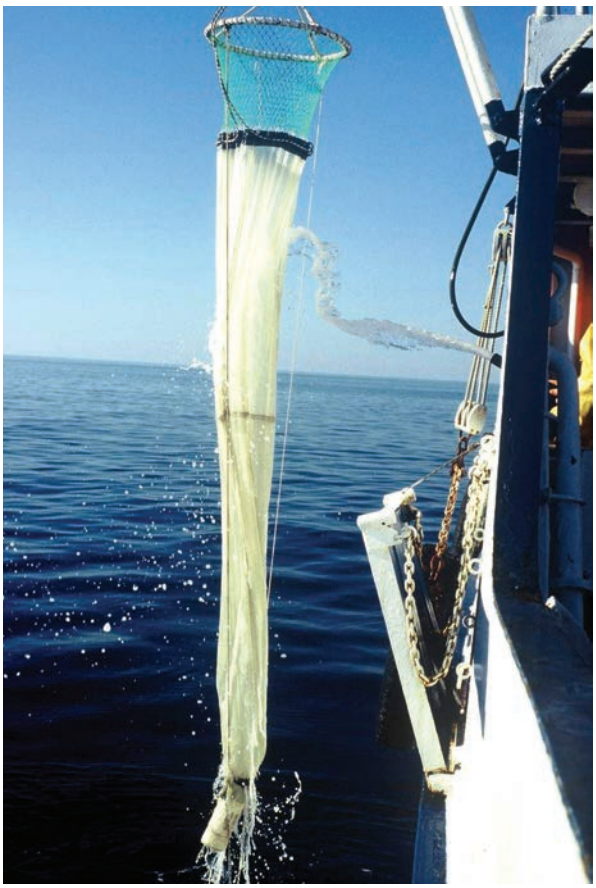

Figure 14. Rinsing of the plankton net for collecting microzooplankton and microphytoplankton (ø53 μm) in 1980 (Photo by D. Viličić).

Figure 15. Frano Kršinić and Alenka Malej (Piran Institute of Biology, Slovenia) on board the *Andrija Mohorovičić* in 1985 (Photo by D. Viličić).

Research in the South Adriatic Pit was later conducted by the Institute using the *Bios* ship (1993–1994) and *Naše more* as part of the Ministry of Science project "Distribution of Plankton, Production, and Regenerative Relationships" (1992–1995). Experimental work on fish farming and cultures for feeding the larvae began (Figures 16, 17).

Figure 16. Small concrete tanks for fish farming at the Institute (Photo by D. Viličić).

Figure 17. Cultivation of phytoplankton for feeding fish larvae in 1984 (Photo by D. Viličić).

Figure 18. Some participants in field research in the Krka River estuary. From left to right: Zvonko Gržetić (HHI), Nenad Jasprica (BZIOR), Ante Škrivanić (IRB), Vera Žutić (IRB), and Mladen Ferenčak (HHI) in 1985 (Photo by D. Viličić).

Some scientists participated in research on the Krka River estuary led by the IRB (Viličić et al. 1989a, Legović et al. 1994) (Figure 18).

The destruction of Dubrovnik in the war between 1990 and 1992 (Figure 19), which included the research vessel, interrupted research at Fort St. John. The Botanical Garden on Lokrum suffered severe damage, and a significant portion of the scientific literature and all the documentation on the garden's plants were lost in a fire. The project documentation for the landscape design of the Garden at the Center for Historical Gardens and Landscape Development in the Inter-University Centre in Dubrovnik was irretrievably lost. Professor Milan Meštrov, who had led field trips for students from the Faculty of Science, attempted to restore the monastery for the needs of the Scientific-Educational Station of the University of Zagreb (Meštrov 1989). However, the ongoing restoration was interrupted by the Croatian War of Independence, and the plan has yet to be realised (Viličić 2004).

Figure 19. Organising shelters for civilians at the Aquarium of the Institute – in Fort St. John, in September 1991 (Photo by D. Viličić).

Research after the end of the Croatian War of Independence

Expansion of space and construction of a new vessel

After the end of the Croatian War of Independence and the stabilisation of political circumstances, Adam Benović and Boško Skaramuca initiated the refurbishment of a new working space in the former saltern within Fort St. John.

From 1998 to 2011, the National Monitoring Program of the Sea "Systematic Research of the Adriatic Sea as the Basis for Sustainable Development of the Republic of Croatia" (the "Adriatic" project) was organised, enabling the acquisition of equipment and interdisciplinary work throughout the Adriatic Sea.

Research on plankton continued in the Mali Ston Bay, the Mljet Lakes, and other coastal waters. Scientific collaboration was established with the Faculty of Science, the Ruđer Bošković Institute, and the Croatian Hydrographic

Institute in Split for research in the estuaries of the Zrmanja River, Velebit Channel, and Pag Channel. Previously unknown endemic species were discovered in submerged caves.

In the new facilities, ecological and experimental research into fish for mariculture was conducted.

Figure 20. Members of the Laboratory for Plankton Research at BZIOR in Dubrovnik in 1995. Damir Viličić (1), Jakica Sanko (2), Marina Carić (3), Frano Kršinić (4), Nenad Jasprica (5), Mirna Batistić (6), Josip Mikuš (7), Igor Brautović (8) (Photo by D. Viličić, published in Viličić 2015).

Figure 21. Collaboration in the research into the Velebit Channel 2002. From left to right: Zrinka Burić (PMF), Božo Grmoljez (BZIOR), Marina Carić (BZIOR), Ivona Cetinić (PMF), Goran Olujić (HHI) (Photo by D. Viličić).

Figure 22. Research into the Velebit Channel 2002; preparation of samples for nutrient analysis (Photo by D. Viličić).

Figure 23. Valter Kožul and the collection of organisms for research in mariculture (Photo by N. Glavić).

Institute for Marine and Coastal Research of the University of Dubrovnik

In 2003, the founding of the University of Dubrovnik required staff and infrastructure support. The university leadership requested the incorporation of two laboratories from the Split Institute of Oceanography and Fisheries (IOR) into the University of Dubrovnik in 2005. These laboratories were the Laboratory for Plankton Ecology and the Laboratory for Ecology and Cultivation of Marine Organisms, both located in Fort St. John in Dubrovnik. At that time, the university had only about ten Ph.D. holders, while the Institute brought in 12 Ph.D. holders, two M.Sc. holders, and three junior researchers. Frano Kršinić remained an employee of the Institute of Oceanography and Fisheries in Split, while Damir Viličić moved to the Department of Biology of the Faculty of Science at the University of Zagreb. The separation of the Dubrovnik laboratories from the IOR was approved by the IOR Scientific Council on November 2, 2005, and by its Administrative Council on November 4, 2005. The Senate of the University of Dubrovnik established the Institute for Marine and Coastal Research as its scientific unit on November 15, 2005. The director organised the internal structure

of the Institute, dividing it into four laboratories: the Laboratory for Plankton Ecology and Population Genetics, the Laboratory for Oceanology, the Laboratory for Aquaculture and Aquarium Studies, and the Laboratory for Terrestrial Flora and Fauna. The Scientific Council was established, and the Institute began operating on January 1, 2006, as the legal successor of the Biological Station of the IOR (BZIOR), but upon joining the University of Dubrovnik, it lost its legal status. Research expanded to include terrestrial flora and vegetation.

In March 2009, the Institute acquired a new research vessel, Baldo Kosić II, co-financed by the Ministry of Science and the Ministry of the Sea, Transport, and Infrastructure, for scientific research and professional tasks in the coastal waters near Dubrovnik. Thus, after 17 years, the Institute obtained a new vessel to replace the one that was mobilised for the defence and destroyed during the Croatian War of Independence in November 1991. Research is also conducted using the larger vessel Naše More, owned by the University of Dubrovnik, in collaboration with other scientific institutions in Croatia.

In its new structure (under the leadership of directors Nenad Jasprica, Valter Kožul, Nenad Antolović), the Institute kept up its main activity – research into plankton - zooplankton (Batistić

Figure 24. The *Baldo Kosić II* in 2009 (Photo by N. Jasprica).

et al. 2007, 2012, 2013, 2014, 2016, 2019, Lučić et al. 2009, 2015, 2017, 2019, Garić and Batistić 2011, 2016, Gangai et al. 2012, 2018, Hure et al. 2018, 2020, Miloslavić et al. 2015, 2016, Njire et al. 2019), phytoplankton (Carić et al. 2011, 2012, Jasprica et al. 2012, Čalić et al. 2013, 2018, Ljubimir et al. 2017), and the research of fish and other marine organisms for mariculture (Kožul et al. 2012, 2013, Glavić et al. 2018a, b, Antolović et al. 2010, 2012), with financial support from the Ministry of Science of the Republic of Croatia, Croatian Science Foundation, National Inter University Consortium for Marine Research of the Republic of Italy – CONISMA, Polish Ministry of Science and Higher Education, and others. In 2007, a new laboratory for plankton ecology and population genetics was established under the leadership of Dr. Mirna Batistić. Molecular methods are used to describe unknown planktonic organisms (Garić and Batistić 2011, 2016, Batistić and Garić 2016).

In September 2008, the Institute hosted and was the main organiser of the International Diatom Symposium (20th International Diatom Symposium), attended by more than 200 scientists from 41 countries worldwide (Figure 25). This event led to international collaboration in research into benthic diatoms (Car et al. 2012, 2019).

Figure 25. Participants of the 20th International Diatom Symposium held in Dubrovnik in September 2008, organized by the Institute in Dubrovnik (Photo by N. Jasprica).

The Institute organises conferences, popularises, and promotes science (Figure 26). In collaboration with professional associations, the Natural History Museum in Dubrovnik, and others, it organises exhibitions, lectures, and book promotions. The Institute participated in the preparation of EU Directives on marine exploitation and protection in the process of Croatia's accession to the European Union and prepared proposals for the NATURA 2000 ecological network on land and at sea, in coordination with the then State Institute for Nature Protection.

Figure 26. From the opening of photography exhibitions organised by the Institute in Dubrovnik: A – group exhibition by multiple authors "Biodiversity in Photography" at the Natural History Museum in Dubrovnik 2010 (Photo Archive of the Croatian Natural History Museum in Dubrovnik), B – exhibition by author Dubravka Šoljan "Plants and Mountains" at the University of Dubrovnik campus in 2015 (Photo by I. Brautović).

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MEASUREMENTS OF PHYSICO-CHEMICAL PARAMETERS AT THE INSTITUTE IN DUBROVNIK

Iris Dupčić Radić

The physico-chemical parameters of the sea are analysed in the Institute's chemical laboratory (Figure 1). These are the basic parameters that characterise the seawater physical properties and influence the distribution of marine life. By monitoring them, we learn more about the processes of heat exchange between the sea and the atmosphere, the mixing of water masses and the effects of freshwater inflows on marine ecosystems. In its early days, the chemical laboratory was located outside Fort St. John, in Pustijerna Street. It was modestly equipped so that only basic hydrographic and chemical parameters, such as temperature,

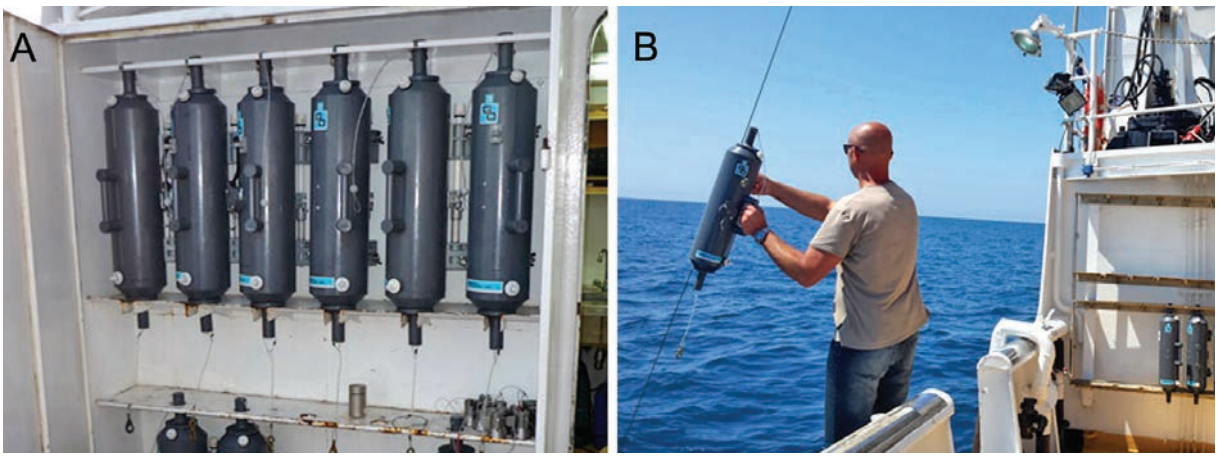
Figure 1. Iris Dupčić Radić and Božo Grmoljez prepare samples for nutrient analysis in the chemical laboratory (Photo by I. Brautović).

Dupčić Radić, I., 2021: Measurements of physico-chemical parameters at the Institute in Dubrovnik. The Seventieth Anniversary of the Institute in Dubrovnik (eds. Jasprica, N., Batistić, M.). University of Dubrovnik, Dubrovnik.

salinity, density, transparency and dissolved oxygen, could be measured. Radimir Balenović (Balenović 1981) began research into physical and chemical parameters. By the end of the 1980s, the laboratory had been equipped with new instruments and other parameters began to be determined, such as the concentration of nutrient salts in the sea, the activity of alkaline phosphatase and the biochemical composition of plankton and shellfish. Contemporary research was started by Marina Carić after the departure of Balenović. In the early 1990s, chemical laboratory was moved to Fort St. John. Research is carried out in various areas along the Adriatic coast (coastal sea, open sea, estuaries, lakes), in collaboration with colleagues from other scientific institutions, numerous scientific papers being published. Standard oceanographic methods and equipment are used to collect and analyse physico-chemical parameters (Figures 2, 3, 4).

Figure 2. Measurement of salinity, temperature and density of the seawater with a CTD (conductivity-temperature-depth) probe (Photo by R. Garić).

Figure 3. Niskin bottles (A) and sea sampling for the analysis of nutrients and dissolved oxygen with a Niskin bottle (B) on the research ship *Naše more* (Photo by R. Garić).



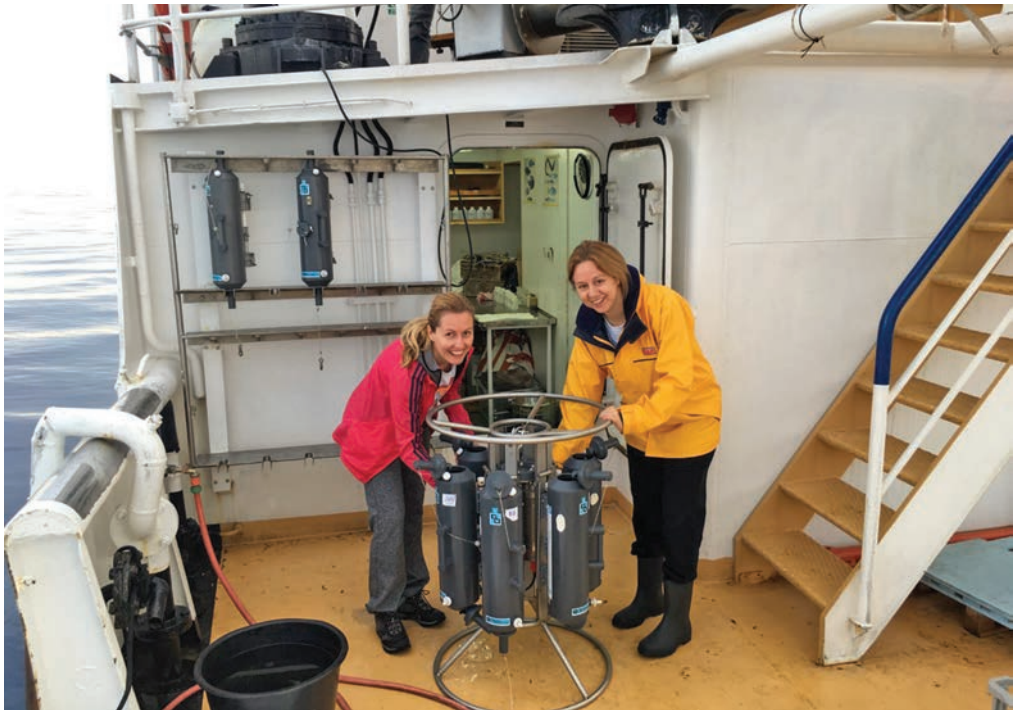


Figure 4. Ana Car and Iris Dupčić Radić prepare a rosette with Niskin bottles for collecting sea samples on the research ship *Naše more* (Photo by R. Garić).

The main activity of the chemical laboratory is to determine the concentration of the nutrient salts of nitrogen, phosphorus and silicon in marine samples. In addition to sunlight, carbon dioxide and water, nutrient salts are important substances that are required for the process of photosynthesis. As they are present in only low concentrations in the sea, they can be limiting factors for the growth of phytoplankton organisms. During the process of photosynthesis, phytoplankton cells use dissolved nutrient salts to produce new organic matter (primary production of organic matter) which thus enters the food chain, from phytoplankton to zooplankton to shellfish and fish. By increasing the concentration of nutrient salts through various chemical and biological processes, brought from the land and by the exchange of water masses, the abundance of phytoplankton and the production of organic matter increases, sometimes beyond the limit of possible decomposition. The intensity of these processes determines the degree of eutrophication. Eutrophication is the process by which the primary production of organic matter increases (compared to the usual one) due to the increased input of nutrient salts into the surface layer of the sea. The decomposition of organic matter consumes

oxygen, leading to a decrease (hypoxia) or deficiency (anoxia) of dissolved oxygen in the bottom layers, changes in the composition of living communities and the death of marine organisms. Eutrophication can occur naturally but is most often caused by human activities (anthropogenic eutrophication), namely the discharge of wastewater and leaching from agricultural land treated with artificial fertilisers.

The open waters of the Croatian part of the Adriatic are generally not very productive, nor are the coastal waters, with the exception of some areas that are under the influence of a stronger supply of nutrient salts from rivers, groundwater or wastewater discharges. In the southern Adriatic, there is occasionally an increased degree of eutrophication in the area of the Neretva estuary when the inflow of river water increases (Dupčić Radić 2012).

Since 1994, the scientists of the chemical laboratory have been involved in systematic research into Lake Rogoznica, in collaboration with the Ruđer Bošković Institute. It is a naturally eutrophic marine lake in which anoxia occurs at a depth of more than nine metres; it is a water system that is unique not only on the Adriatic coast, but also in the entire Mediterranean region. Sulphur compounds accumulate in the oxygen-depleted bottom water layer and the concentrations of phosphates, silicates and ammonium salts increase due to intensive processes of microbial decomposition of organic matter, which is the main source of the natural eutrophication of Lake Rogoznica (Ciglenečki et al. 2005, Čanković et al. 2019). At the beginning of autumn, with the drop in air temperature, the water layers in the lake are usually mixed, so that the oxidation of the high sulphide concentration at the bottom can lead to the sudden consumption of oxygen and the occurrence of anoxia in the entire water column (Ciglenečki et al. 2013) (Figure 5).

The Institute's scientists have been conducting research in Mali Ston Bay for many years. It is an ecologically stable, oligotrophic, well-aerated bay with high marine transparency and phytoplankton biodiversity and a low concentration of nutrient salts (Čalić et al. 2013). Due to the increased inflow of freshwater from the Neretva River, the activity of underground hot springs and the precipitation washing of the steep vertical slopes around

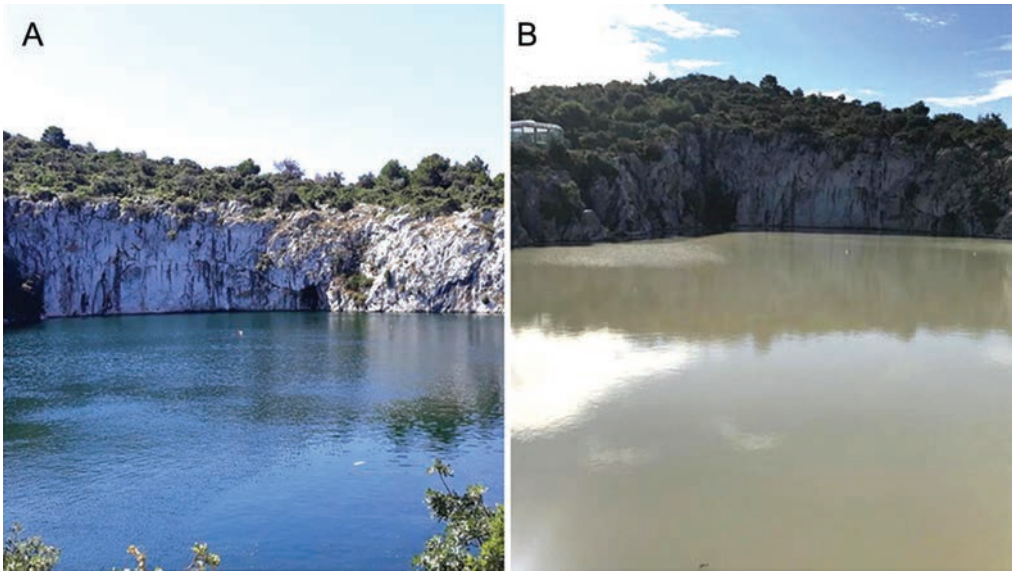


Figure 5. The surface of Lake Rogoznica in conditions without anoxia (A) and during anoxia (B). (Source: HRZZ project MARRES, IP-2018-01-1717, I. Ciglenečki).

the bay, the sea is enriched with nitrates and silicates and the salinity of the sea decreases (Dupčić Radić et al. 2014).

The Institute devotes particular attention to research in the open sea of the southern Adriatic. Physico-chemical parameters and plankton populations have been continuously analysed since 1993 at several stations in the southern Adriatic and as part of various scientific research projects (Figure 6). The water column is well aerated at the analysed stations in the southern Adriatic. The concentrations of nutrient salts in the open sea of the southern Adriatic varied considerably over several years of research (Dupčić Radić et al. 2017). The southern Adriatic is under the influence of the Bimodal Oscillation System (BiOS), which acts as a feedback mechanism between the Adriatic and the Ionian Sea and leads to changes in the circulation of the North Ionian Gyre, which influences the advection (horizontal mixing of water masses) of Atlantic Water (AW) or Levantine Intermediate Water (LIW) into the Adriatic (Figure 6). During anticyclonic circulation (A), the advection of AW from the western part of the Mediterranean is more pronounced, leading to a decrease in salinity, temperature and density and an increase in the concentration of nutrient salts. During the cyclonic circulation (C), there is an advection of LIW from the eastern part of the Mediterranean, which increases the salinity, temperature and density and reduces the concentration

of nutrient salts. In the winter months, the surface layer of the sea cools, its density increases and it sinks to the bottom, while warmer water rises to the surface from greater depths (so-called convection processes). In this way, the water column is mixed and the surface layer is enriched with nutrients from the greater depths, which cause the phytoplankton bloom in spring. In extremely cold winter conditions (low air temperature, strong Bura wind), the vertical mixing of the water column sometimes extends over a depth of more than 800 m (Ljubimir et al. 2017). Therefore, primary production in the southern Adriatic depends mainly on the climatic conditions in winter and the strength of convective mixing of the water column. In spring, the nutrients at the surface are depleted, so their concentration remains low until the next mixing period. In the most recent years of research (2014-2017), during the cyclonic circulation in the open sea of the southern Adriatic, nitrate concentrations were reduced and phosphate concentrations increased compared to previous years (1993-2013).

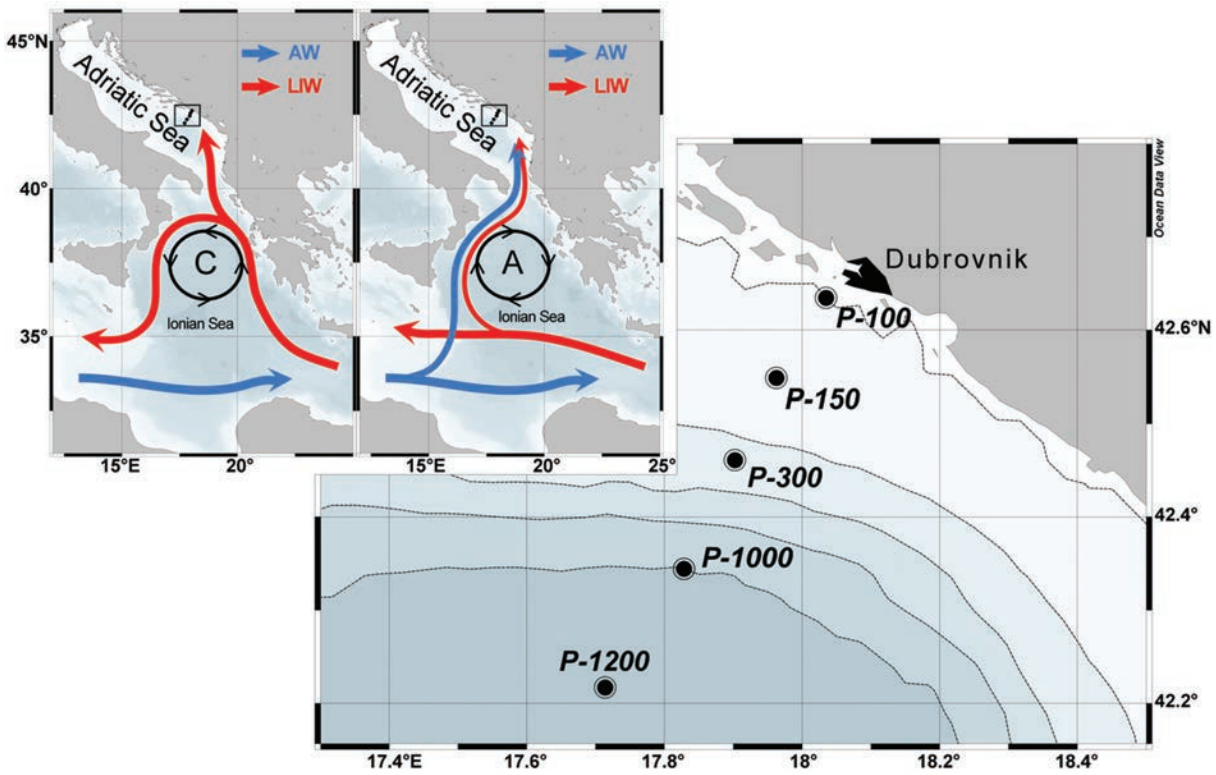


Figure 6. Sampling stations in the southern Adriatic showing different circulations of the North Ionian Gyre (C – cyclonic, A – anticyclonic) and water masses (AW – Atlantic Water, LIW – Levantine Intermediate Water (Batistić et al. 2014).

The southern Adriatic is an area of very great importance for the dynamics of the Adriatic and part of the Mediterranean. The pronounced seasonal and interannual fluctuations in physico-chemical and biological parameters make it an excellent area for scientific research. The study of long time series of data leads to new insights in oceanology, and their existence is extremely important for the understanding of this area as well as of the entire Adriatic basin.

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RESEARCH ON MICROORGANISMS AT THE INSTITUTE IN DUBROVNIK

Svjetlana Bobanović-Ćolić

Microorganisms play a crucial role in aquatic ecosystems. The ecology of marine microorganisms encompasses the study of the microbial community structure and the role of the microbial food web in the flow of matter and energy in pelagic ecosystems. In the sea, indigenous microorganisms include viruses, autotrophic and heterotrophic prokaryotes (bacteria and cyanobacteria), as well as autotrophic and heterotrophic eukaryotes (algae, phagotrophic protists, filamentous fungi, and yeasts).

Given the importance of bacteria in biogeochemical processes in the sea, recent research has focused on the abundance and biomass of bacteria, mostly within the plankton. Bacterioplankton consists of bacteria living in the plankton, participating in all vital processes. They are highly metabolically active, reproduce rapidly, and contribute to both the production and the decomposition of organic matter. Bacterioplankton represents the largest biologically active surface in the sea, and its biomass forms the basis of marine food chains. Therefore, bacterioplankton serves as an excellent indicator of trophic status on spatial or temporal scales.

In addition to researching indigenous microorganisms, the Institute also investigates the presence of fecal pollution indicators in seawater and organisms (especially shellfish), and occasionally certain groups of pathogenic microorganisms. The results of these studies are essential for assessing the sanitary quality of the sea and marine organisms, as well as potential risks to human health. Research also focuses on the survival of microorganisms and other pollutants in the marine environment, as well as the rates of their accumulation in

Bobanović-Ćolić, S., 2021: Research on microorganisms at the Institute in Dubrovnik. The Seventieth Anniversary of the Institute in Dubrovnik (eds. Jasprica, N., Batistić, M.). University of Dubrovnik, Dubrovnik.

shellfish under different ecological conditions. Due to significant human influence and global climate change, studying marine microorganisms is of the utmost importance.

The development of marine microbiology in the southern Adriatic has been paralleled with the advancement and refinement of microbiological techniques, research projects, and the production of assessment reports. The first Croatian research in the southern Adriatic was published in 1955 when Vlaho Cviić, a pioneer in marine microbiology in the Adriatic, investigated the occurrence of sulphur bacteria in the Mljet lakes (Cviić 1955). He also conducted the first research on bacterial distribution and determined their biomass using microscopic methods in the southern Adriatic (Cviić 1963).

Pioneering research on bacteria using direct agar methods was conducted by Damir Viličić in the Malostonski Bay during his dissertation work at the Institute in Dubrovnik (Viličić 1983).

Before work could be begun in the microbiological laboratory (1986), it had to the supplied with basic equipment. The laboratory was initially located in the basement of the Bishop's Palace and was later relocated to the first floor of Fort St. John after its renovation in 1995.

Figure 1. Heterotrophic bacteria on Zobell marine agar during research at a station near the island of Lokrum, Dubrovnik (Photo by S. Bobanović-Ćolić).

For sampling, the MV *Baldo Kosić* was used, for it was additionally equipped for microbiological work. Later, for research in the open sea of the southern Adriatic, the MV *Bios* of the Institute of Oceanography and Fisheries in Split, as well as the MV *Naše more* of the University of Dubrovnik, and the *Baldo Kosić II* were used.

Microbiological research at the Institute in Dubrovnik began in 1988, focusing on determining indicators of faecal pollution (Šoša and Radoničić 1990).

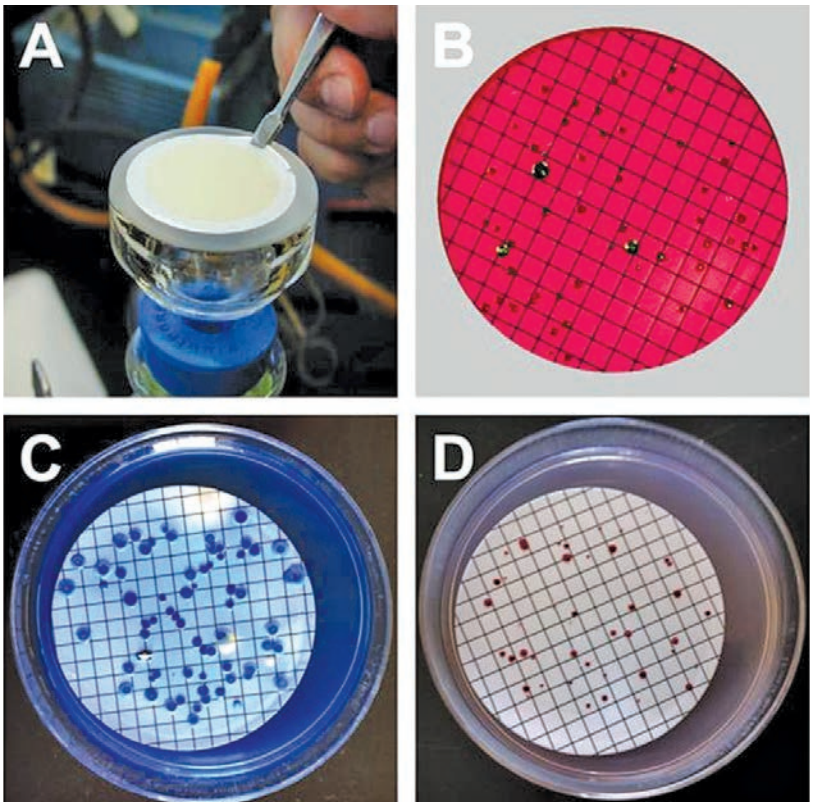

Figure 2. Determining indicators of faecal pollution in the vicinity of the city of Dubrovnik. A – membrane filtration method, B – total faecal coliforms, C – faecal coliforms, D – faecal streptococci (Photo by S. Bobanović-Ćolić).

With the acquisition of an epifluorescence microscope in 1987, research on natural populations of bacterioplankton began as part of plankton studies within several projects. Within the "Adriatic" project (since 1998), the degree of eutrophication of coastal and open sea areas was determined, and the conditions of fish farms from Zadar to Dubrovnik were monitored.

Figure 3. Method for determining the concentration of the pathogenic bacterium *Escherichia coli* in shellfish (Photo by S. Bobanović-Ćolić).

In the southern Adriatic, multi-year research has provided insights into the ecology of picoplankton from the coast to the open sea. The open sea is highly oligotrophic (Radoničić 1990). In the open sea of the southern Adriatic, occurrences of surface water sinking have been recorded, including sinking of picoplankton (Batistić et al. 2012). On the other hand, it has been shown that Gruž Bay (Viličić et al. 1995) and the Ombla estuary (Bobanović-Ćolić 2011) are significantly influenced by anthropogenic factors. In the Veliko Jezero ("Big Lake") on the island of Mljet, increased abundance of heterotrophic bacteria (> 10^6 cells mL^{-1}) was recorded during the period 2015–2016 (Lučić et al. 2019). Additionally, the occurrence of hypoxia in the lakes and the role of bacterioplankton in jellyfish nutrition have been investigated (Hrustić and Bobanović-Ćolić 2017).

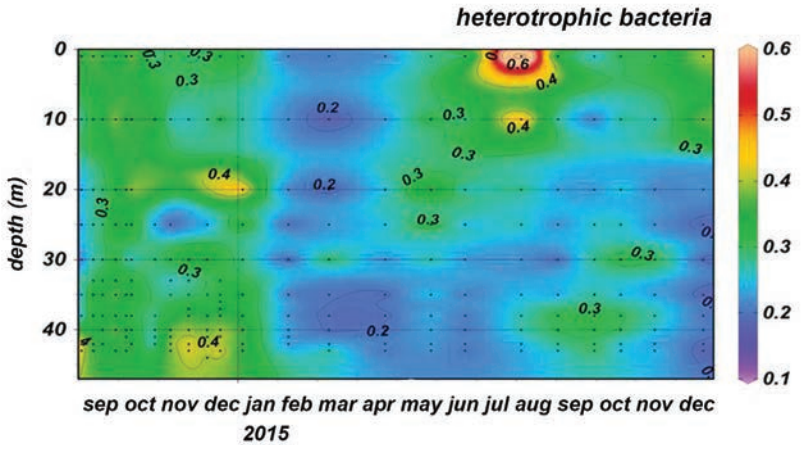

Figure 4. Distribution of abundance (10^6 cells mL^{-1}) of heterotrophic bacteria in the Veliko Jezero ("Big Lake") on the island of Mljet (adapted from Lučić et al. 2019).

The majority of bacterial cells float free in the water column. A higher proportion of cells attached to suspended particles is found in estuaries, coastal waters, and bottom layers. Cells attached to particles also exhibit enzymatic activity different from that of free-floating cells. The ability of bacterial cells to attach is a prerequisite for biofilm formation. In biofilms, the association between bacteria and diatoms, as primary and dominant members attached to surfaces, can be investigated (Figure 5).

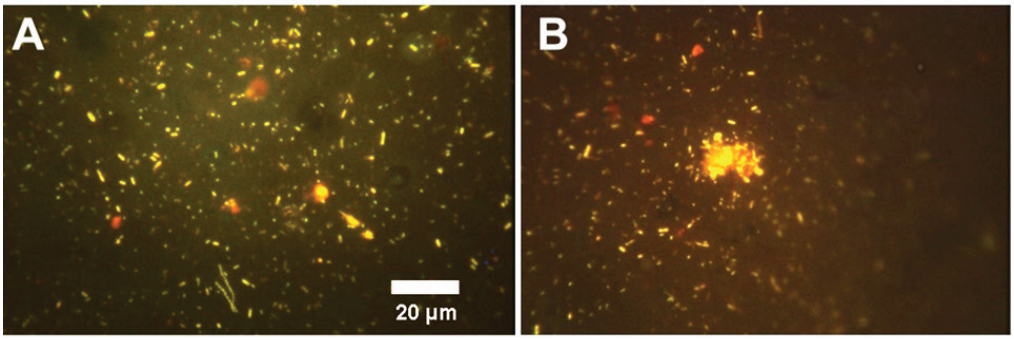

Figure 5. Picoplankton in Gruž Bay (A) and bacteria attached to detritus particles at the Usko station in Mali Ston Bay (B) captured using an epifluorescence microscope (Photo by S. Bobanović-Ćolić).

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PHYTOPLANKTON RESEARCH AT THE INSTITUTE IN DUBROVNIK

Nenad Jasprica

The importance of phytoplankton research

Phytoplankton (from Greek *phyton* - 'plant', *planktos* - 'wanderer, drifter') is a life form in the water column that encompasses microscopically sized organisms, mainly with passive modes of movement (by currents). Phytoplankton includes various taxonomic groups that differ in cell structure. Among the main groups of marine phytoplankton are diatoms, whose cells are encased in frustules made of silica (hydrated amorphous silicon dioxide) (see Figures 1, 2). The cells of armoured dinoflagellates are covered with cellulose plates, while coccolithophores (coccospheres) have cells coated with calcite plates (coccoliths) of various sizes and shapes.

The most important feature of phytoplankton cells is the presence of plastids (chloroplasts) containing the pigment chlorophyll. Chlorophyll is capable of absorbing the blue and red wavelengths, allowing phytoplankton cells to produce organic matter and release oxygen through photosynthesis. Phytoplanktonic groups are found in many evolutionary lineages in phylogenetic trees, including bacteria (cyanobacteria) and multiple eukaryotic lineages that acquired photosynthetic ability through endosymbiosis. The evolution of phytoplankton has gradually influenced the composition of Earth's atmosphere and its redox status. Thus, phytoplankton has shaped life on Earth throughout geological history.

Marine phytoplankton contributes to more than 45% of Earth's photosynthetic primary production, serving as the basis of marine food webs and thus exerting a tremendous influence on the entire Earth system (Karlusich et al. 2020). In addition to oxygen release, it is a source of organic carbon and sustains life for the majority of marine organisms. It significantly contributes to the biological pump as carbon dioxide from the atmosphere is stored

Jasprica, N., 2021: Phytoplankton research at the Institute in Dubrovnik. The Seventieth Anniversary of the Institute in Dubrovnik (eds. Jasprica, N., Batistić, M.). University of Dubrovnik, Dubrovnik.

in the deep ocean. Mineral structures (e.g., silica frustules, calcite plates, etc.) have accumulated and formed deposits throughout geological history. Awareness of the importance of phytoplankton in Earth's hydrosphere emerged only after the discovery of microscopes and microorganisms in the early 18th century. The growth of phytoplankton depends on the availability of carbon dioxide, sunlight, and nutrients. Other factors influencing phytoplankton growth and development, besides temperature and salinity, include water depth, wind and grazers. Sometimes, phytoplankton cells proliferate massively, causing blooms in the sea (Figure 3).

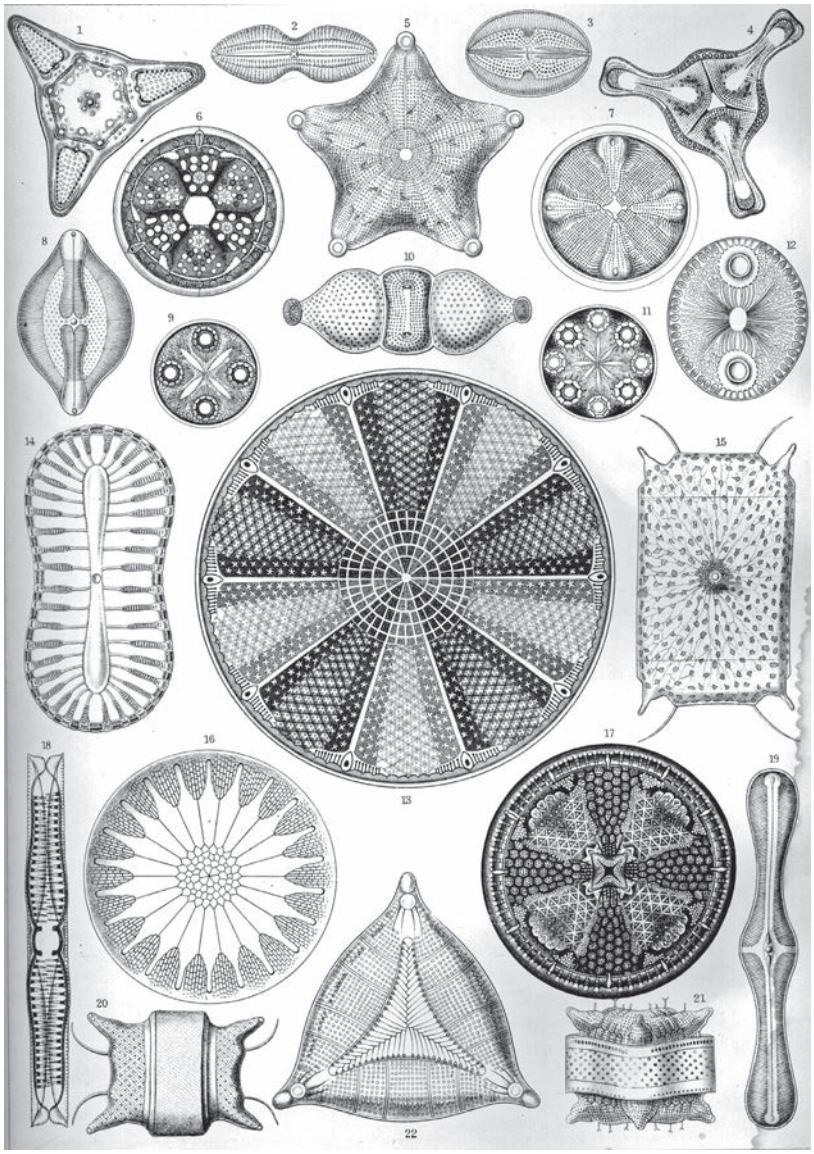

Figure 1. Diatoms (siliceous algae) in Haeckel's lithographs (Haeckel 1899). (Available at: http://algorithmic-worlds.net/Haeckel/haeckel.php, last accessed on February 24, 2021).

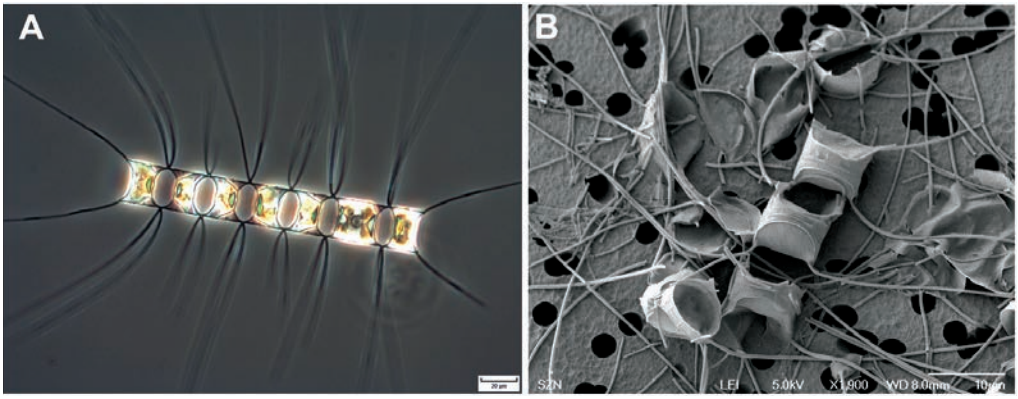

Figure 2. Diatom cells: A – Chain of cells of the species *Chaetoceros brevis* F. Schütt captured with a light microscope, B – Cells of the species *Chaetoceros anastomosans* Grunow captured with the use of an electron microscope (Photo by S. Bosak).

A brief overview of phytoplankton research at the Institute

Phytoplankton research began at the Institute in Dubrovnik in 1977 with the arrival of Damir Viličić, who established the phytoplankton laboratory. The first studies on the taxonomy and ecology of phytoplankton commenced in 1979/1980. Sampling was conducted in 11 bays along the coast. During the same period, sampling was also carried out by the research vessel *Baldo Kosić* in the open sea of the southern Adriatic. The results of the analysis of materials from this sampling were presented in Damir Viličić's doctoral dissertation and later published in papers (e.g., Viličić 1985, 1989, etc.).

Phytoplankton research was also conducted as part of the *Andrija Mohorovičić* expedition from 1974 to 1990. A large amount of data was collected as part of the project "Distribution of Plankton, Trophic, and Regenerative Relationships" (1991–1997, led by F. Kršinić), during which all plankton groups were studied for the first time on a deep-sea profile of the South Adriatic Pit using modern research methods. From 1998 to 2006, a large multidisciplinary and inter-institutional project "Systematic Research of the Adriatic Sea as the Basis for Sustainable Development of the Republic of Croatia" (the "Adriatic" project) was carried out. During this period, several publications provided additions to the taxonomy of Adriatic Sea phytoplankton (Viličić 1998), described the distribution of phytoplankton abundance and biomass expressed in volume, organic carbon (Jasprica 1994), and chlorophyll *a* concentration in the coastal and open seas of the southern Adriatic (Jasprica and Carić 2001), as well as the occurrence of subsurface chlorophyll *a* maxima (Jasprica et al.

2001). According to their phytoplankton abundance and volume, marine ecosystems were categorised on the eastern coast of the Adriatic (Viličić 1989). Ecological relationships were identified in Mali Ston Bay (Jasprica et al. 1997, Čalić et al. 2013) and in the Mljet lakes (Benović et al. 2000). The distribution of phytoplankton in hyperhaline marine lakes (Mala and Velika Solina), the estuaries of the Ombla, Neretva (Lake Vlaška), Zrmanja, and Krka is interpreted according to the specific distribution of physico-chemical parameters in each of these ecosystems (Jasprica et al. 2005, Carić et al. 2011, 2012).

After Damir Viličić, Nenad Jasprica (1984), Marijeta Čalić (2003), and Stijepo Ljubimir (2011) joined the Institute in Dubrovnik as assistants for phytoplankton research.

In recent years, the study of phytoplankton in the open sea of the southern Adriatic within the framework of the Croatian Science Foundation project "The Influence of Changes in Thermohaline Circulation in the Eastern Mediterranean on Plankton Communities in the Southern Adriatic: Ecological and Genetic Approach" (2014–2019, principal researcher M. Batistić) has led to new insights, particularly regarding its distribution during the winter-spring period. It has been established that winter phytoplankton blooms are a common occurrence in the open sea of the southern Adriatic, occurring in both anticyclonic and cyclonic phases of circulation in the northern Ionian Sea, but this phenomenon is conditioned by different mechanisms (Batistić et al. 2019). It has been shown that the open southern Adriatic is not an exclusively oligotrophic ecosystem (Viličić et al. 1989, 1995), and the intensity of winter blooms depends on specific hydroclimatic conditions (Batistić et al. 2012, Ljubimir et al. 2017) (Figure 4).

In addition to the classical and still indispensable method of microscopy for determining the structure of phytoplankton populations, modern research on phytoplankton employs various contemporary methods such as molecular techniques, satellite imagery of chlorophyll *a* concentration (Figure 5), continuous measurements with sensors attached to floats and bio-optical measurements of biomarker pigments (Karlusich et al. 2020). The occurrence of harmful phytoplankton blooms can be determined by the rapid detection of toxin molecules in the water using sensors and satellite transmission of information to laboratories on land and shellfish farmers (Viličić and Ljubešić 2017).

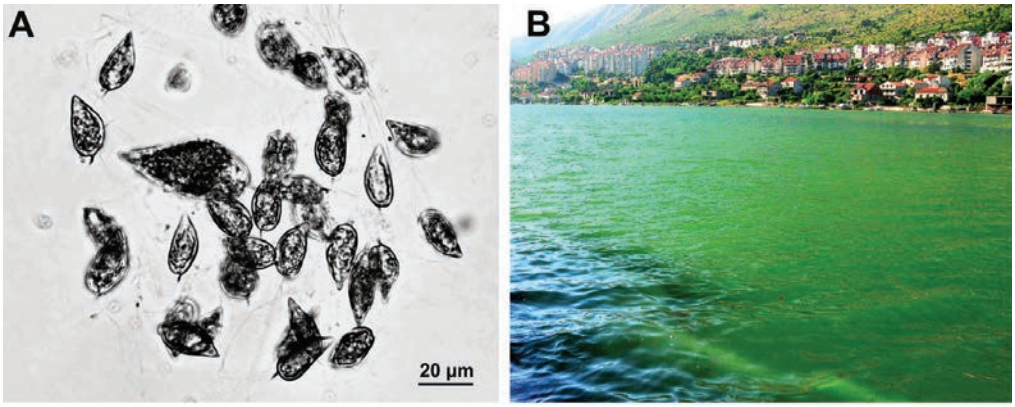

Figure 3. An intensive bloom (phytoplankton bloom) of the dinoflagellate *Prorocentrum triestinum* Schiller (A, light microscope image) in the Ombla estuary in August 2010 (B). The sea-surface took on an intense light green colour, and the water transparency was only 0.5 metres (Photo by N. Jasprica).

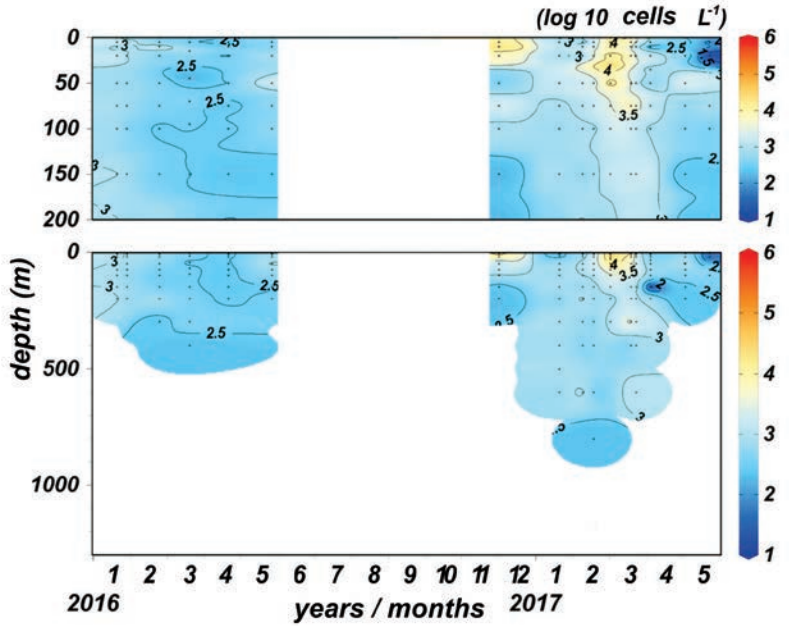

Figure 4. Distribution of diatom abundances in the open sea of the southern Adriatic (station P-1200) during the winter-spring periods of 2016 and 2017. Intense development of diatom cells ($> 10^4$ cells L^{-1}) occurred in March 2017 in the euphotic layer (Source: N. Jasprica)

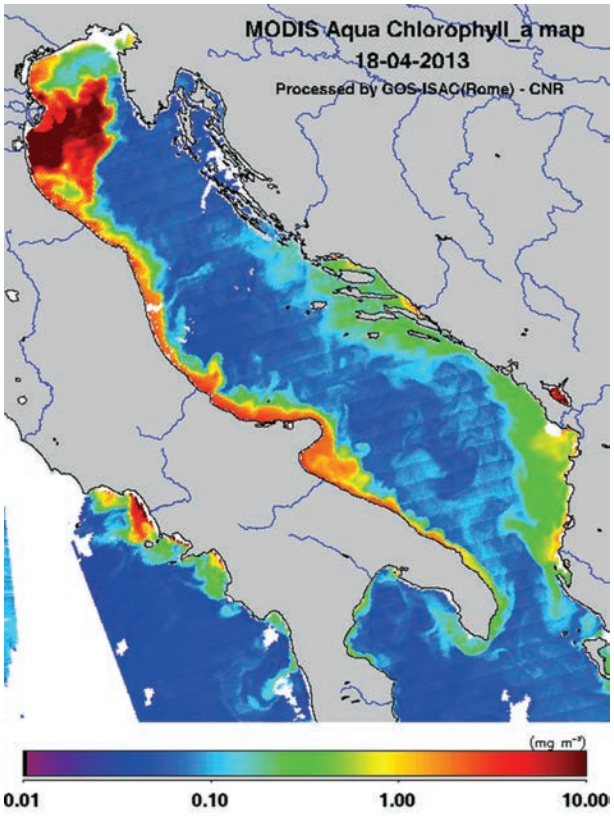

Figure 5. Concentrations of chlorophyll a (mg m-3) in the Adriatic Sea on April 18, 2013, were obtained through satellite observations of the sea surface. Gradients in chlorophyll a concentration are visible, ranging from the lowest in the open northern Adriatic (dark blue colour) to the highest (dark red) along the Italian coast. (Source: Istituto Nazionale di Oceanografia e Geofisica Sperimentale, Trieste, Italy).

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RESEARCH INTO BENTHIC DIATOMS AT THE INSTITUTE IN DUBROVNIK

Ana Car

Since 2008, the Institute has conducted research into microscopic marine benthic (bottom-dwelling) organisms from the diatom group, so far insufficiently studied in the Adriatic Sea. Diatoms are unicellular autotrophic organisms (Round et al. 1990) and are responsible for 25% of global primary production. They are found in all wet places, in the sea, in brackish water and in fresh water. Diatoms are algae with shells (frustules) made of amorphous hydrated silica (hydrated amorphous silicon dioxide; $SiO_2 \cdot nH_2O$) with various architectures. As far as symmetry is concerned, we distinguish between two main groups of diatoms: *Centrales* (radial cell symmetry) and *Penales* (bilateral cell symmetry). A special feature of diatoms is the structure of their frustules, which can have various shapes (Figure 1). The growth of diatoms depends on physicochemical factors such as light and nutrients (Hafner et al. 2018b, Car et al. 2020).

The stability of the ecosystem and its sensitivity to natural and anthropogenic physico-chemical changes can be assessed by evaluating the total biomass and community composition. Although most species are cosmopolitan, the biogeographical classification of diatoms into regional groups shows the existence of species that are characteristic of a particular area. Although phytoplankton communities in the Adriatic have been thoroughly studied, benthic microalgae were generally extremely poorly known until 2008, and research by scientists from Italy was mainly focussed on diatom research in the northern Adriatic.

Car, A., 2021: Research into benthic diatoms at the Institute in Dubrovnik. The Seventieth Anniversary of the Institute in Dubrovnik (eds. Jasprica, N., Batistić, M.). University of Dubrovnik, Dubrovnik.

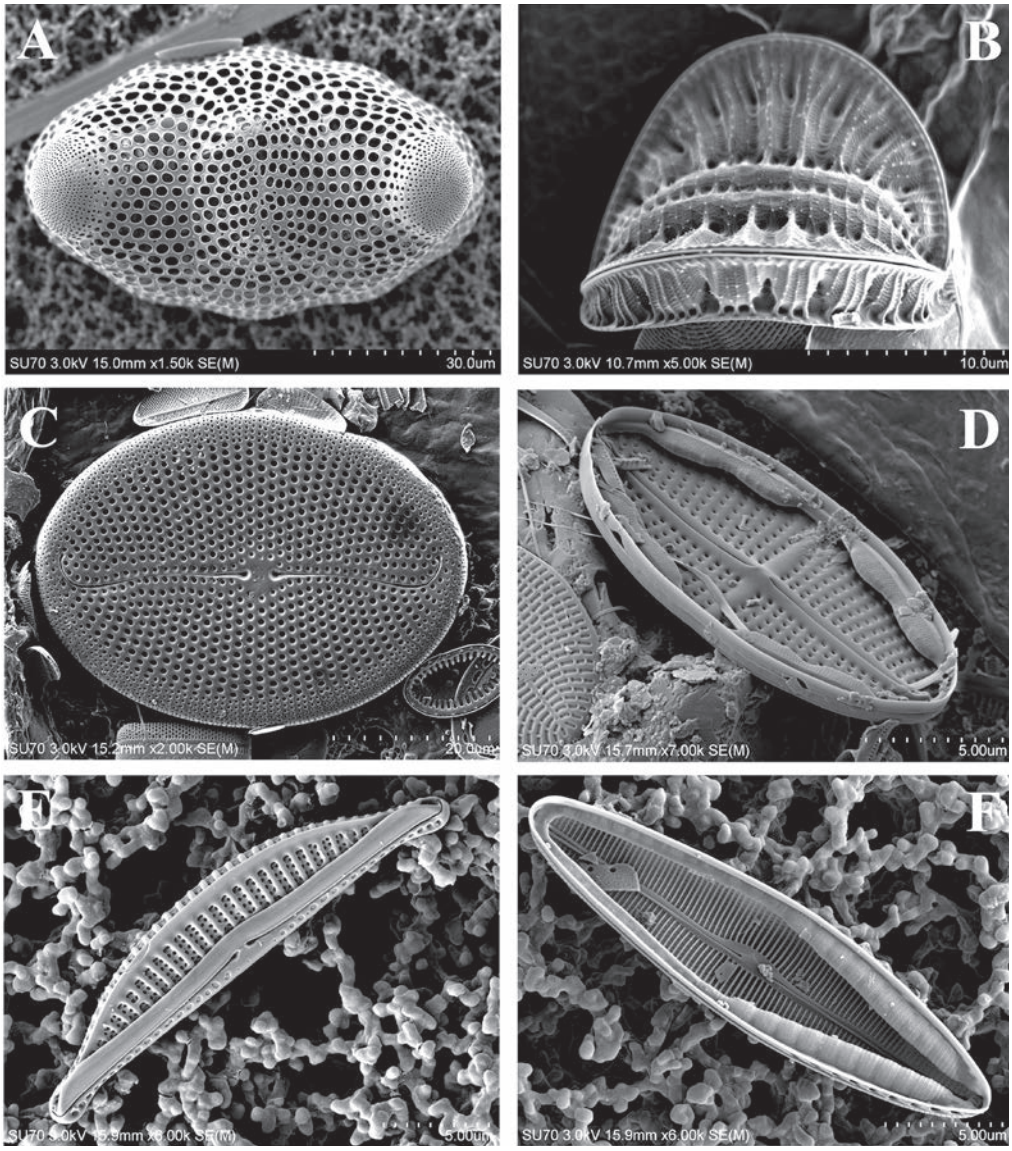

Figure 1. Benthic diatoms from the southern Adriatic Sea, found on the invasive macroalgae *Caulerpa cylindracea* in Dubrovnik in spring 2009, photographed with an electron microscope (Photo by A. Car).

Between 2008 and 2020, samples were collected for diatom research in the southern and central Adriatic, especially near Dubrovnik, the Pelješac peninsula, the islands of Korčula, Mljet and Hvar. In collaboration with colleagues from Poland (University of Szczecin, Warsaw University of Technology), Australia (Griffith University), France (University of Nice-Sophia Antipolis; Université du Maine), Germany (Goethe University, and Senckenberg Forschungsinstitut und Naturmuseum,

Frankfurt), China (South China Normal University), USA (University of Guam, University of Texas) and Turkey (Istanbul University; Dumlupinar University), the taxonomy, ecology and genetics of diatoms are being investigated (Lobban et al. 2015, Witkowski et al. 2016, Hafner et al. 2018a,b, Li et al. 2019).

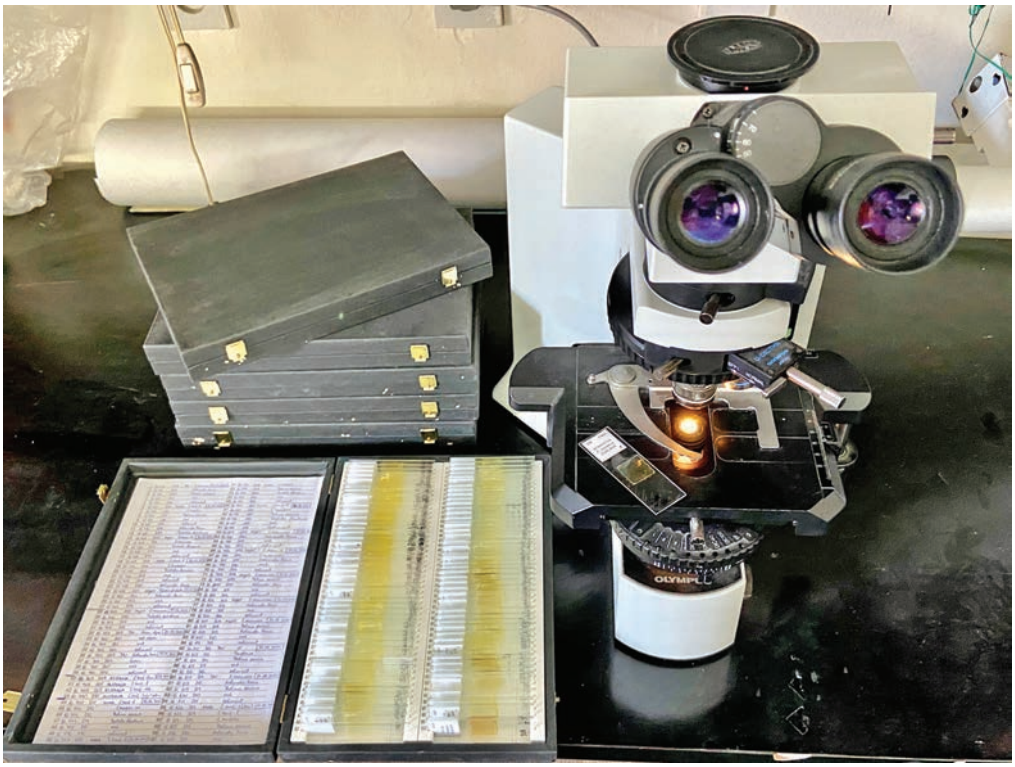

Figure 2. Permanent slides stored in the diatom collection of the Institute for Marine and Coastal Research (Photo by A. Car).

Permanent slides are stored at the Institute (Figure 2) and are prepared by treating the sample with 10% hydrochloric acid (HCl) and 30% hydrogen peroxide (H_2O_2). Light (Figure 2) and electron microscopy are used to determine the taxonomic composition of the diatoms, to describe the morphology and ultrastructure of the individual species and to determine the seasonal dynamics on a fine time scale.

During the taxonomic analysis of diatoms in 2012, scientists from the Institute (Figure 3), together with colleagues from the University of Szczecin (Poland), Andrzej Witkowski and Sławomir Dobosz, discovered and described a new species *Cocconeis caulerpacola* Witkowski, Car et Dobosz (Figure 4, Car et al. 2012).

The name *caulerpacola* (= on *Caulerpa*) was given because it was first described on samples of *Caulerpa* from Hvar (Figure 5). A new diatom species was also found on the surface of another macroalgae invasive species in the Mediterranean - *Caulerpa cylindracea*, in samples from the island of Mljet and from the Dubrovnik area. The main characteristic of *Caulerpa* is the presence of the secondary metabolites caulerpenine, whose main function is chemical defence against predators and colonisers such as the newly described species. The species *C. taxifolia* (colloquially known as "killer algae") accidentally entered the Mediterranean in 1984 off Monaco after being accidentally released from the aquarium of the Oceanographic Museum, probably during cleaning. It then began to spread very quickly and was discovered in 1994 in Starigrad Bay on the island of Hvar, where it can still be found today. The alga *C. taxifolia* has been cultivated as a decorative alga in marine aquariums since the early seventies of the last century. Recently, a genetically, morphologically and physiologically very similar algal population has been found living in the moderately warm seas of Australia, in Moreton Bay near Brisbane, and this is most likely the area where it was collected for aquarium purposes in the early seventies. Interestingly, a new species of diatom has also been found in samples of *Caulerpa* collected off the city of Cannes (southern France) and in Moreton Bay (eastern coast of Australia).

Figure 3. Institute scientists Ana Car and Nenad Jasprica successfully collaborated with colleagues from the University of Szczecin (Poland), which led to the discovery of a new diatom species (Photo by I. Brautović).

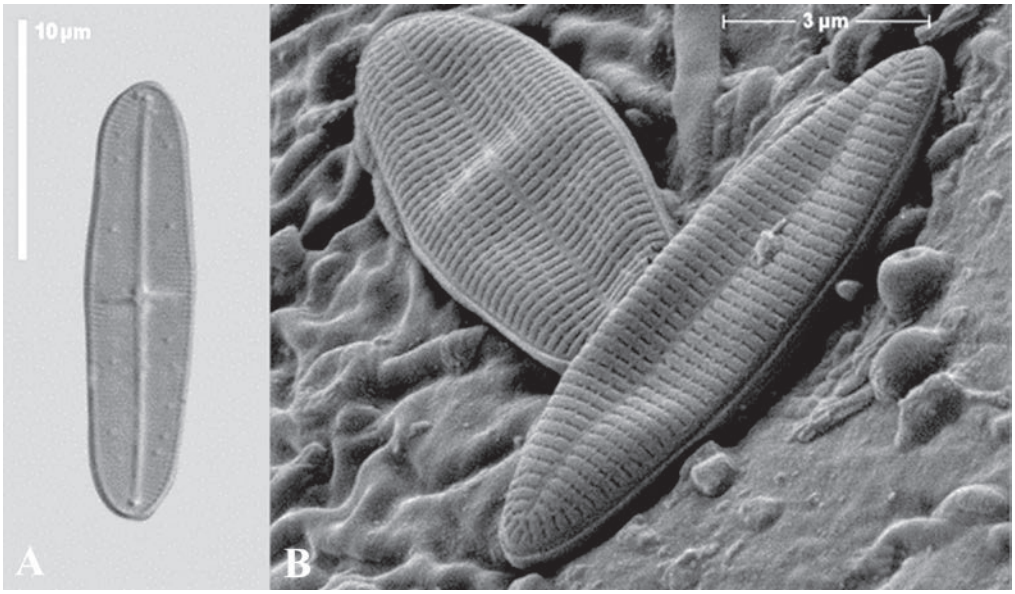

Figure 4. A cell of the diatom *Cocconeis caulerpacola*, photographed with a light (A) and an electron (B) microscope (Photo by A. Car).

Figure 5. *Caulerpa taxifolia*, Stari Grad, the island of Hvar, 2012 (Photo by A. Car).

In order to carry out a comprehensive comparison between the epiphytic diatom communities on the invasive *Caulerpa* and those inhabiting indigenous macroalgae, and considering the insufficient research on this aspect in the Adriatic region, a simultaneous sampling was carried out to assess the taxonomic composition of diatoms on brown algae (*Padina* sp.) and green algae (*Halimeda tuna*) as well as on the leaves of *Posidonia oceanica* in the coastal region of the eastern Adriatic. This strategy of simultaneous sampling facilitated the analysis of the association between epiphytic diatoms and their respective hosts (Car et al. 2019a, Kanjer et al. 2019).

Figure 6. A – Location of the research station (red dot) in the marine Lake Mrtvo More ("Dead Sea") on the island of Lokrum off Dubrovnik in 2016. B – Plate with microscopic slides immersed in the Dead Sea at a depth of 1 m, C-E – Procedure for removing the plate with the microscopic slides to take a sample for diatom analysis (Photo by S. Ljubimir).

In addition to epiphytic diatoms, epilithic diatoms are also analysed (Car et al. 2019b), on both natural (e.g. pebbles, sand) and artificial substrates (growth on glass and Plexiglas), e.g. during a six-month study conducted in 2016 (April-October 2016) in the marine Lake Mrtvo More ("Dead Sea") in the southern part of the island of Lokrum near Dubrovnik (Figure 6, Car et al. 2020), and a one-year study conducted in Mljet National Park in 2019-2020 (Figure 7). Considering the time frequency of sampling and the collection of

Figure 7. A – Collection of sea samples with a Niskin water sampler for the analysis of physico-chemical parameters, B – Plate with slides for the analysis of diatoms in the lakes of Mljet National Park (Photo by S. Ljubimir).

samples for the analysis of physico-chemical parameters, findings on the succession of diatoms under clearly defined environmental conditions will be described for the first time in the Adriatic Sea. The research results will show the affinity of marine diatoms to the investigated materials (glass, Plexiglas), the speed of colonisation of new substrates in the sea and the consequences of glass and plastic pollution in the sea.

Knowledge of the taxonomic composition of diatoms in the southern and middle Adriatic contributes to the knowledge of the global biogeographical distribution of diatoms and is necessary for the assessment of biodiversity and the most effective protection of the Adriatic and the Mediterranean.

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ZOOPLANKTON RESEARCH AT THE INSTITUTE IN DUBROVNIK

Jakica Njire, Igor Brautović, Marijana Hure, Davor Lučić

When you dive into the sea with your eyes open, a picture of extraordinary beauty of form, variety, structure and the magnificence of marine life opens up before you. However, one particularly enchanting world remains inaccessible to the human eye without the aid of a microscope - a privilege granted to planktonologists who explore and reveal new aspects of the vast blue realm every day. Plankton is one of the largest living communities in the ocean and forms the basis of the marine food web.

One of the main activities of the Institute for Marine and Coastal Research is the study of zooplankton in the Adriatic Sea, a tradition that has been maintained since the foundation of the Institute. Zooplankton is a community of animal organisms that live in the entire water column of the sea. Although it can swim, its movement is largely influenced by ocean currents. Zooplankton includes organisms belonging to numerous taxonomic groups. Some spend their entire life in the marine column (holoplankton), while others adopt a planktonic lifestyle in the early stages of development (meroplankton). These include the eggs and larvae of fish (ichthyoplankton) and the larvae of organisms from various other taxonomic groups, such as molluscs, crustaceans, sea urchins and other benthic organisms.

Meroplankton occasionally makes up a significant proportion of zooplankton, especially in coastal areas, while in open seas the proportion of holoplanktonic organisms is much higher. The biological diversity within the planktonic community is reflected in morphological variations. Due to their weak swimming ability, they have developed numerous adaptations over the course of evolution that facilitate movement and suspension. Various protrusions and antennae increase their surface area, and some have oil droplets to increase buoyancy.

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Zooplankton organisms feed on phytoplankton or other zooplankton and are thus an important link in the complex pelagic food web between phytoplankton and organisms at higher trophic levels, from fish to mammals. Zooplankton is an important food source for many larvae of economically important fish species. Therefore, along with phytoplankton, it is a key element influencing the productivity and health of marine ecosystems. Changes in the biomass and composition of zooplankton have a significant impact on the marine food web, making zooplankton biomass a valuable indicator of environmental conditions in the ocean.

The microzooplankton represents the smallest size fraction of the zooplankton. As shown in Haeckel's lithographs

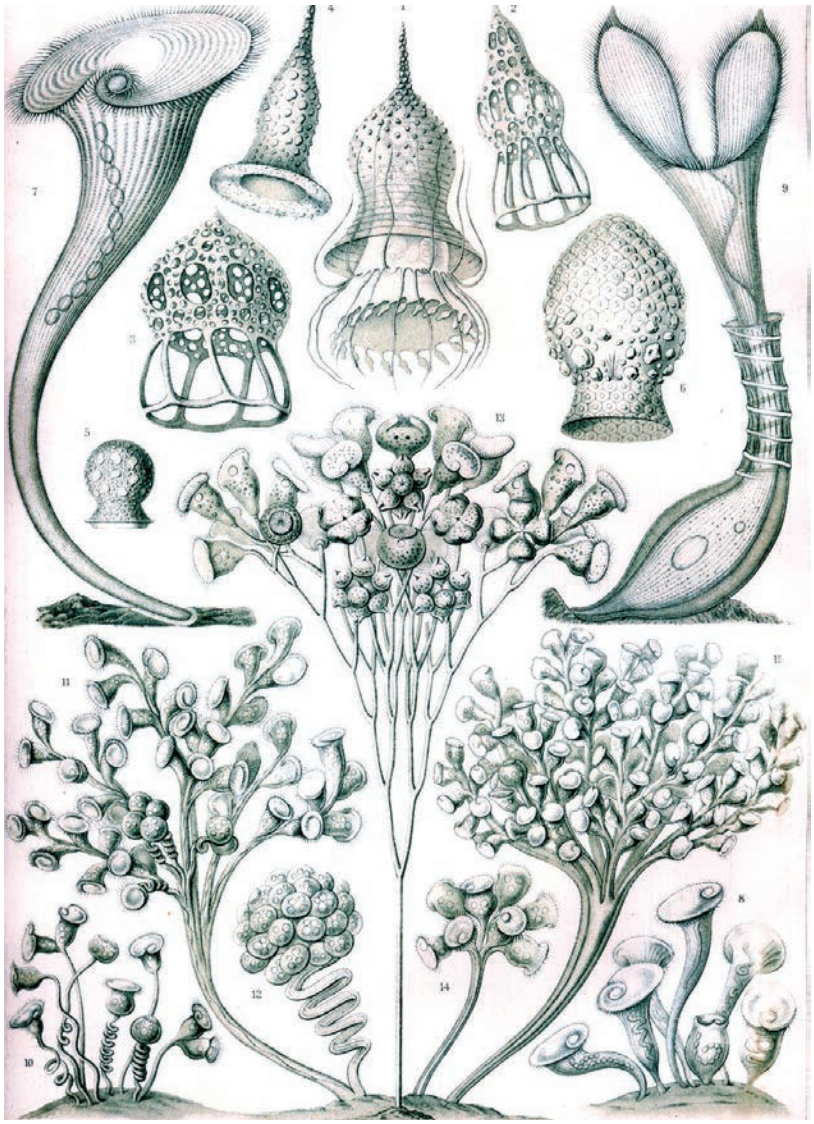

Figure 1. Diversity of microzooplankton depicted in Haeckel's lithograph, Giltsch and Haeckel (1904). (Available at https://www.loc.gov/item/2015647734, retrieved on February 18, 2021.)

(Figure 1), there is considerable diversity in their feeding strategies: from particle phagotrophy in dinoflagellates to the capture and ingestion of prey using appendages in planktonic crustaceans. Their prey is diverse and characteristic of each group, making them particularly important in marine ecosystems.

The sampling of the microzooplankton is determined by the study area. For coastal studies, the standard low-volume Niskin pump with a capacity of 5 litres is used. Before preservation with formaldehyde, the sample is reduced by sedimentation to a volume of 30 mL for subsequent microscopic analysis. The institute has several modern research microscopes that enable detailed examination and analysis of plankton samples (Figure 2). In open seas, samples are collected using the Nansen plankton net with a mesh density of 53 μm. At very deep stations, a closing mechanism is used to catch samples in certain layers of the water column. These are standard methods used by research organisations around the world to study microzooplankton. However, the limitations of these plankton instruments became clear during longer sampling periods: organisms smaller than 50 μm were lost with the net, and the Niskin pump was often not representative of the volume. Therefore, in the late 1980s, Frano Kršinić developed the prototype of a new plankton net for quantitative sampling in layers, the so-called Adriatic trap (Kršinić and Lučić 1994). The development of this net enabled a more comprehensive and detailed study of the vertical distribution of total zooplankton and microzooplankton in shallow areas.

Figure 2. Olympus IX-73 research microscope (Photo by I. Brautović).

Microzooplankton consists of two groups of organisms, separated by size and cellular organisation: protozoa and micrometazoa. Protozoa are smaller, single-celled organisms, comprising ciliates and flagellates. Ciliates can be divided into oligotrich ciliates and tintinnids. Oligotrich ciliates, with a larger representation, are characterised by a delicate structure, lack of skeletons, and a capacity for rapid reproduction (1-2 divisions within 24 hours). One part of oligotrich ciliates are mixotrophs, utilising plastids either from their own or ingested algal prey for photosynthesis. They serve as prey for larger protozoa, many metazoans (especially copepods), and fish larvae. They are highly abundant in coastal systems and estuaries, typically exhibiting the highest abundance in eutrophic areas rich in organic detritus and dissolved organic matter. The second group comprises loricate ciliates or tintinnids. They possess a lorica or shell, which is used as taxonomic determination of tintinnid (Figure 3). The appearance of the lorica, sometimes resembling tubes or vases, is considered by many scientists and artists as microscopic works of art in nature, as mentioned in Ernst Haeckel's classic work "Art Forms in Nature". Tintinnids, overall, comprise a smaller numerical group compared to ciliates; however, their feeding activity on nanophytoplankton can occasionally surpass that of other microzooplankton groups. A significant number of studies at the Institute have been focused on the tintinnid group (Kršinić 1982, 1987a, 1988, Kršinić and Precali 1997, Njire et al. 2019).

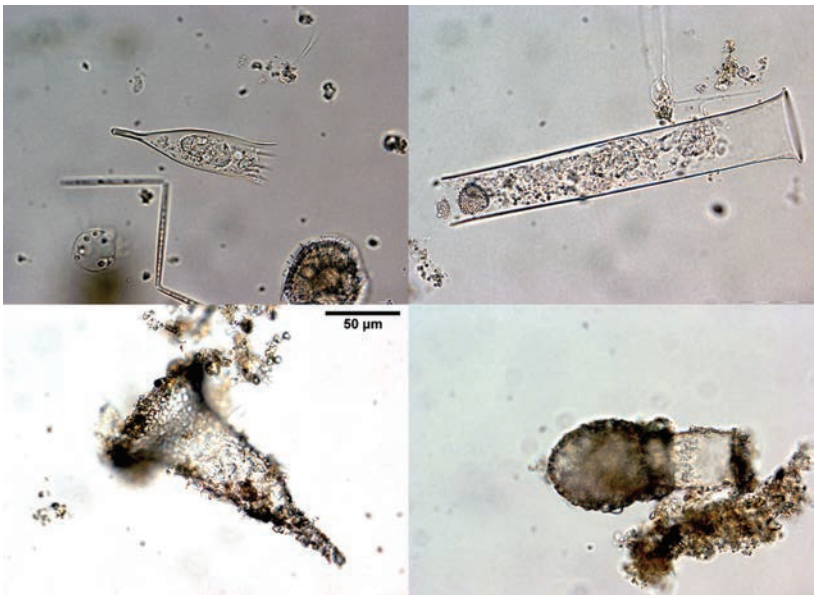

Figure 3. Various species of loricate tintinnids (ciliates) (Photo by P. Lučić).

The second, larger and structurally more complex group within the microzooplankton are the micrometazoans. The most numerous are the first developmental stages of copepods, the nauplii (Figure 4), which are less strongly represented in the entire microzooplankton than the non-littoral ciliates. They can account for up to 60 % of the total number of micrometazoans. Copepodites and adult copepods feed mainly on phytoplankton by filtration, carnivorously or omnivorously and detritivorously. They are undoubtedly the most important zooplankton organisms that regulate the level of phytoplankton production.

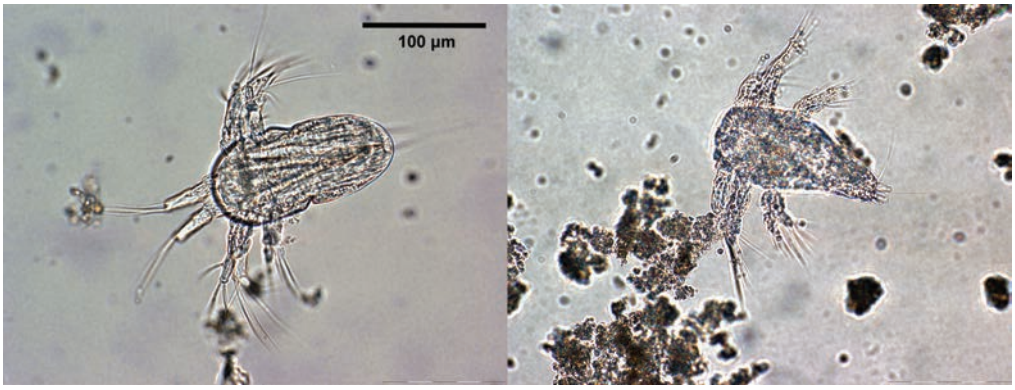

Figure 4. Nauplii are early developmental stages of copepods (Photo by P. Lučić).

Research on larger organisms are primarily analysed using plankton nets with a mesh size of 200 µm for mesozooplankton or more than 500 µm for macrozooplankton. The net is submerged to a certain depth and slowly pulled to the surface. The silk through which the sea flows retains all organisms that are larger than the pores of the net. These organisms are concentrated in the sampling container at the bottom of the net. Fixatives such as formalin or alcohol are often added to the samples to prevent degradation. The samples are then carefully analysed in the laboratory under a binocular loupe and a microscope. Megaplankton, such as large jellyfish (Figure 5), are usually difficult to capture with plankton nets. This group is usually observed in situ using handheld magnifiers, autonomous divers or various vessels. In addition, due to their fragile bodies, many species are damaged beyond recognition or dissolve completely in the net, leaving only a gelatinous mass in the sampling container.

Figure 5. Example of megaplankton, the Mediterranean jellyfish *Cotylorhiza tuberculata* (Photo by M. Babić)

Among the size fractions mentioned, the group of mesozooplankton (Figure 6) is of particular interest, as it plays a crucial role in the food web of marine ecosystems and in the energy flow to higher trophic levels such as fish and marine mammals. Mesozooplankton is represented in marine ecosystems by various well-known representatives of the animal kingdom, from jellyfish to chordates.

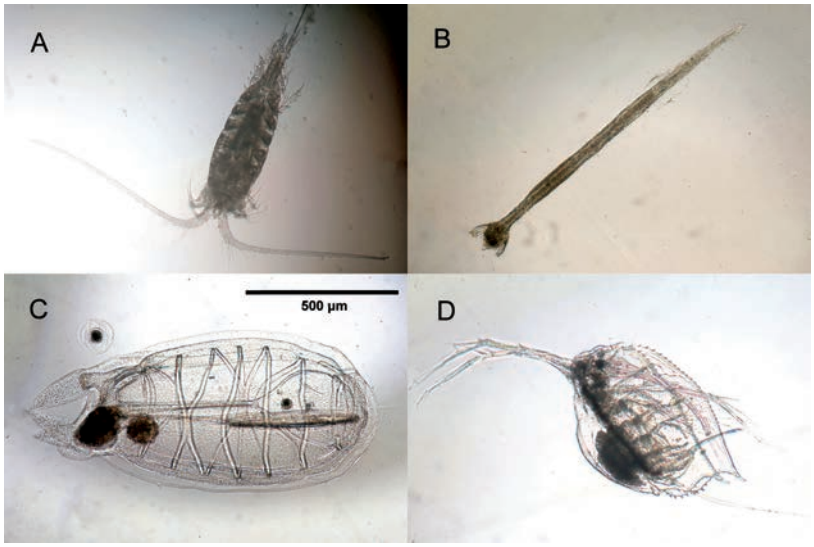

Figure 6. Examples of mesozooplankton: A – copepod, B – chaetognath, C – salp (planktonic tunicate), D – water flea, cladoceran (Photo by I. Brautović).

Copepods, scientifically known as Copepoda (Figure 7), stand out among the mesozooplankton due to their biological diversity, abundance and importance for the energy flow to higher trophic levels, especially to fish. Copepods feed primarily on phytoplankton and microzooplankton and serve as a food source for various fish species in at least one developmental stage of their lives. For example, small blue fish such as sardines and anchovies feed on copepods throughout their lives, while most other fish species consume them during their juvenile development.

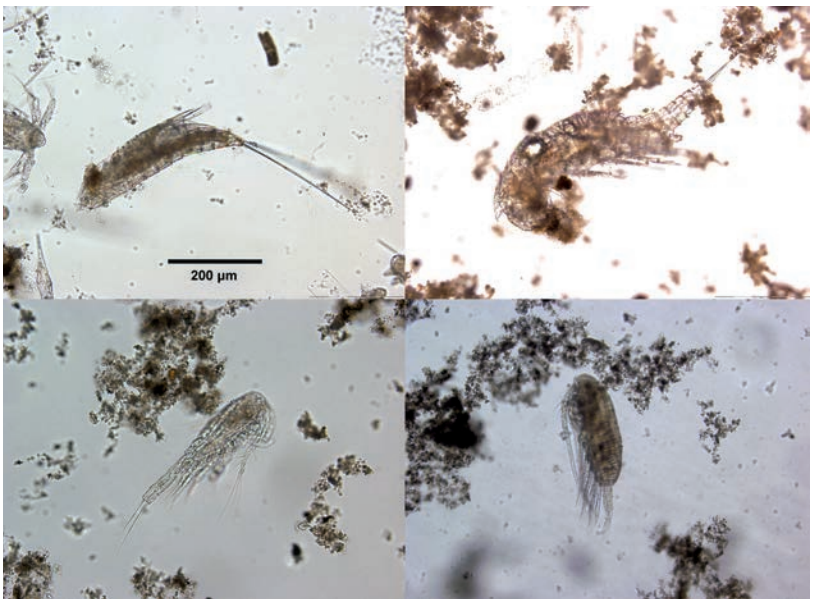

Figure 7. Micro-metazoans consist mainly of small copepods and their later developmental stages (Photo by P. Lučić).

Research at the Dubrovnik Institute focuses on the composition, abundance, biomass and relationships between the species and main groups of zooplankton. Fundamental studies on zooplankton and spawning of pelagic fish species (sardines) have been published by Tomo Gamulin and Jure Hure in prestigious international journals, including Nature. Their work has significantly shaped the future activities of the Institute, and this research legacy has been continued by Adam Benović and Frano Kršinić. The investigations carried out by the zooplankton researchers in Dubrovnik cover the entire Adriatic Sea, numerous bays and estuaries as well as the open sea from Otranto to the Gulf of Trieste. The following text presents the peculiarities of the structure and role of zooplankton in various marine ecosystems of the Adriatic, areas to which the scientists of the Dubrovnik Institute have devoted particular attention.

Mali Ston Bay

Throughout its long history, the bay of Mali Ston has maintained its status as a cultivation area for the Mediterranean mussel. The unique ecological conditions of the bay were of great interest to scientists from Dubrovnik and led to thorough research that began in 1967 and continues to this day. The initial investigations revealed that the bay harbours a distinct zooplankton community due to the continuous nutrient input from the mainland, strong currents, wind influences and thermohaline properties. Protozoa are the most numerous group. Although high densities were recorded throughout the year, the peaks occurred in winter and early spring (Figure 8). This winter-spring dominance generally followed the appearance and development of dense phytoplankton populations (Lučić and Kršinić 1998, Kršinić et al. 2016). Zooplankton played a dual role: together with phytoplankton, it served as a food source for cultivated shellfish, but it also reduced significant amounts of newly formed primary production through its filtration. A particular importance in the diet of oysters during the autumn-winter period is attributed to loricate ciliates, at a time when these shellfish are preparing for spring spawning. The oysters are then of the highest quality for human consumption due to increased glycogen content, which is conditioned by the quality composition of tintinnids and other plankton (Kršinić 1987a,b).

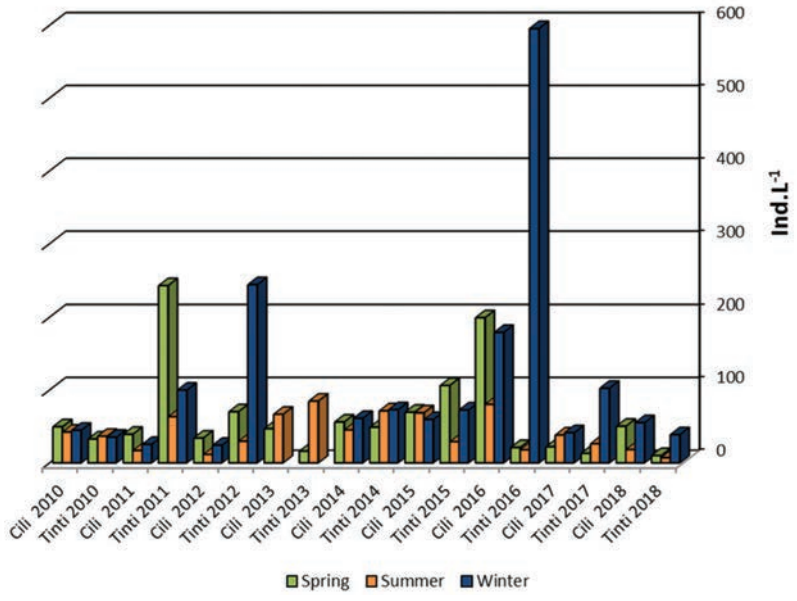

Figure 8. Distribution of ciliates in Mali Ston Bay from 2010 to 2018. The dominance of these organisms in winter and spring is particularly important for the nutrition of oysters when they are preparing to spawn. Ciliates – non-loricate ciliates, tinti – tintinnids.

Mljet lakes

The Mljet Lakes are an ideal object of study for marine ecology and biology due to their nature, the model form of closed oceans, their favourable location, their distance from large urban areas and pollution, and the high degree of nature conservation. In the mid-1980s, the Institute's scientists therefore began continuous hydrographic and planktonological research into this unique marine area. The results of this research have been published in around 50 scientific papers and presentations, emphasising the ecological characteristics of the Mljet Lakes that clearly distinguish them from other bays in the Adriatic and Mediterranean (Benović et al. 2000, Malej et al. 2007). In addition to investigating the influence of environmental factors on the vertical distribution of zooplankton, particular attention was paid to researching the unique jellyfish *Aurelia relicta*, which is found exclusively in this aquatic environment (Scorrano et al. 2017). This large zooplankton species is regularly found in the Veliko jezero ("Big Lake") in huge swarms whose abundance exceeds all previously known values for schyphomedusae. Their daily and nocturnal vertical migrations, reproduction, feeding habits and swimming behaviour have particularly fascinated scientists worldwide (Figure 9).

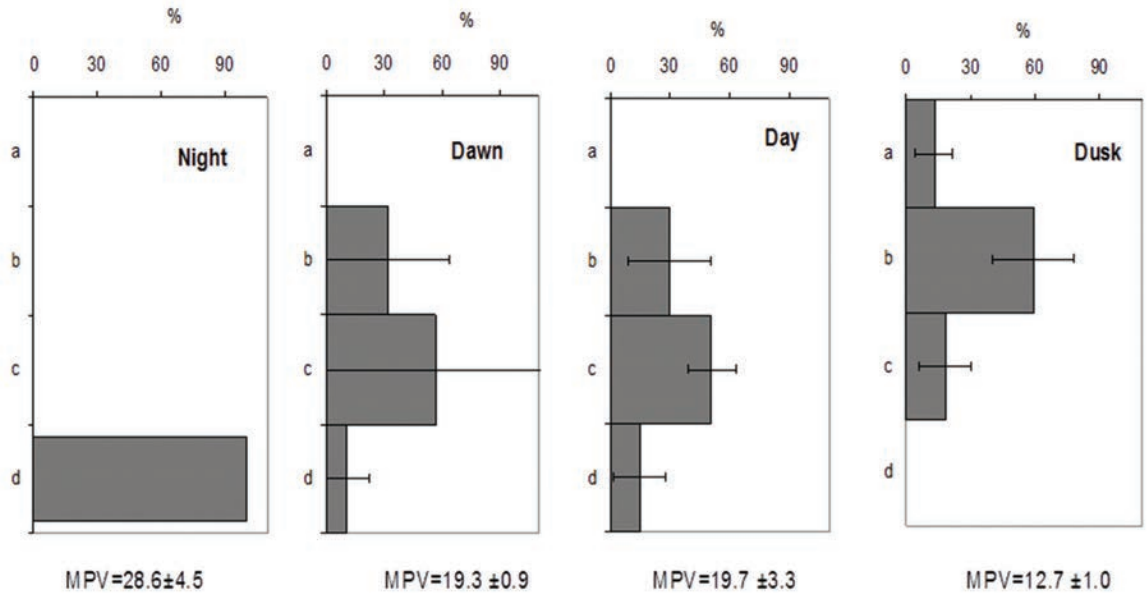

Figure 9. Vertical distribution of populations of the jellyfish *Aurelia relicta* during the daily migration cycle. Layers: a - above the thermocline, b - thermocline, c - below the thermocline, d - deep layer (> 25 m). MPV - mean residence time of the population in the water column, (m) (Malej et al., 2007).

Today we know that the Veliko jezero ("Great Lake") has a consistent hydrographic, chemical and biological stratification with a boundary at a depth of about 20 metres, which is particularly pronounced during the summer temperature stratification. In the deeper layer, where temperatures are within the lowest values found in the deep waters of the Mediterranean all year round, there are zooplankton species that either never or only very rarely (in winter) ascend into the water column above 20 metres during the day. A similar phenomenon is only observed in the deep troughs of the Mediterranean. In the deepest parts of the lake, a unique specimen of the small planktonic copepod *Mesaiokeras hurei* was discovered, which belongs to a very rare family with only a few known species, making it an exclusive find worldwide (Kršinić 2003, Miloslavić et al. 2016). Motivated by these new findings, research is continuing with the aim of modelling the lake and applying the results to predict and explain global processes in larger closed or semi-closed marine ecosystems such as the Black Sea or the entire Mediterranean.

Northern Adriatic

The northern Adriatic Sea is of particular interest for marine research. Although the beginnings of plankton research in the Adriatic are linked to this region, the scientific community, including the Dubrovnik Institute, intensified its studies of this phenomenon after the phytoplankton blooms and the appearance of massive accumulations of mucus between 1988 and 1991. The northern Adriatic is one of the most productive areas of the Mediterranean, highly influenced by all mainland environmental factors and anthropogenic activities (Figure 10). As this is one of the best-studied regions of the European seas, numerous historical records on the composition and abundance of zooplankton and hydrographic parameters provide valuable material for comparison with current research results. For this reason, employees of the Institute have been actively involved in planktonological research in the northern Adriatic since the early 1980s (Kršinić 1995, Kršinić and Precali 1997, Kršinić and Njire 2001, Lučić et al. 2003, Kraus et al. 2015). In addition to analysing the composition and abundance of all groups, the role of zooplankton in the food web was also investigated in order to apply the results to fisheries, in particular to the reproductive biology of anchovies and their

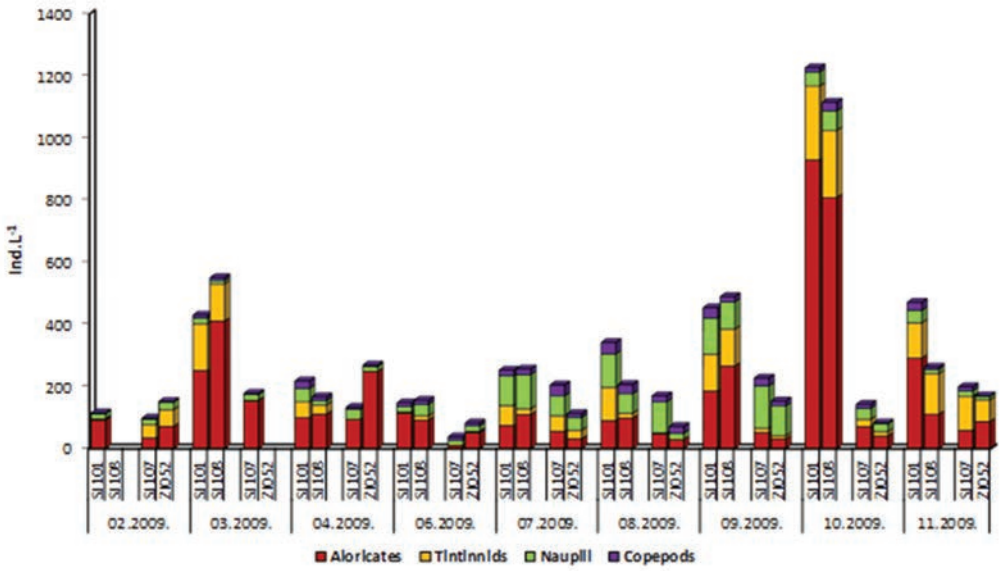

Figure 10. Distribution of microzooplankton groups (aloricate ciliates, tintinnids, nauplii and copepods) in the northern Adriatic Sea at two western (SJ101 and SJ108) and two eastern stations (SJ107 and ZI052) in 2019. The northern Adriatic is the most productive area of the Adriatic Sea. Aloricate ciliates and tintinnids dominate, especially in spring and autumn. At the western stations (SJ101 and SJ108), which are strongly influenced by the Po River, the abundance is significantly higher (Source: J. Njire).

population density. As the northern Adriatic is an area with the largest harbour capacities and maritime traffic, the research also focused on the detection of invasive (alien) zooplankton species that could be introduced by ballast water and their impact on natural populations and the ecosystem as a whole.

South Adriatic Pit

This unique region of the Adriatic lies in the southern area between the Strait of Otranto, the Palagruža Sill, the southern part of Croatia and the coast of southern Italy. With a maximum depth of around 1233 metres, it is the deepest part of the Adriatic, where the bottom sharply descends from 300 metres and forms a depression known as the South Adriatic Basin. This is the only area where we find a continental slope in the Adriatic. This region has therefore attracted the attention of zooplankton researchers from the very beginning of the Institute's scientific activities. After initial but very thorough studies of copepods (Hure 1961, Hure 1965, Hure and Scotto di Carlo 1968, 1970, 1974, Hure et al. 1980, Hure and Kršinić 1998) and planktonic appendicularia (Benović 1973, 1976, 1991, Benović et al. 1987, Gamulin and Kršinić 2000), all groups of zooplankton were studied. The composition and abundance of species, including species new to the Adriatic, the horizontal and vertical distribution of zooplankton in relation to environmental factors

such as changes in the daily light regime, seasonal temperature fluctuations, stratification of the water column and the influence of vertical and horizontal movements caused by wind and/or ocean currents were described (Kršinić and Grbec 2002, Batistić et al. 2004, 2007, 2012, 2014, Benović and Lučić 1996, Benović et al. 2005, Brautović et al. 2018, Lučić et al. 2005, 2009, Garić and Batistić 2011, GangaiZovko et al. 2018, Miloslavić et al. 2015). Inter- and intraspecific relationships between planktonic groups were also described, which contributes to a better understanding of the processes in the food webs of oceanic ecosystems in general. Figure 11 shows the results for the most abundant mesozooplankton group, the copepods, in the southern Adriatic Sea at stations from Dubrovnik to Bari (Italy). The order Calanoida dominates in terms of the number of species, although their number generally decreases with depth. The coastal areas (especially on the western side of the Adriatic) are more densely populated by this planktonic group. In the oligotrophic central part of the Adriatic, there may

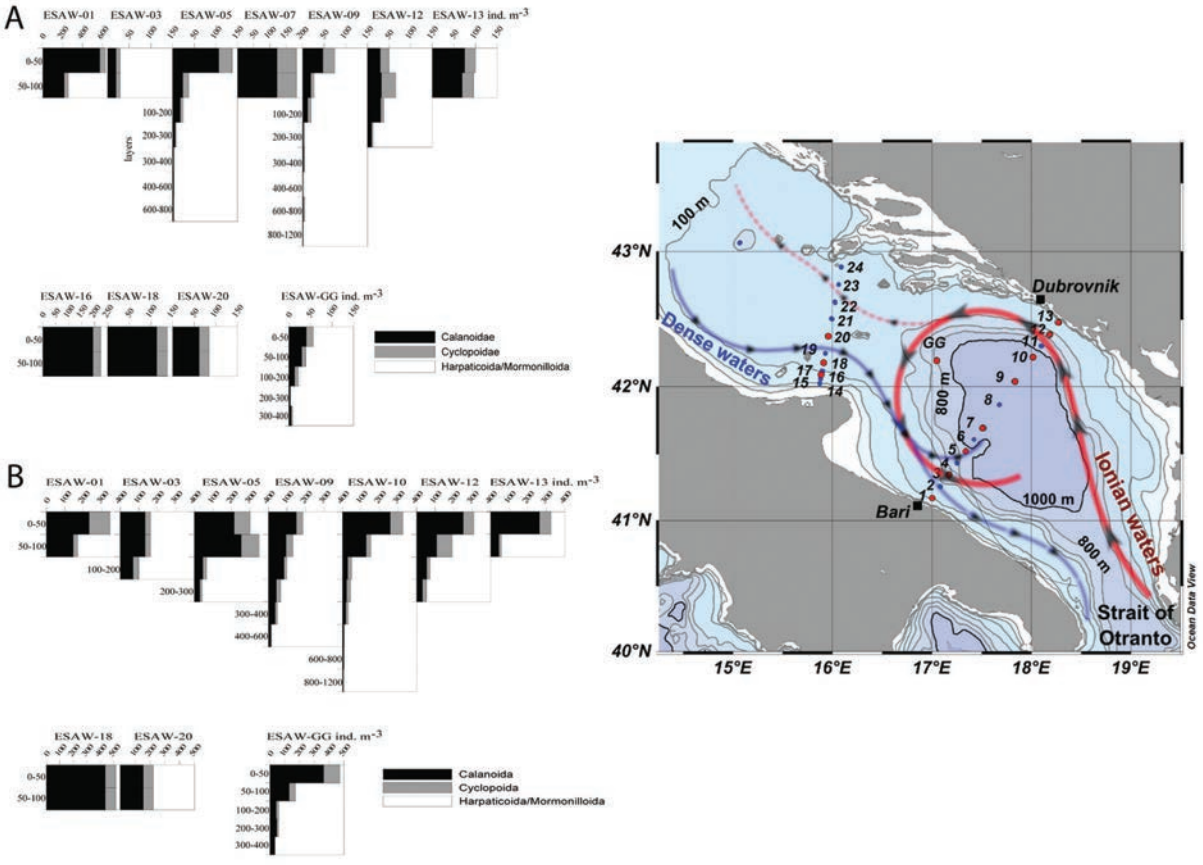

Figure 11. Horizontal and vertical distribution of copepods in two transects in the central and southern Adriatic Sea in December 2015 (A) and April 2016 (B) (Source: M. Hure).

be an increase in copepods in late winter/early spring, and species from the coastal area are often found together with species from the open sea during this period.

The presented results and scientific papers are the outcome of the research efforts of zooplanktonologists from Dubrovnik, whose contributions cover a wide period of time and different regions of the Adriatic Sea. Some of the most important scientists involved in these studies are: Tomo Gamulin (in the field from 1951 to 1979), Jure Hure (1949 – 1985), Andro Marchi (1967 – 1972), Adam Benović (1968 – 2011), Frano Kršinić (1972 – 2005), Velimir Šipoš (1974 – 1977), Ivan Katavić (1974 – 1977), Vladimir Onofri (1978 – 2020), Damir Mušin (1979 – 1993), Ankica Bender (1982 – 1987), Davor Lučić (1983 – present), Marina Rudenjak Lukenda (1983 – 1986), Jakica Njire (1985 – present), Mirna Batistić (1990 – present), Josip Mikuš (1990 – 1999), Igor Brautović (1994 – present), Dubravka Bojanić Varezić (2001 – 2011), Barbara Gangai Zovko (2006 – present), Marijana Hure (2007 – present), Rade Garić (2007 – present), Ivona Onofri (2008 – present). The research covered all parts of the Adriatic Sea and contributed to fundamental knowledge about the biology of zooplankton, the ecology of different groups, the systematics of many organisms and the discovery of ecologically specific areas. Particular attention was paid to negative changes in zooplankton structure due to anthropogenic influences, and certain species were emphasised as indicators of water masses in the open waters of the Adriatic. Despite these successes, many scientific questions remain unanswered, which the Institute's researchers intend to address in future studies.

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GELATINOUS ZOOPLANKTON IN THE ADRIATIC SEA – NEW INSIGHTS AND FUTURE RESEARCH DIRECTIONS

Mirna Batistić, Rade Garić

Newly arrived species of gelatinous zooplankton and hydroclimatic changes

Gelatinous zooplankton, like other zooplankton, cannot actively resist currents; instead, they are spread passively by the motion of waves and currents. For this reason, zooplankton is generally considered a good indicator of marine currents and environmental changes. Gelatinous zooplankton includes representatives from various zooplankton groups such as jellyfish, tunicates, chaetognaths, ctenophores, pteropods,

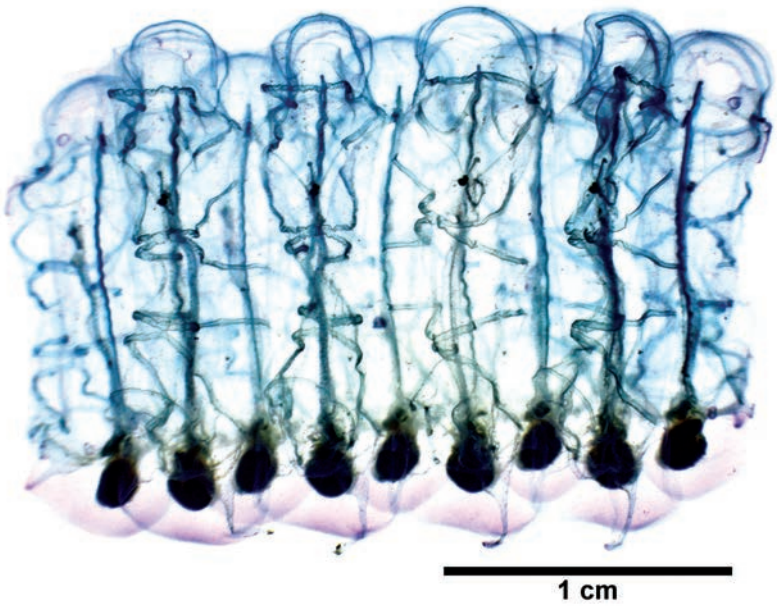

Figure 1. Individuals of the planktonic tunicate species *Pegea bicaudata* linked in a chain (Photo by R. Garić).

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siphonophores, and gastropods. They are characterised by a transparent, soft body without an internal skeleton and a high water content. The lengths of these organisms typically range from a few millimetres to several metres (e.g., planktonic tunicates that form chains, as shown in Figure 1).

In the last three decades, researchers at the Institute have recorded the ingress of 17 new zooplankton species into the Adriatic Sea. They have established a connection between their origin and the type of currents entering the Adriatic, depending on the direction of the gyre in the Ionian Sea (anticyclonic or cyclonic). Changes in circulation patterns can be tracked through changes in temperature and salinity in the deep layers of the Adriatic Sea, at depths of 200 to 800 metres (Figure 2). During an anticyclonic regime, colder and less saline Atlantic water enters the Adriatic (AW), bringing species of Western Mediterranean/ Atlantic origin. In the case of a cyclonic regime, warmer and saltier Eastern Mediterranean water (Levantine Intermediate Water – LIW) enters the Adriatic, carrying species from that part of the Mediterranean (Batistić et al. 2014) (Figure 3). Some of the species coming in with the Eastern Mediterranean current, which are new to the Adriatic, are warm-water Indo-Pacific species. Those coming from the Red Sea into the Eastern Mediterranean through the Suez Canal are called Lessepsian migrants, after Ferdinand de Lesseps (1805-1894), credited with the canal's construction (1869). Some of these newly arrived species have adapted to the conditions in the Adriatic and established themselves.

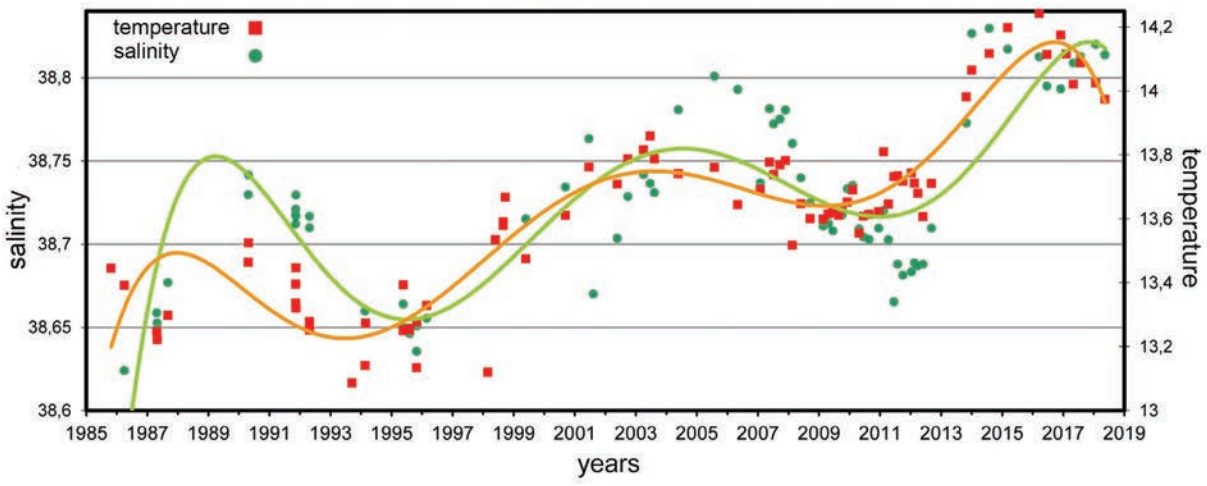

Figure 2. Long-term changes in temperature and salinity in the deep southern Adriatic. Dots represent average temperature or salinity from 200 to 800 m depth. (Data sources: Medatlas database: MEDAR Group, 2002; Institute for Marine and Coastal Research).

Among the established zooplankton species, none are tropical, indicating that the Adriatic Sea, despite the trend of increasing temperatures in recent decades, is still not warm enough for their development, i.e., for the establishment of permanent populations. By contrast, a species of siphonophore, *Muggiaea atlantica* (Siphonophora, Calycophorae), of Atlantic origin which prefers moderately cold waters, has become established in the Adriatic (Figure 3b). Overall, the Adriatic has relatively high biodiversity, with a large number of native species preventing foreign species from proliferating extensively and potentially harming the ecosystem.

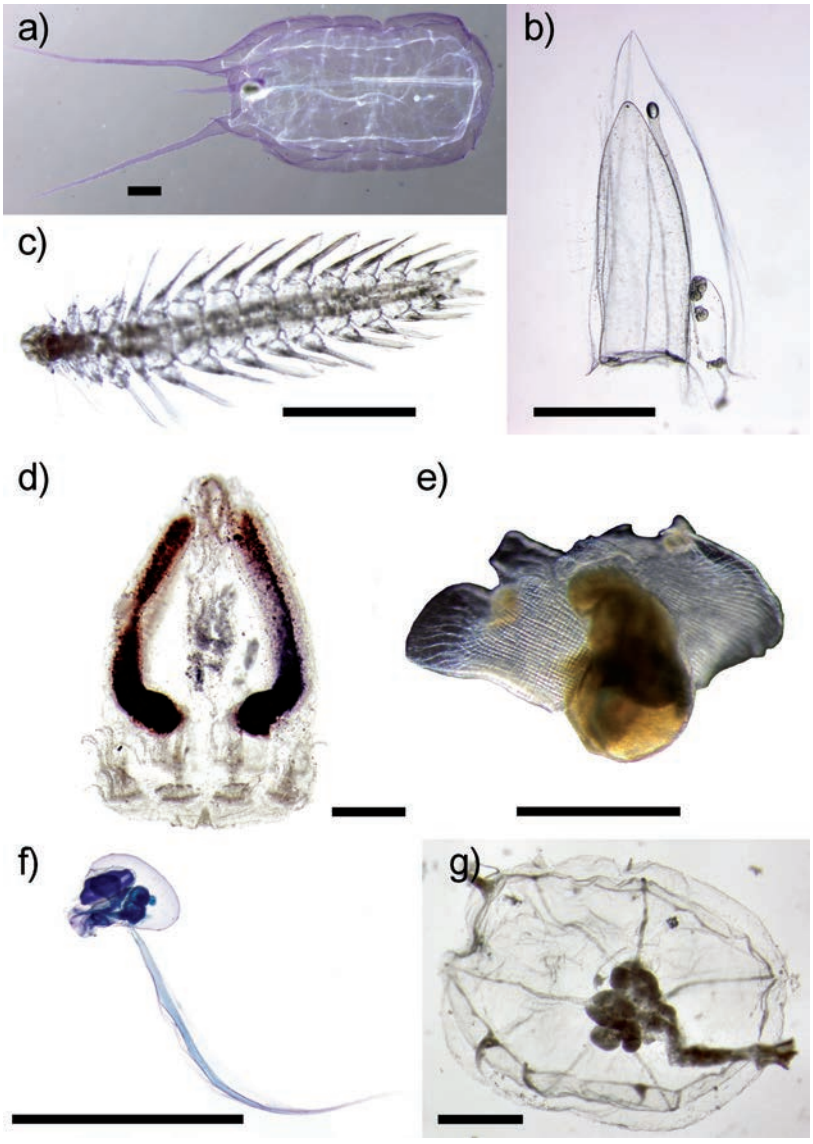

Figure 3. Some of the newly arrived zooplankton species recorded in the last 30 years in the Adriatic Sea: a) *Thalia orientalis* (salpid), b) *Muggiaea atlantica* (siphonophore), c) *Pelagobia longicirrata* (polychaete), d) *Charistephane fugiens* (ctenophore), e) *Desmopterus papilio* (gastropod), f) *Kowalevskia oceanica* (appendicularian), g) *Niobia dendrotentaculata* (hydrozoan) (Photo by R. Garić). Scale: 1 mm.

Since 2008, the Institute for Marine and Coastal Research has been conducting intensive research on the zooplankton of the open waters of the southern Adriatic within the framework of the Ministry of Science and Education project (2008–2013) and the Croatian Science Foundation project (HRZZ; AdMedPlan, 2014–2019). In these interdisciplinary studies, in addition to investigating the influence of changes in circulation patterns in the Ionian Sea on the ingress of new species into the Adriatic, the phenomenon of winter vertical mixing of water masses in the open sea has also been explored. Vertical mixing occurs when the temperature becomes uniform from the surface to the bottom due to winter winds causing evaporation and cooling of the surface layer. The dense, nutrient-rich deep water rises to the surface, leading to the intensive development of phytoplankton under calm weather conditions in the open sea, a phenomenon known as a winter phytoplankton bloom. Additionally, it has been recorded and explained how planktonic organisms sink when subjected to vertical convective currents, and an atypical phytoplankton maximum in the deep aphotic layer of the southern Adriatic can occur (Batistić et al. 2012). Zooplankton also sinks to deeper layers, but the majority of the population remains in the surface layers, indicating that zooplankton actively resists vertical water transport to the bottom. Furthermore, acoustic measurements with the Acoustic Current Doppler Profiler (ADCP) after vertical mixing showed the absence of intense vertical migration of zooplankton, which typically occurs during the night when they move from deeper layers to the surface for feeding. This is likely to be due to sufficient food (phytoplankton) sinking to the depths, while their movement to the surface is either absent or of lesser extent (Ursella et al. 2018) (Figure 4a). In contrast, during the warmer part of the year, high backscatter values (ADCP) in the subsurface layer (Figure 4b) coincide with the maximum chlorophyll-*a* (Chl-*a*) and increased zooplankton abundance in the same layer of the open sea.

Similar observations were made during the mass occurrence of gelatinous zooplankton, mostly planktonic tunicates, during the summer in the open waters of the southern Adriatic (Batistić et al. 2019) (Figure 5).

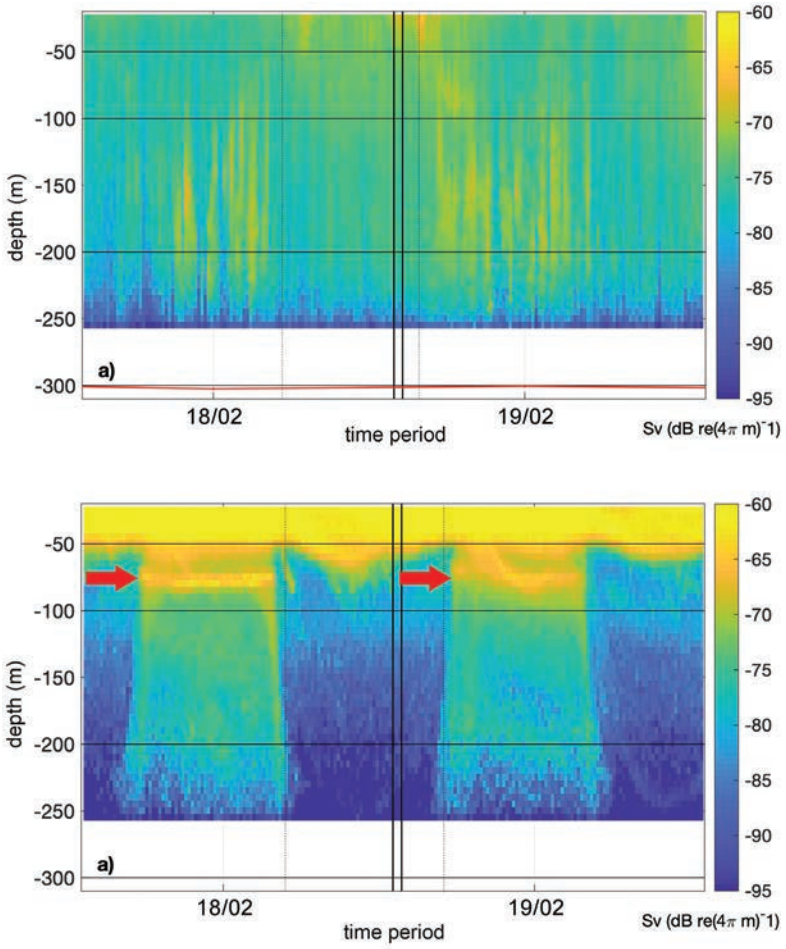

Figure 4. Results of research on diurnal-nocturnal vertical migration of zooplankton using the ADCP instrument, in winter and autumn: a) acoustic backscatter up to 250 m in the open southern Adriatic in February 2008. The diurnal-nocturnal signal is lost, and the entire column has a similar response during the day and night, b) acoustic backscatter up to 250 m in the open southern Adriatic in September 2008. A significantly higher response is observed during the night when plankton from the depths rises to the surface for feeding. Red arrows indicate the deep maximum of chlorophyll-a (Chl-a), where a higher accumulation of zooplankton occurs at night (Ursella et al. 2018).

For a long time, occasional significant increases in the abundance of gelatinous zooplankton, especially jellyfish, have been known. However, in recent decades, the frequency of such occurrences has increased importantly in the Adriatic Sea, and in other seas and oceans. The reasons for more frequent mass occurrences of gelatinous zooplankton are not fully understood, but research points to climate change having a significant impact. Rapid multiplication of gelatinous zooplankton leads to extensive and dense aggregations of individuals, significantly affecting the structure and functioning of marine ecosystems. Periodic mass occurrences of gelatinous zooplankton, whether filter feeders (planktonic tunicates) or predators (e.g., ctenophores or jellyfish), can alter the classical trophic cascade in the marine food web (phytoplankton - zooplankton - planktivorous fish - large carnivorous fish). In recent decades, jellyfish biomass has increased, along with ctenophores and planktonic tunicates, often

accompanied by simultaneous declines in fish resources. Besides consuming the same prey (zooplankton) as planktivorous fish, these gelatinous organisms also feed on fish larvae and juveniles, significantly reducing the fish population. A complete collapse of fisheries occurred in the Black Sea in the 1990s when the ctenophore species *Mnemiopsis leidyi* proliferated in extremely large numbers. Additionally, large aggregations of gelatinous zooplankton can impact other human activities such as tourism. Therefore, continuous monitoring of the dynamics of gelatinous zooplankton populations in the Adriatic Sea, which has been carried out for the past 30 years at the Institute for Marine and Coastal Research, is crucial. For some larger gelatinous organisms, sampling with plankton nets is often ineffective. Due to their fragile bodies, they can be damaged beyond recognition or completely disintegrate in the net. Therefore, in recent research, cameras deployed in real-time on diving platforms and the JellyCo system have been used in addition to nets. The JellyCo system (Makovec and Salvi 2012), developed at the Marine Biological Station (Piran, Slovenia), has proven to be particularly effective in studying gelatinous organisms (used in the open waters of the Mediterranean Sea and Mljet Lakes).

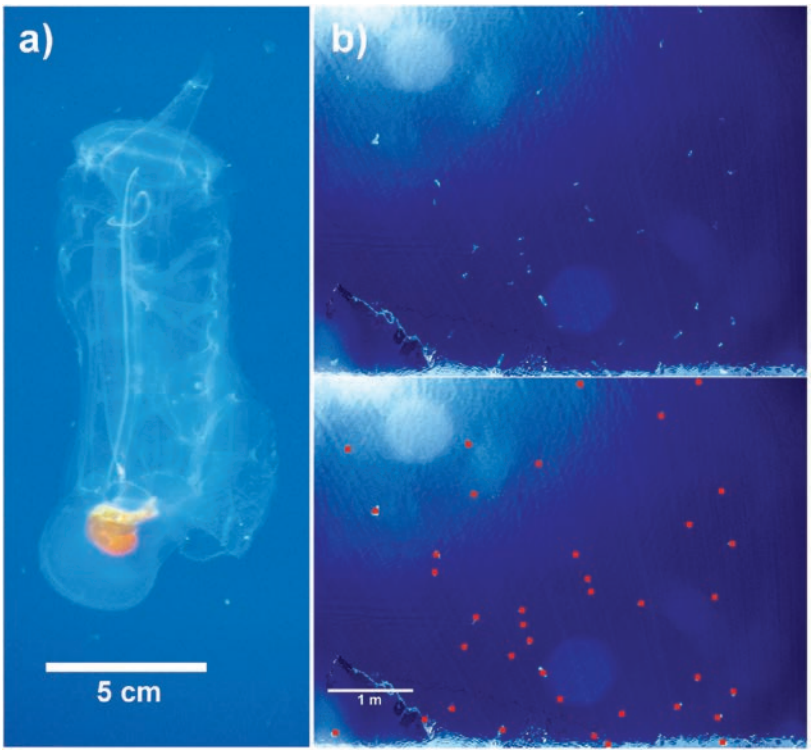

Figure 5. Massive occurrence of the species *Salpa maxima* (planktonic tunicate) in the open sea of the southern Adriatic: a) sexual form of the species *S. maxima*, b) numerous individuals of the species *S. maxima* filmed from the ship's deck. Red dots represent individual organisms (Photo by R. Garić).

Newly discovered and re-established species of gelatinous zooplankton

Taxonomic research conducted at the Institute involves an integrative (morphological and genetic approach) taxonomy. Genetic methods in zooplankton research were introduced at the Institute in 2007 with the establishment of the Laboratory for Plankton Ecology and Population Genetics. Significant achievements in recent years include the scientific discovery of two new species of gelatinous zooplankton, two planktonic tunicates: *Brooksia lacromae* Garić and Batistić, 2016 (Figure 6a) and *Fritillaria ragusina* Garić and Batistić, 2010 (Figure 6b), named after Dubrovnik and the islet of Lokrum.

Genetic methods are useful in detecting cryptic zooplankton species, proving whether the morphological differences among plankton populations are due to environmental variations or have a genetic basis, as well as in studying the degree

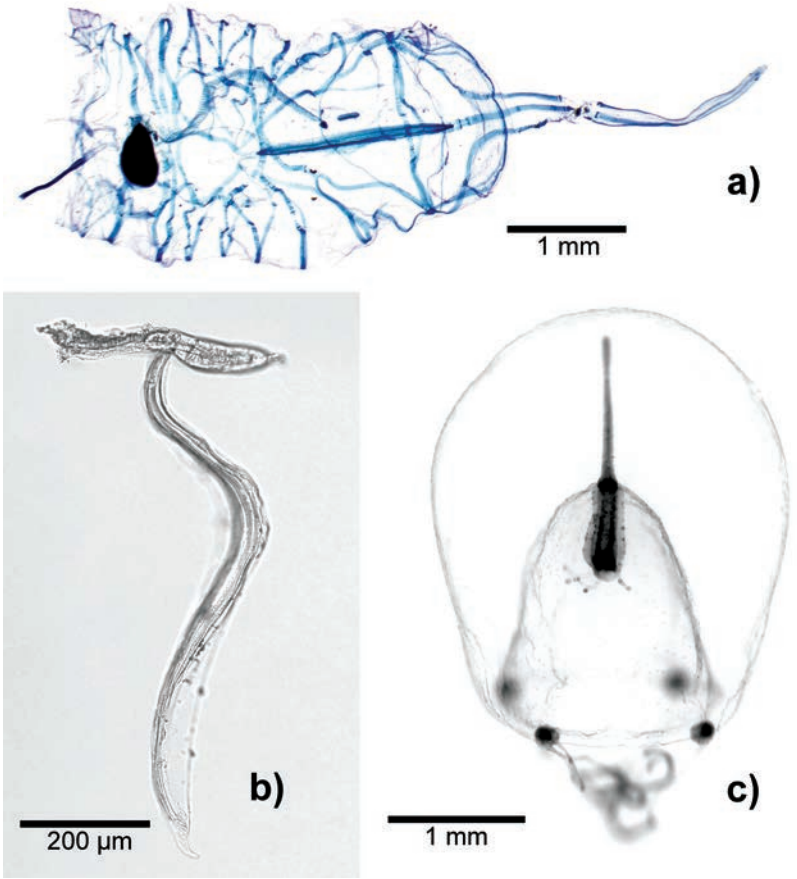

Figure 6. Newly discovered species *Brooksia lacromae* (a) and *Fritillaria ragusina* (b) and re-established species *Bougainvillia triestina* (c) (Photo by R. Garić).

of isolation between various populations of the same species. Alongside classical taxonomy, genetic methods provide insights into the origin of foreign species by comparing their genetic profiles with individuals from other seas and oceans. Cryptic species do not differ morphologically or have extremely small differences. To identify such species, fragments of reference genes, such as the mitochondrial gene for cytochrome c oxidase subunit I (COI), ribosomal RNA genes (16S, 18S, 28S), or highly variable ITS regions, are sequenced. If sequencing results show that sequences from some populations of the same species group separately, and the difference in the sequence of reference genes exceeds a certain "species threshold", it can be concluded that they are separate species. For some planktonic crustaceans, the variability in the COI gene sequence is about 3% within the species, while among species, this difference is 8-10%. An interesting case is the species *Bougainvillia triestina* (Figure 6c), a jellyfish first described in 1911 in the Gulf of Trieste, which was soon invalidated because it was considered just a form of the species *Bougainvillia muscus*, known to be polymorphic depending on ecological conditions. One hundred years after the description of *B. triestina*, genetic methods proved that *B. triestina* and *B. muscus* are two different species, and *B. triestina* was reinstated as a valid species (Batistić and Garić, 2016). In the Adriatic, genetic methods have been used to detect the level of isolation among various populations of the same zooplankton species. Sequencing the COI gene revealed that in the Mljet Lakes, distinct populations of *Calanus helgolandicus* (copepod) and *Sagitta setosa* (arrow worm) exist. These populations have limited contact with populations of their species in the open sea, leading to the development of unique genetic characteristics marked by specific mutations in the gene sequence compared to open sea species. Due to the narrow Solin Channel connecting the Mljet Lakes to the open sea, the ingress of planktonic species from the open sea is restricted.

Genetic methods can also be used to determine the phylogenetic tree of various groups of organisms. At the Institute, they have been employed to determine the phylogenetic position of planktonic tunicates from the class Appendicularia, in relation to other tunicates. It is considered that tunicates, including tunicate larvae, larvaceans, and thaliaceans, form a

sister group to vertebrates. Modern genetic methods are utilised to ascertain the composition of zooplankton populations in the entire sample. After sampling with a plankton net, DNA is isolated from the entire sample, and a fragment of the same gene is amplified from all groups and species of zooplankton in the sample. This fragment is then amplified in millions of copies, resulting in hundreds of thousands of sequences using high-throughput sequencing methods (Next Generation Sequencing, NGS). These sequences are analysed, and with their help, the species composition in the zooplankton sample is determined.

Ongoing research

Research into the phenomenon of diel vertical migration (DVM) of zooplankton in the Adriatic Sea, where this phenomenon was first monitored using an Acoustic Doppler Current Profiler (ADCP) in combination with data from zooplankton net samples, has obtained interesting results and posed new scientific questions. This research will thus continue through the project DiVMAd (IP-2019-04-9043), funded by the Croatian Science Foundation, which was approved in 2019 and will also involve real-time recording of zooplankton by cameras deployed in real-time on diving platforms and with the JellyCo instrument. Additionally, the contribution of zooplankton vertical migration to carbon transport into deeper layers will be investigated by analysing sediment traps at depths of 150 m and 1150 m.

Furthermore, research initiated in 2018 will continue, involving modern genetic methods of high-throughput sequencing, which will be extensively utilised in the study of copepods and planktonic tunicates.

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MARICULTURE ON THE EASTERN COAST OF THE SOUTHERN ADRIATIC AND RESEARCH AT THE INSTITUTE IN DUBROVNIK

Valter Kožul

Introduction

People who live close to the sea have always met part of their food needs by fishing, to which they later added mariculture. On the eastern coast of the Adriatic, there is a long tradition of seafaring, fishing and the cultivation of organisms from the sea. The first data on the cultivation of organisms from the sea refer to the cultivation of shellfish and date back to Roman times, when there is mention of oyster cultivation on the eastern coast of the Adriatic. Even today, the largest shellfish production on the eastern coast of the Adriatic is concentrated in the Southern Adriatic, specifically in Mali Ston Bay. Like shellfish farming, fish farming has a long history. The beginnings of marine fish farming date back to the 19th century when some fish species were extensively kept in ponds. The first attempts at lagoon fish farming in our part of the Adriatic came after World War II, but this extensive method of farming did not take off. Nevertheless, in the middle of the 1970s, cage breeding of sea bass, bream and mullet began, which was successful and economically profitable. In order for such breeding to be fully profitable, it was necessary to scientifically explain and solve the breeding cycle from spawning to consumer product. An important link in this cycle of breeding is certainly the production of a sufficient amount of fry for cage breeding. The early stages of breeding bring with them many pitfalls and unknowns that had to be resolved, and breeding technology constantly improved. The problems faced by scientists in the species that were investigated at the time were high mortality of early stages, size and quality of food for larval stages, cultivation of live food and ensuring quality conditions in hatcheries. This then resulted in the first spawning

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experiments of sea bass, white sea bream, and sea bream, as well as the construction and organisation of the first hatcheries.

Cultivation of planktonic organisms

During the 1980s, Croatian scientists in their research stood shoulder to shoulder with their European colleagues who were working on the same problems in mariculture. At the Institute, since the end of the eighties, marine organisms that are interesting for cultivation have been studied, primarily algae and zooplankton organisms that are used to feed the early developmental stages of fish, crustaceans, cephalopods and bivalves. At the beginning of the work on this issue, Boško Skaramuca (Figure 1), Ivica Prtenjača and Ivan Katavić made a significant contribution. In the Laboratory for Ecology, Cultivation of Marine Organisms and Aquaristics, in the second half of the 80s, the first research on the cultivation of phytoplankton and zooplankton, which are used in the process of cultivation of early developmental stages of organisms in mariculture, were organised.

Phytoplankton cultures (*Phaeodactylum tricornutum*, *Dunaliella* sp., *Chlorella* sp., *Tetraselmis* sp., etc.) are maintained on nutrient media and for experimental purposes we plant and grow them in sufficient quantities in the laboratory for growing phytoplankton and zooplankton. With the required amount of light and a satisfactory temperature, nutrient media prepared in our laboratories were added. In addition to breeding for feeding zooplankton, the technique of plankton breeding was experimentally developed with the aim of achieving higher concentrations in shorter periods of time, but methods of preserving high concentrations of phytoplankton at low temperatures were also investigated (Kožul and Skaramuca 1998, Skaramuca and Kožul 1998). Cultivation and experiments in our laboratory gave good results that were effectively used for the cultivation of zooplankton fed with these algae.

In parallel with the experimental spawning of seabass, the cultivation of bream (*Brachionus plicatilis*) was also investigated. Given that the breeding technique was quickly mastered based on the experiences of other scientists from around the world, the experiments in our laboratory were aimed at more efficient breeding of asexual generations that produced a large number of females with many eggs, which accelerated population growth.

Figure 1. Boško Skaramuca was the long-term head of the Laboratory for Ecology, Cultivation of Marine Organisms and Aquaculture (Photo by V. Kožul).

Technical problems in breeding tanks were investigated, the amount and type of food that needed to be balanced in order to increase the abundance of organisms while maintaining the purity of the culture. Investigations of abiotic and biotic factors on pavements were organised by Boško Skaramuca, Jakica Njire and Valter Kožul (Kožul and Skaramuca 1994).

Fish

Research on improving the process of controlled spawning of sea bass (*Dicentrarchus labrax*) and sea bream (*Sparus aurata*) required the organisation of their parent flocks. The stocks were successfully maintained in the aquarium, which is an integral part of the Institute and plays an important role in our scientific research. Each aquarium pool is a fragment of a natural environment in which natural conditions are simulated so that the behavior and the entire life cycle of organisms resemble those in nature. Certain pools were adapted to research work in such a way that access to organisms or fertilised eggs was facilitated, so the products after spontaneous spawning were harvested in special collectors.

In order to be able to carry out such research with quality, aquarium pools alone were not enough, the space above the engine room with pumps for supplying the aquarium with seawater was remodelled, and an experimental hatchery with a filtration system was built. Numerous species of fish, shellfish,

cephalopods and crabs were studied in this hatchery during 1990s. The results of the research were noticed in the scientific community outside our country, because at that time the research topic of new species in the Mediterranean was similar. First of all, this refers to experimental work with species such as grouper (*Epinephelus marginatus*) and amberjack (*Seriola dumerili*).

We researched the dusky grouper (*Epinephelus marginatus*) during the 90s. As a species that fetches a high market price, it is interesting for mariculture. Most of the results are combined in the works of Branko Glamuzina (Figure 2) and describe the formation of the mother stock, which partly consisted of organisms that we already had in the aquarium. Experiments were also carried out with large specimens of groupers between 15 and 25 kg that had lived in the aquarium for many years. Experimental work included hormonally induced spawning, sex changes through hormonal treatments in younger specimens, nutrition and survival of early developmental stages. Research in the laboratory also included other species of groupers, their growth in controlled conditions, the method of adaptation to pool breeding and spawning (Glamuzina et al. 1998 a,b,c, Glamuzina et al. 1999).

Figure 2. Branko Glamuzina during controlled grouper spawning in 1996 (Photo by V. Kožul).

Another particularly interesting species for mariculture that was investigated in our laboratory at the same time is the amberjack (*Seriola dumerili*). The research covered population dynamics in the southern Adriatic, sexual maturation, formation of breeding stock in pool and cage breeding, growth in cages and pools, hormonal treatments and spawning. The results were particularly significant in controlled breeding until sexual maturity, as this species shows significantly faster growth than all the fish bred in mariculture so far. For example, in six months of cultivation, weights of one kilogram are achieved, while sea bass reach 0.3 kg in 24 months of cultivation (Figure 3). The research results were published in the works of Valter Kožul (Kožul et al. 2001 a,b, Skaramuca et al. 2001).

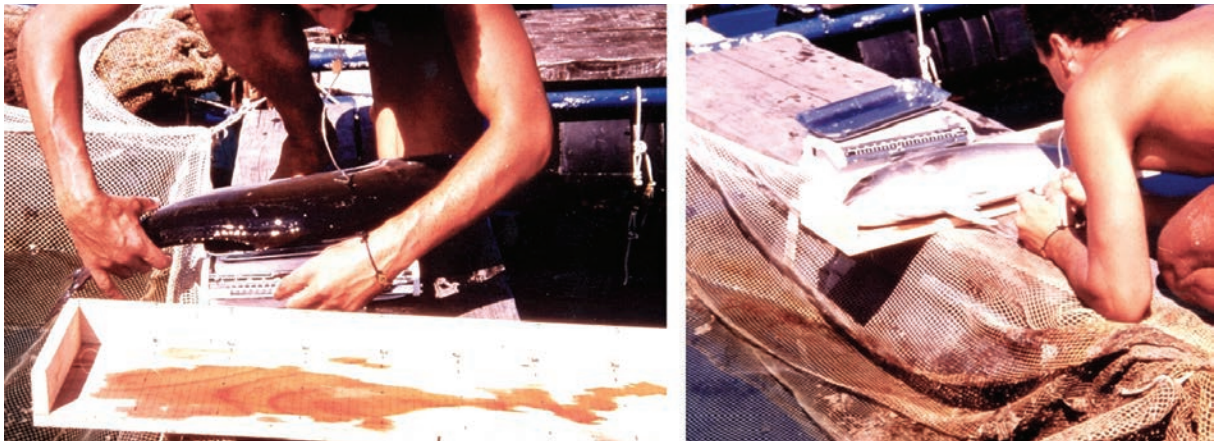

Figure 3. Experimental work on controlled spawning of gophers (*Seriola dumerili*), tissue sampling from gonads and growth control in cage breeding in 1996, Valter Kožul (Photo by J. Bolotin).

In parallel with laboratory work, field research along the coast of the southern Adriatic made a significant contribution to knowledge not only about economically interesting species but also about all other marine organisms. Since the end of the 1990s, the settlements of fish fry have been the object of intensive research, which was published in a series of publications by Pero Tutman (Tutman et al. 2002, 2003, 2004 a, 2007 a,b) Such research revealed particularly significant localities rich in populations of various species in earlier stages of development and provided the possibility of regular controls and protection.

A significant contribution to the possible controlled breeding of fish from the sparid family was made by research on the saddled bream (*Oblada melanura*) carried out in our laboratory at the end of the first decade of this century. Research was published by Nenad Antolović in his works, which report on spawning and the early development phase of life (Antolović et al. 2009).

Of the other species of fish that we experimentally spawned or bred in our hatchery, we should mention: green wrasse (*Labrus viridis*) (Kožul et al. 2011), brown wrasse (*Labrus merula)* (Dulčić et al. 1999), flounder (*Placihtis flesus*) (Kožul et al. 2002), pompano (*Trachinotus ovatus*) (Tutman et al. 2004 b) and leerfish (*Lichia amia*). Among the cephalopods, successful spawning and fry maintenance results were achieved with cuttlefish when the metabolism of oxygen consumption was examined through a series of experiments on the development of the early stages of the organism. The results were published in the works of Nikša Glavić. Crustaceans, such as the European lobster (*Homarus gammarus*), spiny lobster (*Palinurus vulgaris*) and Mediterranean

slipper lobster (*Scyllarides latus*) were also investigated (Glavić et al. 2001), especially their early development stages and adaptation to controlled cultivation with different effects from abiotic factors.

Through fieldwork, sampling from fishing catches, fishing with own tools and trawls, and in cooperation with fishermen and the local population, over the past 30 years or so, the scientists of our laboratory have recorded a number of new organisms in the southern Adriatic (Figure 4). Thus, in our waters, we recorded new species of groupers, barracuda, some crabs and shellfish, as well as algae. The spread of species towards the northern seas is certainly significantly influenced by climate change. Human activities such as mariculture, aquarism and maritime traffic are also the cause of the spread of non-native species.

Figure 4. Fieldwork is often associated with the discovery and examination of specimens of rare, new or protected organisms (Photo by N. Glavić).

Shellfishing

Shellfish occupy a special place in the research work of our Institute. Mali Ston Bay, an area of water where there is a long tradition of shellfish farming, is a challenge for all scientists of the institute, including members of the Laboratory for Ecology, Cultivation of Marine Organisms and Aquaculture (Figure 5).

The tradition of shellfishing related to oysters dates back to the time of the Roman Empire (the Historia Naturalis of C.

Plinius Secundus) and the Republic of Dubrovnik (Decree of the Duke of Ston from 1641). The first available archival record about the method of collecting oysters from natural habitats and semi-cultivation in Mali Ston Bay dates back to 1573, but as early as 1333, the importance of Bistrina Bay in this respect was noticed by the Republic of Dubrovnik.

The specific natural characteristics of Mali Ston Bay in the 1980s became the focus of scientific interest. Due to the special natural conditions confirmed primarily by numerous research works of scientists of the Institute, the sea and land area of Mali Ston Bay was protected in 1983. Today the level of protection is that of "Special Reserve in the Sea", and it is an area in which one or more elements of nature are expressed, and it is of special significance and purpose. It should be noted that the land around the bay from its peaks to the sea is protected, as is the sea in the bay.

The natural characteristics of the waters of the Mali Ston Bay and the traditional method of cultivation and production are also reflected in the excellent quality of Mali Ston Bay oysters, considering the amount of soft tissue produced throughout the year. For many years, Vladimir Onofri and Jakša Bolotin have been interested in research into the Mali Ston Bay oyster, as well as into the mussel, another important shellfish grown in the bay (Bolotin et al. 1993, Bolotin et al. 2005). Research on mussels included the rate of growth and mortality by depth, condition index and reception of fry, while research on oysters included growth by depth, condition index, as well as seasonal variations in the biochemical composition of oyster soft tissue. The spatio-temporal distribution of larvae in Mali Ston Bay was also investigated from 1985, with occasional interruptions until 2019, to help shellfishers in more precisely determining the place and time of placing collectors for successful collection of fry.

Figure 5. Experimental work and sampling in Mali Ston Bay in 2005, Jakša Bolotin, Nikša Glavić (Photo by V. Kožul).

In the mid-eighties of the last century, the scientists of the Institute started testing new types of collectors for collecting oyster fry based on different plastic substrates in Mali Ston Bay. This resulted in the complete abandonment of the traditional collection of fry with bundles of branches, mainly of the holm-oak (*Quercus ilex*) and the lentisk (*Pistacia lentiscus*).

The is also an ideal habitat for other species of bivalves, so induced spawning of some of them was investigated in the Laboratory or ways of collecting fry, growth and mortality rates by depth, reproductive cycles, population structures, age, metabolic activities, condition index and gonadal indices were investigated: small scallops (*Chlamys varia*), white mussels (*Modiolus barbatus*), Noah's Ark (*Arca noae*), noble pen shell (*Pinna nobilis*). Significant results were achieved by research into the strictly protected noble pen shell, which today is on the verge of extinction (Figure 6). Our laboratory was the first

Figure 6. Experimental work with the noble pen shell in Mali Ston Bay on breeding parks in 2005, Nikša Glavić, Valter Kožul and Nenad Antolović (Photo by J. Bolotin).

in the Mediterranean to grow the noble pen shell in the same way as oysters and mussels. Excellent results were achieved that showed how in these semi-controlled conditions, just like on the seabed, this bivalve grows very quickly with minimal mortality.

Institute aquarium, scientific role and popularisation of science

The growth of the human population and its activities tends to be destructive to the environment, and thus to biodiversity, so many organisms become endangered or extinct. Aquariums play an important role in nature conservation through education and research aimed at maintaining organisms in controlled conditions.

The Dubrovnik Aquarium has been part of the Institute since the end of the 1950s. It is located in the protected cultural monument of Fort St. John and depicts life in the Adriatic Sea

Figure 7. Fort St. John, on the ground floor of which the Institute in Dubrovnik and its aquarium are located (Photo by V. Kožul).

Figure 8. Entrance to the Institute in Dubrovnik and the Aquarium in Kneza Damjana Jude Street, 2009 (Photo by V. Kožul).

Figure 9. The interior of the aquarium with pools (year 2012) in the openings where cannons for the defence of the Republic were once located (Photo by V. Kožul).

(Figures 7, 8). The ground part of the fortress has been adapted in such a way as to enable aquarium pools to be located there (Figure 9). Part of them was made in cannon embrasures, part of the Republic's defence engineering.

The supply of sea water is provided from underground under the aquarium (Figure 10). Previously, seawater was pumped directly from the surrounding sea, but due to frequent pollution and particularly high summer temperatures, this has changed. Now the water is drawn from a well in the floor of the aquarium,

Figure 10. Construction of a borehole in 2016 for pumping sea water into the aquarium from the ground below the fortress (Photo by V. Kožul).

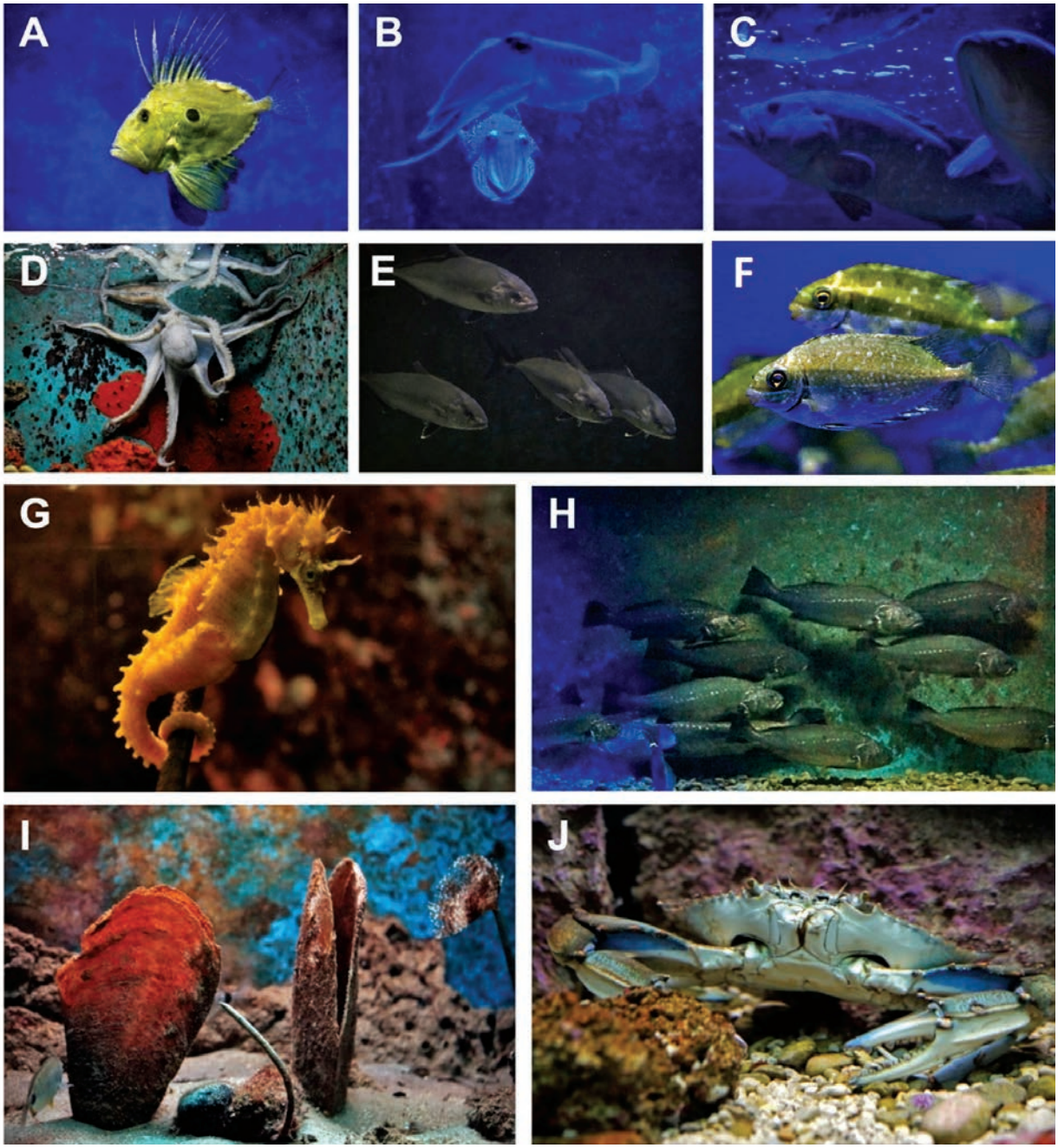

Figure 11. Organisms in aquarium pools: A – blacksmith (*Zeus faber*), B – cuttlefish (*Sepia officinalis*), C – dusky grouper (*Epinephelus marginatus*), D – octopus (*Octopus vulgaris*), E – amberjack (*Seriola dumerili*), F – a new species of Carangidae in the Adriatic, G – seahorse (*Hippocampus hippocampus*), H – meagre (*Argyrosomus regius*), I – noble pen shell (*Pinna nobilis*), J – blue crab (*Callinectes sapidus*) (Photo by I. Brautović).

which is 50 m deep and 12 cm wide. It was drilled in 2016 and provides a constant flow of clean seawater at a stable temperature.

Numerous species of fish, crustaceans, cephalopods and other organisms are successfully maintained in the Dubrovnik aquarium. In addition to protected species such as the seahorse (*Hippocampus romulosus*), green wrasse (*Labrus viridis*), noble pen shell (*Pinna nobilis*), Triton's trumpet (*Charonia tritonis*), giant tun (*Tonna galea*), loggerhead sea turtle (*Caretta caretta*), the aquarium has successfully maintained some non-native species that have appeared in our waters: the blue crab (*Callinectes sapidus*) and squaretail rabbitfish (*Siganus luridus*) (Figure 11).

Living and nonliving food is used in the nutrition of exposed organisms in the aquarium. Organisms for the aquarium are obtained from their own catch, by purchase from fishermen or from farms, and by exchange with other aquariums.

Figure 12. Construction of the aquarium and occasional reconstructions (Photo Archive of the Institute).

Figure 13. The interior of the aquarium before the reconstruction of the floor pools, September 2015 (Photo by V. Kožul).

The institute's aquarium has 32 pools that show below the surface of the Adriatic. This number of pools has changed since its foundation and of course increased, but always in accordance with the possibilities provided by the area of the protected cultural monument (Figure 12). During the first major reconstruction of the aquarium (1958-1959), floor pools were built and the total volume of sea water was almost doubled (Figure 13).

More recently, a number of other pools have been built along the fortress wall. During 2020, the reconstruction of the in-ground pools began as part of the Exchange IPA project. These pools have been reconstructed from floor to above-ground pools, which enable a better presentation of organisms.

Over the past years, research in the aquarium has focused on breeding and maintaining protected species, adapting new species to aquarium conditions, and monitoring the appearance of new species in the Adriatic Sea that are being maintained in the aquarium. It is certainly necessary to emphasise the dual role of the aquarium,

Figure 14. The interior of Aquarium after the reconstructions according to project of the project office "Studio presjek d.o.o."

which is first of all scientific, especially in our Institute, and only then that of popularising science and familiarising citizens with the major ecological problems that threaten the whole of humanity. The aquarium also has a recreational role, the tour offered enabling visitors to relax and enjoy the sight of the organisms, the pool and the overall environment. The future of aquaristics and aquariums lies in mastering the maintenance of new species, the cultivation of protected, endangered and rare species, research into species interesting for mariculture and the adaptation of the programme with respect tog the demands of visitors and available resources.

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CONTRIBUTION OF THE INSTITUTE IN DUBROVNIK TO THE UNDERSTANDING AND PROTECTION OF MALI STON BAY

Nenad Jasprica, Mirna Batistić

At the time when the foundations of the Biological Institute in Dubrovnik were being laid in 1950, according to the concept of the Department for Natural and Medical Sciences of the JAZU (Yugoslav Academy of Sciences and Arts, Zagreb), the aim was to engage in research on terrestrial, primarily the fauna of the underground, flora and vegetation of the coastal zone, and the unexplored islands of the Adriatic Sea in connection with the "practical needs of the economy" (JAZU 1952). This institution was intended to be somewhat complementary to the Oceanographic Institute in Split, which was dedicated to marine research. However, in line with the general conditions at the time, as well as the enthusiasm and scientific interests of the people tasked with organising scientific work at the Institute, research on plankton began. Certainly, one of the reasons for establishing such a scientific institution on the southern Adriatic was the need for research, protection, and monitoring of the environmental conditions in Mali Ston Bay.

Regardless of the administration under which they worked and the internal organisational structure, scientists at the Institute began intensive research in Mali Ston Bay and the surrounding area as early as the 1960s. Decades of acquiring knowledge, experience, and direct contribution to the effective protection of Mali Ston Bay qualify them today to discuss this area with the highest competence.

Mali Ston Bay and the Malo More ("Small Sea") are relatively shallow areas, surrounded by low, occasionally steep, coasts with developed Mediterranean evergreen vegetation (Jasprica and Kovačić 1997a, 2000). The most important factors (temperature, salinity, nutrients) affecting the ecological conditions in Mali Ston

Jasprica, N., Batistić, M., 2021: Contribution of the Institute in Dubrovnik to the understanding and protection of Mali Ston Bay. The Seventieth Anniversary of the Institute in Dubrovnik (eds. Jasprica, N., Batistić, M.). University of Dubrovnik, Dubrovnik.

Bay depend on occasional inflows of freshwater from the Neretva River into the outer part of the bay and more significantly from submarine springs (vrulje) into the inner part. Understanding the structure and dynamics of plankton populations, and natural and cultivated populations of shellfish and fish, nutrient cycles, and the degree of eutrophication (e.g., Viličić et al. 1994, 1998, Jasprica et al. 1994, 1997b, 2012, Čalić et al. 2013, Kršinić et al. 2016, etc.) has enabled the understanding of this complex ecological system, as well as any possible negative impacts on marine life. Most scientists from the Institute obtained their higher degrees through research into material from Mali Ston Bay. These findings were later published in scientific journals.

The Institute participated in the preparation of studies (e.g., Environmental Impact Study for the mainland – Pelješac bridge with the access roads in 2015) and documents significant for assessing the state of Mali Ston Bay (Benović et al. 2005), and since 2005, it has regularly monitored the seawater conditions in Mali Ston Bay (monitoring). Mirna Batistić and Nenad Jasprica, along with Vinicije Lupis, are members of the Main Board of the "Pelješac Bridge" association from Dubrovnik, which from 2012 worked on raising awareness among the scientific, professional, and wider public about the need for and significance of continuing the construction of the Pelješac Bridge for the Republic of Croatia and its territorial integrity (Batistić et al. 2014) (Figure 1).

Figure 1. Scientists from the Institute participated in the preparation of the Environmental Impact Study for the mainland – Pelješac bridge with the access roads in 2015. The Pelješac Bridge under construction, May 2021 (Photo by I. Brautović).

The initial scientific evaluation of the valuable area of Mali Ston Bay (Roglić and Meštrov 1981) served as the basis for its designation as a protected area under the category of a special maritime reserve. Due to the risk of pollution, particularly from development in the town of Neum (Bosnia and Herzegovina) and from planned tourism activities, in 1983 the former municipalities of Dubrovnik and Metković declared Mali Ston Bay a protected area. The State Administration for Nature Protection classified it as a "Special Reserve in the Sea." The protected status of Mali Ston Bay was changed in 1998 by a decision of the Assembly of the Dubrovnik-Neretva County to "Strict Reserve" and in 2002 to a "Special Reserve in the Sea" (Figure 2).

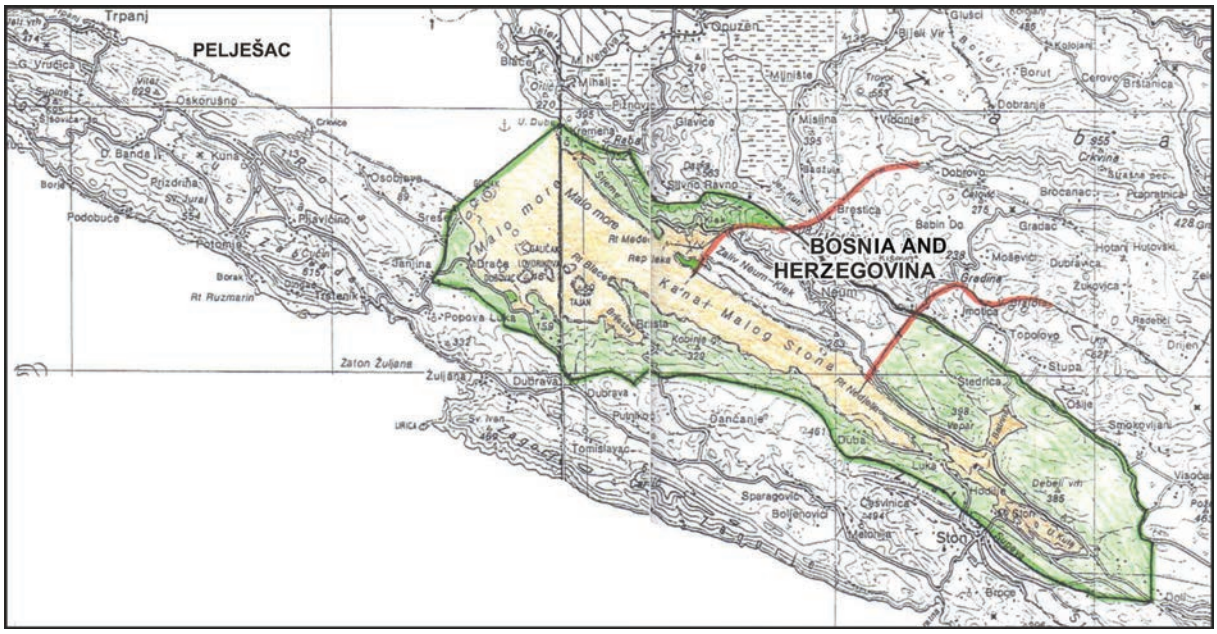

Figure 2. The boundaries of the protected area in Mali Ston Bay (Available at: https://hr.wikipedia.org/wiki/Posebni_rezervat_prirode_Malostonski_zaljev_i_Malo_more, last accessed December 14, 2020, prepared by N. Jasprica).

Debates on the protection of natural heritage sometimes narrow down to the Ecological Network of the Republic of Croatia; the NATURA 2000 network - parts of land and sea where significant species and habitats of interest to the European Union are protected (e.g., Jasprica and Kovačić 2010). The oyster farms in Mali Ston Bay are a great treasure, known since the Middle Ages, so the protection of the terrestrial habitats on which the oyster's life cycle depends is crucial (Carić et al. 2000, Viličić 2017). The local population has always cared for the rational management of this entire area.

Today, generally, and thus also in Mali Ston Bay, the ecosystem is particularly influenced by anthropogenic factors, i.e., human activity. The plan and decision to include the construction of two separate building areas outside settlements, for hospitality-tourism purposes in the area of Duba Stonska (total area of 13 ha and capacity of 550 beds) in 2013, was assessed by the Institute in Dubrovnik as extremely harmful. At the initiative of the Institute and in cooperation with the Croatian Academy of Sciences and Arts (HAZU), Croatian scientific and expert community gathered in 2014 at a round table at HAZU on the topic "Tourist construction in Mali Ston Bay - a special reserve in the sea". The main conclusions from the round table were that Mali Ston Bay is an extremely valuable part of the natural heritage of the Republic of Croatia, and the proposed construction would be extremely harmful to the marine ecosystem in the Mali Ston Bay and contrary to the Nature Protection Act.

Nowhere on the eastern coast of the Adriatic Sea do the sea and land form such a unique whole as in Mali Ston Bay, which was one of the starting points when the decision on the legal protection of this area was made (Figure 3). Mariculture, that is, relies on the natural features of the sea, primarily plankton, the development of which is largely dependent on activities on land. Urbanisation of the area and increased activity on land

Figure 3. The coast of Mali Ston Bay is surrounded by dense evergreen vegetation, connecting the terrestrial and marine parts into an inseparable, ecologically functional whole (Photo by N. Jasprica).

and at sea (movement of people and vessels by sea) increase the risk of introducing and developing toxic and potentially harmful species, not only algae but also other organisms that can alter the current structure of marine and terrestrial life. One possible outcome is the complete closure of the farms. The benefits of investment in construction would be much lower than the potential damage caused by such activities. The municipalities of Pelješac should focus their development and investments in tourist infrastructure on the southern slopes of the peninsula, where the coasts are more attractive for such activities, and the damage to the ecosystem would be much smaller.

The value of Mali Ston Bay transcends the borders of our country; its protection is of wider European cultural and natural importance. Although we are a tourist destination, we do not see a reason to develop tourism at any cost and in every corner, jeopardising an economic sector that has sustained the local population for centuries. We must not replace a profitable and unique economic sector, with a centuries-old tradition (shellfish farming), linked to a rare and valuable natural heritage, with a ubiquitous industry (tourism) that has no place there.

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CONTRIBUTION OF THE INSTITUTE IN DUBROVNIK TO THE ESTABLISHMENT OF THE BOTANICAL GARDEN ON THE ISLAND OF LOKRUM AND THE DEVELOPMENT OF BOTANICAL SCIENCE

Katija Dolina

Establishment of the Botanical Garden

The idea of establishing an acclimatisation garden for the study and production of exotic plants was based on the centuries-old tradition of the successful cultivation of non-native plant species on Lokrum. The idea was expressed as early as 1911 by the famous botanist from Dubrovnik Lujo Adamović (1864 – 1935) in the book *Die Pflanzenwelt Damatiens* (Adamović 1911), in which he emphasised the positive characteristics of the climate and location as well as the horticultural and architectural heritage as advantages of the island of Lokrum.

Adamović's idea to found an exotic garden on Lokrum was not put into practice until 1959, when, at the initiative of the director of the Biological Institute of the former Yugoslav Academy of Sciences and Arts (JAZU), Tomo Gamulin, it was decided to create the Botanical Garden. The neglected agricultural land of the former Benedictine estate was made available for the botanical garden, as was the area in Maximilian's summer house, which housed the offices, tools and other equipment of the Institute's former Department of Terrestrial Botany.

Work on the design of the garden began in 1960, when the Belgrade botanist Lav Rajevski (1910 – 2001) was appointed manager. The garden was spatially divided into four parts. An exotic park was planned for the first and largest part, which was

Dolina, K., 2021: Contribution of the Institute in Dubrovnik to the establishment of the Botanical Garden on the island of Lokrum and the development of botanical science. The Seventieth Anniversary of the Institute in Dubrovnik (eds. Jasprica, N., Batistić, M.). University of Dubrovnik, Dubrovnik.

intended as an exhibition area for visitors. The remaining three parts, intended for professional and scientific work, included: (i) a greenhouse and nursery, (ii) experimental areas with conifers, and (iii) areas with Mediterranean plants that are not native to Lokrum. The conceptual and executive project for the exhibition part of the Botanical Garden was designed by the well-known Dubrovnik landscape architect Bruno Šišić. Within the implementation project, only the structural component was worked out in any great detail, while the plant material was determined and distributed at the conceptual project level, mainly by families, as it depended on the possibilities of obtaining propagation material and the success of production and acclimatisation (Šišić 2010). When selecting the plants, particular attention was paid to species that are important for forestry, horticulture and pharmacy. As the main purpose of the garden was to introduce and acclimatise subtropical plants, care was also taken to select species originating from other areas with a Mediterranean climate, such as central Chile, southern and south-western Australia, central and southern California and southern Africa. The work on building the paths and designing the garden plots took almost a whole decade, so that the garden was officially opened on 29 May 1967 (Kovačić 1994-1995).

History of the Botanical Garden and its restoration after the Croatian War of Independence 1991

Lav Rajevski was the successful garden manager from the founding of the garden until his retirement in 1981. Even after his retirement, he continued his work until the beginning of the Croatian War of Independence in 1991. Thanks to his enormous effort and enthusiasm, this was the most productive period in the garden's entire history. Lav Rajevski published a list of the Botanical Garden's plant collection in 1989, in which he listed 389 species of trees and shrubs and 81 species of succulents cultivated in the Garden's exhibition area. He also listed an impressive number of succulents cultivated in the greenhouse (195 species of cacti and about 60 other species of succulents).

From the 1970s until the beginning of the Croatian War of Independence, botanists Vladimir Birač, Petar Đurasović, Marija Hećimović, Stipe Hećimović and gardener Mirko Šiljeg made a significant contribution to the development of the garden.

The Botanical Garden was severely damaged during the Croatian War of Independence when 42 shells from the aggressors' positions around Dubrovnik fell on the garden's exhibition area alone (Viličić 1992). Some of the plant material was damaged and destroyed. Most of the specialised and scientific literature and all of the documentation on the garden's plants were burnt in the fire, as was Lav Rajevski's flat in the historic centre of Dubrovnik. The documentation of the garden landscaping project was also irretrievably lost when the Center for Historic Gardens and Landscape Development, which was located in the building of the Inter-University Centre in Dubrovnik, was completely burnt down during the bombing of Dubrovnik.

The first phase of the garden's restoration began at the end of 1993, thanks to the financial support of the Ministry of Science and Technology of the Republic of Croatia and the great affection of Deputy Minister Greta Pifat-Mrzljak for the garden. The works were carried out by employees of the Lokrum Reserve. Destroyed trees and bushes as well as exploded and unexploded projectiles were removed and taken away. In the summer of 1994, with the employment of the collection curator Sanja Kovačić, the second phase of the restoration of the Botanical Garden began (Figure 1). It was necessary to map the garden again, identify and list the remaining plant species and compile a list of necessary repairs. With great will and commitment, contacts were established with many botanical gardens around the world and the most necessary specialised literature, seeds, tools and other necessary materials and accessories were purchased with numerous donations. Excellent relations were achieved with the Botanical Garden of the Faculty of Science of the University of Zagreb, where plants were

Figure 1. The collection curators in the Botanical Garden after the Croatian War of Independence and the period in which they worked in the garden (from left to right): Sanja Kovačić (1994 – 1996), Tatjana Lasić Kapetanović (1997 – 2001) and Katija (Đevojić) Dolina (2003 – present) (Photo by N. Jasprica).

grown from the seeds obtained (Kovačić 1994-1995). In April 1997, Tatjana Lasić Kapetanović was hired as a collection curator in the Botanical Garden. In October 2003, the same position was filled by Katija Dolina and the work of mapping, identifying, maintaining and renovating the garden continues. From the beginning of the War of Independence until 2005, the job of gardener was performed on a part-time basis by a retired gardener, and since February 2005 Mario Marlais has been the gardener.

The garden today

The botanical garden on the island of Lokrum is located on the slope between the harbour of Portoč and Dumanjske banje and covers an area of 33,000 m^2. Admission to the garden is free and it is open to the public from April to November, depending on the decision of the Public Institution Lokrum Reserve, whose boats take visitors to the island. Today, the garden is looked after by two employees - a botanist and a gardener who work for the Laboratory of Terrestrial Flora and Fauna of the Institute for Marine and Coastal Research at the University of Dubrovnik.

Figure 2. Eucalyptus trees are the tallest angiosperms on the planet (Photo by K. Dolina).

The exhibition area of the Botanical Garden is built in the English (landscape) style and divided into 13 plots with a total area of 16,120 m^2. Parts of the garden area are shaped in such a way that related plants (e.g., members of the same plant families) are presented in the same area. Today, 462 taxa, mainly trees and shrubs, are cultivated in the exhibition area. The largest number of species belongs to the myrtle family (Myrtaceae). The garden is dominated by species of the genus *Eucalyptus*, and among the other representatives of the myrtle family, species of the genera *Callistemon* and *Melaleuca* thrive (Figures 2, 3). Among the conifers, pines are the most represented by the number of species, mostly American and Mediterranean and, to a lesser extent, Asian. The palms are also well adapted to the climate of Lokrum, so that they do not require protection in winter, although they need to be watered abundantly in summer (Figure 4). The

Figure 3. The filaments of the members of the genus *Callistemon* give their inflorescence a special colour and an appearance reminiscent of "bottle brushes" (Photo by K. Dolina).

Figure 4. Plot with palm trees (Photo by K. Dolina).

most interesting part of the collection for visitors is on the small hills with succulents. Although some succulents were damaged and died in the extremely low temperatures in recent winters, there are still around 50 species growing in the exhibition area of the garden. Of particular note is the collection of around two hundred cacti housed in a dilapidated greenhouse outside the exhibition area of the garden (Figure 5). The aforementioned greenhouse is currently the only indoor working area for the garden's staff, as the rooms intended for staff in Maximilian's summer house stopped being used a few years ago for safety reasons.

Although the Botanical Garden has been managed by the Institute for Marine and Coastal Research, that is, by its legal predecessors, since its foundation, the entire island of Lokrum, including the Botanical Garden, has been owned by the Public Institution Lokrum Reserve since 2011. The dominant species in the garden (e.g., eucalyptus, acacia) were mostly planted 30-60 years ago, and as they are relatively short-lived plants, some specimens die of old age, which also affects the appearance of the garden. Extreme weather and climate events, the appearance of invasive pests (e.g., red palm weevil) and unsuitable conditions for growing and propagating plants, as well as a continued lack of financial resources and staff, have had a negative impact on the diversity and number of plant species in the garden (Figures 6, 7). Complete devastation was caused by the illegal introduction of the European rabbit (*Oryctolagus cuniculus*) to the island (Jasprica and Dolina 2016).

Figure 5. Part of the cactus collection in the greenhouse (Photo by K. Dolina).

Since the Botanical Garden is part of the offer of the Public Institution Lokrum Reserve,

Figure 6. Frequent uprooting by the wind in the Botanical Garden (Photo by K. Dolina).

Figure 7. A rare sight of snow (collection of succulents) in the Botanical Garden, February 2012 (Photo by K. Dolina).

which generates a certain amount of income at the expense of the garden and is also its owner, a project for the restoration of the exhibition area of the Botanical Garden was launched in 2018 in cooperation between the Public Institution Lokrum Reserve and the Institute for Marine and Coastal Research of the University of Dubrovnik. The spatial values were analysed during the preparation of the project documentation: plant collection, microclimatic conditions, topographical and pedological background, ambient values, but also the structure of the visitors and their needs were inventoried and analysed. Based on the data obtained, a solution of the space was created, for which primarily the method of reconstruction and in some places interpolation with new elements was used (Dolina et al. 2019). The restoration works began in October 2019 (Figures 8, 9, 10). Their implementation raised the standard of the Botanical Garden's material equipment and increased the number of educated and informed visitors who will receive additional information about the Botanical Garden's collection.

Figure 8. Aerial view of the Botanical Garden before the renovation in 2019 (Source: Normala d.o.o.).

Figure 9. Start of work on the renovation of the paths in the garden in 2019 (Photo by K. Dolina).

Figure 10. View of the entrance to the Botanical Garden on Lokrum according to the project (Architecture: Normala d.o.o., design: Šesnić & Turković d.o.o.).

Contribution to botanical research and education

In the late 1960s, the Biological Institute of JAZU in Dubrovnik planned botanical research in the Dubrovnik region and bordering areas, based on the assumption that the flora and vegetation of this area had not yet been sufficiently studied. Due to the distance from the existing scientific centres, no systematic research had been carried out in this area for several decades, so that only the results of more or less secondary and short-term observations were available. That this assumption was justified was shown by the Institute's first works, when Stjepan Horvatić collected floristic material and studied and mapped the vegetation on the island of Lokrum. Several new plant varieties and forms were identified in the collected material, as well as several species that were previously unknown for the area (Horvatić 1960). Starting on these facts, the first task of the Institute's botanical department was to study the flora of the Dubrovnik region and neighbouring areas and to create a basic herbarium.

Subsequently, research was started on the flora of Pelješac, Dubrovačko Primorje, Konavle and the Bay of Kotor (Rajevski 1969) as well as on the flora and vegetation of Srđ and Rijeka Dubrovačka (Birač 1973), the Elafiti Islands, Lokrum, Bobara and Mrkan (e.g., Hećimović 1984, Hećimović and Hećimović 1989). A significant contribution was made to the knowledge of the flora

and vegetation of the Dubrovnik area. Particularly noteworthy is the description of a new endemic plant community from the southern part of the eastern Adriatic coast, the association *Limonietum anfracti* (Ilijanić and Hećimović 1982).

Herbarium material was also collected during field research in the same period. Lav Rajevski and Marija and Stipe Hećimović collected around 7,000 herbarium sheets of plant specimens from the southern Adriatic coast. Due to the renovation of Maximilian's summer house and at the request of the Public Institution Lokrum Reserve, the herbarium was temporarily relocated in the main building of the University of Dubrovnik campus in 2019. The herbarium of the Institute for Marine and Coastal Research has great scientific and educational value and is a valuable source of information, both for experts and the general public, which is why it must be systematically processed and protected.

In the post-war period, the few botanists at the Institute have been very active in research into Mediterranean flora and vegetation, invasive and rare plant species and the use of wild plants in people's daily lives. The research conducted at the Institute represents a significant contribution to the knowledge of Croatian, Balkan and Mediterranean flora and vegetation and to the preservation of the long and rich tradition of the utilisation of wild plants on the eastern Adriatic coast. For more than 20 years, the botanists of the Botanical Garden have been performing phenological observations of plants in cooperation with the Croatian Meteorological and Hydrological Service.

In addition to participating in national and international scientific and professional conferences, the botanists are also actively involved in educational work to promote botany, natural history, environmental protection and nature conservation. Educational work is based on professional guidance, workshops, field lessons for students, celebrations of special dates that are important for nature conservation, etc. (Figure 11). During the Week of Botanical Gardens, Arboretums and Botanical Collections of Croatia, exhibitions, lectures, workshops, guided tours, botanical excursions, readings in nature, etc. are organised.

Although the contribution of the Institute's staff to Croatian botany is significant, scientific work in the botanical garden was not continued after the Croatian War of Independence.

Figure 11. Professional guidance in the garden with the aim of education (Photo by K. Dolina).

Since botanical gardens play an important role in the protection of nature, especially of rare and endangered plants, the ecological conditions required for the cultivation of some plant species in the Dubrovnik area, including Croatian strictly protected plants, are being investigated in cooperation with the Department of Mediterranean Plants of the University of Dubrovnik. Successfully cultivated species will be presented in the Botanical Garden on the island of Lokrum and will play an important role in educating visitors to the garden. In addition, the cultivation of strictly protected species will create *ex situ* populations that serve as mother plants, i.e., as a source for the further propagation of these species in nature. In this way, we will try to contribute to the achievement of Target 8 of the Global Strategies for Plant Conservation 2011-2020, according to which at least 75% of threatened plant species should be conserved in *ex situ* collections, preferably in the country of origin. In order to restart scientific research in the garden, it is necessary to include the garden in scientific projects dealing with the wild flora of Croatia or the acclimatisation of exotic plants and to hire at least one scientist in addition to the existing botanist to take care of maintenance. Another prerequisite for scientific work is the construction of a germination facility, the design of a plant nursery, the renovation of the greenhouse and other infrastructure

necessary for the early propagation of plants, which would also improve professional work in the garden.

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THE CONTRIBUTION OF THE INSTITUTE IN DUBROVNIK TO EDUCATION

Nenad Jasprica

Teaching is an integral part of each scientific institution, involving the systematic transmission of knowledge and experience based on scientific research. Scientists at the Institute in Dubrovnik, whether formally appointed to academic positions or not, have served as supervisors in the development of numerous undergraduate and graduate theses, as well as of doctoral dissertations (see the chapter "Defended qualification theses at the Institute in Dubrovnik").

At the Institute in Dubrovnik, Tomo Gamulin (Full Professor) and Lav Rajevski (Assistant Professor) came to work as university lecturers. Throughout their scientific careers, Adam Benović, Nenad Jasprica, Frano Kršinić, Davor Lučić, and Boško Skaramuca held positions as regular (full) university professors, imparting their knowledge and experience to students of undergraduate and postgraduate courses at universities in Split, Zagreb, Dubrovnik, as well as in Mostar and Sarajevo (Bosnia and Herzegovina) (Figure 1).

For years, the Institute has organised education for final-year biology students from Zagreb and other university centres in the country and around the world. They come for field trips, seminars, thesis work, etc. The Institute provides access to laboratories for activities such as microscopy and organism identification, field trips aboard the research vessel *Baldo Kosić*, visits to the Botanical Garden on Lokrum, botanical excursions to the islands around Dubrovnik, and tours of natural history collections. The Dubrovnik Aquarium has made a significant contribution to education, promoting and popularising science not only among students but also among people of all ages and the broader public.

Jasprica, N., 2021: The contribution of the Institute in Dubrovnik to education. The Seventieth Anniversary of the Institute in Dubrovnik (eds. Jasprica, N., Batistić, M.). University of Dubrovnik, Dubrovnik.

Figure 1. Scientists from the Institute are involved not only in doctoral courses but also in teaching at undergraduate and graduate levels. A – Students from France learning plankton sampling methods aboard the research vessel *Naše more* as part of institute projects, 2021. B – Students preparing specimens for phytoplankton microscopy in the Laboratory for Plankton Ecology and Population Genetics at the Institute in Dubrovnik, 2012. C-D – Students on field trips for geobotany and plant systematics. Biology students are led by their professors Nenad Jasprica and Paula Durbešić, along with instructor Ilija Rozić from the Faculty of Science at the University of Mostar (Bosnia and Herzegovina), 2011–2012. (Photo by R. Garić, N. Jasprica, A. Mijatović).

The Institute is one of the organisers of the interdisciplinary postgraduate study of Oceanology, which has been running continuously since 1971 at the University of Zagreb. This study program has evolved into the current doctoral program in Oceanology, jointly organised by the Faculty of Science, University of Zagreb, the Institute of Oceanography and Fisheries in Split, and the Ruđer Bošković Institute in Zagreb. This program constitutes a collaborative effort aimed at delivering high-quality education at the national level in Croatia. Scientists from the Institute in Dubrovnik have completed postgraduate master's (scientific) courses and later obtained doctoral degrees in Oceanology. Today, these scientists are lecturers in the doctoral program in Oceanology and active members of its council.

Regarding the organisation and implementation of the study program, Oceanology was introduced in 1997 as a separate scientific (interdisciplinary) branch in the field of geosciences within the classification of Scientific Fields of the former Ministry of Science and Technology.

IN MEMORIAM

Nenad Jasprica

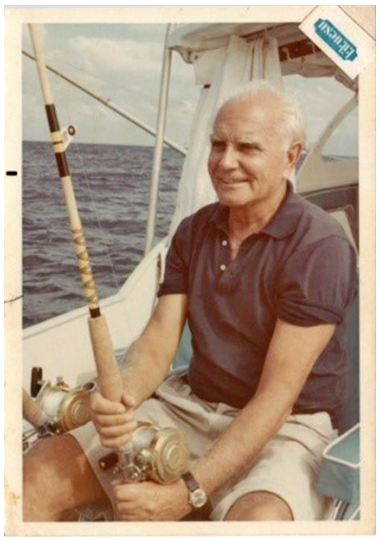

Figure 1. Tomo Gamulin (Source: F. Kršinić).

Tomo Gamulin (April 28, 1906 – June 4, 1991)

Tomo Gamulin was born in Jelsa on the island of Hvar. He began his primary education in Jelsa and completed it in Split. He finished high school in Split as well. He graduated in zoology, botany, and geology from the Faculty of Arts at the University of Ljubljana. In 1939, he obtained his Ph.D. with a dissertation on copepods. He was a teacher in high school and university professor. He taught zoology at the Faculty of Natural Sciences and Mathematics in Zagreb. He worked as a scientific collaborator at the Oceanographic Institute in Split (1945–1947) and the Institute for Marine Biology in Rovinj. After that, he came to Dubrovnik, where he stayed the longest. From 1958 to 1977 he was the director of the Biological Institute, within which he founded the Aquarium. In Dubrovnik, he organised research on the zooplankton of the open sea of the southern Adriatic. Tomo Gamulin's main scientific interests were in the spawning of small pelagic fish, the ecology of zooplankton and ichthyoplankton. He was extremely knowledgeable about the population structure of the zooplankton in the Adriatic Sea. This contributed to research into the Adriatic because he solved many problems in the biology of small pelagic fish, especially sardines in the Adriatic. He studied the life of sardines in the Adriatic: the dependence of their migration on the amount of plankton and its nutritional value, i.e., the withdrawal of sardines during spawning to areas richer in zooplankton, the main spawning areas of sardines, sensitivity to ecological factors; he defined the time of day when they release sexual products, and studied the embryonic development of sardine eggs depending on sea temperature. The results of these studies were published in 1956 together with Dr. Jure Hure in the prestigious scientific journal *Nature*. In addition, he also wanted to study the life of lobsters to protect them, i.e., determine the breeding and retention period of larvae in the plankton. An expert in calycophoran siphonophores, he was also a historian of science. He studied the history of

Jasprica, N., 2021: In memoriam. The Seventieth Anniversary of the Institute in Dubrovnik (eds. Jasprica, N., Batistić, M.). University of Dubrovnik, Dubrovnik.

research on the world's seas. He edited the journal *Thalassia Jugoslavica* for four years. In 1964, he received the annual Award of the City of Dubrovnik for his exceptional contribution to research into the Adriatic Sea, and in 1989/1990, he received the Lifetime Achievement Award of *Slobodna Dalmacija*. The Croatian Natural History Society awarded him the Brusina Plaque in 1985 for his exceptional contribution to the popularisation of marine science. He was elected a corresponding member of the Croatian Academy of Sciences and Arts in 1968. He died in Dubrovnik and was buried at Boninovo Cemetery in Dubrovnik.

Lav Rajevski (November 20, 1910 – March 7, 2001)

Lav Rajevski was born in Izmail (Odessa Oblast, Ukraine). He obtained his Ph.D. in biology from the Faculty of Natural Sciences and Mathematics, University of Belgrade (Serbia) in 1958. From 1945 to 1959, he worked as an assistant at the Faculty of Veterinary Medicine in Belgrade. In 1959, he became an associate professor at the same faculty, which he left in January 1960. In February 1960, he arrived in Dubrovnik. In the 1950s, he did research into the flora of the mountains in southeastern Serbia. His rich herbarium collection is housed in the herbarium of the Botanical Garden in Belgrade. He was the head of the Botanical Garden on the island of Lokrum from its establishment in 1959 until his retirement in 1985. He was responsible for the construction of the garden and the introduction of many plant species from warm regions, especially Australian acacias and eucalyptus, as well as succulent plants and conifers, which made the garden well-known to many foreign botanists and tourists. He also studied the native Mediterranean flora of Croatia. On December 6, 1991, during the heaviest bombing of Dubrovnik and its historic core, the documentation of the Botanical Garden was burned along with Dr. Rajevski's apartment in the old city centre of Dubrovnik. After this tragedy, the Rajevski couple relocated to a retirement home in Venice (Italy), where Lav Rajevski passed away in 2001.

Figure 2. Lav Rajevski and his wife Ksenija in 1988 at the Botanical Garden on the island of Lokrum (Photo from Archive of the Institute).

Figure 3. Jure Hure (Source: Hure Family private collection).

Jure Hure (February 9, 1918 – August 21, 2011)

Jure Hure was one of the founders of organised scientific research of the sea in Dubrovnik. He completed his biology studies in 1946 at the Faculty of Philosophy, University of Zagreb. From 1946 to 1948, he was a high school teacher in Osijek. In late 1948, he began working at the newly established Fisheries (Oceanographic) Station in Dubrovnik, where he worked as an assistant until its abolition in 1956. For a short time (1956–1958), he worked as a curator at the State Museum and was the director of the Natural Science Institution in Dubrovnik. He obtained his Ph.D. in 1958, was appointed as a research scientist in 1959, a senior research scientist in 1969, and a scientific advisor in 1978. From 1958, after the merger of the Natural Science Institution of Dubrovnik with the Biological Institute of the Yugoslav Academy of Sciences and Arts (JAZU), until his retirement at the end of 1984, he was an employee of the predecessor of today's Institute for Marine and Coastal Research. The most important topics Jure Hure focused on in his research were zooplankton and the spawning of small pelagic fish. Together with Professor Tomo Gamulin, he published discoveries about the reproduction of sardines in the prestigious scientific journal *Nature* in 1956. He was a specialist in copepods. His works on this topic are still cited in prestigious international scientific journals today. From 1965, when the Institute established cooperation with the *Stazione Zoologica di Napoli*, Jure Hure was already an established scientist. He maintained contacts with colleagues from Italian and French oceanographic institutes.

Figure 4. Ivan Tutman (Source: P. Tutman).

Ivan Tutman (October 26, 1924 – June 5, 1985)

Ivan Tutman was born in Dubrovnik, where he completed his primary and secondary education. After completing a general agricultural course in Split in 1945, he began working in the Department of Agriculture at the District Committee in Dubrovnik. In 1951, he was employed at the Biological Institute in Dubrovnik as a preparator. He completed his biology studies at the Faculty of Natural Sciences and Mathematics, University of Sarajevo (Bosnia and Herzegovina) in 1965, obtaining his Ph.D. from the same institution in 1981. In the same year, he was promoted to Scientific Advisor. He published the results of his multi-year research in 33 scientific papers and 59 professional-popular articles. During his dedicated scientific work, he maintained contacts with domestic and foreign ornithologists and was a member of many

ornithological societies. From 1980, he was a member of the British Royal Society for the Protection of Birds. He actively participated in public life and held a series of public lectures on the life and migrations of birds, receiving several awards for his contributions.

Adam Benović (April 10, 1943 – December 6, 2011)

Figure 5. Adam Benović (Photo from Archive of the Institute).

Adam Benović was born in Osijek. He completed his primary and secondary education in Dubrovnik, and graduated in biology from the Faculty of Science, University of Zagreb, in 1967. He obtained his master's degree (M.Sc.) in 1971, and his Ph.D. in 1977 at the Faculty of Science, University of Zagreb. In 1970, he was employed at the then Biological Institute. From 1977 to 1990, he held the position of Institute Director. He was appointed scientific assistant in 1972, research scientist in 1978, senior research scientist in 1985, scientific advisor in 1989, and tenured scientific advisor in 1998. His most significant scientific discoveries were published in the prestigious scientific journal *Nature*, and he also wrote articles in professional-popular magazines. His most notable scientific achievement is the discovery of new species of jellyfish in the Kvarner region and Mljet lakes, as well as the discovery of the causal mechanism for the disappearance of many jellyfish species in the northern Adriatic. He confirmed the hypothesis of jellyfish as the evolutionarily oldest species and their acceptance as indicators of stability in marine ecosystems, especially in changes induced by the consequences of global warming. He is credited with the protection and sustainable development of Mali Ston Bay as a special marine reserve and of Mljet National Park. He personally played a very significant role in the construction of the regional sewage system Neum (Bosnia and Herzegovina) – Mljet Channel. Through his engagement, he contributed to the establishment of the Dubrovnik Polytechnic, and later the University, especially the founding of aquaculture studies at the University, the reconstruction of a fishing vessel for marine work, and the reorganisation of the Institute for Marine and Coastal Research. He lectured at universities in Zagreb, Dubrovnik, and Mostar (Bosnia and Herzegovina). He received several awards and honours for his work. President of the Republic of Croatia, Dr. Franjo Tuđman, awarded him the Order of the Croatian Morning Star with the image of Ruđer Bošković for special merits in science in 1996, and in 2009, he received the State Award for Science for significant scientific achievement in the research of marine ecology, especially jellyfish.

SCIENTISTS OF THE INSTITUTE IN DUBROVNIK

Surname, name	Period
Antolović, Nenad	2005 –
Balenović, Radimir	1978 – 1981
Batistić, Mirna	1990 –
Bender (Pojatina), Ankica	1982 – 1987
Benović, Adam	1968 – 2011
Birač, Vladimir	1966 – 1971
Bobanović-Ćolić (Radoničić), Svjetlana	1986 –
Bojanić Varezić, Dubravka	2001 – 2011
Bolotin, Jakša	1983 –
Brautović, Igor	1994 –
Car, Ana	2008 –
Carić-Glunčić, Marina	1986 – 2011
Dolina (Đevojić), Katija	2003 –
Čalić, Marijeta	2003 – 2018
Dupčić Radić, Iris	2009 –
Đurasović, Pero	1968 – 1971
Gangai Zovko, Barbara	2006 –
Gamulin, Tomo	1951 – 1979
Garić, Rade	2007 –
Hećimović, Marija	1978 – 1991

Table 1. List of scientists (in alphabetical order) at the Institute in Dubrovnik and the period spent working at the institution.

Hećimović, Stipe	1977 – 1991
Hrustić, Enis	2007 – 2018
Hure, Jure	1949 – 1984
Hure, Marijana	2007 –
Jasprica, Nenad	1984 –
Katavić, Ivan	1974 – 1977
Kožul, Valter	1991 –
Kovačić, Sanja	1994 – 1996
Kršinić, Frano	1972 – 2005
Lasić (Kapetanović), Tatjana	1997 – 2001
Lučić, Davor	1983 –
Ljubimir, Stijepo	2011 – 2017
Marchi, Andro	1967 – 1972
Mikuš, Josip	1990 – 1999
Mušin, Damir	1979 – 1993
Njire (Sanko), Jakica	1985 –
Onofri, Ivona	2008 –
Onofri, Vladimir	1978 – 2020
Peharda, Melita	1998 – 2001
Prtenjača, Ivica	1981 – 1984
Rajevski, Lav	1960 – 1981
Rudenjak Lukenda, Marina	1983 – 1986
Skaramuca, Boško	1970 – 2006
Šipoš, Velimir	1974 – 1977
Tutman, Ivan	1951 – 1985
Tutman, Pero	1998 – 2003
Viličić, Damir	1977 – 1996

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Birač, Vladimir 1971. Biljni pokrov Srđa i okolice Dubrovačke rijeke. Faculty of Science, University of Zagreb (Supervisor Stjepan Horvatić).

Bojanić, Dubravka 2005. Struktura populacija kalanoidnih kopepoda u otvorenim vodama Srednjeg Jadrana. Faculty of Science, University of Zagreb (Supervisor Frano Kršinić).

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Brautović, Igor 1998. Planktonski ostrakodi i kladoceri Južnojadranske kotline. Faculty of Science, University of Zagreb (Supervisor Frano Kršinić).

Čalić, Marijeta 2009. Sastav i ekološke značajke fitoplanktona u hiperhalinim ekosustavima srednjeg Jadrana. Faculty of Science, University of Zagreb (Supervisor Nenad Jasprica).

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Hećimović, Stipe 1981. Biljni pokrov otoka Lokruma te školjeva Bobare i Mrkana s posebnim obzirom na dinamiku vegetacije. Faculty of Science, University of Zagreb (Supervisor Ljudevit Ilijanić).

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Katavić, Ivan 1976. Kvalitativni i kvantitativni sastav *Taliacea* jadranskog mora u jesen 1974. g. i u proljeće 1975. g. Faculty of Science, University of Zagreb (Supervisor Tomo Gamulin).

Kožul, Valter 1995. Utjecaj naglih promjena temperature na populacije fitoplanktona i zooplanktona u uzgoju. Faculty of Science, University of Zagreb (Supervisor Boško Skaramuca).

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Sanko, Jakica 1989. Utjecaj nekih biotskih i abiotskih faktora na rast populacije rotatorija (*Brachionus plicatilis* Muller). Faculty of Science, University of Zagreb (Supervisor Boško Skaramuca).

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OTHERS ABOUT US

Slobodna Dalmacija, 7.9.2017.

SPEKTAR
PRILOG SLOBODNE DALMACIJE SUBOTA, 2. RUJNA 2017.

DUBROVAČKI DOKTORI VINICIJE LUPIS, MIRNA BATISTIĆ I NENAD JASPRICA :

BAGERE NA PELJEŠKOM MOSTU TREBA UPALITI SUTRA!

Slobodna Dalmacija, 21.6.2012.

Slobodna Dalmacija ČETVRTAK 21.6.2012 DALMACIJA.15

Udruga: Most je jamstvo budućnosti
Izgradnja Pelješkog mosta jamstvo je budućnosti hrvatskog juga, projekt od iznimnog geostrateškog značenja. Trajekti koji bi mogli uzrokovati ekološku katastrofu Malostonskog zaljeva nisu rješenje – ocijenio je Lupis, a druga rješenja su skupa i neprihvatljiva.

NA NAJVIŠE ADRESE UDRUGA DUBROVAČKIH ZNANSTVENIKA UPUTILA ON-LINE PETICIJU

Za pelješki most 6600 potpisa

●● Tekst on-line peticije sa 6600 potpisa potpore izgradnji pelješkoga mosta istoimena dubrovačka udruga šalje predsjedniku RH Ivi Josipoviću, premijeru Zoranu Milanoviću, te predsjednicima Europske komisije José Manuelu Barrosu, Europskog vijeća Hermanu van Rompuyu i Europskog parlamenta Martinu Schulzu.

Najavili su to u srijedu u Dubrovniku predstavnici Udruge "Pelješki most", dubrovački znanstvenici Nenad Jasprica, Vinicije Lupis i Mirna Batistić.

Peticija je prema njihovu mišljenju svojevrstan plebiscit koji potvrđuje visok stupanj informatičke pismenosti stanovnika krajnjeg juga, te nadasve njihovu podršku izgradnji mosta kao najjeftinijeg rješenja za izlazak Dubrovačko-neretvanske županije iz prometne izolacije.

- Podržali su nas većinom ljudi koji nisu članovi političkih stranaka, od intelektualaca iz zemlje i inozemstva, preko uglednih akademika do predstavnika vjerskih institucija. Zahvaljujemo svima koji su pokazali glas hrabrosti i potpisali peticiju - istaknuo je Lupis, napominjući kako akcija nema političku pozadinu.

G. BIJELIĆ

Znanstvenici protiv trajekta u zaljevu

●● Protiv kontroverznog prijedloga trajektnog povezivanja Komarne i Brijeste ustali su i znanstvenici s juga Hrvatske:

- Ako postoji jednakopravnost spolova, mi građani hrvatskog juga tražimo da Hrvatski sabor donese Deklaraciju o jednakopravnosti građana hrvatskog juga s ostalim građanima Hrvatske, jer smo samo ravnopravni u plaćanju poreza, trošarina za gorivo, putarina, ali ne i u slobodi kretanja ljudi i robe - smatraju u Inicijativnom odboru Udruge "Pelješki most" koja je nedavno pokrenula internetsku peticiju za nastavak gradnje "mosta nade" kao najjeftinijeg trajnog rješenja prometne izoliranosti.

Čelnici udruge dr. Vinicije Lupis, dr. Mirna Batistić i dr. Nenad Jasprica trajekte smatraju promašenim rješenjem koje bi naškodilo zaštićenom Malostonskom zaljevu.

Na potencijalne opasnosti za Malostonski zaljev upozorava i ravnatelj Instituta za more i priobalje Sveučilišta u Dubrovniku Valter Kožul. Izražava nadu da nadležni neće poduzimati ishitrene zahvate bez znanstvene podloge koji bi mogli ozbiljno narušiti ekološku ravnotežu i ugroziti tradicionalan uzgoj školjkaša po kojemu je Malostonski zaljev jedinstven u svijetu.

Ravnatelj Kožul pojašnjava kako su unutar Malostonskog zaljeva kao "posebnog rezervata u moru" zabranjene radnje koje mogu narušiti svojstva zbog kojih je proglašen rezervatom, a dopušteni su samo zahvati kojima se održavaju ili poboljšavaju uvjeti u rezervatu.

GABRIJELA BIJELIĆ

Slobodna Dalmacija, 8.6.2012.

Župan Dobroslavić s predstavnicima Instituta za more i priobalje

EKOLOGIJA SASTANAK O ZAŠTITI MALOSTONSKOG ZALJEVA

More se štiti i na kopnu

●● Župan Nikola Dobroslavić sastao se s predstavnicima Instituta za more i priobalje Sveučilišta u Dubrovniku i predsjednikom Ceha za ribarstvo i marikulturu Hrvatske obrtničke komore Dubrovnik Antunom Pavlovićem kako bi raspravio daljnje poteze u realizaciji odluke Županijske skupštine oko Malostonskog zaljeva. Vijećnici su ocijenili kako u morskom pojasu treba zadržati istu razinu zaštite, dok su za zaštitu kopnenog područja Malostonskog zaljeva pokrenuli mjere za izmjenu režima zaštite. Smanjenje zaštite kopnenog područja pokrenuto je potrebama stanovništva Malostonskog zaljeva koje u velikoj većini živi od ribarstva. Na sastanku se razgovaralo i o primjedbama na Zakon o zaštiti prirode, na koje će se pokušati utjecati jer "neka rješenja ne odgovaraju potrebama ljudi koji žive u Malostonskom zaljevu".

Predstavnici sveučilišnog Instituta ukazali su na važnost aktivne zaštite Malostonskog zaljeva, te ustvrdili kako smatraju da je najbolje zadržati istu razinu zaštite na kopnu.

No, iskazali su spremnost na razgovore oko drugih modaliteta i to samo u slučaju ako oni ne bi ni na koji način ugrožavali more u zaljevu. Zaključeno je kako će Odjel za prostorno uređenje, zaštitu okoliša i graditeljstvo će razraditi prijedloge o mjerama za očuvanje kvalitete malostonskog mora, o kojima će se potom očitovati Institut.

DV

Slobodna Dalmacija, 18.12.2012.

MNOGI UŽIVAJU U KAMENICAMA, A MALO TKO IH ŽELI ZAŠTITITI

Malostonski zaljev **nije pitanje politike,** već razuma i budućnosti!

DU list, 21.3.2018.

Valter Kožul s primjerkom zmije zubuše, malo poznate vrste ribe u Jadranu

38 list 5/7/2007

Dubrovački list, 5.7.2007.

SLOBODNA DALMACIJA
subota 23.6.2007.

Slobodna Dalmacija, 23.6.2007.

DUBROVNIK 15
@slobodnadalmacija.hr

MORE I ZDRAVLJE CRUISERA SVE VIŠE, A ZNANSTVENE STUDIJE O NJIHOVU UTJECAJU NA ŽIVOT U PODMORJU I DALJE NEMA

Štete mogu biti nemjerljive

S POVODOM: DR. FRANO KRŠINIĆ - NOVI AKADEMIK HAZU

Slobodna Dalmacija, 11.6.2000.

Nastavak tradicije dubrovačke znanosti

"Moram priznati da ovakovo priznanje još nisam očekivao. Počast je to veća što su me nominirali moji sveučilišni profesori, sada istaknuti članovi Akademije."

Opredjeljenost za struku

Odabirući studij biologije na Prirodoslovno – matematičkom Sveučilištu u Zagrebu, izborom diplomskog rada s temom iz zooplanktona, dr. Frano Kršinić se, čini se, definitvno i nepogrješivo opredijelio u izboru svojih znanstvenih istraživanja. Jer od diplome 1972. preko magisterija i doktorata, kroz svo vrijeme ustrajnog rada u Laboratorijima Dubrovnik, kako sada nosi naziv nekad Biološki zavod, zajedno s postignutim rezultatima dr. Kršinić je postizao unapređenja na ljestvici znanstvenika, do znanstvenog savjetnika Instituta za oceanografiju i ribarstvo, Split, i naslovnog redovnog profesora Prirodoslovno – matematičkog fakulteta Sveučilišta u Zagrebu, do upravo ostvarene krune u redovitog člana HAZU. Sve je to obogaćeno međunarodnim usavršavanjima, sudjelovanjima na domaćim i inozemnim znanstvenim skupovima, rukovođenjem i organiziranjem znanstvenih prokjekata, sudjelovanjima u poslijediplomskoj nastavi, mentorstvom uz diplomske radove, na magisterijima i doktorskim disertacijama. To je tek fragmentarno naznačen dio jednog bogatoga rada.

Dubrovački vjesnik, 31.12.2016.

SUBOTA 31.12.2016.
dubrovacki.hr | broj 3439 | godina LXVI.
10 kn (1.30 €; 2.5 KM)
ISSN 0012-690X

Dr. sc. Nenad Jasprica dobio je godišnju nagradu za popularizaciju i promidžbu znanosti u području prirodnih znanosti, koju dodjeljuje Hrvatski sabor

DUBROVAČKI VJESNIK
BROJ 2791
24. SRPNJA 2004.

AKTUALNO AKTUALNO AKTUALNO AKTUALNO AKTUALNO AKTUALNO

ZNANSTVENA "SLIKA" JUŽNOG JADRANA

Zašto more cvjeta?

Dubrovački vjesnik, 24.7.2004.

Cvjetanje mora tj. stvaranje sluzavih nakupina u moru je poznata prirodna pojava, ali posljednjih desetljeća njezin intenzitet jača, a učestalost joj je veća. Razlozi tome mogu se pripisati negativnim utjecajima čovjeka na prirodu, posebno kroz povećani dotok hranjivih tvari s kopna, uglavnom kroz ispuštanje industrijskih i drugih otpadnih voda u more

AKTUALNO

Autobusni kolodvor idealno je mjesto za širenje ambrozije, kao i aerodrom, željeznički kolodvori i mjesta uz tračnice jer je na tim mjestima velika prohodnost ljudi

Srijeda, 7. rujna 2005. 3

AMBROZIJA: OPASNOST ZA ALERGIČARE I ASTMATIČARE!

Dubrovački list, 7.9.2005.

24 Slobodna Dalmacija, 30.3.2019.

Slobodna Dalmacija
SUBOTA, 30.3.2019.

dalmacija

Ravnatelj dubrovačkog Instituta dr. sc. Nenad Antolović: Treba nam još znanstvenika. Trebalo bi ih biti 25

MORSKI LABOS SPLITSKI I DUBROVAČKI INSTITUT DOBIVAJU DVA NOVA ISTRAŽIVAČKA BRODA

'Bios' odlazi u mirovinu


Mario TODORIĆ

SPLIT • Splitski Institut za oceanografiju i ribarstvo te Institut za more i priobalje Sveučilišta u Dubrovniku uskoro će dobiti dva nova istraživačka broda, vrijedna ukupno 22,5 milijuna kuna. Ugovor o prijenosu 18 milijuna kuna iz državnog proračuna u Splitu je s ravnateljima ovih ustanova potpisao ministar znanosti **Dragan Primorac**.

- U trećoj godini mandata ostvarujem jedno od najvažnijih obećanja koje sam dao, jer znam kako je našim stručnjacima za oceanografiju dosad bilo raditi na zastarjelim brodovima i u neprimjerenim uvjetima - kazao je Primorac. Novi brod, koji će zamijeniti čak 53 godine stari "Bios", služit će i prijenosu oceanografskih podataka s plutača u realnom vremenu - kaže ravnateljica splitskog Instituta **Ivona Marasović**.

D. PETRANOVIĆ

Slobodna Dalmacija, 25.7.2006.

NAŠ STRUČNJAK DR. NENAD JASPRICA NA MEĐUNARODNOM SIMPOZIJU DIJATOMOLOGA U TOKIJU

Japance zanimaju jadranske alge

Vođeni su razgovori s japanskim stručnjacima radi izmjene iskustava i uspostave suradnje

Slobodna Dalmacija, 15.9.1996.

20 | Gospodarstv

OPET U DUBROVNIKU

Uplovio "Baldo Kosić"


ŽELKO TUTNJEVIĆ

Na brodici može boraviti deset znanstvenika

Brod je namijenjen za biološka i hidrografska istraživanja južnog Jadrana do 12 milja od obale

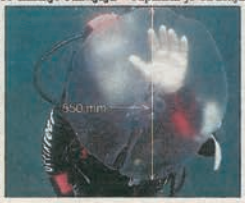
Poslije osamnaest godina u Dubrovniku je ponovno istraživača brodica „Baldo Kosić", stradala tijekom granatiranja Grada. Razlog je to dodatnog zadovoljstva u godini kada se proslavlja 60 godina postojanja Instituta za more i priobalje u Dubrovniku, rečeno je tim povodom u srijedu na konferenciji za novinare u Rektoratu Sveučilišta. Sredstvima Ministarstva znanosti, obrazovanja i športa i vlastitim sredstvima Instituta financirana je izgradnja broda ukupne vrijednosti 8,7 milijuna kuna. Porinut je u pulskom brodogradilištu „Tehnomont" 10.ožujka ove godine, da bi u srijedu doplovio u Dubrovnik gdje će služiti Institutu za more i priobalje. Odjelu za akvakulturu i ostalim sastavnicama Sveučilišta u Dubrovniku koja su programski vezana za istraživanje mora.

Brod je, čulo se i to među ostalim, namijenjen za biološka i hidrografska istraživanja južnog Jadrana do 12 milja od obale, a bit će moguće obavljati i istraživanja u ribarstvenoj biologiji i ribarstvu. Može ukrcati posadu od ukupno osam ljudi, i premda nabava opreme za oceanografska istraživanja tek slijedi Institut je već sada spreman obaviti prva terenska istraživanja na domaćim i stranim projektima na kojima znanstvenici ustanove rade. Na brodici inače može boraviti deset znanstvenika, a ima specijalizirane oceanografske sonde, planktonske mreže raznih dimenzija, krmene platforme s otvorom za rad s roniocima, suhi i vanjski laboratorij na kojima se može provoditi monitoring i analiza pridnevnih zajednica te ih očuvati do dolaska u Institut, rekli su predstavnici Instituta i Sveučilišta na konferenciji za novinare. K.C.

Dubrovački vjesnik, 23.5.2009.

Biolozi na Mljetu otkrili nove vrste meduza velike do 55 centimetara

DUBROVNIK - Znanstvenici dubrovačkog Biološkog instituta i ugledni japanski biolog Shin Kubota, najveći svjetski autoritet kad su u pitanju meduze, našli su prošli tjedan u mljetskim jezerima nekoliko na Mediteranu jedinstvenih i do sada neotkrivenih hidroida. Riječ je o najčešće mikroskopski malim polipima s "diskovima" iz kojih se kasnije razvijaju meduze.



Na skupu najuglednijih svjetskih stručnjaka za meduze, prošle godine održanom u kalifornijskom Botega Bayu, potvrđeno je da se na fotografijama koje im je donio dr. Adam Benović, znanstveni savjetnik dubrovačkog Biološkog instituta, vidi sasvim nova vrsta meduza iz roda Tima. Do sada neotkrivena meduza ima klobuk širok samo 8 cm sa 40 cm dugim tentaklima i najčešće obitava u Malom jezeru, a dio njih vjerojatno nošen morskim strujama završi i u Velikom jezeru. Prozirna je i teško uočljiva jer se uvijek zadržava u pridnenom sloju gdje je temperature između 13 i 17 stupnjeva Celzijusa. Iz tih ju je razloga moguće snimati samo močju, pod svjetlom reflektora koje ocrtava njezinu strukturu. No, da bi se dobila znanstvena potvrda da je u ovom slučaju riječ o do sada neotkrivenoj vrsti, potrebno je opisati cijeli njezin životni ciklus - od malog polipa, hidroida, do potpuno odrasle meduze. Dr. Shin Kubota i njegovi dubrovački suradnici ovaj su put po algama i kamenjima sakupljenima u podmorju mljetskih jezera bezuspješno tragali za Timinim hidroidima. Japanski je stručnjak, međutim, determinirao i sa sobom odnio nekoliko na Mediteranu prvi put viđenih hidroida, a svoje je dubrovačke kolege uputio u tehnologiju pomoću koje će sami ispitati životni ciklus meduze i konačno dati znanstvenu potvrdu teorije o novoj vrsti Time.

Na seminaru u Botega Bayu stručnjaci su potvrdili i da su meduze Aurelia aurita, tzv. barbareške koje žive u mljetskim jezerima najveće te vrste u svijetu. Mljetska Aurelia aurita, koju su snimili dubrovački biolozi, ima klobuk promjera 55 centimetara. Tako velike Aurelije najčešće obitavaju u 26 metara dubokom Malom jezeru, a u većem broju ali manjih dimenzija i u 46 metara dubokom Velikom jezeru. Ronioce i obične kupače razveselit će informacija da je u oba slučaja riječ o sasvim bezopasnim vrstama meduza.

Jadran Kapor

Jutarnji list, 8.4.2000.

PRIPREMA SE SIMPOZIJ O MLJETU

Otok u referatima

ZAGREB/MLJET – U državnoj Upravi za zaštitu prirodne i kulturne baštine u Zagrebu, pod predsjedanjem prof. dr. Paule Durbešić, održan je sastanak organizacijsog odbora simpozija »Prirodne značajke i društvena valorizacija otoka Mljeta«, na kojem će sudjelovati međunarodni stručnjaci. Simpozij će se održati početkom rujna u Pomeni na Mljetu, a organizatori su Hrvatsko ekološko društvo, Nacionalni park Mljet i Institut za oceanografiju i ribarstvo – laboratoriji Dubrovnik (dosadašnji biološki zavod). Tehnički organizator je putnička agencija Atlas te pokrovitelji Hrvatska akademija znanosti i umjetnosti i Županija dubrovačko-neretvanska.

Svrha simpozija je društvena i gospodarska valorizacija Mljeta s naglascima na razvoj i zaštitu te potrebu specifičnih znanstvenih istraživanja. Organizacijskom odboru, kako nas izvijestio član odbora dr. Nenad Jasprica, stiglo je 60 najava tema od zemljopisnog položaja do problematike prometa i vodoopskrbe. Na sastanku Organizacijskog odbora razmatrani su načini financiranja simpozija. (M. P.)

Slobodna Dalmacija, 24.6.1995.

4 SUBOTA 9. ožujka 2002.


Ministar Kovačević s predstavnicima ekoloških udruga

Snimio D. JERKOVIĆ

DOLINA NERETVE USKORO POSTAJE PARK PRIRODE

METKOVIĆ – S obzirom na raznolikost biljnog i životinjskog svijeta, dolina Neretve uskoro bi trebala postati park prirode. Najavio je to, među ostalim, hrvatski ministar prostornog uređenja i zaštite okoliša **Božo Kovačević** na skupu održanom u petak u Metkoviću koji je okupio brojne ekološke udruge iz Hrvatske i Bosne i Hercegovine. Tako bi 24.000 hektara močvarnog prostora u budućnosti bilo pod izravnom zaštitom države, a Hrvatska se, potpisujući Ramsarsku konvenciju, obvezala skrbiti za močvarna i vlažna staništa, ponajprije u funkciji lokalnog stanovništva. U vezi s upitima neretvanskih poljoprivrednika i lovačkih udruga koji se pribojavaju da će se proglašenjem parka prirode ograničiti njihove aktivnosti, ministar Kovačević ovom je prilikom naglasio kako će konačnoj odluci ipak prethoditi opsežna javna rasprava u kojoj će svi stanovnici Neretve moći iznijeti svoje primjedbe i sugestije.

– Proglašenje parka prirode nedvojbeno podrazumijeva promjene navike stanovništva, ali mi nikoga nećemo prisiljavati da prihvati takvu odluku. Ministarstvo će u javnost uputiti prijedloge za koje se nadamo da će biti prihvaćeni – kazao je ministar Kovačević.

S. SOLDO

Slobodna Dalmacija, 9.3.2002.

GOSPODARSTVO I TURIZAM | 22. srpnja 2006. | Broj 2895 | DUBROVAČKI VJESNIK | 23

Dr. Nenad Jasprica, prvi ravnatelj sveučilišnog instituta

Dubrovački vjesnik, 22.7.2006.

OTVORENE DODATNE MOGUĆNOSTI ZA ISTRAŽIVANJE MORA

Početkom godine Sveučilište u Dubrovniku je utemeljilo Institut za more i priobalje kojeg čine zaposlenici bivša dva laboratorija Instituta za oceanografiju i ribarstvo. Senat Dubrovačkog sveučilišta je za prvog ravnatelja Instituta nedavno izabralo dr. sc. Nenada Jaspricu, jednog od znanstveno najproduktivnijih hrvatskih botaničara. Novim ustrojem, Institutu su otvorene dodatne mogućnosti za istraživanje mora i priobalja.

Dubrovački vjesnik, 31.10.2009.

U PREDVORJU KAZALIŠTU MARINA DRŽIĆA

Izložba 'Tajne mora'

U programu svečanosti obilježavanja obljetnica Instituta za more i priobalje predstavljena je i tematska izložba dvoje dubrovačkih umjetnika **Maje Kovačević** i **Valtera Kožula** pod naslovom "Tajne mora". Umjetnici su svojim likovnim pismom predočili skrovit život podmorja i njegovih žitelja pronalazeći ljepotu, maštovitost i poetsku crtu u tom posebnom svijetu koji jest očaravajući ali veoma krhak i osjetljiv na mnoga zagađenja koja mu u našoj bespoštednoj suvremenosti prijete. Izložba snažnim koloristićkim dojmom, maštovitošću i poetikom u predstavljanju ribljeg svijeta ujedno je i poziv na očuvanje njegova zdravlja, ljepote, posebnosti. Izložba je otvorena do 28. listopada. S.S.

56 | Kultura

Dubrovački vjesnik, 31.10.2009.

dubrovački vjesnik • 31.10.2009. • 3065

ŠEST DESETLJEĆA INSTITUTA ZA MORE I PRIOBALJE I PET BOTANIČKOG VRTA NA LOKRUMU

Svečanost u Kazalištu Marina Držića

Slobodna Dalmacija, 18.9.1997.

DUBROVNIK: FOTOGRAFIJE PLANTAE RAGUSINA

SOS za floru

Izložba radova petorice dubrovačkih fotografa u prostoru Lože s primjercima rijetkih biljaka s dubrovačkoga područja iz Crvene knjige, postavljena je s ciljem da se jedinstvenim kulturnim činom javnosti skrene pozornost na nužnost čuvanja biljnoga svijeta, kojemu zbog ugroženosti prijeti izumiranje

Gospin vlasak, dubrovačka zečina, grmoliki ranjenik, primorski slak, mandragora... samo su neke od ugroženih i rijetkih vrsta biljaka sa šireg dubrovačkog područja čijom se temom bavi postav ekološke i edukacijske izložbe endemičnih i rijetkih biljnih vrsta s krajnjeg hrvatskog juga *Plantae Ragusinae* u izložbenom prostoru Luže. Povodeći se činjenicom da je priroda svakim danom sve više ugrožena zahvatima koji oštećuju njezine znanstvene, estetke i kulturne vrijednosti koje smo naslijedili, *Upravni odjel za obnovu, prostorno uređenje i zaštitu okoliša* Grada Dubrovnika u suradnji s dubrovačkim biolozima upriličio je izložbu fotografija biljnih vrsta kojima, najvećim dijelom zbog ugroženosti, prijeti izumiranje.

Na izložbi je ukupno prikazano 40 biljnih vrsta koje rastu na širem dubrovačkom području – Konavlima, Dubrovačkom primorju te na poluotoku Pelješcu prema kriterijima tzv. *Crvene knjige* biljnih vrsta Republike Hrvatske što obuhvaća 226 biljnih sorata (oko 5 posto hrvatske flore). Autori izloženih fotografija biljaka jesu **Nenad Jasprica, Jakša Bolotin, Igor Brautović, Romano Cobenzl** te **Sanja Kovačić**, dok su koncepciju izložbe uz pomoć dubrovačkih biologa osmislili Nenad Jasprica, Sanja Kovačić, ujedno i autori tekstova, kao i autorica **Nike Sudarević**.

● Izložba se održava s ciljem da se svekolikoj javnosti skrene pozornost na potrebno čuvanje biljnoga svijeta, poglavito ovih vrsta koje su u opasnosti i mogle bi iščeznuti. Od ukupno 40 prikazanih biljnih vrsta na izložbi koje rastu na širem dubrovačkom području njih 19 ih je trenutačno uvedeno u *Crvenu knjigu* biljnih vrsta Hrvatske, a od ukupnoga broja ugroženih biljnih vrsta na dubrovačkom području ih je čak 62. Osim ugroženih i osjetljivih vrsta na izložbi je također prikazan stanovit broj hrvatskih endemičnih vrsta koje su, doduše, manje ugrožene, ali je zbog njihove prorijeđenosti u staništima njihov opstanak doveden u opasnost – kazuje autorica izložbe Nike Sudarević, dodajući kako je izložbu u samo dva dana postava pogledalo šestotinjak ljudi.

Izložba *Plantae Ragusinae* koncepcijski je podijeljena na kategorije: ugrožene biljne svojte, osjetljive (ranjive) biljne svojte i rijetke biljne svojte, i šesta je po redu u nizu izložaba koja organizira Gradski odjel za obnovu, prostorno uređenje i zaštitu okoliša. IzložbA će, prema najavama, u Dubrovniku biti otvorena do 9. listopada, kada slijedi njezino postavljanje u svim većim hrvatskim gradovima, da bi se na kraju za kolor-fotografije našao stalni postav u cilju ekološke edukacije djece i odraslih.

Paulina PEKO

Dubrovački vjesnik, 30.3.2019.

Program proslave 70. obljetnice

Institut će sljedeći tjedan u nekoliko posebnih aktivnosti obilježiti sedamdesetu obljetnicu utemeljenja. U četvrtak, 4. travnja organizira se Dan otvorenih vrata Instituta. Ulaz u Akvarij za domaće posjetitelje je besplatan. Taj dan u sveučilišnom kampusu održat će se međunarodni okrugli stol na temu "Istraživanje Jadranskog mora". Moderatori su dr. sc. Mirna Batistić i prof. dr. sc. Nenad Jasprica.

Poslijepodne od 17 do 17.30 sati na sveučilišnom kampusu predavanje za javnost pod nazivom "Udahnimo duboko" održat će dr. sc. Nikša Glavić. Navečer, u 19 sati u Akvariju će se otvoriti izložba dubrovačkih slikara na temu "Tajne morskih dubina". U petak, 5. travnja, u 10 sati upriličit će se svečanost obilježavanja 70. obljetnice Instituta u Kazalištu Marina Držića.

Slobodna Dalmacija, 11.9.2000.

NA MEĐUNARODNOM SIMPOZIJU DIJATOMOLOGA

Dubrovački znanstvenici u Grčkoj i Turskoj

Znastvenici dubrovačkog Instituta za oceanografiju i ribarstvo dr. sc. **Marina Carić** i dr sc. **Nenad Jasprica** boravili su prošloga tjedna u Grčkoj i Turskoj, gdje su kao jedini predstavnici Hrvatske sudjelovali u radu 16. međunarodnog simpozija dijatomologa.

Susret je okupio više od dvjesto znanstvenika iz čitavog svijeta koji se bave dijatomejama, odnosno skupinom sićušnih algi koje obitavaju u moru, slatkim vodama ili u tlu. Skupina broji oko 20 tisuća različitih vrsta, od kojih neke uzrokuju »cvjetanje« mora, dok druge pak mogu sadržavat posebne spojeve koji mogu biti toksični, a sve one imaju odgovarajuću ulogu u funkcioniranju ekosustava čiji su sastavni dijelovi.

Plenarni dio simpozija održan je u Ateni, dok se rad u sekcijama odvijao na putničkom brodu koji je obilazio grčke otoke i tursku obalu. Dubrovački znanstvenici prezentirali su tom prigodom svoje radove iz područja ekologije i toksonomije, sudjelovali u radu više okrugljih stolova i skupštini Međunarodnog dijatomološkog društva. Sudionike simpozija odvojeno su primili i gradonačelnik Atene i rektor atenskog Državnog sveučilišta, a imali su prigodu upoznati se i s kulturno-povijesnim i prirodnim znamenitostima zemalja domaćina skupa.

A. MARUNIĆ-LISIČIĆ

16. Slobodna Dalmacija
UTORAK 19.1.2010.

Slobodna Dalmacija, 19.1.2010.

DUBROVNIK

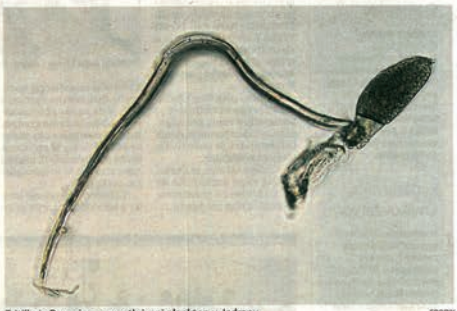
dubrovnik@slobodnadalmacija.hr

POVIJESNO OTKRIĆE ZNANSTVENICI PREDSTAVILI NOVOOTKRIVENI PUČINSKI ZOOPLANKTON

'Dubrovnik' velik milimetar

Riječ je o prvoj, ikada u povijesti otkrivenoj vrsti pučinskog zooplanktona u Jadranu. Živi u otvorenim vodama južnog Jadrana na udaljenosti većoj od šest nautičkih milja od kopna, hrani se bakterijama i algama mikroskopske veličine

PIŠE: PAULINA PEKO/EPEHA



Fritillaria Ragusina, novootkriveni plankton u Jadranu CROPIX

Znanstvenici Instituta za more i priobalje Sveučilišta u Dubrovniku u ponedjeljak su prvi put slikom i riječju predstavili javnosti novootkrivenu vrstu planktona o kojoj smo već pisali. Riječ je, naime, o vrsti organizma nazvanog Fritillaria Ragusina, prema latinskom imenu Dubrovnika - Ragusa. Riječ je, naglasili su dubrovački znanstvenici, o prvoj, ikada u povijesti otkrivenoj vrsti pučinskog zooplanktona u Jadranu.

Znanstvenici dubrovačkog Instituta, ujedno i voditelji projekta, dr. **Mirna Batistić**, znanstvena suradnica i dipl. ing. **Rade Garić**, asistent, novu vrstu organizma otkrili su u otvorenim vodama južnog Jadrana tijekom istraživanja provedenih u siječnju prošle godine istraživačkim brodom "Naše more". Istraživanje je provedeno u sklopu projekta "Struktura planktonskih populacija u tročičkom gradijentu u južnom Jadranu".

Otkrivena vrsta, rečeno je, pripada skupini repnjaka (Appendicularia). Živi u otvorenim vodama južnog Jadrana na udaljenosti većoj od šest nautičkih milja od kopna, u stupcu mora od površine do maksimalno tri stotine metara dubine. Veličine je do milimetra, a hrani se bakterijama i algama mikroskopske veličine. To je jedna od najmanjih vrsta repnjaka i prva opisana pučinska vrsta zooplanktona. Prva pohrana ovoga otkrića, otkrio je ravnatelj Instituta dr. **Nenad Jasprica**, bit će u dubrovačkoj muzeološkoj zbirci.

Nalaz nove vrste u Jadranu već je publiciran ugledni britanski znanstveni časopis. Znanstvenici Instituta za more i priobalje ovim su otkrićem dobili potvrdu da je Jadran još uvijek nedovoljno istražen. Prema istraživanjima koje već dulje vrijeme provodi dr. Mirna Batistić i njezini kolege, evidentno je da se zadnjih desetak godina, pretpostavlja se zbog klimatskih promjena, u Jadranu pojavljuju nove vrste organizama porijeklom iz područja Indijskog oceana. Nove vrste, naime, nisu prije obitavale u Jadranu, već su u njega došle preko Sueskog kanala, no za sada u Jadranu nema naznaka o eventualnim promjenama, odnosno utjecaju novih vrsta na postojeći morski svijet.

Dubrovački vjesnik, 22.11.2014.

zadnja

MIJENJA SE MORE, A I PESKARIJA

Daj mi po kila, kako se ono zove...

Piše: Maja Rilović Koprivec

Plankton Desmopterus papilio

Novi vrste planktona u Jadranu donosi i nove vrste riba u toplih mora

Tko zna što ćemo sutra sve kupovati na peskariji? Hoće li stare i nove vrste riba jesti neke nove uvezene morske trave i organizme? Koliko na more utječe čovjek, kroz unos vrsta balastnom vodom ili utjecajem na promjenu klime?

Desmopterus papilio, Muggiaea atlantica, Protatlanta souleyeti, Lensia subtiloides, samo su neke od novih planktonskih organizama u Jadranskom moru, a čiji je dolazak posljedica klimatskih promjena. Znanstvenici Instituta za more i priobalje Sveučilišta u Dubrovniku, doktori Mirna Batistić i Rade Garić u suradnji s kolegom Juan Carlos Molinerom, objavili su najnovije rezultate istraživanja o utjecaju klimatskih promjena na pojavu novih vrsta planktonskih organizama u Jadranu. Rad je objavljen u prestižnom znanstvenom časopisu Climate Research koji objavljuje rezultate istraživanja o utjecaju klime na organizme, okoliš i ljudsko društvo općenito.

Dubrovački znanstvenici su dokazali da podrijetlo stranih vrsta koje ulaze u Jadran ovisi o smjeru morskog vrtloga (kazaljke na satu ili obrnuto) u Jonskom moru, a koji uvjetuje klima iz Sjevernog Atlantika. Ovisno o smjeru vrtloga, u Jadran ulazi voda kao i vrste podrijetlom iz Atlantskog oceana, ili istočnog Mediterana.

U ovom radu pokazano je da u Jadran ulazi sve više toplovodnih vrsta što je u skladu s povećanjem temperature mora zadnjih godina.

U Jadranu je, od 1993., zabilježeno ukupno 11 novopridošlih vrsta zooplanktona, a 3 vrste su se ponovno pojavile nakon što više godina nisu bile prisutne u pelagijalu Jadrana. Ove promjene započele su kada su se u istočnom Mediteranu dogodile promjene u cirkulacijskom režimu, a što je vezano za ulaz vode, a time i vrsta različitog podrijetla u Jadransko more. Novozabilježene vrste donesene strujama iz Atlantskog oceana ili iz istočnog Mediterana uglavnom su toplovodne vrste što je u skladu s trendom povećane temperature mora u Jadranu u zadnjih dvadeset godina. Vrste iz istočnog Mediterana, a nove za Jadransko more, su većinom iz Crvenog mora i Indo-pacifičkog porijekla, tzv. Lesepsijski migranti koji čine toplovodne vrste ušle preko Sueskog kanala – pojašnjava dr. Mirna Batistić i upozorava kako zajednički učinci ovih procesa i trend povećanja temperature mora u Jadranu mogu dovesti do značajnih promjena u bioraznolikosti Jadrana.

Osim toga, ove promjene mogu utjecati na veću ili manju brojnost planktona što može značajno utjecati na brojnost ekonomski važne pelagičke ribe u Jadranu. Stoga rezultati istraživanja mogu biti korisni u svrhu procjene ribljeg fonda u Jadranu.

- Plankton direktno može djelovati samo na plavu ribu koja se njime hrani. Što se tiče povećanja temperature, to je faktor koji donosi i stranu ribu, posebno vrste iz toplih mora. Sve je zajedno vezano za izmjenu cirkulacija u istočnom Mediteranu. Zbog toga sada s kolegama fizičarima Talijanima radimo na izradi niza od 100 godina da vidimo ponavlja li se promjena u nekakvom pravilnom periodu, ili se promjena strujanja pa time i ulazak tih vrsta u Jadran događa u zadnjih 30 godina stvarno zbog većih promjena temperature - govori dr. Batistić.

Kontinuirano praćenje novih vrsta i novih promjena u okolišu nužno je, ističu znanstvenici Instituta, no njihova nova istraživanja ovise dakako o novcu.

NOVI PLANKTONI REZULTATI NOVIH ZNANSTVENIH ISTRAŽIVANJA JUGA JADRANA

S Lokruma alarm sjevernom Jadranu

Dr. Mirna Batistić s Instituta za more i priobalje

Slobodna Dalmacija, 26.1.2008.

Zadnjih 15 godina znanstvenici dubrovačkog Instituta za more i priobalje utvrdili su promjene u planktonu i ulazak stranih vrsta koje su se s vremenom udomaćile u plitkom sjevernom Jadranu i već postale dominantne

PIŠE AHMET KALAJDŽIĆ

Unatoč pojavi novih, stranih morskih organizama u akvatoriju južnog Jadrana, još uvijek nema razloga za paniku zbog mogućeg poremećaja ekološke ravnoteže. "Crveno svjetlo" je ipak upaljeno, osobito za sjeverni Jadran kojem iz Dubrovnika šalju upozorenje zbog pojave planktonskih organizama koji inače stižu iz mnogo toplijih oceanskih voda. Poznavanje ekologije i bioraznolikosti južnog Jadrana temelj su predviđanja pojava i promjena cijelog Jadrana, tvrde u dubrovačkom Institutu za more i priobalje.

- Zadnjih 15 godina smo utvrdili promjene u planktonu i ulazak stranih vrsta koje su se vremenom udomaćile u plitkom sjevernom Jadranu i već postale dominantne. Planktonski žarnjak Muggiaea atlantica, organizam srodan meduzama, živi u Atlantiku i zapadnom Sredozemlju, otkriven je 1995. na jugu Jadrana. Oko Istre i u Tršćanskom zaljevu je vrlo brzo potpuno zamijenio domaćeg žarnjaka Muggiae kochi.

Otkriveni su i mnogočetinaš Pelagobia longicirrata, planktonski puž Desmopterus papilio i plaštenjak Kowalewskia oceanica koji žive u toplim vodama Atlantika, Pacifika i Indijskog oceana. Te promjene u planktonu vjerojatno su rezultat promjene klime koja je uzrok promjene temperature i slanosti Jadrana - ističe znanstvenica Instituta za more i priobalje Sveučilišta u Dubrovniku dr. sc. **Mirna Batistić**.

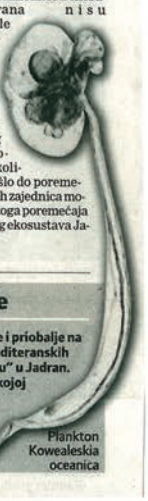
Dubrovački je Institut uključen u međunarodni projekt "Utjecaj globalnih promjena na želatinozni plankton Mediterana", koji financira EU, a u koji su uključene znanstvene ustanove iz Atene, Kiela, Plymutha, Tunisa, Pirana, Villefrancha i Palma de Mallorce.

Prvi sastanak sudionika projekta održan je upravo u Tvrđavi sv. Ivana u kojem su smješteni Institut za more i njegov akvarij. Cilj projekta je utvrditi indikatore, odnosno vrste koje će ukazivati na određene promjene.

Istina je da nove vrste osim povećanja raznolikosti ekosustava Jadrana nisu prouzročile veću štetu, ali je svakako nužno njihovo kontinuirano praćenje i zbog novih promjena u okolišu ne bi došlo do poremećaja životnih zajednica mora i uslijed toga poremećaja cjelokupnog ekosustava Jadrana.

Dubrovnik prvi doznaje

Istraživačka postaja Instituta za more i priobalje na Lokrumu nalazi se "na udaru" ulaznih mediteranskih morskih struja koje "pumpaju svježu vodu" u Jadran. To je prava, idealna pozicija zahvaljujući kojoj znanstvenici dubrovačkog Instituta za more i priobalje prvi na Jadranu uopće mogu utvrditi nove organizme i da zbog toga odmah svima ostalima pošalju alarm za oprez.



Plankton Kowealeskia oceanica

Brod »Baldo Kosić« pogođen granatom izgorio 1991.

Podvodni.hr › More › Ekologija › Promjena klime donosi nove vrste planktona

Promjena klime donosi nove vrste planktona

www.podvodni.hr

Znanstvenici Instituta za more i priobalje Sveučilišta u Dubrovniku, doktori Mirna Batistić i Rade Garić u suradnji s kolegom Juan Carlos Molinerom, objavili su najnovije rezultate istraživanja o utjecaju klimatskih promjena na pojavu novih vrsta planktonskih organizama u Jadranu. Rad je objavljen u prestižnom znanstvenom časopisu Climate Research s faktorom odjeka 2,7 u 2013./2014. Climate Research objavljuje rezultate istraživanja o utjecaju klime na organizme, okoliš i ljudsko društvo općenito. Dubrovački znanstvenici su dokazali da podrijetlo stranih vrsta koje ulaze u Jadran ovisi o smjeru morskog vrtloga (kazaljke na satu ili obrnuto) u Jonskom moru, inače uvjetovanog klimom iz Sjevernog Atlantika. Ovisno o smjeru vrtloga, u Jadran ulazi voda kao i vrste podrijetlom iz Atlantskog oceana ili istočnog Mediterana. Vrste iz istočnog Mediterana, a nove za Jadransko more, su većinom toplovodne vrste ušle preko Sueskog kanala iz Crvenog mora ili su Indo-pacifičkog podrijetla. U ovom radu pokazano je da u Jadran ulazi sve više toplovodnih vrsta što je u skadu s povećanjem temperature mora zadnjih godina. Rezultati istraživanja, također, mogu biti korisni u svrhu procjene ribljeg fonda u Jadranu.
Zajednički učinci ovih procesa i trend povećanja temperature mora u Jadranu mogu dovesti do značajnih promjena u bioraznolikosti Jadrana. (HRT)

Večernji list, 23.12.2015.

HRVATSKA BiH

Hrvatska - Večernji.hr

Dubrovački biolozi potvrdili postojanje zasebne vrste meduze u Jadranu

Hrvatska imena za meduzu također pokazuju njezinu neobičnu povijest: na jednom dijelu Jadrana zovu je klobuk, na drugom misečina, na trećem pizdurinka, na četvrtom zlogodina, uključujući još niz drugih imena.

23. PROSINCA 2015. U 14:31 3 KOMENTARA 1085 PRIKAZA

PODIJELITE ČLANAK

Dubrovački biolozi genetičkim su metodama konačno potvrdili postojanje zasebne vrste meduze u Jadranu, nakon više od stotinu godina znanstvenih polemika.

Kako su priopćili sa **Sveučilišta u Dubrovniku**, meduza "Bougainvillia triestina", velika **do jedan centimetar**, pronađena je do sada u Malostonskom zaljevu, Pločama, Hvarskom kanalu i Tršćanskom zaljevu.

Meduze su zvonolike morske životinjice iz velike skupine žarnjaka za koje se zna da nastanjuju svjetska mora duže od pola milijarde godina. Dobile su ime po liku iz grčke mitologije, lijepoj djevojci Meduzi kojoj je božica Atena prekrasnu kosu pretvorila u zmije otrovnice.

Hrvatska imena za meduzu također pokazuju njezinu neobičnu povijest: na jednom dijelu Jadrana zovu je **klobuk**, na drugom **misečina**, na trećem **pizdurinka**, na četvrtom **zlogodina**, uključujući još niz drugih imena.

Nedugo nakon što je prvi put opisana, znanstvenici su odbacili da se radi o novoj vrsti "Bougainvillia triestina", nego o već postojećoj vrsti "Bougainvillia muscus" za koju je poznato da je sklona promjenama izgleda jer se vješto prilagođava okolišu.

To se opet ponovilo tijekom 20. stoljeća s drugim vrstama, te neposredno prije nego su znanstvenici Instituta za more i priobalje Mirna Batistić i Rade Garić objavili znanstveni članak u međunarodnom znanstvenom časopisu "Marine Ecology - an evolutionary prespective", u kojem su genetičkim metodama sekvenciranja DNA dokazali da je to zasebna vrsta. Najbliži živući srodnik joj je, tvrde ti znanstvenici, vrsta "B. carolinensis" koja živi uz atlantske obale Sjeverne i Južne Amerike.

Dubrovački institut je poznat po svom istraživanju planktona i morske ekologije. Prije nekoliko godina bili su domaćini velikom međunarodnom projektu tijekom kojeg su primjenjivali cijeli niz metoda, a iz kojeg je nastao veliki broj znanstvenih radova.

Početkom prošlog desetljeća istaknuti dubrovački morski biolog Adam Benović (1943 – 2011) otkrio je u Mljetskim jezerima jednu iz skupine meduza Aurellia, čiji se najbliži srodnici nalaze u Arktiku, Pacifiku i Atlantiku.

Benović je uspio dokazati da meduze mogu poslužiti kao indikator stabilnosti tzv. oligotrofnog pelagičkog ekosustava.

Dubrovački vjesnik, 25.7.2015.

16 reportaža dubrovacki vjesnik | 25.07.2015. | 3364 | www.dubrovacki.hr

DUBROVAČKI AKVARIJ

SVIJET JADRANSKOG PODMORJA U TVRĐAVI SV. IVANA

Osim što je otvoren za posjetitelje i prezentaciju, služi i u znanstvene svrhe pa se tako tamo - doduše, iza zatvorenih vrata - mogu vidjeti laboratoriji gdje se uzgajaju fitoplankton i zooplankton, tu je i pokusno mrijestilište, ali i karantena za nove primjerke u akvariju

BokaNews

Boka News

Promjena klime donose nove vrste

Boka News

www.bokanews.me, 8.11.2014.

Znanstvenici Instituta za more i priobalje Sveučilišta u Dubrovniku, doktori Mirna Batistić i Rade Garić u suradnji s kolegom Juan Carlos Molinerom, objavili su najnovije rezultate istraživanja o utjecaju klimatskih promjena na pojavu novih vrsta planktonskih organizama u Jadranu.Dubrovački znanstvenici su dokazali da porijeklo stranih vrsta koje ulaze u Jadran ovisi o smjeru morskog vrtloga (kazaljke na satu ili obrnuto) u Jonskom moru, inače uvjetovanog klimom iz Sjevernog Atlantika. Ovisno o smjeru vrtloga, u Jadran ulazi voda kao i vrste podrijetlom iz Atlantskog oceana ili istočnog Mediterana. Vrste iz istočnog Mediterana, a nove za Jadransko more, su većinom toplovodne vrste ušle preko Sueskog kanala iz Crvenog mora ili su Indo-pacifičkog podrijetla. U ovom radu pokazano je da u Jadran ulazi sve više toplovodnih vrsta što je u skadu s povećanjem temperature mora zadnjih godina.Rezultati istraživanja, također, mogu biti korisni u svrhu procjene ribljeg fonda u Jadranu.Zajednički učinci ovih procesa i trend povećanja temperature mora u Jadranu mogu dovesti do značajnih promjena u bioraznolikosti Jadrana.

Rad je objavljen u prestižnom znanstvenom časopisu Climate Research s faktorom odjeka 2,7 u 2013./2014.

Climate Research objavljuje rezultate istraživanja o utjecaju klime na organizme, okoliš i ljudsko društvo općenito.

RAZGOVOR S DR.SC. RADOM GARIĆEM S INSTITUTA ZA MORE I PRIOBALJE

Dosta će vrsta **izumrijeti** i prije nego ih opišemo

Talijani imaju jako dobre stručnjake za meduze, ali nemaju stručnjaka za repnjake, skupinu kojom se ja bavim. Repnjaci pripadaju skupini Tunicata ili plaštenjaka. **Oni u biti nama dođu rođaci jer smo i mi i oni u koljenu svitkovaca.** Rani svitkovci su imali taj svitak koji je kasnije postao kralježnica...

DU list, 29.11.2017.

Freemail PRIJAVI SE

ZNANOST

www.net.hr., 18.1.2010.

U Dubrovniku otkrivena nova vrsta zooplanktona

Autor: Net.hr18.01.2010
16:47

Znanstvenici Instituta za more i priobalje Sveučilišta u Dubrovniku otkrili su za znanost novu vrstu zooplanktona, nazvanu po latinskom imenu Dubrovnika (Ragusa) Fritillaria ragusina.
Zooplankton je otkriven u otvorenim vodama južnog Jadrana u tijeku istraživanja u siječnju 2008. brodom "Naše more", u okviru projekta "Struktura planktonskih populacija u trofoičkom gradijentu u južnom Jadranu".
Taj projekt vodi znanstvena suradnica **Mirna Batistić**, koja je zajedno s kolegom Radom Garićem danas na konferenciji za novinare predstavila to otkriće.

Istaknuto je kako ta vrsta pripada skupini repnjaka i nazvana je po latinskom imenu Dubrovnika – Ragusa. Živi u otvorenim vodama južnog Jadrana, na udaljenosti šest nautičkih milja od kopna, veličine jedan milimetar, a hrani se bakterijama i algama mikroskopske veličine.
Ravnatelj instituta **Nenad Jasprica** kazao je kako otkriće te vrste pokazuje kako još nedostatno poznamo Jadransko more, a prva pohrana tog otkrića bit će u Muzeološkoj zbirci u Dubrovniku.

Dulist

FOTO/ DULIST NA 'NAŠEM MORU' U čarobnom svijetu morskih bića

Dulist 31.3.2015
PODIJELI 00

ZG-magazin

www.zg-magazin.com.hr., 29.1.2016.

Batistić i Garić dokazali postojanje nove vrste meduze u Jadranu

ZNANOST
11:09 29/01/2016
Foto: *Bougainvillia triestina*
Kao glavni razlog zbog kojeg sve do sada znanstvenici nisu otkrili kako je riječ o novoj vrsti meduze je nedostupnost genetičke analize, koja se u prošlosti nije primjenjivala. Upravo je genetička analiza pomogla našim znanstvenicima da riješe ovu stoljetnu dvojbu.
Prošlo je više od sto godina kada je njemački morski biolog Clemens Hartlaub pronašao dotad neotkrivenu vrstu meduze u uzorcima Tršćanskog zaljeva. Bilo je to davne 1911. godine, a Hartlaub je dao ime meduzi *Bougainvillia triestina*. No već dvije godine poslije njegovog otkrića, točnije 1913. godine biolozi Neppi i Stiasny su objavili znanstveni članak u kojem su opovrgnuli Hartlaubove zaključke. Tada su naveli kako je meduza, koju je on opisao pod imenom *Bougainvillia triestina*, zapravo već poznata vrsta *Bougainvillia muscus*. Smatrali su da je to zapravo njezin nerazvijeni oblik.

„S obzirom na činjenicu da je Jadransko more relativno dobro istraživano more i da se ne radi o nekom nedostupnom zatvorenom ekosustavu, otkriće do sada nepoznate vrste govori o tome koliko još uvijek imamo nepoznanica koje treba istražiti", smatra Batistić

Slovenska znanstvenica Polonca Babnik 1943. godine ponovno je pronašla ovu vrstu u uzorcima iz Hvarskog kanala i ne znajući za Hartlaubov rad, opisuje ju kao *Bougainvilla autumnalis var. magna*. Schmidt i Benović zatim 1977. godine ponovno ukidaju vrstu, smatrajući da se radi o vrsti *Bougainvillia muscus*. Vrsta je tako bila ukinuta sve do