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AADRAY

RESULTS OF THE RESERACH ACTIVITIES OF THE INSTITUTE OF OCEANOGRAPHY AND FISHERIES FOR THE FIFTY YEARS OF ITS EXISTENCE

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To our dear late colleagues, to whom we wish to record our appreciation of contribution received from them: DSc Ante Ercegović, DSc Vlaho Cviić, DSc Dinko Morović, DSc Tonko Šoljan, DSc Miljenko Buljan, and DSc Otmar Karlovac.

This Report has been written using as sources of information the results published in the Institute's publications. Unfortunately, it has not been possible to consult all the papers of the workers and associates of the Institute published in publications other than Institute's, either Yugoslav or foreign. However, contributions of some associate members of the Institute published in the Institute's publications are also included. This refers to those whose work here added, either through field work or in any other way, to the general work of the Institute. This Report includes a complete Bibliography. Therefore, the authors are not separately cited in the body of the Report.

The principal scientific journal of the Institute, »Acta Adriatica«, first issued in 1932, has so far published 21 volumes with a total of 270 papers. »Bilješke« (»Notes«) include short communications which require quick publication. About 40 short communications have been published up to now. »Izvješća« (»Reports«) publish the results of the Fishery-Biology Expedition HVAR, wherein 6 volumes and 17 papers have been issued. The exclusive publication »Fauna i flora Jadrana« (»Fauna and Flora of the Adriatic) includes 3 monographs. The series »Posebna izdanja« (»Special Issues«) has 7 issued books.

Two Annual Reports (1938 and 1939) with 23 papers were published in the pre-war period. In the post-war period the Annual Reports have been published for internal use only. »Zbornik radova« (»Collected Reprints«), including the papers of the Institute's workers published in the publications other than Institute's, have been edited since 1968. Two volumes issued up to now include 86 papers. More than 150 specialist publications (»Studije i elaborati« — »Studies and Projected Reports« — 43 recorded) should also be mentioned. They were made on request of different firms and socio-political communities.

So far, i.e. in the preceeding 50 years, a total of 598 scientific and specialist papers have been printed in the Institute's publications. It has not been possible to determine the number of papers issued in publications other than the Institute's. This number is likely to exceed 600 papers. Thus, it may be said that the number of papers of the Institute's workers and associates amounts to more than 1,200. However, very intensive activities on popularization of science have not yet been mentioned. This refers to a large number of Popular science articles and collaboration with the press, radio broadcast and television.

Unfortunately, it has not been possible to discuss individually all the results obtained. Therefore, they have been grouped by themes and results summarised. Almost all the investigations refer to the Adriatic Sea. The scientific achievements of the Institute have been segregated into the following twelve categories.

1. Expeditions and Field Work
2. Hydrography
3. Dynamics
4. Flora and Fauna
5. Ecology
6. Primary and Secondary Organic Production
7. Promotion of Fisheries
8. Relations between the Adriatic and Mediterranean
9. Relations between the Coastal Sea and Open Waters
10. Impact of Man on the Sea, Co-operation with Firms and International Co-operation
11. New General Knowledge of the Adriatic Sea
12. Perspectives of the Future Research Activities

EXPEDITIONS AND FIELD WORK

Collection of data at the sea, their systematizing and processing are the basis of any oceanographic research. Therefore, it is quite natural that these activities have been widely developed by the Institute.

In the pre-war period, 1932—1937, the data from 4 stations among the central Adriatic islands were systematically collected by the small vessel BIOS. After the war, Fishery-Biology Expedition HVAR was organized in 1948—1949. Samplings carried out at 176 stations covered the whole of the open Adriatic, greatest depths excluded. No material supplied since then has been more complete and abundant than the material on spatial distribution of pelagic and particularly benthic settlements collected during these cruises.

During the International Geophysical Year, in 1957—1958, the Institute being the co-organizator of the expeditions MINER and SPASILAC, collected a comprehensive oceanographic material from 5 cross-sections in the open central and southern Adriatic in the course of 6 cruises. The purpose

of their cruises was to determine what oceanographic changes had occurred since the completion of the work of the NAJADE and CICLOPE expeditions 42 years previously (1911—1914).

The long-term data collection from permanent stations in the central and southern Adriatic was an excellent supplement to these spatial researches. The origin of this well organized data collection can be traced back to 1948. Ever since than it has been performed, either on monthly intervals or on seasonal ones, at the stations representative of the coastal area, central Adriatic channels and open sea. The number of parameters observed has been steadily widened over the years to embrace today the studies of complete hydrography, including marine chemistry and dynamics; all plankton, as well as the control of pelagic and demersal settlements. All this has been realized through well organized team work. Control of fish settlements has also been carried out in the course of ample field work. Thus, a large part of the Adriatic has been echo-sounded. Demersal resources at Blitvenica have been under continuous control, as well. Large number of stations located among the islands of the central Dalmatia have repeatedly been sampled for the ichthyopelagial studies (plankton and nekton). The experiments of sardine tagging to observe their migrations have also been carried out.

The Kaštela Bay has been investigated in detail on several occasions. In addition to the monthly monitor at one station the investigations of larger extent have been performed at a series of stations on three occasions (1953—1954; 1972—1973; 1975—1976). Properties of the sea water in the vicinity of submarine springs have been under similar monitor as well.

The Institute carried out successfully a long-term experiment of fertilization of the sea in the Mljet Island lakes, simultaneously carrying out the intensive observations of relevent parameters. A similar experiment of lesser extent was carried out in the Bay of Marina.

From 1970 on, the coastal area has been more carefully investigated within the contract studies on pollution and protection of the sea undertaken for various organizations. Very intensive studies have been gradually widened to include now the areas of Zadar (adjacent to the Vir Sea), Šibenik, Split and Dubrovnik. In collaboration with other Institutes there have also been included the areas of Rijeka and the Montenegro coastal area. Monitoring for the purposes of the control of the quality of the coastal sea from the Vir Island to Konavli has also been undertaken.

In addition to a series of sporadic works at sea, the field work that has been described represents a vast number of data which contribute greatly to a better and more profound knowledge of the Adriatic. The increase in the number of data may be well illustrated by the current meter data. Direct systematic measurements started in 1956. From 1956 to 1970 about 2,000 data were collected. Later on, in the course of only one campaigne in the Split area in 1972—1973, there were collected 16,000 data. However, in 1975—1979 period, 130,000 data were collected just from the area of Vir Sea. This rapid development of instruments and methods requires also a modern classification, as well as the modern statistical approach accompanied with the new methods of processing and presentation of the material. This has been successfully achieved.

HYDROGRAPHY

This part embraces the morphological, geological, chemical, and physical properties, without dynamics. These researches were, in the first place, carried out within the studies of biological problems. This is particularly applicable to the pre-war period. In the recent years these objectives have become more accurate due to the groming demands for the practical applications of the knowledge attained.

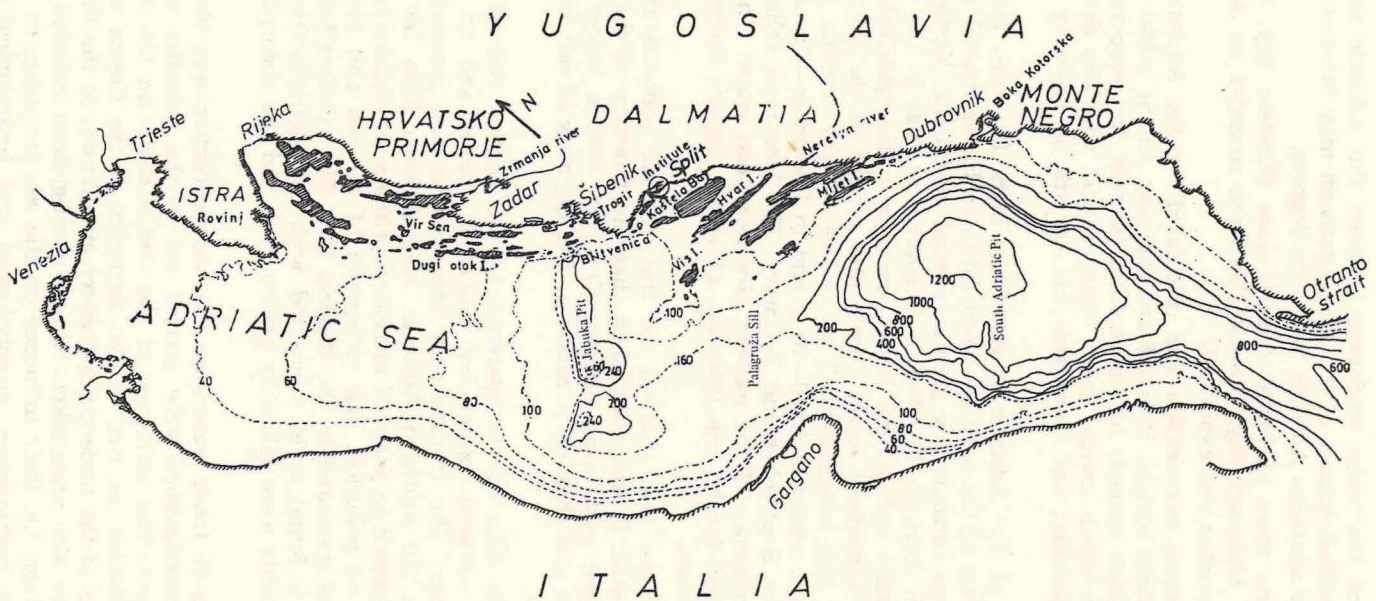
In the course of ordinary cruises, there were recorded some new bottom relief characteristics, i.e. some new banks were discovered in the central Dalmatian archipelago.

Mechanical composition of the open Adriatic sediments was determined. It was found that the bottoms are clayey-loamy at 58 percent of stations, and sandy at 42 percent of stations. Bottoms in the northern Adriatic are mainly covered with sand. The distribution of sediments follows a regular pattern in the open Adriatic, the muddy bottoms prevailing in deeper areas. However, in some of the channels along the eastern coast the distribution of sediments is not regular due to the peculiar dynamic properties. The island area acts as a barrier for the deposition of sediments originating from the northern Adriatic. Peculiar vertical stratification of sediments in the Mljet Island lakes was shown. It was connected with the occurrence of H_2S and a volcanic component.

The Adriatic forminifera are distributed in 4 depth zones. Their distribution depends on temperature, but first of all on depth.

The long time series of fundamental hydrographic factors such as temperature, salinity, transparency, oxygen content, nutrient salts, alcalinity and other, show well the horizontal and vertical distributions, as well as seasonal and long-term fluctuations of these parameters in the open sea and in the coastal area.

The Adriatic is a temperate warm sea. Temperature does not fall below 11°C even in the deepest layers. Temperature decreases with depth. At 10—30 m the thermocline occurs in the warmer part of the year. The autumn isothermal layer is recorded at 18—19°C in the southern Adriatic. The cooling of the sea water is more intensive along the shores thus the isothermal layer occurs earlier. In the coastal area the annual maximum is recorded in July and August and minimum in February. However, about a month's lag of the extremes is noted in the open sea. Annual temperature ranges also decrease as one proceeds from the coast towards the open sea. The normal graphs of vertical temperature distribution in the course of the year were constructed. Horizontal temperature distribution also varies during the year. In winter, the southern Adriatic is about 8—10°C warmer than the central and northern parts, depending on the year. In other seasons, however, the horizontal distribution of temperature is more uniform. The open sea is warmer than the coastal sea. Sea surface temperatures exceed the air temperatures (on an average for 1.1°C in Split, and 2.2°C in Rovinj). This difference is greater when the air temperature is affected by land breezes. The annual variations in the sea surface temperature are affected by wind and cloudiness. The long-term variations in temperature of the open Adriatic are due to the



Map o the Adriatic Sea indicating geographical locations mentioned in the text
Mapa Jadrana koja ima označene lokalitete koji se spominju u tekstu

uneven amount of the water exchange between the Adriatic and Mediterranean. The intensified impact of the Mediterranean may increase the temperature of the open southern Adriatic for a few degrees.

Sea ice in the more sheltered coastal areas (Kaštela Bay, Mljet Lake, Zrmanja estuary, Maloston Bay, Pirovac Bay) was recorded on several occasions and its occurrence was explained.

The mean annual evaporation was calculated for the Adriatic using the equation for the heat budget. It is 106 cm per year. In the colder part of the year the evaporation exceeds for more than twofold the evaporation in the warmer part. The mean annual fresh water runoff was also determined. It exceeds the evaporation and therefore the Adriatic is basically a basin of dilution.

The salinity of the Adriatic is relatively high. It varies from 38.43 to 38.85‰ in the waters of the open southern Adriatic. In the coastal area salinity is lower and shows considerably greater annual variations. Vertical distribution in the South Adriatic Pit (Basin) is similar to that in the Ionian Sea. Surface, intermediate and bottom layers are clearly distinguished. Salinity is highest in the intermediate layer. Charts and graphs of the normal salinity distribution were also constructed. Two surface salinity minima occur along the eastern Adriatic coast: in April—May and in December—January, as well as two maxima: in September and February. The long-term salinity changes are due to the influence of the eastern Mediterranean water. This influence might be accounted for by the intensity of some climatic factors over the eastern Mediterranean.

Cyclic salts were also studied, i.e. the chloride contents in the rain--water of the littoral. It was established that the quantity of chloride in the rain-water increased with wind forcing. However, over a longer period the ratio of the rinfall and chloride is constant. The quantity of salt in the coastal area was assessed.

The long-term data on transparency in the central Adriatic show the lowest values in autumn, rather low values in winter and an increase in spring and summer. The transparency increases as one proceeds from the northern towards the southern Adriatic, and offshore from the coast. The transparency is reduced in years of increased primary production and recently by the influence of pollution. The extinction of the red and blue segments of the spectre was measured in the Kaštela Bay. The relation between these two components is found to be connected with the phytoplankton quantity. Optical measurements were taken by photometer, and the absorption of daily light measured.

The influence of fresh waters on the sea properties was observed. The most intensive investigations were carried out in the estuaries of the Krka and Zrmanja rivers. The influence of the Jadro River on the Kaštela Bay water was also studied, as well as the estuaries of the Cetina and Neretva rivers. The studies of the underground water circulations in the littoral of the Dinaric Karst were also undertaken. These investigations included the studies of submarine springs, i.e. their influence on the sea properties in the Kaštela Bay (sedimentary, bathymetric, morphological and hydrological aspects). In winter, the submarine springs affect the properties of the adjacent sea. However, their influence is not felt in summer.

Morphology, hydrography, hydrological properties and geotectonic relations of submarine springs as the phenomena of the fresh water bursting at the sea bottom from the Karst sink holes were examined. The material of terrigeneous origin was found on their brims. The Split Baths were investigated from a hydrologic aspect. The sea water was found to be their principal component, then the underground water with a lot of sulphates and precipitation water in years with aboundant rainfall.

As to the chemical properties, the quantity of oxygen and nutrient salts were particularly studied, since these parameters are of importance for marine primary production.

Vertical distribution shows normal increase of oxygen content in the surface-bottom direction, down to the depths of 10—40 m where the saturation is frequent. The great depths of the South Adriatic Pit (Basin) are rich in oxygen since it comes there by the advection from the northern Adriatic. The age of this water might be clearly determined from the oxygen content in the deeper layers of the Jabuka Pit (Basin). There is evidence that the water is not renewed every year.

The comparison between the free phosphate contents in two Adriatic basins shows that from the surface down to 200 m the South Adriatic Pit is richer than the Jabuka Pit. This is indicative of the fact that these layers of both the central and southern Adriatic are enriched in free phosphate coming from the south. The intensive research into the bottom layer show that the Jabuka Pit is the principal supplier of nutrients for this layer for both the South Adriatic Pit and Palagruža Sill.

Among the nitrogen salts amonium dominates along the shores of the central and southern Adriatic. There are more nitrates in the colder part of the year. Nitrite's maximum occurs along the coast in January. Deep Adriatic waters are also rich in fluorides due to their solution from the bottom.

The frequency of elements in the sea and lithosphere in relation to the natural system of elements was also observed. Frequency decreases with the atomic number. Grouping of elements made possible the forecasting of some elements in the sea which afterwards were verified by experiments.

Laboratory work has introduced some methodological innovations. Among them was the method for determination of contact petroleum water, i.e. the water which was in contact with carbohydrates. This would make possible the detection of carbohydrate deposits with the use of an oceanographical method.

DYNAMICS

The large-scale investigations of the Adriatic show that the circulation in the Adriatic is particularly affected by the elongated shape of this basin and its continental features. These features are, first of all, manifested through the marked seasonal extreme temperatures and other properties, particularly in the northern Adriatic. Therefore, the northern Adriatic is considerably colder than the other parts in winter, and somewhat warmer in summer. This accounts for the corresponding seasonal variations in current regime. Meteorological conditions were also studies and their strong influence on dynamic properties established.

The open Adriatic is vertically divided into three layers: surface, intermediate and bottom. The calculated gradient currents and direct observations by moored currents meters and buoys show that the cyclonic flow of the surface layer is in winter characterized by the prevalence of the inflow with the greater speeds along the eastern coast, and in summer by the prevalence of the outflow with greater speeds along the western coast. Even though these seasonal variations are, in the first place, due to the geostrophic flow component, winds exert their influence, as well. Namely, the outflow in summer is maestral (NW wind) forced and the inflow in winter is scirocco (SE wind) forced. These two winds are the most frequent in the respective seasons. No direct evidence of this relationship was found, but it was indicated by the correlation found between zonal differences of air pressure over the eastern Mediterranean and the Adriatic water salinity. In winter, density gradients between the northern and southern Adriatic in the surface layer are due to the differences in temperature, and in summer to the differences in salinity. In spring and autumn, these gradients are smaller and therefore the exchange of water between the northern and southern Adriatic is reduced. Thus, while in summer and winter the longitudinal flow prevails in the wide area of the open central and southern Adriatic, the transversal flow is dominant in spring and autumn. This affects also the rhythm of prevailling directions in the area of Palagruža Sill, i.e. the sill between the Jabuka Pit and South Adriatic Pit. The NW direction prevails in winter, N in spring, SE in summer and SW in autumn. This circulation affects in turn the distribution of salinity and temperature. The charts of mean seasonal isotherms of the surface layer are clearly indicative of the influence of the incoming current in winter. This current carries warmer Mediterranean water. In spring, two separate regions are formed by the transversal flow, north and west from the Palagruža Sill (Split—Gargano). A similar situation is found in autumn, as well. The differences in annual salinity variations between the eastern and western Adriatic coast might be accounted for by the seasonal variations in current regime.

T-S diagrams well show the presence of the intermediate layer. The depth of 20—40 m separates it from the surface layer, depending on the area and season. The layer descends to about 200—400 metres in the central and southern Adriatic respectively. The NW flow prevails in this layer throughout the year. In summer, this flow may be understood as a flow compensatory to the SE flow in the surface layer. In winter, the same flow occurs both in the surface and intermediate layers. This inflow is compensated by the outgoing SE flow in the bottom layer. The flow intensity and the quantity of the Mediterranean water entering the Adriatic in intermediate layer vary considerably from one year to another. These variations depend on certain climatic factors in the whole of the eastern Mediterranean. Otherwise, the flow in the intermediate layer is most consistent. Its frequency in the area of Palagruža Sill amounts to 30—50%.

The outflow prevails in the bottom layer. In winter the entire water column is cooled in the northern Adriatic. This dense water flows into the bottom layer of the Jabuka Pit thence farther to the deep south Adriatic. It has been suggested that spreading over the Otranto Strait this water affects the bottom layer of the whole of the eastern Mediterranean.

On the basis of some presumptions the water transport through the Otranto Strait was calculated to be 7.8×10^3 km^3 per year. This means that

the complete renewal of the Adriatic water takes 5 years. According to a computation of water transport at a profile across the central Adriatic, it may vary up to 30-fold from one year to another. Therefore, the long-term fluctuations of the rate of water exchange between the Adriatic and the Mediterranean are considerably high. Periods of intensive impact of the Mediterranean upon the Adriatic are called the Adriatic ingressions. Nutrient salts introduced by these intensive inflows and their fluctuations exert an obvious impact on production. Therefore the investigations of these long-term fluctuations were given particular attention. Annual maximum salinity at Split—Gargano cross-section proved to be a good indicator of the intensity of Mediterranean water into the Adriatic. It may be due to the air pressure gradients over the eastern Mediterranean. Seasonal rhythm of water exchange between the Adriatic and the Ionian Sea might also be brought into connexion with the seasonal rhythm in the baric field over the eastern Mediterranean, i.e. with the prevailing zonal gradients in summer and meridional gradients in winter. The long-term climatic changes were studied in the larger area, since these changes were shown to cover very large regions and that they might be easier understood upon their being investigated in the wider area. For example the quantity of ice in the North Atlantic, which is an indicator of climatic conditions of the large area of the North Atlantic and Europe in turn appears to coincide with salinity variations in the Adriatic.

Determination of water types in the open Adriatic gave better insight in the way deep water is formated. Four types of Adriatic water may be distinguished. These are the waters formed in the northern, central and southern Adriatic. Fourth type of Adriatic water is the intermediate eastern water originating from the Levant. The north Adriatic water is the densest Adriatic water. However, only sometimes does this water attain the density necessary to affect the central Adriatic, i.e. to renew the bottom water of the Jabuka Pit. The waters of the central and southern Adriatic are formed in winter under the conditions of reduced influence of the eastern water on the Adriatic and intensified vertical mixing. It is of importance that in some winters the South Adriatic Pit water is homogeneous from surface to bottom. The bora is another factor of importance for the formation of deep water. The inflow of the larger quantities of eastern intermediate water affects the surface temperature so that it increases in winter and decreases in summer. This inflow also increases salinity and influences a number of other hydrographical and biological properties.

The better the detection of some properties, the better the upwelling phenomenon was observed. Due to the rise of intermediate water along the outer islands, this phenomenon was first recorded along their shores in summer. These islands act as a barrier for the flow in the intermediate layer. The influence of the maestral was also noted. The upwelling recorded in winter was found to be due to the bora.

The vast number of data collected for the last ten years has given a better insight into a series of peculiarities of the coastal sea as related to the open sea. The two layers mainly occurring here, are separated by a thermocline in the warmer part of the year. Current speeds are somewhat lower here than in the open sea. The NW direction prevails in the surface layer here, as well, however less frequent. Tidal currents are of small speed (4—5 cm/sec) and prevalently rotating. Cyclonic as well as anticyclonic flow occurs

in the surface layers of the coastal basins. The type of flow occurring there depends on the basin's shape and wind direction. An oscillation of several days is pronounced. It may be due to the occurrence of synoptic disturbances. The flow phenomena in the sea as related to atmospheric influences were observed in more detail. Continuous measurements of a series of parameters gave better insight into the structure of some dynamic phenomena. The summer response of the sea is predominantly baroclinic and the appearance of upwelling due to the offshore wind. In winter. however, the response is predominantly barotropic.

A simple model of water renewal in coastal basins was employed to compute the assimilation capacity of some threatened basins. A simple model, as well, of water exchange between the semi-closed basins and adjacent sea was also used. The coefficient of Fickian diffusion was experimentally determined at a series of localities. The diffusion was also theoretically studied. Some theoretical postulations for the application of fundamental hydrodynamical equations to peculiar sea conditions were also examined. Under certain conditions they proced to be well applicable to the accounts of distribution of some properties of the sea (e.g. salinity). It was also shown that further studies would be able to give a complete theoretical description of fields of different values in the sea. The hydrodynamical model was as well developed for the area of Vir Sea.

Some wave phenomena studies were also carried out, such as seiches and the occurrence of a catastrophic wave. Wind forced waves were also examined.

The variations in the mean sea level due to some dynamic properties were also investigated.

Modern statistical methods were applied to the analyses of a series of parameters such as flow, sea level, air pressure and temperature.

FLORA AND FAUNA

Floral and faunal research include the inventoring, cataloging, revisions, keys for determination and monographs of different taxa of the Adriatic flora and fauna, as well as the reviews of flora and fauna of some smaller and larger areas of the Adriatic.

Monographs of faunal and floral groups, published in the series »Fauna i flora Jadrana« (»Fauna and Flora of the Adriatic«) give a significant contribution to the knowledge of the Adriatic flora and fauna. Three monographs have been published. These are: »Ribe Jadrana« (»The Fishes of the Adriatic«) with the key for determination, review of species and comment; »Die Anthozoenfauna der Adria« (»Fauna Anthozoa of the Adriatic«) with the list of Adriatic species and general characteristics; »Jadranske cistozire« (»The Adriatic Cystoseira«), their morphology, ecology, development and atlas. The monograph »The Adriatic Foraminifera«, with the list of species, atlas and the account of their depth and geographical distribution is in press. A monograph »Genus *Sargassum* in the Adriatic« with the morphological and ecological data and atlas is also in press.

Studies of benthic flora of the islands Jabuka, Vis—Biševo, and Hvar were also carried out. The composition of Rhodophyta, Phaeophyta, Chlorophyta and Cyanophyta, and phytogeographical relations of benthic flora (543 taxa) were investigated in the area of the central Adriatic. A total of 622 taxa from the first three groups was established in the flora of the coastal, channel, insular and open areas of the eastern Adriatic. The composition of this flora embraces the floral elements of the Atlantic—Mediterranean, Circumtropical, Circumboreal and Indopacific phytogeographical regions as well as Cosmopolitan and Adriatic endemic species and Mediterranean endemic species.

Algal vegetation from the fisheries grounds of the Adriatic was worked out. Some species of benthic algae were found to reach to depths exceeding 260 m. The biothermal vegetation of the port of Split was also studied.

Pelagic diatoms of the central Adriatic (120 species) were also investigated, as well as the phytoplankton in the areas of Mljet Island, Boka Kotorska, and eastern Adriatic coast.

Some new or insufficiently studied Pheophyta and Rodophyta species of the central Adriatic were given special attention. Revisions were made in some algal families (Codiacea, Champiacea, and the species of genus *Ectocarpus, Halymenia, Nemastoma, Platoma, Rhodymenia, Bonnemaisonia, Calosiphonia* and *Thuretella* not registered or slightly known in the Adriatic. The genera of algae new for the science were also discovered (*Yadranella, Padinopsis, Pterocladiopsis, Adriologia, Dalmatologia* and others).

Faunal papers embrace the studies of some systematic groups of different parts of the Adriatic, their catalogues and revisions. Thus, the data on Anthipataria, Zooantaria, and Actiniaria collected during the HVAR Expedition cruises were published. Research into the Anthozoan funa of the Kaštela Bay was carried out, as well as into Octocorals, stone corals and Cirripedia of trawling grounds of the open Adriatic. Echinoderms and planktonic copepods of Boka Kotorska as well as Echinoderms of the Krk Island were worked out. Contributions to the knowledge of the zooplankton of the central Dalmatian archipelago and Mljet Island lakes were published. Marine Halacaridae and Hydrachnellae of the Dalmatian coast near the town of Split were surveyed. Family Ampeliscidae (Amphipoda) were studied in more detail. The identity and distribution of 29 Cephalopoda species were given. Rather intensive studies of individual taxa from the fish group were carried out. Meanidae group was, thus, worked out from the morphological and taxonomic aspects. The development stages, from larval to the adult one, of 23 fish species of families Sternoptychidae, Stomatidae and Scopelidae were analysed and the data on their distribution given. Morphological, biological and ecological characteristics of the population of lesser spotted dogfish were worked out.

The revision of Pardaliscidae (Amphipoda) family was done with the diagnosis of genera, data on the species distribution and bibliography. The Adriatic Folliculinidae (Eufolliculinidae) were also worked out.

Catalogues of the Echinoderm group of the Adriatic and Polychaetous Annelids of the northern and central Adriatic are a significant contribution to the knowledge of the Adriatic fauna. Studies of the larvae of the Adriatic Crustacea Decapoda were also carried out.

The records of some bathypelagic fishes new in the Adriatic were also analyzed. Particular attention was given to the findings of the rare and new

species in the Adriatic (*Bellotia apoda, Trachipterus trachypterus, Zu cristatus, Citharus macrolepidopus, Lepidopus caudatus*).

Investigations of the Adriatic flora and fauna have not always been carried out with equal intensity. Unfortunately, for the last ten years this work has suffered some stagnation due to the shortage of specialized staff and insufficient financial assistance, even though these floral and faunal studies are the basis for some other disciplines such as biocoenology and ecology.

ECOLOGY

Since founding of the Institute, ecological investigations have been the principal objective of its activities. However primary and secondary production will not be included in this section. It will be separately dealt with in terms of its importance for the problems of resources exploitation.

Planktonic communities were studied in detail. Studies of the composition, seasonal variations in density, horizontal and vertical distribution of phyto- and zooplankton were carried out already in the pre-war period, as well as of their relations to different environmental factors. Four stages of phytoplankton dynamics are distinguished in the course of the year: winter bloom, winter-spring decrease, spring bloom and summer-autumn stagnation. Winter maximum is due to the offshore wind and upwelling, and the spring bloom to the influence of fresh water.

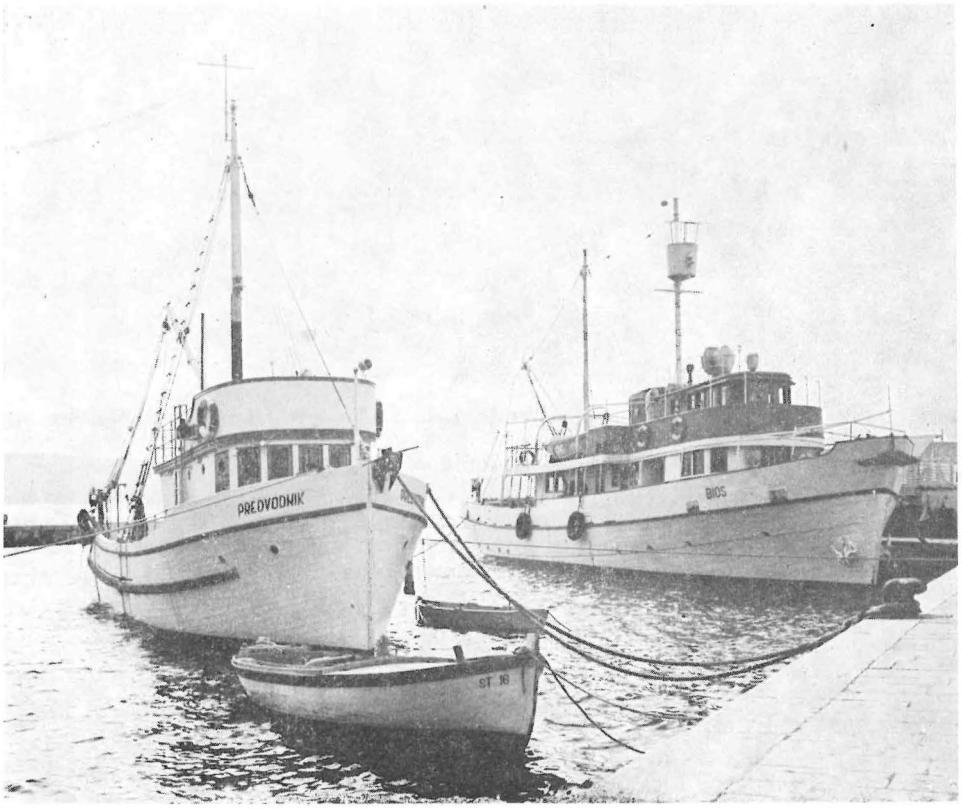
The long-term observations of the qualitative-quantitative plankton composition carried out in the post-war period gave new significant contributions to the knowledge already attained. Seasonal rhythms of phytoplankton density were found to be synchronous in the areas along the eastern Adriatic coast. Due to the pollution influence the phytoplankton from the coastal areas remains high in summer, as well. Therefore, seasonal density variations are reduced. However, the seasonal cycle in the open waters shows markedly small quantities of phytoplankton in summer.

Studies of the relations between principal phytoplankton groups (diatoms, coccolithophorids and dinoflagellates) showed also the factors which caused these relations. While diatoms are typical in the coastal waters, coccolithophorids are used as an indicator group of the presence of typical eastern intermediate water in the Adriatic. The »microflagellate« group was assessed quantitatively. Unfortunately, their composition is still unknown, either here or in the world, owing to the difficulties in their determination. Growth of small planktonic fractions was found to be more intensive. Continuous observations of phytoplankton biomass gave better insight into the long-term variations. The work on determination of chemical composition of phyto- and zooplankton organisms has started. Proteins, carbohydrates and lipids have been determined as well as their caloric value.

Vertical distribution of zooplankton in the Mljet Island lakes showed that copepod *Calanus helgolandicus* had day-night vertical migrations. It has 5 generations per year. This species feeds on diatoms.

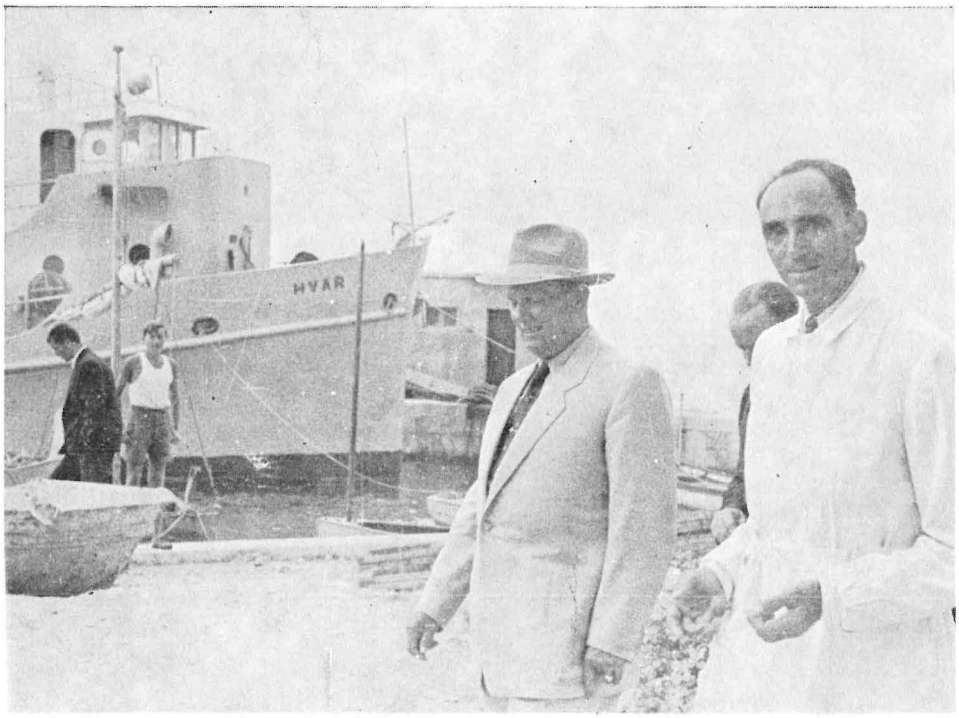
Vertical distribution of zooplankton in the open central Adriatic shows that as a whole it keeps closer to the surface in autumn and winter and below 100 m in other seasons. The major proportion of species inhabits the mean level of 50—100 m. Two maxima of zooplankton density occur in the

Glavna zgrada Instituta
Institute center



Institutski istraživački brodovi
Institute research vessels

Foto M. Alajbeg



Predsjednik Tito je posjetio Institut u julu 1951. Na slici je s Dr Šoljanom, tadašnjim direktorom Instituta. U pozadini je brod HVAR, kojim je izvršena prva ribarstveno-biološka ekspedicija na Jadranu (1948—49.)

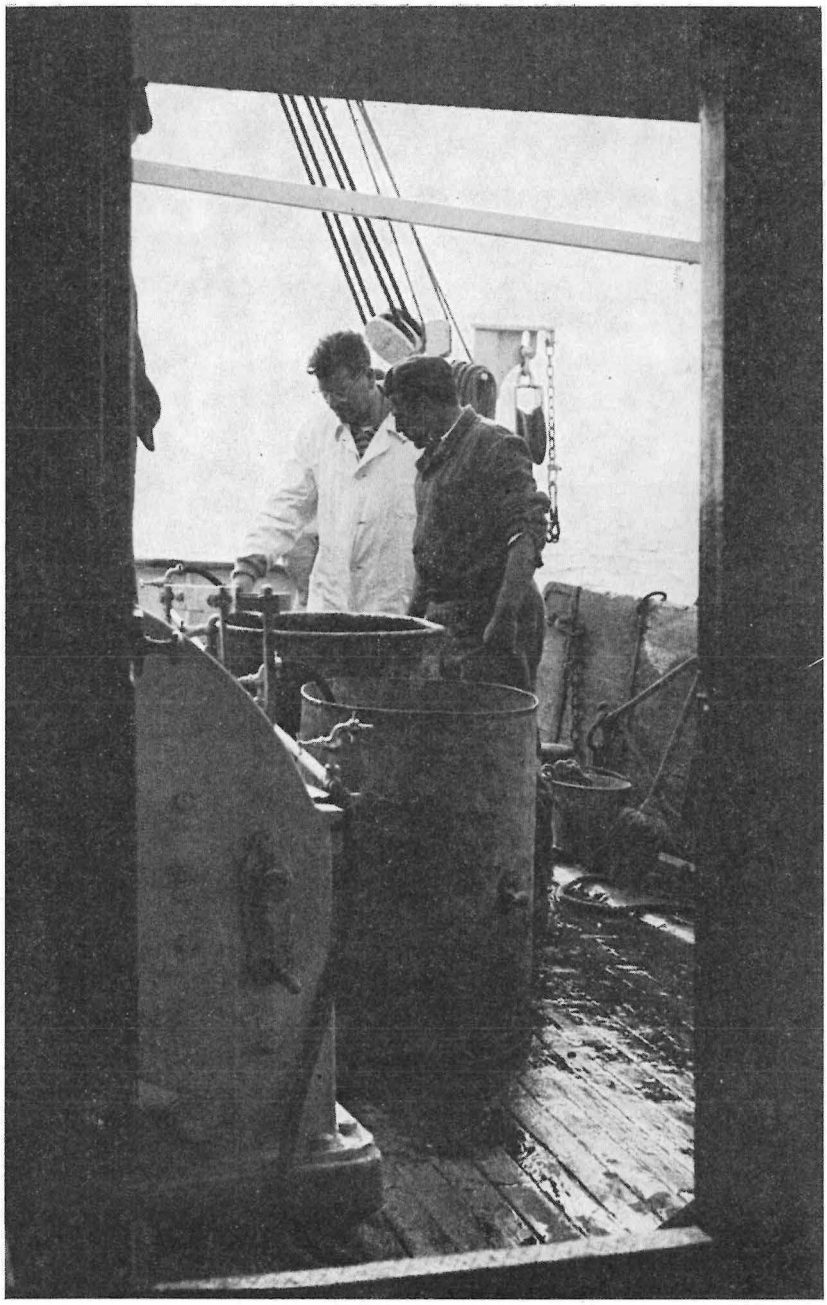
President Tito visited the Institute in July 1951. Here he was accompanied by the late Dr. Šoljan, director of the Institute. The HVAR which served as the research vessel for the first fishery-biological expedition in the Adriatic (1948—49) is in the background

Dr Ercegović govori na Prvom simpoziju jugoslavenskih oceanografa održanom u Institutu 1962. On je bio direktor Instituta u predratnom periodu i drugogodišnji rukovodilac Biološkog odjela

The late Dr Ercegović addressed the First Symposium od Yugoslav Oceanographers held at the Institute in October 1962. We was director of the Institute in the pre--war period and chief of the biological department for many years

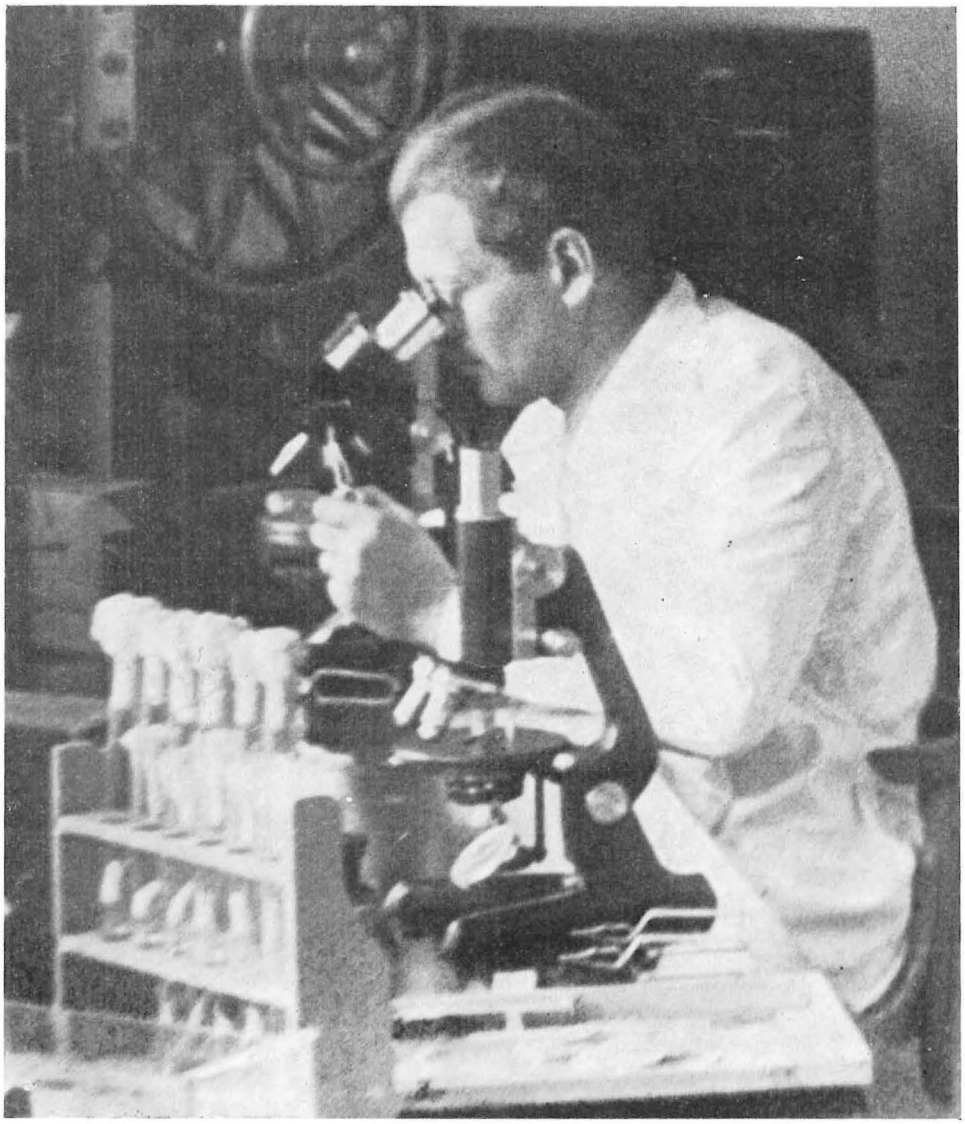
Dr Buljan govori mornarima na brodu MINER na ekspediciji u toku Međunarodne geofizičke godine 1956—57. On je bio u dva navrata v.d. direktora Instituta i dugogodišnji rukovodilac Odjela za fiziografiju

The late Dr Buljan talking with mariners on the vessel MINER during the campaign of International Geophysical Year 1956—57. He served Institute as acting director twice and chief of the Departement of physiography for many years.



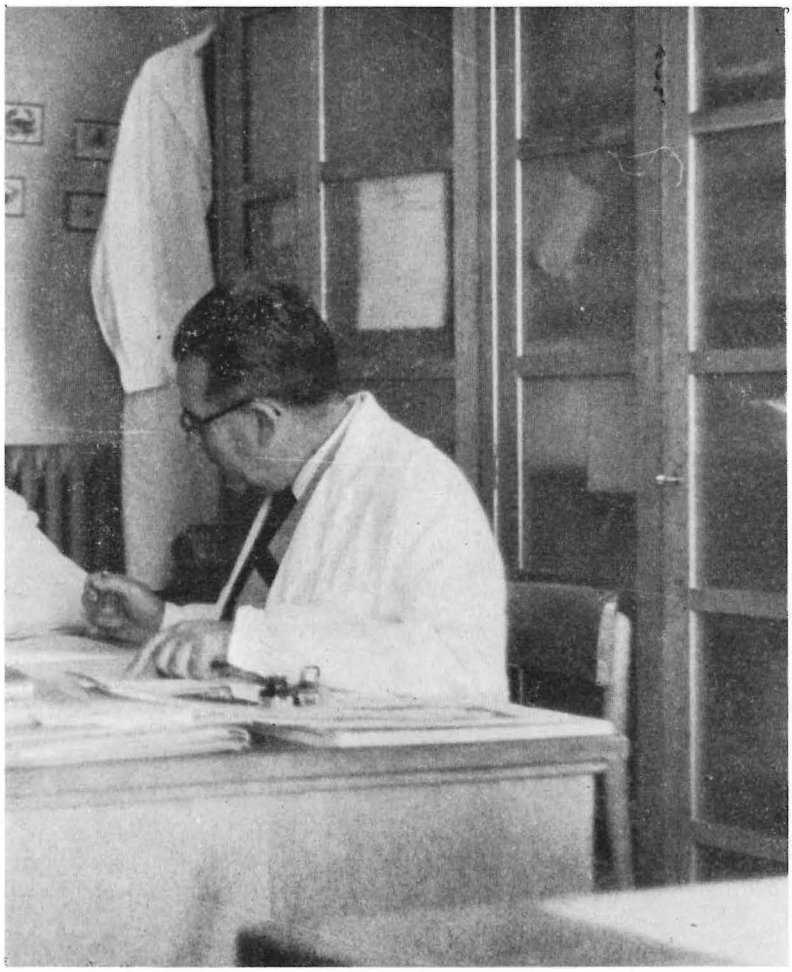
Pokojni ribarski stručnjak Dr Morović eksperimentira sa ribom na palubi m/b »BIOS«. On je bio također dugogodišnji urednik institutskih publikacija

The late Dr Morović, fisheries expert, performing an experiment with living fish on the BIOS. He served as editor of the Institute's publications for many years.



Dr Cviić u radu u laboratoriju za mikrobiologiju, koji je on osnovao 1947. Bio je direktor Instituta od 1956—1960

The late Dr. Cviić, director of the Institute from 1956 to 1960 working in the microbiology laboratory which the founded in 1947



Dr Karlovac na radu u svom laboratoriju 1962. godine. On je bio višegodišnji rukovodilac Odjela za ribarstvenu biologiju

The late Dr. Karlovac, shief of ficheries biology for many years, in his laboratory in 1962.

U oktobru 1976. je u Splitu održan XXV kongres i generalna skupština Međunarodne komisije za znanstveno istraživanje Mediterana (CIESM). Tom prilikom sastanak Biroa je održan u biblioteci Instituta

The session of ICSEM Presidency during the XXV Congress and Plenary Assembly of ISCEM (International Commisssion for the Scientific Exploration of the Mediterranean Sea) took place in the Institute's library in 1976.

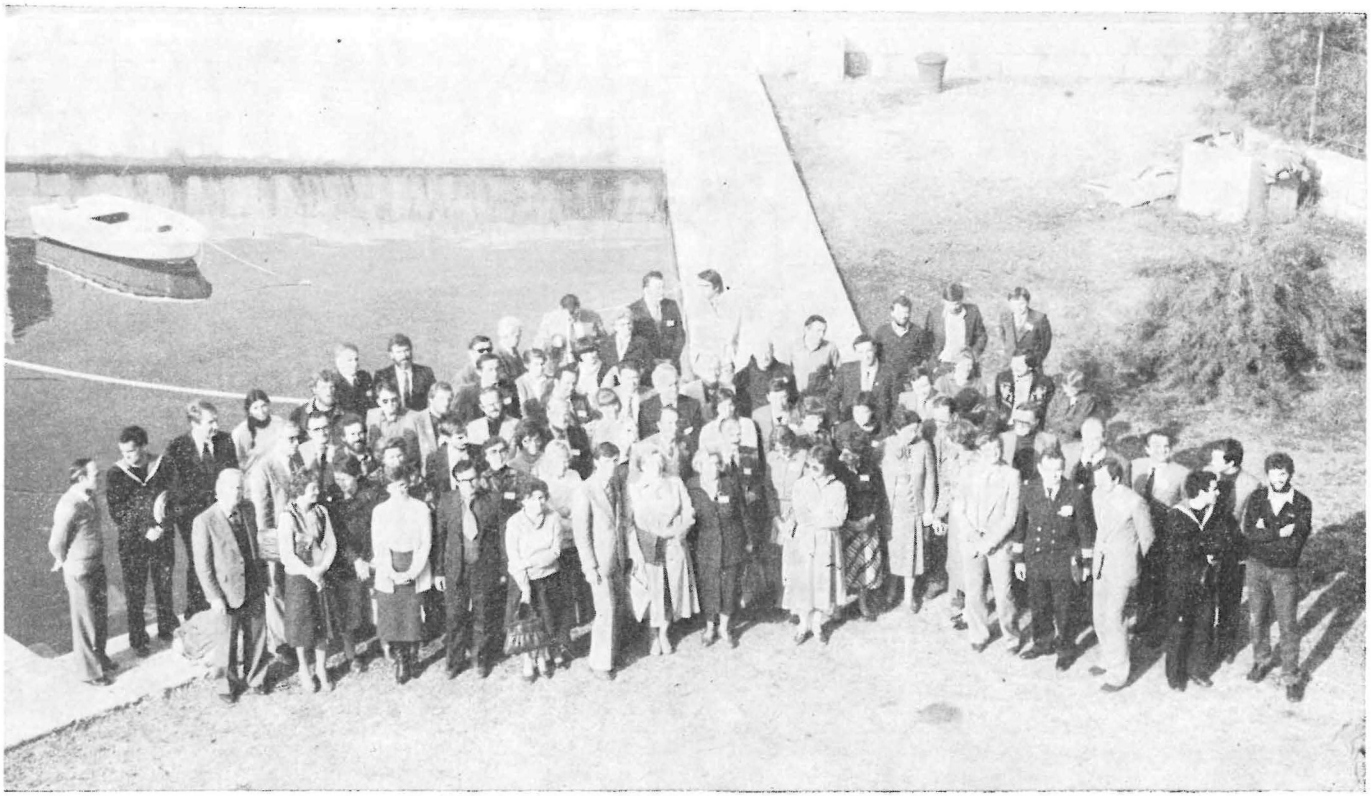
U vrijeme održavanja kongresa CIESM u oktobru 1976. organizirana je za predsjednika te organizacije, princa Rainiera III od Monaka, ekskurzija sa m/b BIOS

An excursion on the research vessel BIOS was organised during the ICSEM Congress in October 1976 of the Chairman of that organisation, H.S.H. Prince Rainier III of Monaco

U novembru 19977. posjetio je Institut komandant Cousteau sa svojim brodom Calypso

Commander Cousteau visited the Institute in November 1977.

Foto M. Alajbeg



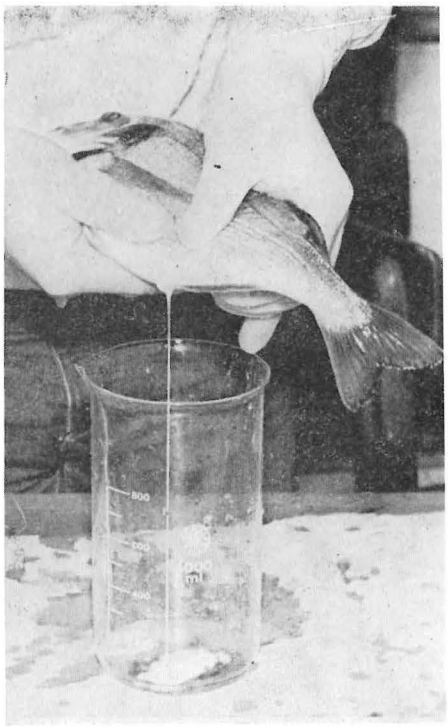
Učesnici Četvrtog simpozija jugoslavenskih oceanografa, održanog u Institutu u novembru 1980. povodom proslave 50-godišnjice Instituta

The Fourth Symposium of Yugoslav Oceanographers was held at the Institute in November 1980 during the celebration of the Institute's 50th anniversary

Foto M. Alajbeg

Spuštanje strujomjerne plutače u more sa m/b BIOS

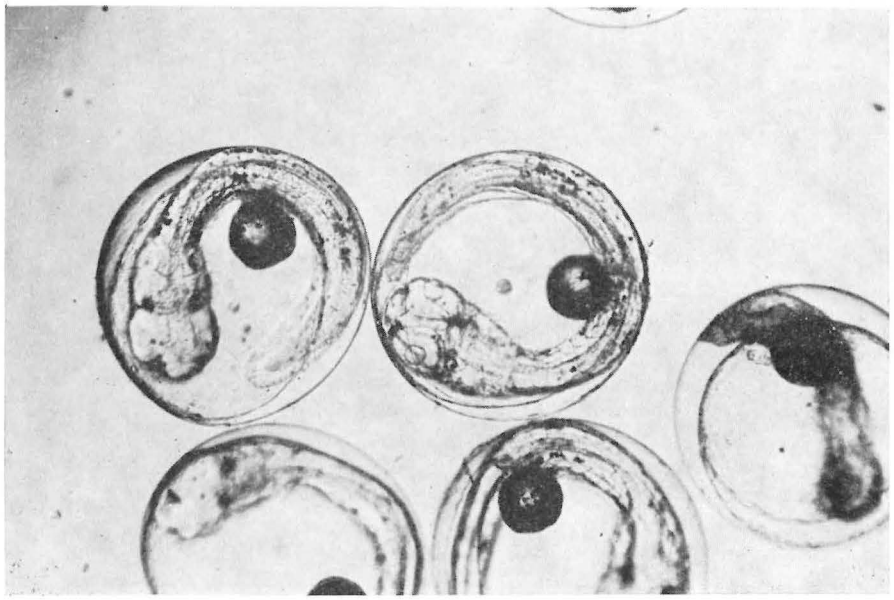
Mooring a bouy from the BIOS for current measurements



Umjetni mrijest komarče, *Sparus aurata*

Artificial spawning of the gilthead sea bream *Sparus aurata*

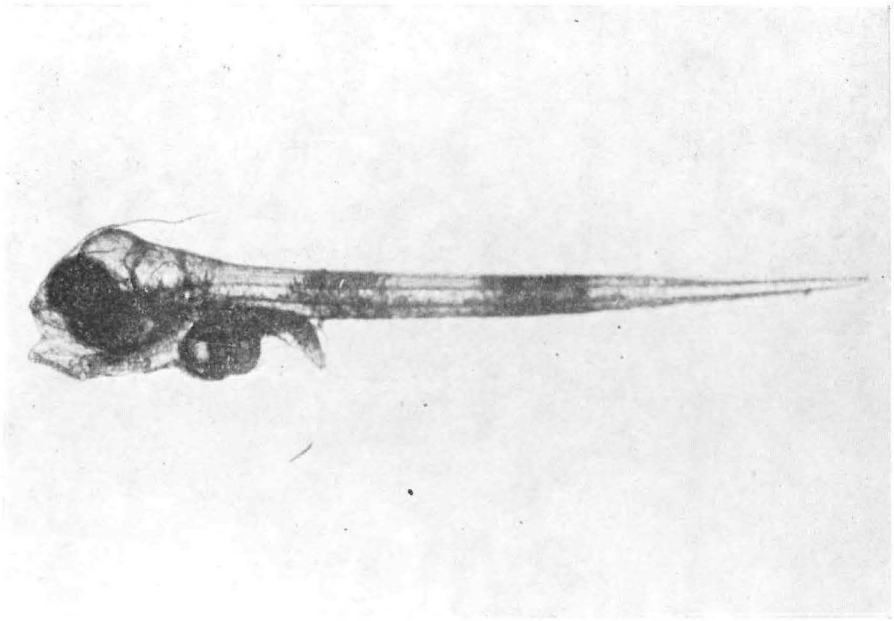
Foto M. Alajbeg



Embrionski stadiji komarče

Embryonic gilthead sea bream

Foto M. Alajbeg



15 dana stare postlarve komarče
Cultured gilthead sea bream at 15 days

course of the year: a somewhat more pronounced one at the beginning of spring with the species occurring at mean diurnal level below 100 m depth, and the shorter summer one with the species occurring at mean diurnal level above 100 m.

Being quantitatively best represented among the zooplankton groups, copepods were studied in detail. Horizontal distribution in an offshore direction is in connexion with the water motions. Variations in quantity are due to some abiotic and biotic environmental factors. Dominant species were given special attention since their abundance determines the density of the whole group. Pollution was found to affect copepods so that some changes in seasonal oscillations were observed in the Kaštela Bay, as well as the first negative signs of eutrophication in the Šibenik area.

Determination of the zooplankton weight was done for the first time in the Mediterranean. Continuous observations showed seasonal and long-term variations and horizontal distribution of zooplankton biomass. This made possible the classification of the Adriatic in relation to the other Mediterranean basins and Atlantic with respect to the quantity of zooplankton biomass. At the same time, some zooplankters may be taken as indicator species of some typical water masses.

Plankton communities include eggs, larvae and early stages of fish and other animals. Owing to the commercial importance of sardine and anchovies, their eggs in the plankton already were studied in the pre-war period. Observation, however detailed, proved that an area with a large number of stations would provide better for the determination of spawning grounds. This work was done in the course of the HVAR Expedition and later on several occasions in the selected area. Four areas of sardine spawning were determined: westward from the island Dugi otok, among the central Dalmatian islands, in the waters round Palagruža and in the southernmost part of the Adriatic. Horizontal distribution of eggs changes during the spawning season. Thus, eggs occur earlier in the western part of the Hvar channel where larger concentrations are also retained longer than in the open sea. The largest concentrations of sardine eggs were recorded from depths exceeding 150 m in the autumn-spring period. They were not recorded in June—September. The number of eggs increases as one proceeds from the coast towards the open sea. Namely, towards the end of sexual maturation sardine leave the coastal and shallower waters looking for the more stable temperature and salinity. They are likely to migrate for food since these migrations coincide with the zooplankton maximum. Sardine spawn by night at time intervals of 3 hours. In December, at higher temperature, the embrionic development lasts for 2 days and in March at lower temperature it lasts for 4 days. Spawning time varies from one year to another. Sardine larvae are recorded from October to April. They seem to be migrating from the open sea onshore. They are found everywhere, but least at depths exceeding 100 m. This indicates that they mainly keep in the areas where spawning occurs. The mortality of larvae is high owing to the poor feeding. It is higher along the coast than in the channels of the central Adriatic.

Anchovy eggs are found from March to November with the maximum in June—July. Anchovy eggs are concentrated in the layer down to 10 m, and larvae between 10 and 20 m. Egg size is inversely proportional to the sea temperature. Dead eggs are most frequent in early stages. The critical

period in the life of larvae occurs when they consume the yolk (at 3.5—4 mm in length). The quantity of eggs coincides with the increased primary production. This may not be said for the quantity of larvae. Eggs size seems to be crucial for the survival. Apart from being studied among the central Dalmatian islands, anchovy spawning was also investigated in the vicinity of the island Dugi otok. The embrionic development was found to last for 40 hours.

An examination was made of the influence of temperature on the developmental rate of anchovy eggs and larvae as well as on the growth rate of larvae and postlarvae under experimental conditions. On the one side, this made possible the computation of their mortality in nature and on the other the computation of egg production and number of larvae and postlarvae of this fish per unit time and area.

The method of spectral analysis was applied to determine the relation between the long-term fluctuations of anchovy eggs production, as well as the abundance and coefficient of mortality of anchovy eggs and the fluctuations of some abiotic and biotic environmental factors. It was established that all the parameters analyzed showed similar basic periods of oscillations and that the population of anchovies as a whole responded to the environmental changes with a phase lag of approximately one year. It is most affected by the changes of trophic bases.

Planktonic stages of horse mackerel are also widely distributed. Planktonic stages of family argentinidae were recorded from the open sea from March to June. Since recorded more northerly than the adults, they are likely to be driven there by currents. Recently (from 1964 on) the planktonic stages of gilt sardine have been noted.

The description of eggs and development stages of picarel were also given. Two species of picarel, i.e. *Spicara maena flexuosa* and *Spicara smaris* may be cross-bred in nature. This was experimentally proved, as well.

The records of the species of fish larvae from the open sea exceed those from the coastal area.

Larvae and decapod crustaceans from the Mljet Island lakes were found to have more stages than those reported from the cold seas. A larger number of species was found closer to the coast than on the open sea. They spawn both in winter and summer, however 4—6 months earlier than in the colder North Sea. The maximum number of larvae in the lakes of the Mljet Island occurs about a month earlier than in the open sea. Vertical migrations by day were observed. Thus, at sunset they are concentrated at the surface.

Since then the microbiological laboratory was founded in 1947 the observations of bacterial populations began. Bacterial biomass indicates that the middle layer of the euphotic zone (20—50 m) is the richest one in bacteria in the central and southern Adriatic. They were vertically widely distributed but they are more abundant at depths not exceeding 100 m. The stations closer to the coast are richer. Diurnal vertical migrations were established in the coastal area. Maxima occur both in winter and summer and minima in spring and autumn. Quantities of bacteria and phosphates are inversely proportional. To make better assesment of bacterial biomass the mean volume of bacterial cells by strains was determined in both the native and fixed state. Two bacterial strains with red pigments were found to develop under aerobic conditions and cause the occurrence of red water recorded from 20 m

depth in the lake Malo jezero on the Mljet Island. Under laboratory conditions the reproduction of heterotrophic bacteria at different H-ion concentrations is slower on acid than on alkaline medium. Bactericidal and bacteriostatic impact of antibiotics (penicilin and streptomycin) on 41 bacterial strains were examined and the lowest harmless concentrations determined. The activity of bacteria at phosphate excretion from marine sediments was studied on pure cultures in the laboratory. More phosphate is excreted under anaerobic than under aerobic conditions.

With respect to the special interests of fishery practice, the investigations of commercially important and other fishes, both benthic and pelagic, were carried out. Studies were made of the morphology, growth and development of otoliths, life cycle, reproduction, sexual maturation, sex relations, length at first sexual maturity, fluctuations of fat contents, some physiological properties such as oxygen consumption as well as hemoglobin concentration and fish activity, behaviour, group formation, light responses, vertical and horizontal distribution, migrations, settlements size, mortality, nutrition, parasitism, body anomalies, digestive tract by x-rays and the relations to the environment.

Sardine larvae feed both on phyto- and zooplankton. Small sardines, in the stage of metamorphosis, feed mainly on phytoplankton (predominantly dinoflagellates, somewhat less diatoms and coccolithineae), then on eggs and larvae of crustaceans (copepod and cirripede nauplii) and on fish eggs. They seem to select food. Before the sunrise they do not take food (except under artificial light). Stomach glut increases from sunrise up to 3 p.m.

Stomachs of adult sardine exculsively contained zooplankton (30% of copepods, 23% of decapod larvae and 9% of fish larvae and some other organisms in smaller percents). They take the least food in August, and most food in December. The adult sardine feed intensively in the afternoon. They do not take food by night, except under artificial light.

There is a single population of sardine along the eastern Adriatic coast. Sardine settlements from Istra and those from central Dalmatia do not mix together. The Jabuka Pit acts as a barrier. The degree of sexual maturity indicates that sardine spawn from the end of autumn to spring. Bigger individuals reach maturity earlier. The beginning of sexual evolution coincides in both sexes. However, in the prematuration stage (October, November) males are more advanced. At the peak of sexual maturity fish weight is reduced. At fish length of 13—14 cm all the individuals are sexually mature. Some mature even at smaller lengths. At the same age females are longer than males. Periintestinal fat is lost at spawning. Individuals found along the outer islands are bigger than those found closer to the coast, where younger fish stay for the major part of the year. Sardine migrate transversely in the central Dalmatian insular area. During the catch season the adult fish move onshore, and later in autumn offshore. Spring sardine onshore migration coincides with the maximum zooplankton biomass, particularly with that of copepods and decapod larvae in the coastal area. Fat content in sardine tissues is lowest in May, i.e. upon spawning, and highest in August and September. Mean length of sardine from the open waters varies from one year to another in dependence on the presence of individual age classes. Development of otoliths in younger individuals depends on the time of hatching. In the Kaštela Bay sardine stay deper in the morning than in the afternoon. In the evening they move even higher up. They are more abundant

in the shallower parts of the bay. In the coastal area their quantity starts to increase from March to April, reaching the peak in July and October (least in February—March).

Planktonic stages of mackerel feed on zooplankton, larvae of other fish, and they even take their own larvae as food. Their digestive tract is fullest in February.

Spanish mackerel spawn later in spring and summer in the central and southern Adriatic. Of their planktonic stages only postlarvae were found.

Horse mackerel are widely distributed, particularly in the area of Blitvenica and Jabuka Pit. Small specimens were found closer to the coast. Their distribution does not depend on the composition of substrata.

Gilt sardine have recently been recorded from the Adriatic. They were for the first time found to spawn in this sea. Young gilt sardine were also recorded for the first time. Otherwise, they inhabit warmer seas.

The growth of striped mullet in the waters of the town of Split is similar to that in the southern part of France. The growth lag in the waters of the southern France is attributed to the lower winter temperatures. This stagnation in growth is recorded in our waters from February to May. Two migrations are observed during the year: the onshore one and the offshore one. Growth rate of females is higher. They spawn once during the year, and males may spawn twice. First sexual maturity occurs at 10.5 cm. These fish inhabit muddy and sandy bottoms but not depths exceeding 200 m. More females were recorded from the channel area and more males from the open waters. Seven age groups were established. Juveniles migrate offshore and adult fish onshore. They feed on worms and shellfish.

Bogue feed mainly on zooplankton, more intensively at higher temperatures.

Three eel species were studied in the waters of the Neretva River, towns of Split and Trogir. The surveys of the distribution of the species of Mugilidae family were also carried out. The most numerous species are *Mugil cephalus* and *Mugil chelo*. Variations in the occurence of individual species at studied localities are due to the variations in temperature and salinity, as well as to their migrations for spawning. During the first year of life, the growth rate of females exceeds that of males. These differences are gradually reduced with years. *Mugil cephalus* reaches the first sexual maturity at 35 cm in the fourth year of life. They spawn from July to September and *Mugil chelo* from January to March.

Hake are widely distributed. The greatest density of their settlements was found in the Jabuka Pit, southerly from it and along the northeastern edge of the South Adriatic Pit. In shallower areas they prefer sardine, anchovy and sprat as food. In deeper waters the bigger hake specimens prefer mackerel as food. In addition, they feed on crustaceans and cephalopods. Small individuals feed on planktonic copepods.

Studies of lesser spotted dogfish were very detailed. A larger number of males than of females was recorded. Specimens of the same age keep together. They migrate vertically to greater depths for spawning and come back up for food. They feed on crustaceans, fish, cephalopods and polychaetes. Other cartilaginuous fish take similar food. Their most intensive feeding coincides with the most intensive spawning. Liver oil of cartilaginuous fish indicates differences between males and females, as well as those between

fertilized and non-fertilized individuals. Development of gonads seems to be connected with the metabolism of fat in livers. Thornback ray occur at depths not exceeding 160 m and they are frequent at 100—130 m, predominantly on mud. Brown ray prefer sandy-shelly bottoms.

Apart from fish, crustaceans and edible invertebrates were studied in detail. Settlements of Norway lobster are densest in the Jabuka Pit at 150——250 m. They prefer clayey-loamy bottoms. Individuals from the channels were found to be greater than those from the open sea. Females spawn every year, and they appear with outer eggs in July—January. Shrimps are recorded at depths exceeding 130 m, on muddy bottoms. Lobster larvae were recorded in December—April. They are hatched in January—February and their development lasts for 3—4 months.

Benthic algae were also investigated in detail. The inventory of benthic flora is rather rich. Algal vegetation has features of an independent subunit of the Atlantic—Mediterranean region with the particularly pronounced endemic and boreal characters. Four vertical bionomic steps and three substeps of the littoral may be distinguished: supralittoral, mediolittoral, infralittoral (upper to 5—6 m, middle from 6—30 m and lower down to 100 m) and eulittoral down to depths exceeding 200 m. Vegetation of benthic algae is horizontally divided into the subfacies of the open sea and subfacies of the coastal waters. Outer subfacies of open waters includes larger number of species than the inner one. However, some species distributed in outer subfacies are not distributed in the inner one, and some species distributed in the inner subfacies are not present in outer subfacies.

The trottoires (girdles) of calcareous algae are better developed in the outer subfacies. Red algae are mainly distributed in deeper waters, green algae in shallower waters, brown algae for the most part in the shallower areas but some of them are exclusively depth species.

A lithophytic zone of the supralittoral and partly mediolittoral was found to be formed of lythophytic Cyanophyceae. Substratum, temperature, light, salinity and waves affect the development and distribution of the species of genus *Cystoseira*.

The plasmolysis of brown algae was studied. It is held to be due to the increase in permeability.

A quantity of *Cystoseira* was assessed in an area of 1,300 km of the coasts of the mainland and islands. Total quantities are small and are estimated to amount up to 70,000 tons. Mean biomass value is 2.32 kg/m^2. Biomass of the mainland shores (13.1 t/km) exceeds that of the islands shores (4.84 t/km).

Iodine content of 60 examined algal species varies in the course of the year, as well as with depth. Mannitol content was also analyzed. Content of physodes is relatively low; low content of reductive substances was established to be in some connexion with salinity. The quantity and quality of alginic acid was analyzed in brown algae, as well as the quantity and quality of agar and agaroides in some of the red algae.

Twenty seven benthic biocoenoses were established to be formed on both hard and mobile bottoms of the coastal, channel and open Adriatic. By their basic composition they belong to the Mediterranean entity, however they display some properties of their own. The Adriatic biocoenoses are distingui-

shed by some special properties such as the occurrence of some endemic and boreal species, bathymetric distribution of some species and by the development of some typical biocoenoses of transitive character among which the biocoenoses of muddy bottoms of the open sea *Nephrops norvegicus* — *Thenea muricata* are of particular significance. These special properties of benthic biocoenoses are most marked in the northern Adriatic where the influence of the land and land waters is particularly intensive. Therefore, typical Mediterranean flora and fauna are impoverished to a certain extent and different euryvalent species are dominant with the occurrence of some endemic and boreal forms. As to the florial and faunal composition the biocoenoses of the central Adriatic are very similar to those of the northern part of the western Mediterranean. However, they also include some endemic forms. Biocoenoses of the southern Adriatic are similar to those of the central Adriatic. However, they include rather high proportion of thermophilous species. Biocoenoses of bathyal mud are well developed on the bathyal step (200—500 m). Some elements of the biocoenosis of large coral colonies are recorded from the solid substrata of the bathyal step.

Faunal beds of supralittoral, mediolittoral and upper infralittoral of rocky shores were described as well as their dependence on the shore slope, exposure to light and waves action.

Fish settlements of the central Adriatic channels were described. Dominant fish species were determined for three communities (of clayey, loamy and sandy substrata). Demersal fishes migrate onshore in spring-summer period and offshore to deeper waters in winter-spring period.

PRIMARY AND SECONDARY ORGANIC PRODUCTION

Basic significance of the investigations of production are the attempts to assess, as well as possible, the quantity of production so that this assessment may be applied in fishery practice.

Production in waters of the eastern Adriatic coast was investigated already in the pre-war period. Particular attention was given to the determination of factors affecting the production, either positively or adversely. By getting a better knowledge of different relations and parameters, the productive properties of the Adriatic Sea were described. Nutrient salts enter the Adriatic from the Mediterranean and from the rivers. They are also activated by the upwelling in the coastal zone. Plant cover of the coastal zone is also of importance. Four production zones were distinguished on the basis of distribution of quantities of nutrients. These zones were, as well, quantitatively defined by direct measurements. According to this division, zone A covers open and the central and southern Adriatic, zone B the shallow northern Adriatic, zone C the insular area of the eastern coast and zone D lagoons and some other productive basins. Mean annual production of the Adriatic was estimated to amount to 9 million tons of carbon. Within the adopted classification of world seas into five categories made by a group of the Russian authors on the basis of the daily primary production range, the Mediterranean as a whole belongs to the third category. The respective areas

of the Adriatic belong to the second, third or fourth categories. With respect to quantities of primary production, the Adriatic approaches the Mediterranean.

Production varies to a considerable extent from one year to another, due to the amount of Mediterranean water which enters the Adriatic. As it is well known, this water carries nutrients. This is the factor which affects the production of the major part of the open Adriatic. However, the influence of the north Italian rivers is also felt as far as the central Adriatic. The intrusion of Mediterranean water into the Adriatic is related to certain climatic parameters (bora wind, air pressure gradients). The long-term data proved the connexion between these parameters and production. It was also statistically determined that secondary production had a phase lag of, on an average, three years. These facts made possible a successful forecast of fish catch. On the basis of the data on primary production, as well as on the basis of some presumptions concerning the efficacy at individual trophic steps, annual fish production was estimated at 380,000 tons. Fluctuations of fish production in relation to the described factors were also estimated. Fish production was assessed on the higher trophic steps, as well — using the zooplanktion and fish eggs.

Fish biomass was estimated also by different methods. An attempt was made to make an assesment through counts of eggs and larvae. These estimations gave higher values. Thus, the biomass of anchovy was estimated to amount to 927,000 tons for the area of about half the Adriatic.

The existing stock of pelagic fish was assessed in different areas by a direct method using an echointegrator. Further, the pelagic trawl was used for the assessment of the fish quantity in the experimental spatial intervals.

Data on sardine catches from the eastern Adriatic covering a period of a hundred years, were studied by spectral analysis. A correlation was found to exist between the sardine catch and the Sun spot cycles. Thus, maximum catches are realized, on an average, two years upon the maximum Sun activity. A tentative forecast of the trend of sardine catch for the period of hundred years was given on the basis of the analysis carried out.

Bottom settlements may be assessed from the long-term trawling data records. Using these data as representative, edible trawling biomass in the area of the epicontinental belt was estimated a 230,000 tons. The limits of biological levels of exploitation are somewhere between 50,000 and 80,000 tons per year. These limits have already been exceeded.

With respect to the relatively low level of Adriatic production, continuous attempts have been made in the post-war period to find a cheap and practical method for fertilization of the sea. The hypothesis was posed that soluble nutrient matter would be better and that it would suffice to add only phosphate fertilizers that the plants themselves could make the compounds with nitrogen from the air. The large-scale experiments on the Mljet Island lakes gave good support to these assumptions. The eutrophication of the basin was established. Positive effects were best evident on shellfish. Unfortunately, the rezults of this experiment have never been apllied in practice to any significant extent.

PROMOTION OF FISHERIES

The investigations aiming to promote fisheries have had a prominent role from the very beginning of the work of the Institute. This is particularly applicable to the post-war period.

After 20 years of exploitation by trawling it was established that the settlements in the channel »Planinski kanal« (Hrvatsko primorje) were damaged. The channel »Podvelebitski kanal« was richer but with a lot of chondichthyes. Statistical analysis of the trawl catches from the eastern Adriatic showed that the density of settlements of the open sea exceeded that in the channels. Quantity of hake was also found to be reduced by the intensive fishing.

Bottom settlements of the very large area were very well described by the data collected during the HVAR Expedition. This material remained the main source of these data since the experimental trawling has never been repeated in an area of such a large extent. These data have been used on different occasions. Thus, they have been used for the assessment of settlements and as the basis in negotiations with Italy for the exploitation of the Yugoslav territorial waters. Settlements control has been continuously carried out at selected stations. Settlements of the demersal edible species of the Adriatic have been categorized in 7 areas: channels of the northern Adriatic, western Istrian coast, island Dugi otok, Blitvenica and Jabuka Pit, open central Adriatic channels and the Montenegro coastal area. The nothern Adriatic channels and the open central Adriatic are the best exploited areas. Trawling grounds in the central Adriatic were separately described on the basis of the relations between the principal groups, density of edible settlements and the relations between the edible and non-edible bycatch. The best trawling grounds are those in the biocoenoses *Thenea muricata — Nephrops norvegicus*. The data collected from the area of Blitvenica in 1960—1970, showed that the diurnal catch per trawler was reduced for the edible part and that the exploitation did not effect the structural changes of the settlements. It was earlier held that the proportion of chondrichthyes decreased with the intensive fishing, and that that of gadidae increased. The mesh size was recommended and the opinion on the economy of catches given together with the recommendations for the improvement of fishing methods.

Algal vegetation from the trawling grounds was described, as well.

The catches realized by nets »tartane« were studied in northern Dalmatia, where picarel are predominant with 87%. Winter catches exceed the summer ones.

Statistical analysis of the catches of norway lobster did not show that a relation exists between the fishing effort and catch.

The effectiveness of hauling with different bridles (steel or manila) was examined. Steel bridles proved to be somewhat better.

The deep Adriatic was studied by the use of long lines. Cartilaginuous and bony fishes were found. Settlements might be vertically divided in three layers. No influence of hydrographical properties on distribution was established. The most suitable baits were examined. Horse mackerel is the best one, then come hake, bogue and sardine.

Maturity time and the time of spawning were determined for more than 60 fish species, as well as their maximum lengths.

Variations in the catch of the pelagic fish have also been continuously observed and studied. In the pre-war period already the significance of catch statistics was pointed out. It has been continously attempted to improve fishery statistics in compliance with our scientific demands and international obligations.

Statistics of the catch of small pelagic fish showed that anchovy and sprat coincided, while sardine and anchovy, anchovy and mackerel, and sardine and sprat alternated in the catches realized in the central Adriatic in the pre-war period. Anchovy, sardine and mackerel occur throughout the Adriatic but two areas of larger concentrations are separated by the Jabuka Pit. Depth is the factor of horizontal distribution of small pelagic fish. Annual changes in the mean length of sardine from the open central Dalmatian insular area were found to be due to the frequency of occurrence of individual annual classes.

Mixed catches of pelagic fish show that sardine and anchovy may be caught together. However, at considerably different lengths they do not make coherent groups but only temporary aggregations. Horse mackerel and bogue may be caught with sardine.

The annual distribution of small pelagic fish shows that seasonal fluctuations of catches are due to the physiological state of fish as well as their migrations for spawning and food.

To provide relevant information to the fishery industry small pelagic fish were tracked by the ultrasonic detectors. This was carried out in the large areas of the northern and central Adriatic during some few seasons. These investigations showed the uneven distribution of small pelagic fish, but, as well, the possibility of fishing throughout the year.

Attempts have recently been made on the artificial rearing of fish. The review of the basins suitable for the lagoonar fisheries and fish farming has been given. Some recommendations concerning the building of fish farms for mullet on our coast have been given. The sea bream feeding was experimentally examined, as well as some aspects of fish behaviour under captivity conditions.

Specialists from the Institute take an active part in fisheries legislation and are the consultants for the questions of fishery practice.

A series of scientific meetings on the application of ultrasonic detection in the Adriatic fisheries were very successfully organized. This resulted in a more efficient catch of small pelagic fish.

RELATIONS BETWEEN THE ADRIATIC AND MEDITERRANEAN

The Adriatic may be understod to be one of the adjacent basins of the Mediterranean sea. As to its hydrographical properties, the Adriatic is more continental, particularly in its northern part. The open southern and central Adriatic are under the continuous influence of the Mediterranean. However, the intensity of this influence is not always the same. This influence is particularly felt in the intermediate layer. The Mediterranean intermediate

water exerts positive effects on the production since it is richer in nutrients than the Adriatic water. On the other side, due to its more pronounced continentality, i.e. owing to the intensive winter cooling, the Adriatic is one of the main source areas of formation of the Mediterranean bottom water, since the densest Mediterranean water was recorded in the northern Adriatic. This is due to the shallow depths and the influence of the bora. In biological terms boreal flora and fauna are characteristic for the northern Adriatic. However, as one proceeds more suthwardly the Adriatic plant and animal communities become more and more that of the Mediterranean type. Groups and species taken as the indicators of the Mediterranean water in the Adriatic were determined in the plankton communities. Their long-term fluctuations were also observed.

RELATIONS BETWEEN THE COASTAL SEA AND OPEN WATERS

The eastern Adriatic coast is characterized by the large number of islands which act as a barrier for the water exchange between the coastal waters and those of the open sea. This insular belt is in any case the cause of the lower current speeds. Thus, while the mean current speed is 20 cm/sec in the open central Adriatic ,in its coastal area the mean current speed is half that in the open sea. The fact that the flow is, on an average, more rapid along the western coast than along the eastern one proves that the insular belt causes this reduction in speed. Flow mainly takes place in two layers in the coastal area, and in three layers in the open sea. Further, flow directions are more dispersed in the coastal zone. Therefore, the sedimentation rate is smaller in the open sea than in the coastal one. Particles deposited in the coastal area are coarser and the terrigeneous component is marked so that the occurrence of mud is possible. The coastal sea is also under the strong influence of the land waters. Both the rivers and the rain introduce the terrigeneous component and nutrient matter. Apart from all this, upwelling occurs there in summer and winter. It enriches the coastal waters by nutrient matter from the bottom. Thus, due to the land drainages and the upwelling of nutrient matter from the bottom the coastal sea is richer in nutrient salts and therefore production is higher there. Production has also recently been increased there as a consequence of pollution of that zone. Due the conditions that have been previuosly mentioned, the sea transparency is reduced in the coastal area. Further, the relationship between nutrient salts in this zone differs from that in the open waters. Thus, the amonium dominates among the coastal waters nitrogen salts. Due to the more continental character of this area, the annual ranges of temperature and salinity as well as of some other properties are greater. All this affects the composition of pelagic and demersal communities.

Algae are developed at greater depths owing to the higher transparency of the open sea. As to the vegetation, the outer belt of open waters is clearly distinguished from the inner belt of the coastal-channel waters. The trottoire of the calcareous algae is better developed in the outer belt owing to the more favourable substratum. Different biocoenoses are formed in the coastal

region as distinct from the open waters. The density of trawling settlements was found to be greater in the coastal zone. However the ratio edible bycatch — nonedible bycatch is somewhat less satisfactory.

The higher production in the coastal waters is, in the phytoplankton, characterized by the dominance of diatoms. In the open sea, coccolithineae and different flagellate forms prevail. More larval species were recorded from the open sea as well as more zooplankton organisms and higher quantity of eggs of some fish species (anchovy). The proportion of the genus *Clausocalanus* is increased in the zooplankton of the open sea, however its absolute density is reduced. Pelagic fish undertake either offshore or onshore migrations in the respective stages of their lives (spawning, feeding).

In general, the number of species in the open sea exceeds that in the coastal waters. However, the production in the open sea is lower than in the coastal one.

IMPACT OF MAN ON THE SEA, CO-OPERATION WITH FIRMS AND INTERNATIONAL CO-OPERATION

Even though man has affected the sea by fishing over a long, long period, due to the magnitude of resources and low scale of exploitation, the resources were not seriously treatened until recently. The magnitude of resources has been approximately assessed and the potentialities for future fishing estimated. The associates of the Institute took an active part in a series of national and international conferences treating these problems. The continuous co-operation with fishery firms has been developed for a long time.

A series of papers of both our and foreign workers have been published which have come as a result of successful international co-operation. Here the work on zooplankton, herring, striped mullet, sardine, anchovy and some other commercially important demersal fish species are noted. Joint work of the Yugoslav and Italien workers on the assessment of the total fish stock is of particular importance for the more rational exploitation and management of fisheries resources.

Apart from its co-operation with the fisheries business firms, the Institute has realized a successful co-operation with other branches of economy such as Water Management and Electric Power Industry. Thus, for the purpose of marking out the submarine electric cables through which some of the Adriatic islands were supplied the electric power, the relief and geological composition of the Adriatic channels were studied. Large-scale investigations were carried out at the site where a nuclear power plant is likely to be erected.

Marine pollution has recently become a serious problem. Owing to desire to exploit to the maximum the potentialities for economic development offered in the coastal belt the erection of a series of industrial buildings and installations has been planned. Thus, the Institute worked out a large number of Project Reports in which were published the results of investigations on the potentialities of assimilation of different waste materials and the prospects for protection measures. This was a serious task, since the forecasting of the changes affected by man is a complex one and requires organized

team work of the large number of specialists. As to the pure scientific approaches, some few new tasks have been successfully solved by the application of a large number of modern methods. Individual areas should have been defined in terms of dynamics by means of the employment of the appropriate schemes and models. Some chemical and biological parameters, not earlier determined have had to be determined. Thus, the work on determination of food chains in the sea, on the quantification of eutrophication, on the influence of polutants (pesticides, lead) on marine organisms and the composition of communities in polluted waters has been undertaken. Marine poollution has also become the problem on an international level. International co-operation has been organized on the Mediterranean. The institute has been successfully included in 6 pilot projects, undertaken to show the state of pollution in the Mediterranean.

In general, from its foundation the Institute has taken an active part in international co-operation. Institute's associates have been the participants in almost all the congresses and consultations in oceanography and fisheries. They are particularly active in the General Fisheries Council for the Mediterranean (FAO), in the International Commission for the Scientific Exploration of the Mediterranean Sea (CIESMM). One General Assembly of this Organizations was, therefore, held in Split in 1976, as well as the FAO GFCM Meeting in 1967. The publications of the Institute are exchanged with more than 400 institutes all over the world.

NEW GENERAL KNOWLEDGE OF THE ADRIATIC SEA

From this summary of the scientific achievements of the Institute it may easily be inferred that they have given a significant contribution to the knowledge of the Adriatic Sea. This, in the first place, refers to the ecology of populations and communities. The investigations of phyto and zooplankton, as related to the evironment, were the pionner ones in the Mediterranean. So far, all the principal groups of organisms, particularly those of commercial importance have been studied. The structure of different settlements have been surveyed and they have been quantitatively assessed. A series of new data on flora and fauna have been obtained. The biology of a large number of organisms has been well investigated. The large-scale ivestigations of the long-term seasonal fluctuations of dynamic, hydrographical and biological properties have been carried out. Their fluctuations have been accounted for. Factors affecting the wider area of the Mediterranean, and not only the Mediterranean, have been noted, as well as those the activity of which is only locally felt. The Adriatic has been estimated as related to the other seas, and its production, as well as the potentialities of its exploitation assessed. The basic natural fluctuations of biota and its environment have been studied. They have already been used in global forecastings of the catch and the changes in the sea due to exploitation and other factors.

PERSPECTIVES OF THE FUTURE RESEARCH ACTIVITIES

The starting points for the future investigations are the exploitation and protection of the sea. They are connected in their functions, since it is quite obvious that with the intensified exploitation the protection should also be intensified in order that the natural environment will not be threatened seriously. The collection of the ever larger number of data requires a more organized approach to their processing and the application of modern statistical methods of processing. The need for the application of models, both dynamic and ecological, is particularly pronounced. They would make possible more accurate forecasting of the changes due to the already existing exploitation of the sea and the disturbances of natural balances. To achieve these goals it would be necessary to make more profound researches of different physical, chemical, geological and biological processes through continuous observations of all changes as well as through experimental work.

REZULTATI ZNANSTVENOG RADA INSTITUTA ZA OCEANOGRAFIJU I RIBARSTVO U PROTEKLIH 50 GODINA

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Posvećeno dragim pokojnim kolegama, koji su svojim radom trajno zadužili Institut: dr Ante Ercegoviću, dr Vlahi Cviiću, dr Dinku Moroviću, dr Tonku Šoljanu dr Miljenku Buljanu i dr Otmaru Karlovcu.

Ovaj referat je pisan prvenstveno prema rezultatima objavljenim u publikacijama Instituta, jer je bilo vrlo teško obuhvatiti i sve radove njegovih suradnika u raznim vanjskim publikacijama. Obuhvaćeni su i radovi nekih vanjskih suradnika publiciranih u edicijama Instituta, i to oni koji su ili terenskim radom ili na neki drugi način bili direktno vezani uz rad Instituta. Uz ovaj referat se posebno daje bibliografija radova, pa se u samom referatu iz tehničkih razloga ne citiraju posebno autori.

Osnovni znanstveni časopis Instituta, »Acta Adriatica«, je počeo izlaziti 1932. godine i do danas je tiskan 21 volumen s ukupno 270 radova. Za potrebe brzog publiciranja kraćih saopćenja Institut izdaje »Bilješke« u kojima je do danas tiskano 40 priloga. U publikaciji namijenjenoj rezultatima Ribarstveno-biološke ekspedicije »HVAR« tiskano je do sada u 6 volumena 17 radova. U elitnoj ediciji »Fauna i flora Jadrana« izašla su tri djela, a u ediciji »Posebna izdanja« 7 knjiga. U prijeratnom razdoblju tiskana su i 2 Godišnjaka Instituta (1938. i 1939) i u njima 23 rada. U poslijeratnom razdoblju Godišnjaci su publicirani samo za internu upotrebu. Od 1968. izlazi i edicija »Zbornik radova« sa člancima instituta suradnika tiskanim u vaninstitutskim publikacijama. U dva volumena je do sada sabrano 86 radova. U ovaj pregled još treba uključiti i preko 150 elaborata (43 evidentirana u internoj ediciji »Studije i elaborati«) izrađena u dogovoru s raznim privrednim organizacijama ili društveno-političkim zajednicama.

Do sada je, tj. u proteklom 50-godišnjem razdoblju, u institutskim publikacijama objavljeno ukupno 598 znanstvenih i stručnih radova. Teško je precizno odrediti broj radova u vaninstitutskim publikacijama, ali taj broj premašuje 600, pa ukupan broj objavljenih radova institutskih suradnika premašuje 1200. Ovdje nije uključen vrlo aktivan rad na popularizaciji znanosti, tj. velik broj stručno-popularnih članaka i suradnja sa sredstvima javnog informiranja.

U ovom pregledu nije bilo moguće iznijeti pojedinačno sve dobivene rezultate, pa su oni grupirani u nekoliko tema i iznijeti u sumarnom obliku. Ne treba posebno istaknuti, da se gotovo sva istraživanja odnose na Jadransko more, pa se to dalje uvijek posebno ne ističe. Izdvojene su slijedeće teme:

1. Ekspedicijski rad
2. Hidrografija
3. Dinamika
4. Flora i fauna
5. Ekologija
6. Produkcija
7. Unapređenje ribarstva
8. Odnos Jadrana i Mediterana
9. Odnos obalnog i otvorenog Jadrana
10. Utjecaj čovjeka na more, suradnja s privredom i međunarodna suradnja
11. Nova opća saznanja o Jadranskom moru
12. Perspektive daljnjih istraživanja

EKSPEDICIJSKI RAD

Sakupljanje podataka na moru, te njihovo sistematiziranje i obrada je baza svih oceanografskih istraživanja, te je prirodno da je Institut tu aktivnost svestrano razvijao.

U prijeratnom razdoblju (1932—1937) s malim brodom »BIOS« sistematski su sakupljani podaci na 4 postaje srednjedalmatinskog otočnog pojasa. Poslije rata je 1948—1948. organizirana Ribarstveno-biološka ekspedicija »HVAR« koja je sa 176 postaja pokrila cijeli otvoreni Jadran, osim najvećih dubina. Materijal te ekspedicije do danas je nenadoknadiv u smislu podataka o prostornoj rasprostranjenosti pelagičnih i posebno bentoskih naselja. U toku Međunarodne geofizičke godine 1957—1958. Institut je bio suorganizator ekspedicija »MINER« i »SPASILAC«, kada je na 5 profila otvorenog srednjeg i južnog Jadrana na ukupno 6 krstarenja prikupljen bogat oceanografski materijal, koji je trebao pokazati eventualne promjene iza 42 godine, tj. poslije završetka rada ekspedicije »NAJADE« i »CICLOPE«. Ovakvo prostorno uzorkovanje dobilo je svoju odličnu nadopunu u dugogodišnjem prikupljanju podataka na permanentnim postajama srednjeg i južnog Jadrana. Tako organizirano prikupljanje hidrografskih podataka otpočelo je još 1948. sa reprezentativnim postajama za obalno područje, kanale srednjeg Jadrana i otvoreno more, u mjesečnim ili sezonskim intervalima. Postepeno se je povećao broj parametara, te je on danas takav da obuhvaća kompletnu hidrografiju uključujući kemizam i dinamiku, kompletan plankton, te kontrolu pelagičnih i pridnenih naselja uz dobro uhodan timski rad. Kontrola ribljih naselja se još provodila u vrlo opsežnim terenskim radovima, pa je ultrazvučnom detekcijom bio pokriven velik dio Jadrana, a pridnena naselja su trajno praćena i u području Blitvenice. Srednjedalmatinski arhipelag je bio opetovano pokriven

velikim brojem postaja u okviru rada na ihtiopelagijalu (plankton i nekton), kao i eksperimentima markiranja srdele zbog studija njezinog kretanja.

Kaštelanski zaljev je u više navrata vrlo temeljito istražen. Osim trajne kontrole na jednoj postaji, u tri navrata (1953—1954, 1972—1973, 1975—1976) je ona izvršena na nizu postaja. Osim toga se trajno prate svojstva mora na postajama u blizini vrulja.

Institut je proveo uspješan višegodišnji eksperiment gnojenja mora na Mljetskim jezerima s intenzivnom kontrolom relevantnih parametara, a sličan eksperiment kraćeg trajanja je proveden u Marinskom zaljevu.

Od 1970. g. se pažljivije istražuje obalno područje u vezi s raznim projektima iz domene zagađenja i zaštite mora. Postupno je vrlo intenzivno obuhvaćeno područje Zadra (uz Virsko more), Šibenika, Splita i Dubrovnika, a u suradnji s drugim institutima i Riječko područje, te Crnogorsko primorje. Od 1976. godine uspostavljen je monitoring za kontrolu kvalitete obalnog mora od Vira do Konavlja.

Uz niz drugih sporadičnih radova na moru ovo predstavlja golemi fond podataka koji doprinosi sve boljem i dubljem poznavanju Jadrana. Povećanje broja podataka dobro ilustriraju strujomjerni podaci. Direktno sistematsko mjerenje struja je započeto 1956. godine. U razdoblju do 1970. je prikupljeno cca 2000 podataka. Kasnije je samo u jednoj kampanji u Splitskom području 1972—1973. prikupljeno 16 000 podataka, da bi od 1975—1979. samo u području Virskog mora bilo prikupljeno cca 130 000 podataka. Ovakav nagli razvoj instrumentalnih metoda zahtijeva i modernu klasifikaciju, te suvremen statistički pristup uz usvajanje novih metoda obrade i prezentiranja materijala, što je uspješno usvojeno.

HIDROGRAFIJA

U ovom poglavlju su obuhvaćeni morfološko-geološka, kemijska i fizikalna svojstva bez dinamike. Ova su se istraživanja prvenstveno odvijala povezano s biološkim problemima, osobito u predratnom razdoblju. U novije vrijeme ova je problematika sve prisutnija zbog raznih novih potreba prakse.

Na redovnim krstarenjima registrirani su neki novi podaci o reljefu nalazom nekoliko novih brakova u području srednjedalmatinskog arhipelaga.

Određen je mehanički sastav taloga otvorenog Jadrana, te je nađeno na 58% postaja glinasto-ilovasto, a na 42% postaja pjeskovito dno. Pjeskovito dno je osobito rašireno u sjevernom Jadranu. U otvorenom Jadranu je nađen pravilan raspored sedimenata s pretežnim muljem u većim dubinama, ali u nekim kanalima istočne obale raspored sedimenata nije pravilan, što je u vezi s posebnim dinamičkim svojstvima. Otočni pojas djeluje kao barijera za taloženje sedimenata porijeklom iz sjevernog Jadrana. Ukazano je na posebnu vertikalnu stratifikaciju sedimenata na Mljetskim jezerima, koja je povezana s pojavom H_2S i vulkanskom komponentom.

Jadranske foraminifere su raspoređene u 4 dubinske zone, a njihov raspored ovisi o temperaturi i prvenstveno o dubini.

Dugogodišnja kontrola osnovnih hidrografskih faktora kao temperature, slanosti, prozirnosti, sadržaja kisika i hranjivih soli, alkaliniteta i drugih,

omogućila je dobivanje dobre slike o horizontalnoj i vertikalnoj rasprostranjenosti, te sezonskim i višegodišnjim fluktuacijama tih parametara na otvorenom moru i u priobalju.

Jadran je umjereno toplo more, te mu u najdonjim slojevima temperatura ne pada ispod 11°C. Temperatura opada s dubinom a na 10—30 m se u toplom razdoblju godine javlja termoklina. Jesenska izotermija se u južnom Jadranu uspostavlja na temperaturama od 18—19°C, a hlađenje uz obale je intenzivnije i izotermija se ranije uspostavlja. U obalnom području godišnji maksimum nastupa u julu i augustu, a minimum u februaru. Na otvorenom moru nastup ekstrema zakašnjava oko mjesec dana. Godišnje amplitude temperature također opadaju idući od obale prema otvorenom moru. Izrađeni su normalni grafovi za praćenje vertikalnog rasporeda temperature tokom godine. Horizontalni raspored temperature također se mijenja tokom godine. Južni Jadran je zimi topliji od srednjeg i sjevernog i to za 8 do 10°C, ovisno o godini, a u ostalim sezonama su temperature horizontalno izjednačenije. Otvoreno more je toplije od obalnog. Površina mora je toplija od zraka (u Splitu u prosjeku za 1.1°C, a u Rovinju 2.2°C). Veća razlika se javlja, kada kopno više utječe na temperaturu zraka. Na godišnji hod temperature površine mora utječu vjetar i naoblaka. Višegodišnje fluktuacije temperature otvorenog Jadrana povezane su s nejednakim obimom izmjene vode između Jadrana i Mediterana. Pojačan utjecaj Mediterana može povisiti temperaturu otvorenog južnog Jadrana za nekoliko stupnjeva.

U zaklonjenijim obalnim područjima u nekoliko navrata je zabilježena pojava leda na moru i objašnjen njegov nastanak.

Pomoću jednadžbe za toplinski budžet izračunata je srednja godišnja evaporacija za Jadran s vrijednosti od 106 cm godišnje. U hladnom dijelu godine je evaporacija više nego dvostruko veća nego u toplom dijelu. Izračunat je i srednji godišnji priliv slatke vode, koji je veći od evaporacije, pa je Jadran u osnovi bazen dilucije.

Salinitet Jadrana je relativno visok i u otvorenim vodama južnog Jadrana varira od 38.43 do 38.85‰. U obalnom području je niži i ima znatno veće godišnje fluktuacije. Vertikalni raspored u južnojadranskoj kotlini je sličan kao u Jonskom moru, a jasno se razlikuju površinski, intermedijarni i pridneni sloj. Najviša slanost je u intermedijarnom sloju. Izrađene su karte i grafovi normalnog rasporeda slanosti. Na istočnoj obali površinski salinitet ima dva minimuma: u aprilu-maju i decembru-januru i dva maksimuma: u septembru i februaru. Višegodišnje promjene saliniteta su povezane s utjecajem istočne mediteranske vode, a taj je utjecaj mogao biti objašnjen intenzitetom nekih klimatskih faktora u istočnom Mediteranu.

Studirane su ciklične soli, tj. sadržaj klorida u kišnici obalnog pojasa, pa je nađeno da uz jači vjetar raste količina klorida u kišnici, ali je u dužem razdoblju odnos kiše i klorida konstantan. Data je procjena količine soli u obalnoj zoni.

Dugogodišnji podaci o prozirnosti u srednjem Jadranu pokazuju najniže vrijednosti u jeseni, niske zimi i porast u proljeće i ljeti. Prozirnost raste idući od sjevernog prema južnom Jadranu, te idući od obale prema otvorenom moru. Prozirnost se smanjuje u godinama povišene produkcije, a u novije vrijeme i pod utjecajem polucije. U Kaštelanskom zaljevu je mjerena ekstinkcija crvenog i plavog dijela spektra, pa je nađeno da se odnos te dvije kom-

ponente može povezati s količinom fitoplanktona. Optička mjerenja su vršena i fotometrima, a također je mjerena apsorpcija dnevnog svjetla.

Studiran je utjecaj slatkih voda na svojstva mora. Posebno su istraživani estuari Krke i Zrmanje, ali i utjecaj rijeke Jadro u Kaštelanskom zaljevu, kao i ušće Cetine i Neretve. Studirana je i cirkulacija podzemnih voda u obalnom području Dinarskog krša; u vezi s tim i vrulje. Istražen je utjecaj vrulja u Kaštelanskom zaljevu na svojstva mora (sedimentološki, batimetrijski, morfološki i hidrološki aspekt). Zimi one vidljivo djeluju na svojstva okolnog mora, a ljeti se njihov utjecaj ne osjeća. Promatrani su morfologija, hidrografija, hidrogeološka svojstva i geotektonski odnosi vrulja kao fenomena izbijanja slatke vode na morskom dnu iz potopljenih vrtača. Na njihovu obodu je nađen materijal terigenog porijekla. Hidrološki su istražene i splitske toplice, te je nađeno da im je najobimnija komponenta morska voda, zatim podzemna voda sa dosta sulfata i oborinska voda u godinama s dosta kiše.

Od kemijskih svojstava su posebno studirane količina kisika i hranjivih soli, zbog povezanosti tih svojstava s produkcijom mora.

U vertikalnom rasporedu sadržaj kisika se normalno povećava od površine prema dubini od 10—40 m, gdje je često prezasićenje. Dubokojadranska kotlina je bogata kisikom u velikim dubinama, jer on tu dolazi advekcijom vode iz sjevernog Jadrana. Starost te vode se je lijepo mogla ustanoviti prema sadržaju kisika u dubljim slojevima Jabučke kotline, što je bio dokaz da se ta voda ne obnavlja svake godine.

Usporedba sadržaja slobodnih fosfata u dvije jadranske kotline je pokazala da je do dubine od 200 m južnojadranska kotlina bogatija od Jabučke kotline, što znači da se srednji i južni Jadran u tom sloju slobodnim fosfatima obogaćuju s juga. Intenzivna istraživanja pridnenog sloja su pak pokazala da je u tom sloju Jabučka kotlina snabdjevač svim hranjivim solima za južnojadransku kotlinu i palagruški prag.

Od dušikovih soli u srednjem i južnom Jadranu je uz obalu dominantan amonijak. Nitrata ima više u hladnom dijelu godine, a nitriti imaju uz obalu maksimum u januaru. Duboke jadranske vode su također bogatije fluoridima, zbog njihova otapanja s dna.

Promatrana je čestost elemenata u moru i zemaljskoj kori u odnosu na prirodni sustav elemenata. Čestost opada s porastom atomskog broja. Svrstavanje elemenata po grupama je omogućilo predviđanje nekih elemenata u moru, koji su kasnije utvrđeni eksperimentalno. Laboratorijski rad je dao i nekoliko metodskih inovacija. Također je dat način određivanja kontaktne petrolejske vode, tj. vode koja je bila u kontaktu s ugljikovodicima, a što bi omogućilo da se uz pomoć jedne oceanografske metode detektiraju nalazišta ugljikovodika.

DINAMIKA

Svestrano istraživanje je pokazalo da je strujanje u Jadranu naročito utjecano izduženim oblikom bazena, te njegovim kontinentalnim karakteristikama. One se očituju u prvom redu u jako izraženim sezonskim ekstremima temperature i drugih svojstava, osobito u sjevernom Jadranu. Iz tog razloga je sjeverni Jadran zimi znatno hladniji od ostalog dijela, a ljeti nešto topliji. Time su protumačene znatne sezonske varijacije u strujnom režimu.

Meteorološki uslovi su također studirani i nađen je njihov jak utjecaj na dinamička svojstva.

Vertikalno je otvoreni Jadran podijeljen na tri sloja: površinski, intermedijarni i pridneni. Izračunate gradijentske struje i direktna opažanja stacionarnim strujomjerima i plovcima pokazuju da se u uopćeno ciklonalnom strujanju površinskog sloja zimi pojavljuje pretežno ulazno strujanje u Jadran s većim brzinama uz istočnu obalu, a ljeti pretežno izlazno strujanje s većim brzinama uz zapadnu obalu. Iako su ove sezonske promjene prvenstveno uslovljene geostrofičkom komponentom strujanja, vjetar također utječe u tom smislu, jer ljeti prevladavajući maestral daje izlaznu komponentu, a zimi jugo ulaznu. Nije nađena direktna evidencija za takovu vezu, ali se ona manifestira nađenom korelacijom između zonalnih razlika tlaka zraka nad istočnim Mediteranom i salinitetom jadranske vode. Gradijenti gustoće između sjevernog i južnog Jadrana u površinskom sloju su zimi pretežno uzrokovani razlikama u temperaturi, a ljeti razlikama u salinitetu. U proljeće i u jesen ti se gradijenti smanjuju, pa se smanjuje i izmjena vode između sjevernog i južnog Jadrana. Tako dok ljeti i zimi u širokom području otvorenog srednjeg i južnog Jadrana prevladava longitudinalno strujanje, u proljeće i jesen prevladava transverzalno. S tim u vezi je i godišnji ritam prevladavajućih smjerova u području palagruškog praga, tj. praga između Jabučke i južnojadranske kotline. Zimi je prevladajući smjer NW, u proljeće N, ljeti SE, a u jesen SW. Ovakovo strujanje povratno utječe na raspored slanosti i temperatura. Karte srednjih sezonskih izotermi površinskog sloja jasno pokazuju utjecaj ulazne struje zimi, koja donosi topliju mediteransku vodu. U proljeće transverzalno strujanje u području palagruškog praga (Split-Gargano) uvjetuje južno i sjeverno od njega dva odijeljena područja, a slično je i u jesen. Sezonskim promjenama u režimu strujanja mogle su se objasniti i razlike u godišnjem hodu slanosti na istočnoj i zapadnoj obali Jadrana.

T-S dijagrami su vrlo dobro izrazili pojavljivanje intermedijarnog sloja. Od površinskog sloja je odijeljen dubinom od 20 do 40 m, ovisno o području i sezoni, a proteže se do cca 400 m u južnom i cca 200 m u srednjem Jadranu. U tom sloju u toku cijele godine prevladava sjeverozapadno strujanje. Ljeti se to strujanje može shvatiti kao kompenzacijsko jugoistočnom strujanju u površinskom sloju. Zimi se u površinskom i intermedijarnom sloju pojavljuje isto strujanje, a kompenzira se izlaznim jugoistočnim strujanjem u pridnenom sloju. Intenzitet strujanja i količina mediteranske vode, koja u tom sloju ulazi u Jadran, jako variraju iz godine u godinu u ovisnosti o određenim klimatskim faktorima koji zahvaćaju cijelo područje istočnog Mediterana. Inače je sjeverozapadno strujanje intermedijarnog sloja najkonzistentnije, te se u području palagruškog praga pojavljuje s frekvencijom od 30 do 50%.

U pridnenom sloju prevladava izlazno strujanje. Zimi se u plitkom sjevernom Jadranu voda ohladi u cijelom stupcu i ta gusta voda struji u Jabučku kotlinu, a iz nje u pridnenom sloju u duboki južni Jadran. Izneseno je mišljenje, da ta voda prelazom preko Otrantskog praga utječe na pridneni sloj cijelog istočnog Mediterana.

Izračunat je transport vode preko Otrantskih vrata na osnovu određenih pretpostavki i on iznosi 7.8×10^3 km^3 na godinu, što bi dalo izmjenu vode u cijelom Jadranu u roku od 5 godina. Prema jednom proračunu transporta na profilu preko srednjeg Jadrana, on može varirati iz godine u godinu do 30 puta. Višegodišnje fluktuacije u brzini izmjene vode između Jadrana i Medi-

terana su svakako vrlo velike. Razdoblja intenzivnog djelovanja Mediterana na Jadran su nazvana jadranskim ingresijama. Tim putem unesene količine hranjivih soli, te fluktuacije imaju vrlo uočljiv utjecaj na produkciju. Zbog toga su te višegodišnje fluktuacije pažljivo istraživane. Godišnji maksimum saliniteta na profilu Split-Gargano se je pokazao kao dobar indikator za intenzitet advekcije mediteranske vode u Jadran. On se je mogao dobro dovesti u vezu sa gradijentima tlaka zraka nad istočnim Mediteranom. Također se je i sezonski ritam izmjene vode između Jadrana i Jonskog mora mogao povezati sa sezonskim ritmom u baričkom polju nad istočnim Mediteranom, tj. pretežno zonalnim gradijentima ljeti i meridionalnim gradijentima zimi. Višegodišnje klimatske promjene studirane su i za šire područje, jer se je pokazalo da se takove promjene odigravaju istovremeno nad vrlo velikim područjem i da je za njihovo razumijevanje potrebno istražiti veliki areal. Nađeno je npr. da se promjene slanosti u Jadranu mogu dobro povezati s količinom leda u sjevernom Atlantiku, koji je indikator klimatskih prilika širokog prostora sjevernog Atlantika i Europe.

Određivanje tipova vode otvorenog Jadrana dalo je uvid u način formiranja duboke vode. Od 4 tipa jadranske vode, po jedan se formira u sjevernom, srednjem i južnom Jadranu, a četvrti je intermedijarna istočna voda porijeklom sa Levanta. Sjevernojadranska voda je najgušća, a samo u nekim godinama dosegne potrebnu gustoću da utječe na srednji Jadran, odnosno da obnovi pridnenu vodu Jabučke kotline. Srednja i južnojadranska voda se formiraju zimi u uslovima manjeg djelovanja istočne vode na Jadran, a uz pojačano vertikalno miješanje. Značajno je da je nekih zima voda u južnojadranskoj kotlini potpuno homogena sve do dna. Bura je važan faktor za formiranje dubinske vode. Pojava većih količina istočne intermedijarne vode zimi povećava, a ljeti smanjuje površinsku temperaturu mora, povećava salinitet, te djeluje još na niz drugih hidrografskih i bioloških karakteristika.

S boljom detekcijom raznih svojstava, sve se je češće uočavala pojava upwellinga. Prvo je uočena ljeti na obalama vanjskih otoka i povezana s dizanjem intermedijarne vode uz te otoke, koji djeluju kao barijera strujanju u intermedijarnom sloju. Također je uočen utjecaj maestrala. Zatim je nađen upwelling uz obalu zimi pod djelovanjem bure.

Velik broj podataka prikupljanih posljednjeg decenija u obalnom području dao je uvid u niz specifičnih karakteristika priobalja i odnosu prema otvorenom moru. Ovdje se pretežno pojavljuju dva sloja, odijeljena u toplom razdoblju termoklinom. Brzine struja su nešto manje nego na otvorenom moru, a sjeverozapadni smjer i ovdje prevladava u površinskom sloju, ali s manjom frekvencijom. Plime struje imaju male brzine (4—5 cm/sek) i pretežno su rotirajućeg karaktera. U obalnim bazenima se u površinskom sloju pojavljuje ciklonalno i anticiklonalno strujanje, što ovisi o obliku bazena i smjeru vjetra. Istaknuta je oscilacija od nekoliko dana koja se može povezati s prolazom sinptičkih poremećaja. Detaljnije je praćen tok zbivanja u moru u odnosu na djelovanje atmosfere, a kontinuirana mjerenja niza parametara su omogućila da se uđe dublje u strukturu nekih dinamičkih pojava. Ljeti je reakcija mora pretežno baroklina, a upwelling uzrokovan vjetrom od obale, dok je zimi reakcija pretežno barotropna.

Dat je jednostavan model za izmjenu vode u obalnim bazenima i korišten za izračunavanje kapaciteta asimilacije nekih ugroženih bazena. Dat je također jednostavan model za ocjenu izmjene vode između poluzatvorenih bazena

i okolnog mora. Određivan je koeficijent Fickove difuzije na nizu lokaliteta eksperimentalnim putem, a difuzija je studirana i s teoretskog aspekta. Studirane su još neke teoretske pretpostavke za primjenu osnovnih hidrodinamičkih jednadžbi na posebne uslove u moru. Pokazalo se je da se uz određene pretpostavke mogu dobro primijeniti na opisivanje rasporeda nekih svojstava (npr. slanosti), te da će daljnjim studijem biti moguće potpuno teoretski opisati polja raznih veličina u moru. Postavljen je i hidrodinamički model za područje Virskog mora.

Studirane su i neke valne pojave, kao seši i pojava katastrofalnog vala. Osim toga su studirani i valovi vjetra.

Praćene su i promjene srednjeg nivoa mora i povezane s nekim dinamičkim karakteristikama.

Moderne statističke metode su primijenjene na analizu niza parametara, kao strujanja, nivoa mora, te tlaka i temperature zraka.

FLORA I FAUNA

Floristička i faunistička istraživanja obuhvatila su rad na inventarizaciji, katalogizaciji, revizijama, ključevima i monografijama pojedinih viših i nižih taksona jadranske flore i faune i pregleda flore, odnosno faune užih ili širih područja Jadrana.

Značajan doprinos poznavanju flore i faune Jadrana predstavljaju monografije pojedinih faunističkih i floristićkih skupina, koje se objavljuju u ediciji Flora i Fauna Jadrana. Dosad su objavljene Ribe Jadrana, sa ključem za determinaciju, pregledom vrsta i komentarom; Fauna antozoa Jadrana sa popisom jadranskih vrsta i općim karakteristikama; Jadranske cistozire — njihova morfologija, ekologija, razvitak i atlas. U tisku je monografija Foraminifera Jadrana koja sadrži popis vrsta i atlas te podatke o njihovoj dubinskoj i geografskoj rasprostranjenosti. Monografija Rod *Sargassum* u Jadranu sa morfološkim i ekološkim podacima i atlasom pripremljena je za tisak.

Istražene su bentonske flore otočića Jabuka, otoka Visa — Biševa i Hvara. U području srednjeg Jadrana istraženi su sastavi crvenih, smeđih, zelenih i modrozelenih algi i fitogeografski odnosi bentoske flore (543 taksona), a u flori obalnog, kanalskog, otočnog i otvorenog područja istočnog Jadrana utvrđeno je 665 taksona iz prve 3 skupine. U sastavu tih flora uključeni su florni elementi atlantsko-mediteranske, cirkumtropske, cirkumborealne i indopacifičke fitogeografske regije te kozmopolitske, endemskojadranske i endemsko mediteranske vrste.

Obrađena je vegetacija alga na ribarskim dnima Jadrana i utvrđeno je da neke vrste bentoskih alga sežu i preko 260 m dubine. Istražena je tiotermalna vegetacija luke Splita.

Istražene su pelagične dijatomeje srednjeg Jadrana (120 vrsta). Ispitan je fitoplankton u području otoka Mljeta, Boke Kotorske i istočne obale Jadrana.

Posebno su izučavane neke nove ili slabo istražene feoficejske i rodoficejske vrste srednjeg Jadrana. Izvršena je revizija nekih porodica algi (Codiaceae, Champiaceae te vrste rodova *Ectocarpus, Halymenia, Nemastoma, Platoma, Rhodymenia, Bonnemaisonia, Calosiphonia* i *Thuretella,* koje nisu bile

registrirane ili su bile slabo poznate za Jadran). Otkriveni su za znanost i novi rodovi alga (*Yadranella, Padinopsis, Pterocladiopsis, Adriogloia, Dalmatogloia* i drugi).

Faunistički radovi obuhvaćaju obrade pojedinih sistematskih skupina iz raznih dijelova Jadrana uz izradu kataloga i revizija. Tako su objavljeni podaci o antipatarijama, zoantarijama i aktinijarijama koje je sabrala ekspedicija »HVAR« na svojim krstarenjima. Istražena je antozojska fauna Kaštelanskog zaljeva, te oktokoralji, kameni koralji i ciripedni rakovi kočarskih dna otvorenog Jadrana. U Boki Kotorskoj su istraženi bodljokošci i planktonski kopepodi. Obrađeni su i bodljokošci otoka Krka. Objavljeni su prilozi poznavanju zooplanktona srednjodalmatinskog otočnog područja i zooplanktona Mljetskih jezera. Istražene su morske Halacaridae i Hydrachnellae dalmatinske obale kod Splita. Objavljen je doprinos poznavanju porodice Ampeliscidae (Amphipoda) na Jadranu. Za jadranske glavonošce dati su podaci o sinonimiji i rasprostranjenju 29 vrsta. U području oko Splita istraženi su školjkaši. Dosta intenzivan rad izvršen je na obradi pojedinih taksona iz skupine riba. Tako je s morfološkog i taksonomskog gledišta obrađena skupina Meanidae. Izvršena je obrada razvojnih stadija, od larvalnog do adultnog, 23 vrste riba iz porodica Sternoptychidae, Stomatidae i Scopelidae sa podacima o njihovim rasprostranjenju u Jadranu. Obrađene su morfološke, biološke i ekološke karakteristike populacije mačke bljedice.

Izvršena je revizija porodice Pardaliscidae (Amphipoda) sa dijagnozama rodova, podacima o rasprostranjenosti vrsta i bibliografijom. Obrađene su jadranske folikulinide (Eufolliculinidae).

Značajan doprinos poznavanju faune Jadrana predstavljaju katalozi skupine bodljokožaca Jadranskog mora i skupine polihetnih anelida sjevernog i srednjeg Jadrana. Obrađene su larve jadranskih dekapodnih rakova.

Istraženi su nalazi batipelagijalnih riba novih za Jadran. Posebno su obrađeni nalazi rijetkih ili novih vrsta riba za Jadran (*Bellotia apoda, Trachipterus trachypterus, Zu cristatus, Citharus macrolepidopus, Lepidopus caudatus*).

Rad na izučavanju flore i faune Jadrana odvijao se je dosta neujednačeno. U zadnjem desetljeću je nešto zaostao zbog pomanjkanja stručnog kadra i nedovoljnog financiranja, premda su floristička i faunistička istraživanja osnov nekim drugim disciplinama kao biocenologiji i ekologiji.

EKOLOGIJA

Obzirom da je Institut od samog osnivanja bio usmjeren prvenstveno na ekološka istraživanja, ona su najobimnija, pa je zbog toga iz ovog poglavlja izdvojena produkcija, koja će biti posebno obrađena kao veza prema problemima iskorištavanja resursa.

Planktonske zajednice su detaljno istraživane. Već u prijeratnom razdoblju je u području srednjedalmatinskog arhipelaga praćen sastav, sezonsko kolebanje gustoće, te horizontalni i vertikalni raspored fito- i zooplanktona, a studiran je i odnos prema raznim faktorima sredine. U toku godine se izdvajaju 4 faze u dinamici fitoplanktona: zimska cvatnja, zimsko-proljetno

opadanje, proljetna cvatnja i ljetno-jesenska stagnacija. Zimski maksimum je povezan s vjetrom s kopna i upwellingom, a proljetni s utjecajem slatkih voda.

Dugogodišnje praćenje kvalitativno-kvantitativnog sastava planktona u poslijeratnom razdoblju dalo je niz novih saznanja. Ustanovljen je sinhroni sezonski ritam gustoće fitoplanktona na istočnoj obali Jadrana. Zbog utjecaja polucije ostaju uz obalu u novije vrijeme količine fitoplanktona visoke i ljeti, pa je zbog toga smanjeno sezonsko kolebanje gustoće. Na otvorenom moru je u sezonskom ciklusu jasno izraženo ljetno siromaštvo fitoplanktona.

Studij odnosa između glavnih fitoplanktonskih grupa (dijatomeja, kokolitoforina i dinoflagelata) je ukazao i na faktore koji ga uslovljuju. Dok su dijatomeje tipične za obalne vode, kokolitoforine se mogu shvatiti kao indikatorska grupa tipične mediteranske (istočne intermedijarne) vode u Jadranu. Kvantitativno je obrađena i grupa »mikroflagelata«, ali njihov sastav još nije detaljnije ni u svijetu poznat zbog poteškoća u određivanju. Nađeno je da male planktonske frakcije intenzivnije rastu. Trajno praćenje biomase fitoplanktona omogućilo je i uvid u višegodišnje promjene. Započet je i rad na određivanju kemijskog sastava fito- i zooplanktona, pa su određivani proteini, ugljikohidrati i lipidi, te kalorična vrijednost.

Vertikalni raspored zooplanktona na Mljetskim jezerima je pokazao da kopepod *Calanus helgolandicus* ima dnevno-noćne vertikalne migracije. Ima 5 generacija godišnje. Hrani se dijatomejama.

Vertikalni raspored zooplanktona u otvorenom srednjem Jadranu je pokazao da se on u cjelini u jeseni i zimi drži bliže površini, a u ostalim sezonama ispod 100 m. Najveći broj vrsta ima srednju razinu na 50—100 m. Gustoća zooplanktona ima tokom godine dva maksimuma: izrazitiji početkom proljeća uvjetovan vrstama sa srednjom dnevnom razinom ispod 100 m, a kraći ljetni uvjetovan vrstama sa srednjom dnevnom razinom iznad 100 m.

Detaljno su obrađeni kopepodi kao kvantitativno najbolje zastupljena skupina zooplanktona. Horizontalna distribucija od obale prema otvorenom moru povezana je i gibanjem vode, a promjene kvantiteta s nekim abiotskim i biotskim faktorima sredine. Posebno su proučene dominantne vrste, jer one svojom brojnošću diktiraju gustoću cijele skupine. U vezi s djelovanjem zagađenja na skupinu kopepoda nađene su promjene u toku zesonskih oscilacija u Kaštelanskom zaljevu kao i prvi negativni znakovi eutrofikacije u području Šibenika.

Određivanje suhih težina zooplanktona prvo je na Mediteranu, a trajno praćenje je dalo uvid u sezonske i višegodišnje promjene te u horizontalnu rasprostranjenost njegove biomase. To je omogućilo i klasifikaciju Jadrana po količini zooplanktonske biomase u odnosu na druge mediteranske bazene i Atlantik. Ujedno je ustanovljeno da neki zooplanktonti mogu biti shvaćeni kao indikatorske vrste za neke tipične vodene mase.

U planktonske zajednice pripadaju i jaja i rani stadiji riba i drugih životinja. Zbog privredne važnosti srdele i brgljuna, još prije rata su studirana njihova jaja u planktonu, ali se je pokazalo da je za određivanju mrijestilišta potrebno pokoriti područje s velikim brojem postaja. To je ostvareno u okviru rada Ribarstveno-biološke ekspedicije »Hvar« i kasnije u više navrata na odabranom arealu. Određena su četiri mrijestilišta srdele: zapadno od Dugog otoka, u srednjedalmatinskom otočju, u vodama Palagruža i u najjužnijem dijelu Jadrana. Horizontalna raspodjela jaja u toku sezone mri-

ješćenja se mijenja, pa se u zapadnom dijelu Hvarskog kanala ranije pojavljuju uz duže zadržavanje većih koncentracija nego u otvorenim vodama. Najveće koncentracije jaja srdele su nađene iznad dubina do nešto preko 150 m, i to od jeseni do proljeća, a nema ih od juna do septembra. Broj jaja raste idući od obale prema pučini. Naime, srdela krajem spolnog sazrijevanja napušta obalu i pliće predjele i traži stabilniju temperaturu i salinitet, a moguće je i u potrazi za obilnijom hranom, jer to koincidira s maksimumom zooplanktona. Srdela ispušta jaja u toku noći u razmacima od tri sata. Embrionalni razvoj u decembru pri višoj temperaturi traje 2 dana, a u martu pri nižoj temperaturi 4 dana. Mriješćenje ne traje jednako dugo svake godine. Larve srdele se javljaju od oktobra do aprila. Čini se da se kreću od otvorenog mora prema obali. Nalazi ih se svugdje, ali najmanje u područjima s dubinom preko 100 m, što pokazuje da se zadržavaju pretežno u području mriješćenja. Larve imaju veliku smrtnost jer se slabo hrane. Smrtnost je veća uz obalu nego u kanalima srednjeg Jadrana.

Jaja brgljuna su nalažena od marta do novembra, s maksimumom obično u junu-julu. Jaja su koncentrirana u sloju do 10 m, a larve brgljuna u sloju od 10 do 20 m. Veličina jaja je obrnuto srazmjerna temperaturi mora, a mrtva jaja su najčešća u ranim stadijima. Kritičan period u životu larvi je kada istroše žumanjce (ima 4—8 mm dužine). Količina jaja se podudara s povećanom produkcijom, ali ne i količina larvi. Čini se da je za preživljavanje odlučna veličina jaja. Osim u srednjedalmatinskom arhipelagu, mriješćenje brgljuna je istraživano i kod Dugog otoka. Nađeno je da je za embrionalan razvoj potrebno 40 sati.

Ispitan je utjecaj temperature na brzinu razvitka jaja i larvi, te na brzinu rasta larvi i postlarvi brgljuna u eksperimentalnim uvjetima, što je omogućilo s jedne strane izračunavanje njihove smrtnosti u prirodi, a s druge izračunavanje proizvodnje jaja i brojnosti larvi i postlarvi ove ribe po jedinici vremena i površine.

Metodom spektralne analize ispitan je odnos dugoročnih fluktuacija proizvodnje jaja brgljuna, te brojnosti i koeficijenta smrtnosti njegovih postralvi prema fluktuacijama nekih abiotskih i biotskih faktora sredine. Ustanovljeno je da svi analizirani parametri pokazuju slične osnovne periode oscilacija i da populacija brgljuna u cjelini reagira na promjene sredine sa faznim zakašnjenjem od jedne godine, pri čemu na nju u najvećoj mjeri djeluju promjene trofičke osnove.

Planktonski stadiji šnjura su također široko rasprostranjeni. Planktonski stadiji obitelji argentinide nađeni su na otvorenom moru od marta do juna i to i sjevernije od odraslih primjeraka, pa je vjerovatno da ih tamo nosi struja. U novije vrijeme (od 1974. g.) su se u Jadranu pojavili i planktonski stadiji srdele goleme.

Opisana su jaja i razvojni stadiji gira. U prirodi se međusobno mogu križati gira oblica i oštrulja što je potvrđeno i u eksperimentu.

U otvorenom Jadranu je nađeno više vrsta larvi riba, nego u obalnom području.

Larve dekapodnih rakova prema podacima sa Mljetskih jezera imaju više stadija nego u hladnim morima. Uz obalu je nađen veći broj vrsta nego na otvorenom moru. Mrijeste se ljeti i zimi, ali 4—6 tjedana ranije nego u hladnijem Sjevernom moru. Također je maksimum pojave larvi u Mljetskim jeze-

rima za oko mjesec dana raniji nego na otvorenom moru. Uočene su i dnevne vertikalne migracije, te se pri zalazu Sunca koncentriraju na površini.

Osnivanje mikrobiološkog laboratorija 1947. godine omogućilo je i praćenje bakterijskih populacija. Bakterijska biomasa u srednjem i južnom Jadranu pokazuje da je bakterijama najbogatiji srednji sloj eufotske zone (20—50 m). Vertikalno su inače dobro rasprostranjene, ali ih ima više u sloju do 100 m nego dublje. Postaje bliže kopnu su bogatije. U obalnom području su ustanovljene dnevne vertikalne migracije. Maksimum u toku godine je zimi i ljeti, a minimum u proljeće i jesen. Količine bakterija i fosfata stoje u obrnutom odnosu. Za bolje određivanje biomase određen je srednji volumen bakterijskih stanica po sojevima u nativnom i fiksiranom stanju. Nađeno je da dva bakterijska soja sa crvenim pigentom, koji se razvijaju u aerobnim uslovima uzrokuju pojavu crvene vode, koja je bila uočena u Malom jezeru na otoku Mljetu na 20 m dubine. Razmnažanje heterotrofnih bakterija u laboratorijskim uslovima pri raznim koncentracijama H-iona pokazuje se u početku brže u kiseloj nego u alkalnoj sredini. Ispitano je i baktericidno i bakteriostatičko djelovanje antibiotika (penicilina i streptomicina) na 41 bakterijski soj i određene su najniže neškodljive koncentracije. Laboratorijski je na čistim kulturama istraživana i aktivnost bakterija pri izlučivanju fosfata iz morskih sedimenata. Više se fosfata izlučuje pri anaerobnim nego pod aerobnim uslovima.

Obzirom na poseban interes ribarstvene prakse, raznovrsno su istraživane ekonomski važne, a i druge ribe, pelagične i bentonske. Studirana je morfologija, rast i razvoj otolita, životni ciklus, razmnažanje, spolno sazrijevanje, odnos spolova, dužina pri prvoj spolnoj zrelosti, kolebanje masnih rezervi, neke fiziološke karakteristike kao potrošnja kisika te koncentracija hemoglobina i aktivnost riba, ponašanje, formiranje grupa i reakcija na svjetlo, vertikalna i horizontalna rasprostranjenost, migracije, veličina naselja, mortalitet, ishrana, parazitizam, tjelesne anomalije, probavni trakt rentgenskim snimanjem, te odnos prema sredini.

Larve srdele hrane se i fitoplanktonom i zooplanktonom. Mala srdela u stadiju metamorfoze se hrani pretežno fitoplanktonom (najviše dinoflagelati, a manje dijatomeje i kokolitineje), zatim jajima i larvama rakova (kopepodski i ciripejski naupliusi), te ribljim jajima. Čini se da biraju hranu. Prije izlaza sunca po noći ne jede (osim pod vještačkim svjetlom), a zasićenost želuca raste od izlaza Sunca do 15 sati.

U želucu odrasle srdele je nađen isključivo zooplankton (30% kopepoda, 23% dekapodnih larvi i 9% ribljih larvi, te nekih drugih organizama u manjim procentima). Najslabije se hrane u augustu, a najviše u decembru. Odrasla srdela se intenzivno hrani u poslijepodnevnim satima, a noću ne jede, osim uz umjetno svjetlo.

Na istočnoj obali srednjeg Jadrana populacija srdele je jedinstvena. Naselja srdele Istre i srednje Dalmacije se ne miješaju, a Jabučka kotlina je barijera. Prema stupnju spolne zrelosti se vidi da se srdela mrijesti od konca jeseni do proljeća. Veći individui sazrijevaju ranije. Spolna evolucija počinje istovremeno kod oba spola, ali su u fazi prematuracije (oktobar, novembar) mužjaci napredniji. Za maksimalne spolne zrelosti težina ribe se smanjuje. Pri dužini ribe od 13 do 14 cm svi primjerci su spolno zreli, a neki sazrijevaju i pri manjoj dužini. Pri istoj starosti ženke su duže od mužjaka. Pri mriješćenju se gubi periintestinalna mast. Uz vanjske otoke su nađene veće

srdele nego bliže obali, gdje se normalno u većem dijelu godine zadržava mlađa riba. U srednjedalmatinskom otočnom području srdela se giba transverzalno. U sezoni lova odrasla riba se kreće od otvorenog mora prema kopnu, a u kasnijoj jeseni od obale prema otvorenom moru. Proljetna migracija srdele prema kopnu koincidira s maksimumom biomase zooplanktona, posebno kopepoda i dekapodnih larvi u obalnom području. Sadržaj masti u tkivu srdele je najmanji u maju poslije mriješćenja, a najveći u augustu i septembru. Prosječna dužina srdele u otvorenim vodama varira iz godine u godinu u ovisnosti o zastupljenosti pojedinih starosnih klasa. Razvoj otolita kod mlađih primjeraka ovisi o vremenu izvaljivanja iz jaja. U Kaštelanskom zaljevu se srdela u jutarnjim satima zadržava dublje nego popodne. U večernjim satima se još diže. Ima je više u plićem dijelu zaljeva. U ovom obalnom području joj se povećava količina počam od marta i aprila, a najviše je ima u julu i oktobru (najmanje u februaru-matru).

Planktonski stadiji skuše se hrane zooplanktonom, larvama drugih riba, a jedu i sami sebe. Probavni trakt im je najpuniji u februaru.

Plavica se mrijesti u kasnijem proljeću i ljeti u srednjem i južnom Jadranu. Od planktonskih stadija ustanovljene su samo postlarve.

Šnjur je vrlo rasprostranjen, a mnogo ga ima u području Blitvenice i Jabučke kotline. Mali primjerci su nađeni bliže obali. Rasprostranjenost mu ne ovisi o sastavu dna.

U posljednjih nekoliko godina registrirana je u Jadranu i srdela golema. Prvi put je zabilježeno da se mrijesti u Jadranu, a prvi put je registrirana i mlada srdela golema, inače stanovnik toplijih mora.

Rast trlje u vodama Splita i južne Francuske je sličan, a zaostajanje u rastu u vodama južne Francuske se pripisuje nižoj zimskoj temperaturi. U našim vodama ima zastoj u rastu od februara do maja. Tokom godine su opažene dvije migracije: prema obali i od obale. Ženke rastu brže a mrijeste se jednom godišnje a mužjaci mogu i dva puta. Prva spolna zrelost nastupa kod 10.5 cm. Zadržava se na muljevitom i pješčanom dnu, ali ne na preko 200 m dubine. U kanalima je nađeno više ženki a na otvorenom moru više mužjaka. Ustanovljeno je 7 starosnih grupa. Mlađ migrira od obale prema pučini, a odrasla riba natrag. Jede crve i školjke.

Bukva se pretežno hrani zooklanktonom i to intenzivnije pri višoj temperaturi.

Istražene su i tri vrsti jegulja u vodama Neretve, Splita i Trogira. Studirana je i rasprostranjenost vrsta obitelji mugilida. Najbrojnije vrste su *Mugil cephalus* i *Mugil chelo*. Varijacije u pojavljivanju pojedinih vrsta na istraživanim lokalitetima povezane su sa kolebanjem temperature i saliniteta, kao i migracijama zbog mriješćenja. U prvim godinama života ženke rastu brže od mužjaka, a u kasnijim godinama se te razlike postepeno smanjuju. Prva spolna zrelost vrste *Mugil cephalus* nastupa kad riba pređe 35 cm, a u četvrtoj godini života. Mrijesti se od jula do septembra, a *Mugil chelo* od januara do marta.

Oslić je vrlo rasprostranjen. Najveća gustoća naselja mu je nađena u Jabučkoj kotlini, južno od nje i duž sjeveroistočnog ruba južnojadranske kotline. U plićim vodama preferira kao hranu srdelu, brgljuna i papalinu, a u dubljim vodama, gdje je i sam veći, preferira u ishrani skušu. Osim toga uzima za hranu rakove i glavonošce. Mali primjerci se hrane planktonskim rakovima.

Detaljno je istraživana mačka bljedica. Nađeno je više mužjaka nego ženki, a primjerci iste starosti se drže zajedno. Pomiče se prema većoj dubini zbog razmnožavanja i vraća natrag zbog ishrane. Hrani se rakovima, ribama, glavonošcima i polihetima. I druge hrskavičnjače jedu sličnu hranu, a najintenzivnije se hrane u vrijeme najintenzivnijeg mriješćenja. Ulje jetra hrskavičnjača pokazuje razliku između mužjaka i ženke, te između oplođenih i neoplođenih primjeraka. Čini se da je razvitak gonada u vezi s metobolizmom masti u jetrima. Raža kamenica se pojavljuje do 160 m dubine, a najčešća je na 100 do 130 m dubine, pretežno na mulju. Raža modropjega preferira pjeskovito ljušturasto dno.

Osim riba, detaljno su studirani i rakovi te jestivi beskralježnjaci. Norveški rak (škamp) ima najgušća naselja u Jabučkoj kotlini na 150—250 m dubine. Vezan je na ilovasto-glinasta tla. U kanalima su nađeni nešto veći primjerci nego na otvorenom moru. Ženke se mrijeste svake godine, a s vanjskim jajima se pojavljuju od jula do januara. Kozice se nalaze od 130 m dubine pa dalje na muljevitom dnu. Larve jastoga su nalažene od decembra do aprila, oslobađaju se u januaru i februaru, a razvoj im traje 3-4 mjeseca.

Vrlo su dobro istražene i bentoske alge. Inventar bentoske flore je bogat, a vegetacija ima obilježje samostalne podjedinice atlantsko-mediteranske regije sa jako naglašenim endemskim i borealnim karakterom. Razlikuju se 4 vertikalne bionomske stepenice i 3 podstepenice litorala: supralitoral, mediolitoral, infralitoral (gornji do 5—6, srednji 6 do 30 i donji do 100 m) i eulitoral do preko 200 m. U horizontalnom pogledu vegetacija bentoskih alga podijeljena je na subfacijes otvorenih voda i subfacijes obalnih voda. Vanjski subfacijes otvorenih voda sadrži veći broj vrsta od unutrašnjeg, a tu su rasprostranjene neke vrste kojih nema u unutrašnjem i obratno. Trotoari vapnenačkih alga su bolje razvijeni u vanjskom pojasu. Crvene alge su pretežno rasprostranjene u dubokoj vodi, zelene u plićim zonama, a smeđe su većim dijelom u plićim, ali ih ima isključivo dubinskih.

Za litofitsku zonu u supralitoralu i dijelu mediolitorala je nađeno da nju formiraju litofitske cijanoficeje. Na razvoj i rasprostranjenje vrsta roda *Cystoseira* utječu supstrat, temperatura, svjetlo, salinitet i gibanje vode.

Studirana je plazmoliza smeđih alga i smatra se da nastaje zbog povećanja permeabilnosti.

Izvršena je procjena količina cistozira na preko 1300 km obale kopna i otoka. Ukupne količine su male i procijenjene su na oko 70 000 tona, a srednja vrijednost biomase iznosi 2,32 kg/m^2. Priobalna naselja su bogatija (13,1 t/km) od otočnih (4,84 t/km).

Sadržaj joda u ispitanih 60 vrsta alga koleba tokom godine i s dubinom. Ispitan je i sadržaj manitola. Sadržaj fizoda relativno je nizak te je utvrđen i nizak sadržaj reduktivnih supstanci, što je u vezi sa salinitetom. Ispitan je i kvantitet i kvalitet alginske kiseline u smeđim, a u nekim crvenim algama agara i agaroida.

Biocenološkim istraživanjima utvrđeno je da je na čvrstim i pomičnim dnima priobalnog, kanalskog i otvorenog Jadrana formirano 27 betonskih biocenoza. Te biocenoze po svojoj temeljnoj građi pripadaju cjelini Mediterana, ali se odlikuju i nekim svojim individualnim osobinama. Specifičnost jadranskih biocenoza očituje se osobito u pojavi endemskih i nekih borealnih vrsta, batimetrijskoj distribuciji nekih vrsta i razvitku nekih tipičnih biocenoza pre-

laznog karaktera, među kojima je osobito značajna biocenoza muljevitih dna otvorenog mora *Nephrops norvegicus* — *Thenea muricata*. Posebne karakteristike bentoskih biocenoza najizrazitije su u sjevernom Jadranu, gdje vlada jak utjecaj kopna i kopnenih voda, pa je tu tipična mediteranska flora i fauna donekle osiromašena, a prevladavanju razne eurivalentne vrste uz pojavu endemskih i borealnih oblika. U srednjem Jadranu su biocenoze po floristič-kom i faunističkom sastavu veoma slične onima u sjevernom dijelu zapadnog Mediterana, ali sadrže i neke endemske oblike. Biocenoze južnog Jadrana slične su onima u srednjem Jadranu ali sadrže i znatnu primjesu termofilnih vrsta. Na batijalnoj stepenici (200 do 500 m) dobro je razvijena biocenoza batijalnih muljeva, a na čvrstom supstratu batijalne stepenice se nalaze neki elementi biocenoze velikih kolonijskih koralja.

Opisana su faunistička naselja supralitorala, mediolitorala i gornjeg infralitorala hridinastih obala i promatrana njihova ovisnost o kutu nagiba obale, osvjetljenju i mlataranju valova.

Opisana su i riblja naselja kanala srednjeg Jadrana te su za tri zajednice (glinastih, ilovastih i pjeskovitih tala) određene dominantne vrste riba. Pridnene ribe u ljetno-jesenskom razdoblju migriraju prema kopnu, a u zimsko-proljetnom periodu prema dubljim vodama.

PRODUKCIJA

Osnovna značajka istraživanja u vezi s produkcijom su pokušaji da se ona što je moguće bolje kvantitativno ocijeni, kako bi se te ocjene mogle primijeniti u ribarstvennoj praksi.

Produktivnost voda istočne obale Jadrana je istraživana već u prijeratnom razdoblju, posebno s aspekta određivanja faktora koji povoljno ili nepovoljno djeluju. Sve dubljim upoznavanjem raznih odnosa i parametara mogao se je Jadran opisati kao produkcioni bazen. Hranjive soli u Jadran dolaze iz Mediterana, zatim rijekama, a aktiviraju se i upwellingom u obalnom području. Važan je i biljni pokrov obalne zone. Na osnovu rasprostranjenosti količina hranjivih soli definirane su 4 produktivne zone, koje su s direktno mjerenim podacima mogle biti kvantitativno definirane. Prema toj podjeli zona A obuhvaća otvoreni i srednji i južni Jadran, zona B plitski sjeverni Jadran, zona C otočno područje istočne obale i zona D lagune i najproduktivnije zaljeve. Srednja godišnja produkcija za Jadran je ocijenjena na 9 milijuna tona ugljika. Ako se prihvati klasifikacija svjetskog mora u pet kategorija, Mediteran u cjelini ulazi u treću, a Jadran već prema zonama od druge do četvrte, te se prema vrijednostima primarne produkcije približava Mediteranu.

Produkcija jako varira iz godine u godinu, a uslovljena je obimom mediteranske vode koja uđe u Jadran, a koja unosi hranjive soli. Ovo je faktor koji djeluje na područiju najvećeg dijela otvorenog Jadrana, premda se utjecaj sjevernotalijanskih rijeka također osjeća do visine srednjeg Jadrana. Taj se je faktor mogao povezati s nekim klimatskim parametrima. Dugogodišnji podaci su potvrdili vezu između tih parametara i produkcije. Također je statistički određeno da sekundarna produkcija zaostaje u fazi za prosječno 3 godine. Te su činjenice omogućile, da se uspješno prognozira ulov ribe. Na osnovi poda-

taka o primarnoj proizvodnji, te nekih pretpostavki o ekološkoj efikasnosti na pojedinim trofičkim stepenicama date su procjene o godišnjoj produkciji ribe (300 000 t) i njezinim fluktuacijama u odnosu na opisane faktore. Proizvodnja ribe procijenjena je i na višim trofičkim stepenicama — preko zooplanktona i ribljih jaja.

Biomasa ribe je procjenjivana još raznim drugim metodama. Vršen je pokušaj procjene preko jaja i larvi. Te procjene daju više vrijednosti, pa je za brgljuna procijenjena biomasa na cca pola površine Jadrana dala vrijednost od 927.000 t.

Za procjenu postojećeg stoka pelagične ribe je korištena direktna metoda pomoću echointegratora, za razna područja. Nadalje, je korištena i lebdeća koča za procjenu biomase uz pomoć određivanja količine ribe u probnim prostornim intervalima.

Spektralnom analizom ispitani su stogodišnji podaci o ulovu srdela na istočnoj obali Jadrana. Ustanovljena je korelacija između ulova srdela i aktivnosti sunca, pri čemu maksimumi ulova nastupaju u prosjeku dvije godine nakon maksimuma sunčeve aktivnosti. Na osnovi izvršene analize data je tentativna prognoza kretanja ulova srdela za razdoblje od sto godina.

Za ocjenu pridnenih naselja služe dugogodišnji kontrolni podaci kočarenja. Koristeći se takvim podacima kao reprezentativnim, procijenjena je jestiva kočarska biomasa u ribolovnom području epikontinentalnog pojasa (cca 230.000 t) i od toga razina biološkog nivoa iskorištavanja se kreće između 50.000 i 80.000 t/godinu. Ti nivoi su već pređeni.

Obzirom na relativno nizak nivo produkcije Jadrana, u poslijeratnom razdoblju je trajno prisutno nastojanje da se nađe jeftina i praktična metoda gnojenja mora. Postavljena je hipoteza da će se hranjive materije u moru bolje otopiti i iskoristiti, ako mu se snizi pH, te da je dovoljno dati fosfatna gnojiva, a da će biljke same vezati dušik iz zraka. Obimni eksperimenti na Mljetskim jezerima su potvrdili ove pretpostavke. Utvrđena je eutrofikacija bazena, a povoljni se je efekt osobito odrazio na školjkašima. Šteta je da, rezultati ovog eksperimenta nisu šire korišteni u praksi.

UNAPREĐIVANJE RIBARSTVA

Istraživanja sa ciljem da se unaprijedi ribarstvo su od samog početka rada Instituta imala istaknut položaj, ali naročito u poslijeratnom razdoblju.

Već prije rata je ustanovljeno da je kočarenje u Planinskom kanalu (Hrvatsko primorje) poslije 20 godina iskorištavanja oštetilo naselja. Podvelebitski kanal je bio bogatiji, ali s dosta landovine. Statistička analiza kočarskih lovina istočnog Jadrana je pokazala da je gustoća naselja otvorenih voda veća od one u kanalima, te da se tokom intenzivnog izlovljavanja smanjuje veličina oslića.

Podaci ribarstveno-biološke ekspedicije »HVAR« su omogućili dobro upoznavanje pridnenih naselja vrlo širokog areala, a to je do danas glavni izvor takovih podataka, jer eksperimentalno kočarenje u tako širokom arealu nije moglo biti ponovljeno. Ti su podaci korišteni u raznim prilikama za procjenu naselja i bili baza za pregovore s Italijom za korištenje jugoslavenskih teritorijalnih voda. Kontrola naselja se uz to trajno provodi na odabranim posta-

jama. Naselja pridnenih jestivih vrsta Jadrana su kategorizirana u 7 područja: kanali sjevernog Jadrana, zapadna obala Istre, Dugi otok, Blitvenica i Jabučka kotlina, otvoreni srednji Jadran, kanali srednjeg Jadrana i Crnogorsko primorje. Najeksploatiranija područja su kanali sjevernog Jadrana i otvoreni srednji Jadran. Posebno su opisana kočarska područja u srednjem Jadranu na bazi odnosa glavnih grupa, gustoće jestivih naselja i odnosa jestivog i nejestivog prilova. Najpovoljnija kočarska područja su unutar biocenoza »*Thenea muricata — Nephrops norvegicus*«. Na osnovu podataka 1960—1970. godine sa područja Blitvenice utvrđeno je da se postepeno smanjuje dnevni ulov po kočaru za jestivi dio, a da eksploatacija nije bitno utjecala na strukturalne promjene naselja. Ranije je bilo izneseno mišljenje da intenzivnim ribolovom opada učešće landovine, a raste učešće gadida. Date su preporuke za veličinu oka mreže i mišljenje o ekonomici ulova uz preporuke za moderniziranje načina lova. Opisana je i vegetacija algi na kočarskim dnima.

Ispitane su lovine tartanama u sjevernoj Dalmaciji, gdje dominiraju gire sa 87%. Ulov je veći zimi nego ljeti.

Statistička analiza ulova škampa nije pokazala odnos između ribolovnog napora i ulova.

Ispitivana je ribolovna efikasnost vuče sa različitim strugarima (čelik ili manila), pa su se čelični strugari pokazali kao nešto malo bolji.

Duboki Jadran je istraživan uz pomoć parangala. Tu su od riba nađene hrskavičnjače i koštunjače. Vertikalno su se naselja mogla razgraničiti u tri sloja. Nije nađen utjecaj hidrografskih svojstava na rasprostranjenje. Ispitani su prikladni mamci: najbolji je šnjur, oslić nešto slabiji, a zatim dolaze bukva i srdela.

Određeno je vrijeme zrelosti i vrijeme mriješćenja za preko 60 vrsta riba, isto kao i njihova maksimalna dužina.

Oscilacije ulova pelagične ribe su također trajno praćene i istraživane. Još prije rata je ukazano na značaj statistike ulova, a postoji trajno nastojanje da se statistika poboljša u skladu s našim znanstvenim potrebama i međunarodnim obavezama.

Statistika ulova male plave ribe je pokazala da su u prijeratnom ulovu u srednjem Jadranu koincidirali brgljun i plavica, dok su alternirali srdela i brgljun, brgljun i skuša, te skuša i plavica. Brgljun, srdela i skuša se javljaju posvuda, ali su im dva područja veće koncentracije odijeljena Jabučkom kotlinom. Dubina je faktor horizontalne raspodjele male plave ribe. Godišnje promjene srednje dužine srdela u otvorenom srednjodalmatinskom otočnom području uslovljene su fluktuacijama jačine pojedinih godišnjih klasa.

Miješane lovine pelagijskih riba pokazuju da se zajedno mogu uloviti srdela i brgljun, ali pri bitno različitoj dužini ne formiraju koherentne grupe, već privremene agregacije. Uz srdelu se lovi povremeno i šnjur, a tako i bukva.

Godišnja raspodjela ulova male plave ribe pokazuje da na sezonske fluktuacije ulova utječe fiziološko stanje ribe, te njezine migracije u vezi s mriješćenjem i ishranom.

U svrhu obavještavanja ribarske privrede vršena je pilotaža male plave ribe uz pomoć ultrazvučnih detektora kroz nekoliko sezona na širokim prostranstvima sjevernog i srednjeg Jadrana. Ta su istraživanja ukazala na nejednoliku rasprostranjenost male plave ribe, a i na mogućnost lova tokom cijele godine.

U novije vrijeme je prisutan rad i na umjetnom uzgoju ribe. Dat je pregled pogodnih uvala za lagunarno ribarstvo i ribogojstvo. Dati su prijedlozi u vezi izgradnje ribnjaka za cipla na našoj obali, i opisana je uloga nasipa i zimovališta. Eksperimentalno je ispitano hranjenje komarče, a istražene su i neke pojave pri držanju ribe u kaptivitetu.

Stručnjaci Instituta aktivno učestvuju pri izradi ribolovne legislative i kao konzultanti u svim pitanjima ribarstvene prakse.

Organiziran je vrlo uspješno niz seminara za primjenu ultrazvučne detekcije u jadranskom ribolovu što se pozitivno odrazilo na efikasnije rezultate lova sitne plave ribe.

ODNOS JADRANA I MEDITERANA

Jadran se može promatrati kao jedan pokrajni bazen Mediterana. Po svojim hidrografskim karakteristikama Jadran je znatno kontinentalniji, a to osobito važi za njegov sjeverni dio. Južni i srednji otvoreni Jadran su trajno pod utjecajem Mediterana, ali ne uvijek u istom obimu. Taj utjecaj se osobito osjeća u intermedijarnom sloju. Mediteranska intermedijarna voda utječe povoljno na podukciju, jer ima nešto veći sadržaj hranjivih soli od jadranske vode. S druge strane, zbog svoje izraženije kontinentalnosti, odnosno zbog intenzivnog zimskog hlađenja, Jadran je jedan od glavnih izvornih područja za formiranje pridnene vode Mediterana, jer je u sjevernom Jadranu nađena njegova najgušća voda. Razlog tome su male dubine, kao i utjecaj bure. Biološki se sjeverni Jadran javlja sa prisustvom borealne flore i faune, a idući prema jugu sve se više približava mediteranskom tipu biljnih i životinjskih zajednica. U planktonskim zajednicama mogle su se odrediti indikatorske grupe i vrste za mediteransku vodu i pratiti njihove višegodišnje fluktuacije.

ODNOS OBALNOG I OTVORENOG MORA

Istočna obala Jadrana je karakterizirana velikim brojem otoka, koji čine prepreku izmjeni vode s otvorenim morem. Otočni pojas svakako uslovljuje manje brzine strujanja. Dok je prosječna brzina strujanja u srednjem otvorenom Jadranu cca 20 cm/sek, ona je u obalnom području od prilike za pola manja. Da je tome uzrok dijelom upravo otočni pojas vidi se iz toga, što je strujanje uz zapadnu obalu Jadrana prosječno brže nego uz istočnu. U obalnoj se zoni strujanje pretežno odvija u dva sloja, dok su na otvorenom moru prisutna tri sloja. Nadalje su u obalnoj zoni smjerovi strujanja raspršeniji. Prva posljedica toga je polaganije taloženje u otvorenom i brže u oblanom pojasu, a u obalnoj zoni se talože krupnije čestice i preteže terigena komponenta, pa je moguće i zamuljivanje. Obalno more je također pod većim utjecajem voda s kopna, kako kiše tako i rijeka, koje unose terigenu komponentu i hranjive materije. Osim toga tu se i ljeti i zimi pojavljuje upwelling, koji obogaćuje obalne vode hranjivim materijama s dna. Tako je zbog priliva s kopna, te dizanja hranjivih materija s dna, obalno more bogatije hranjivim solima i tu je produkcija viša. U novije vrijeme ona se i povećava kao posljedica polucije

mora u toj zoni. Iz svih tih razloga je i prozirnost obalnog mora niža. Nadalje, odnos hranjivih soli je različit, pa od dušikovih soli u obalnoj zoni ima više amonijaka. Uz to su zbog veće kontinentalnosti, veće godišnje amplitude temperature i slanosti, kao i nekih drugih svojstava. To sve utječe i na sastav pelagičnih i pridnenih zajednica.

U bistrijem otvorenom moru se alge razvijaju do većih dubina. Vegetacijski se jasno razlikuje vanjski pojas otvorenih voda od unutarnjeg pojasa obalno-kanalskih voda. Trotoar vapnenačkih algi je razvijeniji u vanjskom pojasu zbog prikladne podloge. U obalnom otočnom području se formiraju različite biocenoze, nego na otvorenom moru. U obalnoj zoni je nađena veća gustoća kočarskih naselja, ali s manje povoljnim odnosima jestivog i nejestivog prilova.

Uz veću produkciju u oblanoj zoni, u sastavu fitoplanktona tu prevladavaju dijatomeje, a na otvorenom moru kokolitineje i razni flagelatni oblici. Na otvorenom moru je nađeno više vrsta larva, zooplanktonskih organizama a i veće količine jaja nekih riba (brgljun). Unutar zooplanktona na otvorenom moru raste udio roda *Clausocalanus,* iako mu se apsolutna gustoća smanjuje. Pelagične ribe migriraju u toku života između otvorenog i obalnog mora tražeći prikladnije prilike u određenoj fazi života (mriješćenje hranjenje).

Općenito je na otvorenom moru broj vrsta veći, ali je produkcija manja nego u obalnom području.

UTJECAJ ČOVJEKA NA MORE, SURADNJA S PRIVREDOM I MEĐUNARODNA SURADNJA

Premda je čovjek izlovljavanjem utjecao na more u dugom razdoblju, zbog veličine resursa i niskog stupnja iskorištavanja, to se nije u većoj mjeri uočavalo do novijeg vremena. Sada je približno procijenjena veličina resursa i mogućnosti daljnjeg izlovljavanja. Suradnici Instituta su vrlo aktivno učestvovali na nizu nacionalnih i međunarodnih savjetovanja i konferencija koje su tretirale tu problematiku. Postoji i trajna suradnja s ribarskom privredom.

Publiciran je i niz radova institutskih suradnika s inozemnim istraživačima kao rezultat uspješne međunarodne suradnje. Spomenimo rad na zooplanktonu, haringi, trglji, srdeli, brgljunu i nekim ekonomski važnim pridnenim ribama. Posebno je važan zajednički rad jugoslavenskih i talijanskih istraživača na procjeni ukupnog stoka ribe zbog racionalne eksploatacije i pravilnog gospodarenja ribljim resursima.

Osim sa ribarstvenom, Institut je vrlo aktivno surađivao i s drugim granama privrede, osobito sa Elektroprivredom i Vodoprivredom. Tako je za trasiranje podmorskih električnih kabela radi uključivanjt jadranskog arhipelaga na elektroenergetsku mrežu ispitan reljef i geološki sastav jadranskih kanala. Također su na potencionalnoj lokaciji nuklearne elektrane izvršeni vrlo obimni istraživački radovi.

Općenito se je u novije vrijeme kao jako prisutan problem pojavila i polucija mora. Zbog orijentacije da se maksimalno iskoriste mogućnosti obalnog pojasa za privredni razvoj, planirana je izgradnja niza velikih objekata i Institut je izradio velik broj elaborata, koji su trebali odrediti mogućnost asimi-

lacije raznih otpadnih materija i mjere zaštite. Ovo je bio vrlo velik zadatak jer je prognoziranje promjena pod utjecajem čovjeka vrlo složeno te zahtijeva organiziran timski rad velikog broja suradnika. Sa čisto znanstvene strane postavio je nove zadatke, koji su uspješno riješeni primjenom većeg broja suvremenih metoda. Pojedina područja trebalo je definirati dinamički uz pomoć odgovarajućih shema i modela, trebalo je određivati neke kemijske parametre, koji ranije nisu bili određivani, trebalo je raditi na definiranju lanaca ishrane u moru, na kvantitativnom određivanju eutrofikacije, utjecaju zagađivača na organizme (pesticidi, olovo) i sastava zajednica u zagađenim vodama. Polucija mora je shvaćena i kao međunarodni problem. Na Mediteranu je organizirana međunarodna suradnja i Institut se je uspješno uklopio u 6 pilot projekata, koji trebaju ukazati koliki je stupanj zagađenja dostignut na Mediteranu.

Uopće se je Institut od samog početka svojeg postojanja vrlo aktivno uklopio u međunarodnu suradnju. Njegovi suradnici su učesnici gotovo svih kongresa i savjetovanja iz domene oceanografije i ribarstva, a osobito su aktivni u Generalnom savjetu za ribarstvo Mediterana FAO kao i u Međunarodnoj komisiji za znanstveno istraživanje Mediterana CIESM. Jedna generalna asambleja te organizacije je zato i održana u Splitu i to 1976. godine kao i jedan sastanak Generalnog savjeta za ribarstvo 1967 g. Vrši se i izmjena publikacija sa gotovo 400 srodnih institucija iz cijelog svijeta.

NOVA OPĆA SAZNANJA O JADRANSKOM MORU

Sumirajući znanstvene rezultate Instituta može se mirno zaključiti, da su oni bitno upotpunili naše znanje o Jadranskom moru. Ovo se prvenstveno odnosi na ekologiju populacija i zajednica. Istraživanja fito- i zooplanktona u odnosu na sredinu su pionirska na Mediteranu, a do danas su s tog aspekta istražene sve glavne grupe organizama, posebno onih od privrednog značenja. Istražena je struktura naselja i ona su i kvantitativno ocijenjena. Dobiven je niz novih podataka o flori i fauni. Dobro je upoznata biologija velikog broja organizama. Svestrano su istražene sezonske i višegodišnje fluktuacije dinamičkih, hidrografskih i bioloških svojstava i dato je tumačenje tih fluktuacija. Uočeni su faktori koji djeluju nad širokim područjem Mediterana, a i van njega, kao i takovi koji djeluju sasvim lokalno. Jadran je ocijenjen u odnosu na druga mora, a procijenjena je njegova produktivnost kao i mogućnost njegove eksploatacije. Upoznate su osnovne prirodne fluktuacije živog svijeta i njegove sredine, koje su već korištene pri davanju globalnih prognoza ulova i promjena u moru zbog eksploatacije i raznih zahvata.

PERSPEKTIVE DALJNJIH ISTRAŽIVANJA

Polazne točke daljnjih istraživanja su eksploatacija i zaštita mora. One su funkcionalno povezane, jer je jasno da se s većom eksploatacijom mora pojačati zaštita kako se ne bi kritično ugrozilo prirodni ambijent. Prikupljanje sve većeg broja podataka zahtijeva organiziraniji pristup njihove obrade i primjenu suvremenih statističkih metoda u obradi. Naročito je prisutna potreba

za izradom modela, kako dinamičkih, tako i ekoloških, koji će omogućiti sigurnije prognoziranje promjena uz prisutnu eksploataciju mora i remećenje prirodne ravnoteže. Da bi se to ostvarilo, potrebno je daljnje dublje ulaženje u razne fizikalne, kemijske geološke i biološke procese, trajnom kontrolom svih promjena kao i eksperimentalnim radom.

Staff of the Institute at 31 December 1980
Osoblje Instituta na dan 31. decembra 1980.

(In alphabetical order, in brackets date of arrival to the Institute)
(Po abecednom redu u zagradama godina dolaska u Institut)

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Duje PRGA	Deckhand *Kormilar*	(1950)
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