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THE CENTRAL ADRIATIC SHELF

IMPORTANT RESEARCH AND DATA PROCESSING METHODOLOGY

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A methodological approach in the analyses of the seawater oceanographic states is determined by the purpose of the paper and general purpose of the research. In the recent decades the scientific work in this area has advanced thanks to computer data processing, particularly owing to modern technical and technological achievements that allow us to obtain important results, which significantly augment application of scientific results. This paper is a review of the research on the Central Adriatic shelf. Until now, papers dealing with geographical and oceanographic features regularly used the terms Palagruža Shelf and Jabuka concavity in the meaning of independent entities in the Adriatic basin which partly define physicogeographic features of water masses. However, such perception should be corrected. The Central Adriatic shelf is situated between the north Adriatic and the south Adriatic basin. Its length is greater than the width. Therefore, it deserves more attention and more cautious scientific approach. In this paper there are also evaluations of some methodologies used in the research and in the measuring of oceanographic parameter values, and also new technical solutions are proposed. The purpose of this paper is to analyse some methods of approach in the presentation of oceanographic states of seawater in the area of the Central Adriatic shelf. The purpose is also to introduce a succession of articles in which this maritime zone should be given its deserving significance from the geographic and oceanological aspects.

Key words: the Central Adriatic shelf, methodology, oceanography, data

Metodološki pristup analizama oceanografskih stanja morske vode određuje namjena rada i opća svrha istraživanja. U posljednjih nekoliko desetljeća, znanstveni je rad u ovom području napredovao, zahvaljujući računalnoj obradi podataka, čemu osobito pogoduju suvremena tehnička i tehnološka dostignuća. Temeljem vrsnih podataka dolazi se do dobrih rezultata, a time se značajno povećava aplikativnost znanstvenih zaključaka. Ovaj je rad osvrt na istraživanja srednjojadranskog praga, koja su izostala u dugogodišnjoj znanstveno-istraživačkoj tradiciji o Jadranskom moru. Do sada se u radovima s geografsko-oceanografskim naznakama redovito spominjalo Palagruški prag kao temeljnu stubu u jadranskom bazenu, koja određuje sve dinamične uvjetovanosti vodenih masa. Međutim, takvo shvaćanje valja ispraviti. Prag između sjevernog Jadrana i južnojadranske kotline nije stuba,

već podmorski plato, dulji nego širi, pa mu sa znanstvenog stajališta valja prići s puno više opreza, te mu posvetiti znatno više pozornosti. Rad se još ocjenjivački odnosi na neke metodološke pristupe u istraživanjima i mjerenjima vrijednosti oceanografskih parametara, te se predlažu nova tehnička rješenja. Sama svrha rada analiza je nekih metodoloških pristupa u prezentaciji oceanografskih stanja morske vode u području srednjojadranskog praga i uvod u niz članaka koji ovom akvatoriju moraju opravdati puno značenje s geografskog i oceanološkog stajališta.

Ključne riječi: srednjojadranski prag, metodologija, oceanografija, podatak

Introduction

This paper is meant to be an introduction to a succession of articles on the subject of the Central Adriatic shelf dealt with in a manner that has not been previously attempted. Namely, the Central Adriatic shelf is the area situated in the Central Adriatic, which is a far larger and wider area than the Central Adriatic shelf itself, and the results obtained by such an approach do not show the real situation in the maritime zone of the Central Adriatic shelf. An important part of the problem is the disposition of the research stations, which determine the research of considerably narrower or wider sea areas.

In the comprehensive analyses special attention was paid to geographic, geological, geomorphological, climatic, oceanographic and other features that are important for the acquisition of a better awareness of the Central Adriatic shelf area and its significance in the physicogeographic functioning of the Adriatic basin.

The purpose of this paper is to determine the importance and requirements for general compatibility relating to the space and time (disposition of stations, measuring depths, allowed parameter aberrations from the referential measuring values within the whole research area, frequency of measuring throughout the year, length of statistical data listings, etc.).

It is very important to use suitable equipment and measuring instruments. Interpolations were performed for data when the measuring was not carried out, and they were done in a proper and appropriate manner, in accordance with the generally accepted measuring standards.

Previous experience based on the value analyses of several oceanologic parameters in the area of the Central Adriatic shelf has been used as the basis for critical reviews. Some solutions are being offered which might seem unattainable at the moment due to investment requirements, such as well - equipped field workers. Such solutions might be feasible sometime in the future. However, priorities definitely need to be scheduled; whether to have more frequent research works or fewer and more comprehensive ones that offer almost fully acceptable data. Although we have been doing multidisciplinary research for thirty years now with well organised multi-institution cruises, with one or more research boats (*MOHO* report, 19829), after studying published material it seems that consistent multidisciplinarity has not been applied. Unfortunately, it seems that multidisciplinarity is still only a principle that has not been fully applied in the active scientific and research works. Multidisciplinarity of oceanographic research imposes a need for co-ordination of the existing scientific capacities, information exchange, and definition of general trends in scientific activities as well as the most economical and efficient co-ordination of scientific orientations for longer periods of time. For the purpose of performing complex analyses and correct interpretation of

physical, chemical, biological and geological processes in the sea, it is essential to know the dynamics of the basin where they are being performed.

Special attention has been paid to physicogeographic changes during the last ten years or so. One of the reasons for that is the assumption that direct anthropogenic influence might also be causing these changes. Within the climatic system /land-sea-atmosphere/ climatic changes are a result of natural processes caused by human activities. Unfortunately, sometimes anthropogenic influence on the environment is more intense than the influence of nature, as the human activities at this level of technological development, can cause many positive, but also negative changes.

Area

Hydrographic and unique features of the Croatian Adriatic originate from its geographic position in Central Europe and the Mediterranean. The position of the Central Adriatic in the middle of the Temperate Zone directly affects the climate, flora and fauna.

The Central Adriatic shelf encompasses the greater part of the Central Adriatic area. According to some earlier oceanological divisions, the Adriatic basin was divided into two parts (north and south), and the border between the two was the Palagruža shelf. More recent divisions recognise three parts of the basin (the north, middle and south). The Palagruža shelf is one, and the line joining Ancona – Zadar the other borderline (between the north and the central Adriatic). Some scientists consider the line joining Anacin – the island of Premuda to be the borderline. Both are acceptable as they extend along 50m isobath (Fig. 1). From the geomorphologic aspect it divides the two basins (the north and the middle), which considerably affects the dynamics of seawater, and also directly and indirectly affects all the other oceanographic parameters.

The Adriatic relief is a complex mountain-encircled valley (The Dinarids – Alps – Apennines) flooded by the sea. It is a basin with morphological structure characterised by two basins and two shelves. Regarding the morphogenesis of the Adriatic there are two main parts divided by the Central Adriatic shelf: the southern bathetic basin with mainly steep coast (average depth 900 m), and considerably shallower north-western part (average depth 40 m), with gradual inclinations of the coasts and seabed. 100 m isobath points to the assumption that these two territories were connected during the Pleistocene.

The north-western part of the Central Adriatic shelf whose longitudinal axis lies on the line joining the island of Žirje – Ortona, is 130 km long and from 12 to 44 km wide. The latest research shows that inside there are three concavities: the *Žirje depression* with the maximum sea depth of 239 m, the *Jabuka depression* (middle part) with the maximum depth of 273 m, and the *Ortona depression* with depth of 256 m.

Between the Jabuka and Žirje depressions there is underwater elevation at the position $\varphi = 43° 10.2'$ N; $\lambda = 0.15° 09.8'$ E with the maximum depth of 173 m. From that elevation to the north-west, sea depth rises sharply to 230 m isobath, and to the south-east the depths are from 220 to 230 m. The diameter of the under-sea elevation basis is about 1 Nm.

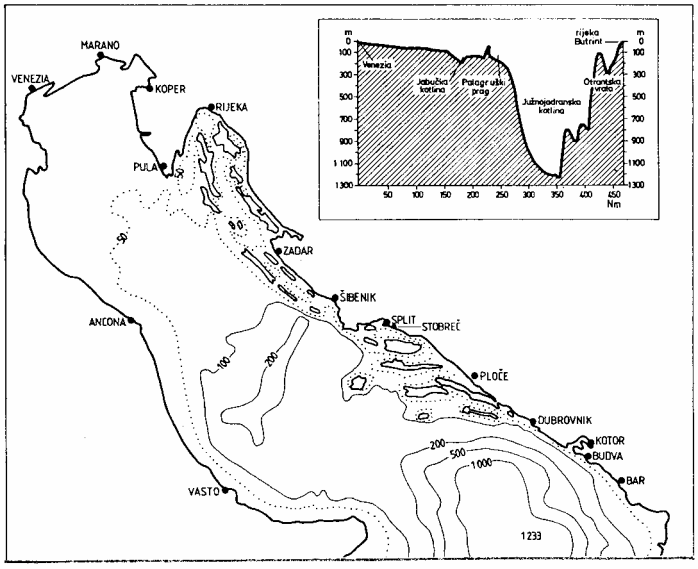

Fig. 1 Geographic structure of the Central Adriatic (according to RIĐANOVIĆ, 1993)
Sl. 1. Geografska struktura srednjeg Jadrana (prema RIĐANOVIĆ, 1993.)

From the north-western part of the Central Adriatic shelf to the south Adriatic, the seabed is slightly rising up to the rim of the south-eastern part of the Shelf (Palagruža), and the greatest depth is 178 m. Further to the south-east, that is towards the south Adriatic concavity, depth abruptly increases to the maximum of 1233 m (the deepest point in the Adriatic). This under-sea step divides the Central Adriatic shelf from the bathetic part of the south Adriatic, and with its configuration makes a natural barrier to the inlet and outlet branch of the general Adriatic cyclonic drift in the sea.

Apart from the longitudinal differences in dimensions and depth features, there are also pronounced differences when comparing the Central Adriatic shelf sea depth transversally, between the east and west coast. The west coast has been rising in recent times, so its indentedness is weak. Sea depth gradient, vertical to the shore, is considerably smaller in that part of the Adriatic than in its eastern coast. (JAŠIĆ ET AL., 1999).

Shelves are positive morphostructures, under-sea elevations formed by fault movements associated with under-sea volcanoes. The Central Adriatic shelf is a wide and flat under-sea elevation, formed partly by the disturbed Quaternary and proportionally dislocated Tertiary and Mesozoic sediment strata, penetrated by diabaz-porphirit and diapiriz (JAŠIĆ, 1997). It stretches in the direction of northeast -southwest and connects Mt. Gargano with the Croatian coast via the islands of Tremiti, Pianosa, Palgruža, Vis, Lastovo and Mljet (Fig. 2). At the same time it divides the more shallow northwest part from the deeper south-eastern basin. With structure contact, the depth sharply increases from 100 to 200 m and further on to 1200 m (JAŠIĆ, 1999).

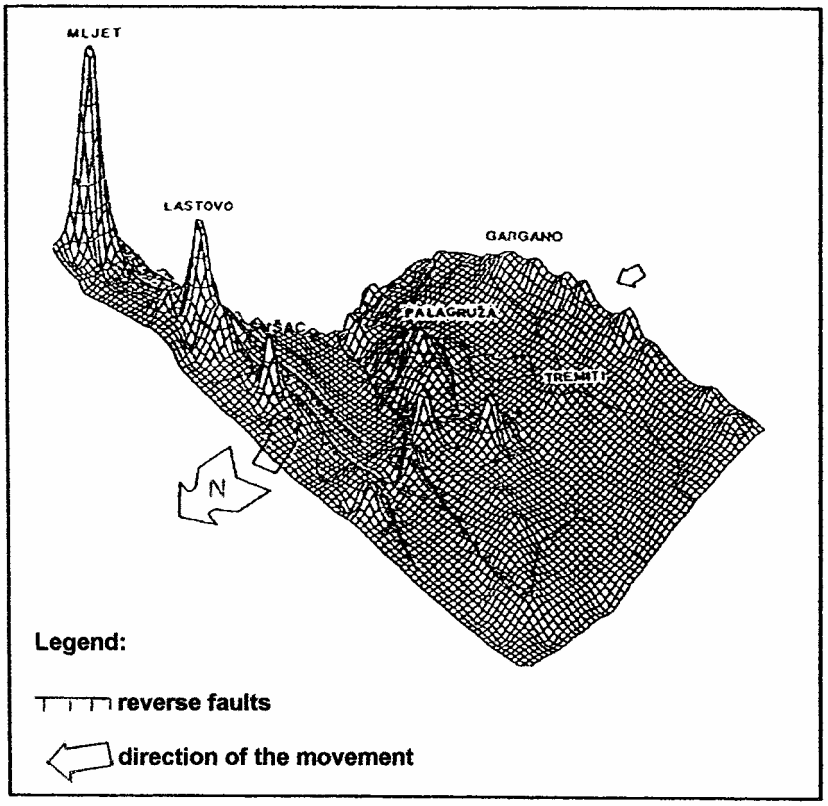

Fig. 2 Isometric presentation of the south part of the Central Adriatic shelf and seabed (according to BOGNAR, 1996).
Sl. 2. Izomatrijski prikaz reljefa južnog dijela srednjojadranskog praga i podmorja (prema BOGNAR, 1996.)

Morphostructurally and geotectonically, the shelf can be divided into three entities, conditionally called the *Hvar block* (depths smaller than 150 m), the *Mt. Gargano block* (depth less than 150 m) and *gutter recess* which connects the Jabuka with the south Adriatic basin with depths from 150 to 200 m (BOGNAR, 1996, BATIMETRIJSKA KARTA, 1994).

The length of the shelf is 80, and average width (between the western coast and external borders of the Croatian islands) about 50 m. According to the aims of the latest oceanographic research, the Adriatic is divided into eight cross-sections (profiles), according to the *Najade* and *Ciclope* research from 1911 to 1914 (NAJADE and CICLOPE). They are designated by numbers from I to VIII, starting from northwest towards southeast. At the cross-sections, depending on length, there are four to five oceanographic stations (Fig. 3, Tab. 1).

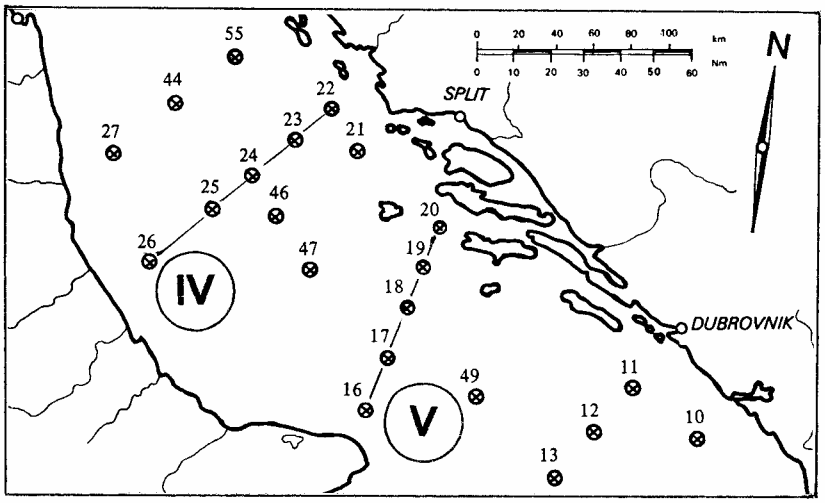

Fig. 3 Negative projections of cross-sections on sea surface and disposition of oceanographic stations
Sl. 3. Negativna projekcija poprečnih presjeka na morsku površinu i raspored oceanografskih postaja

The area of the Central Adriatic shelf is covered by cross-sections IV and V where there are permanent stations designated by numbers from 16 to 20 and from 22 to 26. Cross-section IV stretches from Ortona to the island of Žirje, and cross-section V from Mt. Gargano (Vieste) to the area southeast of the island of Vis (BIĆANIĆ, 1986). Supporting oceanographic stations 21, 46 and 47 are between these two cross-sections.

Tab. 1 Stations in the maritime zone of the Central Adriatic shelf
Tab. 1. Pregled postaja u akvatoriju srednjojadranskog praga

PROFILE	STATION	LATITUDE – LONGITUDE	APROX. DEPTH (m)
V	16	φ = 42°09.0' N λ = 16°10.0' E	130
V	17	φ = 42°19.0' N λ = 16°12.0' E	130
V	18	φ = 42°32.0' N λ = 16°15.0' E	170
V	19	φ = 42°46.0' N λ = 16°14.0' E	155
V	20	φ = 43°00.0' N λ = 16°20.0' E	100
	21	φ = 43°27.0' N λ = 15°56.0' E	135
	46	φ = 42°54.0' N λ = 15°29.0' E	180
	47	φ = 42°42.0' N λ = 15°53.0' E	166
IV	22	φ = 43°32.0' N λ = 15°32.0' E	200
IV	23	φ = 43°21.0' N λ = 15°24.0' E	217
IV	24	φ = 43°06.0' N λ = 15°08.0' E	270
IV	25	φ = 42°52.0' N λ = 14°46.0' E	250
IV	26	φ = 42°35.0' N λ = 14°28.0' E	95

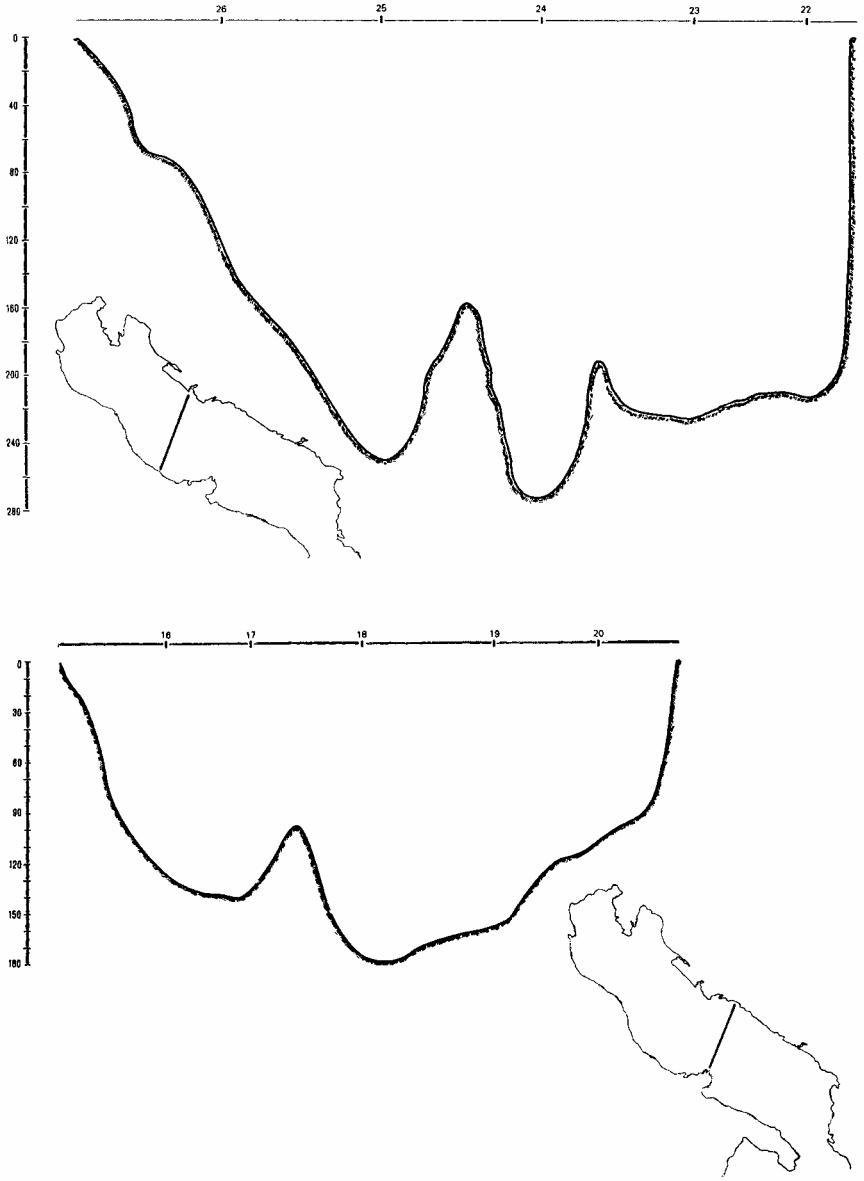

Fig. 4 Diagonal cross-section of the Central Adriatic shelf IV (Ortona – Žirje) and V (Viesta – the island of Vis)
Sl. 4. Izgled poprečnih srednjojadranskih presjeka IV (Ortona – Žirje) i V (Vieste – otok Vis)

Research

Apart from research projects that took several years in the area of Central Adriatic, there were also several that did not last long, and they have all contributed to the new awareness relating to oceanographic features of the Central Adriatic shelf and provoked a great deal of theoretical issues. Although insufficiently, we can still say that multidisciplinarity has raised oceanography from a descriptive to an analytical scientific level (JAŠIĆ, 1999).

The foundation of the Vienna *Academy of Science* and the Trieste *Zoological stations* in the middle of the 19th century followed by the foundation of the *Yugoslav Academy of Science and the Art* and *Science Museum* in Zagreb were the basis for the development of Adriatic oceanography and many scientists found new methods of studying the Adriatic. The Academy organised the *Permanent Adriatic Commission* and they deserve the credit for research organisation of the whole Adriatic basin from February 1911 until mid -1914 by the *Najade* and *Ciclope* boats, at eight cross-sections. The furthest to the south was at Otranto.

Austria organised 12 independent cruises and among known researchers there were Bruckner, Grunda, Coria, Kesslitz, Leder and Croats A. Gavazzi and L. Car. Italy organised 10 cruises, under the guidance of De Marchi, Feruglio, Issel, Brunelli and Manuelli. Apart from recording meteorological values, the measuring also included seawater temperature, currents, drifts; salinity level and density, oxygen content, cause of sea bottom sedimentation was determined, batimetry was performed etc. At the same time biological research was taking place.

Apart from *MOHO* research these were certainly the most complex and comprehensive scientific ventures in the area of the Central Adriatic shelf. Material gathered at that time was and still is a very precious fundus that has been often used as the source of information by many scientists. Between the two wars oceanographic activities stagnated apart from the *Sea Biology Institute* from Rovinj (1892).

After World War II, oceanographic activities intensified and equipment became more sophisticated and technologically developed. Data processing gradually became automated, simple and fast. Research was planned and programmes became more complex and multidisciplinarily conceived. Among better known cruises we should point out m/b *Hvar* (the Institute for Oceanography and Fishing, Split from 1948 to 1949). In 1955, *M-306* mine-sweeper performed sedimentologic research in the Central Adriatic, and during the *International Year of Geophysics* (1957 –1958) research was organised by the Hydrographic Institute of Split in the area of the Central Adriatic by m/bs *Predvodnik*, *Bois II*, *Miner* (ex *Najade*) and *Spasilac*.

Certainly, the second largest research project (apart from *Najade* and *Ciclope*) was the *MOHO* project. It was lead by the Andrija Mohorovčić –Board for Co-ordination of Cruise programme. The cruise programme was approved and scientific multidisciplinary methodology was co-ordinated. Zoran Vučak was the leading scientist who managed the research teams. Until the end of 1990, 22 cruises were organised. Undoubtedly it was the largest material gathering in the history of oceanology in the Adriatic. It has been extremely beneficial to the economy and other social operations. The material has been used by scientists for almost a thousand scientific papers, masters and doctorate degrees. Special contribution was made to electrification of the seaside and islands, construction of water supply and telecommunication infrastructure, liquid waste

collectors, hydrographic, sports, military and tourist facilities, protection of the sea and seaside environment, designation of waterways, safety at sea, production of navigation charts, manuals and aids, as well as, the contribution to the fishing industry and maritime industry in general. After expiry of the referential part (1976), the programme was continued until 1980. In this way one entity was completed and such research works have continued until now with modern programmes and equipment, and with increased numbers of direct and indirect participation. One of the more significant programmes was *P-163*, *Research, utilisation and protection of the Adriatic until 2000*.

In the *MOHO* programme multidisciplinarity was achieved by participation of many oceanographers (75 scientists and technical staff). There were 140 days of research work (VUČAK, ŠKRIVANIĆ, 1986). Analyses of hydrometeorological conditions and features of the Adriatic current regime enabled division of important oceanographic conditions:

-prevailing inlet current in the basin during September/October, 1974,
-prevailing outlet current from the basin during July, 1976,
-non-typical winter hydrometeorological situation in January, 1980,
-typical winter hydrometeorological situation in February, 1976 and
-variable hydrometeorological conditions in April/May 1975.

The research works determined close interdependence of the current regime, hydrometeorological conditions and disposition of physical, chemical and biological parameters, and the *zone of hydrologic discontinuity* was noticed.

Scientific research of the Adriatic so far has produced a huge amount of material and created a sound basis for further investments and development. Therefore, the Adriatic belongs to the group of better-researched world seas and on account of historical background and potential resources there is reason to believe that these developments will continue in the future.

Data, processing methodology and discussion

Some science-research institutions and scientists have not been using the same data sources in their research of the Central Adriatic. That is considered to be a certain methodological lack of coordination, which can explain insufficient results relating to the space and time component of scientific research. Notwithstanding determined measuring cross-sections, stations and interstations when researching for specific application, limited area is being researched. Research is organised at the positions that are not within the agreed ones (MOHO REPORT, 1982, Fig. 3). Selection of such micro-locations is usually justified by the purpose of the research and limited funds. That can be accepted, but research programmes that do not in any way relate to so-called referential research cross-sections and stations cannot be fully accepted. As the projects with specific purposes (apart from the ones relating to sea and seabed at micro-locations with the purpose of research activities under the surface and on the drilling rigs) mainly refer to the territory between islands (internal seawater masses), some are carried out in the area of territorial sea and therefore they can be related to a referential research area by their topic of study.

In the oceanographic analyses of the conditions in particular areas, it is best to use the results obtained from the same types of programme and in as long a time period as

possible. In the analyses of years-long periods, oceanology accepts at least 50-year periods, and meteorology 80-year statistical data listings (VUČAK, 1992).

For example, in doctoral dissertation (*Geographic and Oceanographic features of the Central Adriatic Shelf*, JAŠIĆ, 1999), the data used was gathered from several scientific and expert institutions also from merchant vessels that sail on regular routes in the Adriatic, and from the *ZAGREB I* rig, as well as from the database of the Croatian Hydrographic Institute, Maritime Meteorological Centre and The Institute for Fishing and Oceanography in Split.

Generally accepted standards and methods in oceanology and meteorology were used for methodology of research, measuring and data processing. Methods were standardised and in compliance with customary norms applied in contemporary science relating to sea. This allows more or less successful comparison of the present and previous results.

Apart from national authors, foreign literature is also useful, Italian scientists, for example, who were researching the western part of the Central Adriatic (Shelf). The earlier mentioned Croatian institutions keep a considerable amount of hydrographic and meteorological data in their databases. Years-long statistical data listings of oceanographic parameter values and meteorological elements in the area of the Central Adriatic Shelf are of special value. Also of great importance is the data collected from the drilling rigs. From 1984 until 1987, Zagreb I rig researched at several locations in the Central Adriatic (*Kornati – sea 1*, *Palagruža – 1*, *Perina – 1*, *Vlasta – 1*).

Meteorological data used in the dissertation was gathered from 1957 until 1990 (such as: temperature, humidity, atmospheric pressure, wind, clouds, precipitation and fog – database of DHZ Maritime Meteorological Centre in Split). The data was gathered during the execution of oceanographic operations on the rig and merchant vessels, and at Palagruža lighthouse. Physicogeographic data (temperature, salinity, transparency, seawater colour, currents and geological features) was gathered at oceanographic stations, designated by numbers 8, 9, 11, 12, 13 and the numbers from 203 to 213, and on the rig (Fig. 5), from 1961 until 1987 (database: Institute for Oceanography and Fishing in Split).

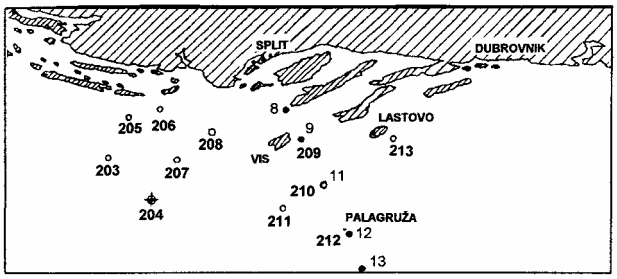

Fig. 5 Disposition of oceanographic stations in the north-eastern part of the Central Adriatic Shelf (according to JAŠIĆ, 1999).
Sl. 5. Raspored oceanografskih postaja u sjeveroistočnom dijelu srednjojadranskog Praga (prema JAŠIĆ, 1999.)

The Croatian Hydrographic Institute data was also used from the period between 1957 and 1989 (currents, surface waves, and seawater temperature). The data was

gathered at *Stončica* and *Palagruža* stations and in other parts of the Central Adriatic shelf. The stations have been well distributed although there might be two more required between the stations 208-211and 204-211 (Fig. 5). The aim of the increased density would be for better supervision of water masses movements, especially in supervision of cyclonic drift of inlet Adriatic NW surface current towards SW in the narrower (wider) area of the island of Vis (BULJAN, ZORE-ARMANDA, 1971). It is also satisfactory that the station network relies on referential stations 16, 17, 18, 19, and 20 (Fig. 3).

An example of a different methodological approach is presented in the M.Sc. thesis with the title: *Contribution to the knowledge of thermohaline characteristics of the Central Adriatic*, BIĆANIĆ, 1986. The data of many shorter time periods was analysed from five seasonal *MOHO* cruises (MOHO REPORT, 1982) between 1974 and 1976. Although many value sampling and measuring activities of various oceanographic parameters were recorded, the paper dealt with (as in the title) temperature, salinity and density of seawater.

The research went on as follows:

- cruise 1 September 25th 1974 until October 15th 1974 (the end of summer and beginning of autumn)
- cruise 2 March 2nd 1975 until March 16th 1975 (the end of winter)
- cruise 3 April 20th until May 11th 1975 (the beginning of summer)
- cruise 4 February 5th until February 20th 1976 (mid-winter)
- cruise 5 July 8th until July 23rd 1976 (the beginning of summer).

As the oceanographic seasons start about 20 days following the calendar seasons, the above table clearly shows that only 4 research works were performed during mid-season. From the professional point of view it means that it would be difficult to refer to the rest as being *seasonal*. Of course, it is well known that a season is defined by prevailing weather conditions and that long-term forecasts are difficult to attain, but it should be taken into account that the irregularities in distribution and wavering of oceanographic parameter values happen on wide areas and their influence on condition in some micro-locations might be quite distant. Therefore, when determining the terms for oceanographic measuring, uniform or similar weather conditions should be sought. Seasonal research should be done during the middle month of each season (February, May, August and November).

In the Central Adriatic shelf area research, (BIĆANIĆ, 1986) the data that was used came from well-distributed stations. It can be suggested that there should have been a few supporting stations in the SW part, between the cross-sections IV and V. The existing are the referential oceanographic stations on referential cross-sections, with three supporting stations (21,46 and 47; Fig. 3). The problem is in the fact that the works were taking a long time, thus between measuring at the first and the last stations weather and oceanographic states of seawater considerably changed. There were also changes in warm and cold winds, air temperature, seawater surface temperature, salinity and density, waves, current regimes etc. However, it is positive that at the same time, climatic element values were also measured (determined), and in the analysis introduction for each cruise meteorological conditions during the research were given, as well as the analysis of the prevailing currents in the area.

With such disposition of measuring stations, dispersed on large area, there should be three fast, well-equipped crafts with technically compatible instruments. Two teams would work separately at their cross-sections, and the third would work on the

supporting stations. The complete task would be done in a day, in the environment of approximately uniform weather conditions. Such would be valuable data that would give first class analyses and superb results. Existing material conditions in research institutions would make this feasible. There are sufficient number of experts (although some analysts would not agree claiming that there is not enough expert staff), the equipment is also satisfactory and the problem of covering the expenses of sailing (hired) boats can also be solved. Unnecessary and time consuming sampling should be excluded and the research should be in accordance with its aims.

On the other hand, the research in the field of geophysics takes a long time and requires specialised vessels with facilities for deep-freezing of samples (geological sampling), and there are frequent stoppings. Same as above, in this case accurate DGPS navigation is required. It is needless to say that all navigation safety regulations must be observed and that is something that is not easily done in such conditions.

When the tasks ask for currents (speed and direction) to be measured, current-measuring instruments should be installed at the beginning of the research and taken out when it is completed. If they are to be laid on fairways (routes) or in the area of intensive fishing activities, they should be protected from damage, and the practice is to have an assistance boat or craft close to the instrument (device) when the weather conditions allow it.

Prior to starting any research activities the announcement about the nature of activities should be given over shore radio station and notices to mariners including the type of work, time and suspension of sailing during the works. In this way the research party has legal and material coverage from undesired incidents.

Certain uniformity should be reached for the analyses of scientific research results and for their written form presentations. For example, it would be very useful if there was an agreement on diagrams (parameter value designation points, units, size, shape of curves and lines etc.); or graphs (colour, shape, interpretation, designations etc.)

There are some other difficulties on the spot that need to be overcome. We can often hear that the sea charts that were made during the rule of the Austro-Hungarian Monarchy are suitable for navigation even in the present day. That is partly true. In those first hydrographic research works it was easy, as it is nowadays, to measure depths at certain positions mechanically, but it was impossible to plot them accurately on the chart. Nowadays, it is solved easily, accurately and quickly by modern electronic positioning systems such as GPS, DGPS.

Furthermore, bottles are often used during seawater sampling. Once in the sea on the steel rope, bottles are never on the desirable depth as the currents and friction effect slant the rope. Although there is a formula for correction of this problem it does not quite eliminate the mistake. The formula is not mentioned here because the fact is that it is much better not to use it because due to characteristics of the Adriatic current regimes, as in the most part of the world sea, the slanting of the carrier rope is not hypotenuse in a triangle with kathetes being the depth and distance from the sea-bottom. In the water columns of medium and particularly of great depths, there are at least three water layers (surface, intermediary and bottom layer) in which the direction of the water flow is often different, sometimes even opposite (the area in the SW part of the Central Adriatic shelf serves as an example here). As a result of this effect, the rope is swerved in different direction from the surface to the bottom. The modern instruments solve this problem by installing the sensors for hydrodynamic pressure. They are connected to computer

memory and after they have been taken out to the surface and connected to computer they show the exact depth where the instruments were, or the depth from which the water sample was taken.

One of the latest developments is *SEA bird probe*. It has sensors for oceanographic parameter measuring. It takes the measurements as it is being dipped into water or out of it through the water column and stores them in the memory. It uses batteries as an energy source. It is connected to the computer on a boat (shore) and it gives measuring data in digital form. However, despite its sophistication, *SBE* has made mistakes caused by the great trust of the users. During delicate and very important research of a fresh-water spring in Croatian Territorial waters, the probe was lowered right to the bottom of the spring. The data did not show any evidence of fresh water. The paper presented entirely wrong conclusions. Only a few years later it was proven that on the sea surface right above the spring there was a thin layer of fresh water which the probe had not recorded. This time it was not a human error but the error of *human aid* to which we put our trust ever more.

Conclusion

The principle of multidisciplinarity has not been satisfactorily applied yet in the research and scientific activities. Multidisciplinarity of the oceanographic research imposes the requirement for the association of existing scientific capacities, exchange of information, definition of general trends in scientific activities, and the most economical and efficient co-ordination of scientific orientations for longer periods of time. The latest research of physicogeographic changes showed that anthropogenic influence might be one of the causes.

Projects *Najade* and *Ciclope* conducted the best-known and most important research of the whole Adriatic basin, as well as the *MOHO* programme. The last achieved multidisciplinarity principle by participation of many oceanographers.

The research of the Adriatic determined close interdependence of the current regime, hydrometeorological conditions and distribution of chemical, biological parameters. The zone of hydrometeorological discontinuity has also been noticed. The *MOHO* cruise had the disadvantage of works being time-consuming, which caused the change of seawater oceanographic state from measuring at the first to the last stations.

Research of the Adriatic is presently confined to limited areas, works are organised outside agreed areas although they could be related to the referential research area according to their study.

Seasonal research is often mentioned. It is known that the seasons are determined by the prevailing weather conditions that are difficult for long-term forecasts. That is why, when deciding about terms for oceanographic measuring, attention should be paid to uniform and approximately same weather conditions. The seasonal research should be conducted in the middle month of each season.

The way to avoid all negative sides in research on larger territories, with dispersed disposition of measuring stations rests on organisation. If circumstances allow, it is most favourable for the works in the smaller areas to be finished within one day, with rather uniform weather conditions. Unnecessary and long sampling should be avoided in such research.

In order to avoid any undesirable incidents on sea, before starting research activities, shore radio stations and notices to mariners should relay an announcement informing about oncoming activities.

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SUMMARY:

Damir Jašić, Zlatimir Bićanić, Josip Kasum: The central Adriatic shelf – important research ad data processing methodology

This paper is an introduction to a succession of articles on the Central Adriatic shelf, and its aim is to determine the significance and requirements for general compatibility relating to time

and space. Topical reviews and discussions were based on experience with value analyses of many physicogeographic parameters in the area of the Central Adriatic shelf. Also some solutions are being proposed, which might not seem acceptable in present conditions but might become so in the future.

The principle of consistent multidisciplinary quality of the oceanographic research imposes the requirement of assembling the existing scientific experience, exchange of information, designation of general directions in the scientific activities, and the most effective and economical long-term adaptation of scientific orientations. The latest research on physicogeographic changes made us aware that they might also be caused by anthropogenic influence.

The Central Adriatic shelf is situated in the area of the Central Adriatic. It extends in the directions of northeast – southwest and it connects Mt. Gargano with the Croatian coast via the islands of Tremiti, Pianosa, Palagruža, Vis, Lastovo and Mljet.

Physicogeographic analyses rarely use the term *Central Adriatic* but rather *Palagruža shelf*. There is the issue of approach accuracy here, as it is quite clear that area wise these two terms define two different territories. Namely, the Palagruža shelf is a ridge in the south area of the Central Adriatic shelf which spreads to the northwest approximately to the line joining Vasto-Šibenik, or to the southeast border of the Jabuka Valley. Therefore we can say that the Central Adriatic shelf is a positive morphological structure between the isobath 200 m to the northeast and southwest. Differentiation of these two geographic terms is suggested.

Palagruža has ridgeous structure and the islands formed in its peak area. It belongs to the middle area of the Central Adriatic shelf. Morphostructurally and geotectonically, the shelf can be divided into three divisions, conditionally called: the Hvar block, the Mt. Gargano block and the gutter recess which connects the Jabuka and the South Adriatic basin. The length of the shelf is about 80m and average width about 50m.

Apart from the long lasting research ventures in the area of the Central Adriatic there have also been some lesser ones and they have all contributed to the new awareness relating to the oceanographic parameters in the area of the Central Adriatic shelf and they have also raised many theoretical issues. The most significant and known research works of the whole Adriatic Basin were conducted in the period between 1911 and 1914 by the boats *Najade* and *Ciclope* on eight cross-sections, and between 1974 and 1976 by the *Andrija Mohorovčić* boat.

The results of the five seasonal research sessions within the *MOHO* project have greatly contributed to electrification of the seaside and islands, construction of water supply and telecommunication infrastructure, liquid waste collectors, hydrographic, sports, military and tourist facilities, protection of the sea and seaside environment, designation of waterways, safety at sea, production of navigation charts, manuals and aids as well as contribution to the fishing industry and maritime industry in general. In the *MOHO* programme multidisciplinarity was achieved by participation of many oceanographers from various scientific institutions.

Close interdependence of tidal range, hydrometeorological conditions and disposition of physical, chemical and biological parameters have been determined and the Adriatic Basin was divided into a few kinematics entities.

Even nowadays when researching the Central Adriatic the same data sources are not being used. That seems to be a certain methodological discrepancy. Notwithstanding certain measuring cross-sections, stations and interstations, when researching mainly for specific purposes, limited areas are being researched, they are being organised outside agreed positions although they can be related to the referential research area.

Five seasonal *MOHO* cruises are constantly being referred to. The seasons in the oceanography start twenty days following the calendar seasons, and after checking the calendar it can be determined that only four research works were done during the mid-season. The other four can hardly be called seasonal from the expert viewpoint. Of course it is well known that the season is determined by the prevailing meteorological conditions and that long-term forecasts are difficult to obtain. However, it must be borne in mind that irregularities in the timetable and variation of oceanographic parameter values refer to wide areas and their influence on conditions in some

micro-locations area wise can be long to come. Therefore when deciding about terms for oceanographic measuring, same or similar weather conditions should be favoured. Seasonal research should be performed during the middle month of each season.

Another problem with *MOHO* cruises is that the works took a long time so from the first to the last station, measuring meteorological and oceanographic conditions of the seawater changed considerably. But it is positive that concurrently with oceanographic also climatic element values were measured and therefore analyses were able to produce meteorological conditions during the research as well as the analysis of the prevailing tidal field in the area.

The way to avoid all negative sides of the research in the greater area (the Central Adriatic shelf for example) with dispersed disposition of measuring stations would be to use three, fast well - equipped boats with technically compatible instruments. Two teams would work on their cross-sections separately and the third one would work on the supporting stations. The whole work would be completed within one day with uniform weather conditions. Such analyses should exclude unnecessary and long sampling, complying with research purposes. The possibility of accurate navigation data is also necessary. Current measuring instruments should be laid at the beginning of research activities, and should be taken out after the completion of the task. If they are to be laid on the fairways (routes) or in the areas where there are intensive fishing activities in progress, they should be protected from damage. Prior to conducting any research activities, announcements should be given via radio and notices to mariners about the area and time of research, and partial or complete suspension of sailing in the area should be proclaimed. In that way the project has legal and financial coverage against any undesirable incidents.

SAŽETAK

Damir Jašić, Zlatimir Bićanić, Josip Kasum: Srednjojadranski prag – važnija istraživanja i metodologija obrade podataka.

Rad je uvod u niz članaka koji obrađuju temu Srednjojadranskog praga. Najčešće ga se spominje u sklopu Palagruškog praga, što se drži neprihvatljivim. Svrha ovog rada ustanoviti je značenje i potrebu za općom kompatibilnosti koja odnosi se na prostor i vrijeme. U kritičnim osvrtima i raspravi o temama, kao podloga poslužila su neka dosadašnja iskustva, temeljena na analizama vrijednosti više oceanoloških parametara u akvatoriju srednjojadranskog praga. Također se nude i neka rješenja koja u postojećim materijalnim uvjetima izgledaju neprihvatljiva, ili prihvatljiva tek u daljoj budućnosti.

Načelo dosljedne multidisciplinarnosti još uvijek nije dobilo zadovoljavajuću primjenu u aktivnom istraživačkom i znanstvenom djelovanju. Multidisciplinarnost oceanografskih istraživanja nameće potrebu udruživanja postojećih znanstvenih kapaciteta, razmjenu informacija, određivanje općih smjerova znanstvenog djelovanja, te najekonomičnije i najdjelotvornije usklađivanje znanstvenih orjentacija za dulja vremenska razdoblja. U novijim istraživanjima fizičkogeografskih promjena spoznalo se da bi jedan od njihovih uzroka mogao biti i neposredan antropogeni utjecaj.

Srednjojadranski je prag u dijelu područja srednjeg Jadrana. Proteže se smjerom sjeveroistok – jugozapad i povezuje poluotok Gargano s hrvatskom obalom preko otoka Tremiti, Pianosa, Palagruža, Vis, Lastovo i Mljet. U oceanološkim se analizama gotovo nikad ne operira pojmom s*rednjojadranski*, već *Palagruški prag.* Postavlja se pitanje ispravnosti pristupa, jer je očito da u prostornom pogledu pod ova dva pojma valja podrazumijevati dva područja. Naime, Palagruški prag je hrbat na južnom dijelu srednjojadranskog praga koji se prema sjeverozapadu proteže približno do spojnice Vasto – Šibenik, odnosno do jugoistočne granice Jabučke kotline. Dakle, srednjojadranski je prag pozitivna morfostruktura između izobata 200 m na sjeveroistoku i jugozapadu. Predlaže se razdvajanje ova dva geografska pojma.

Palagruža ima hrptasta strukturu i u njezinom se vršnom dijelu oblikovalo otočje. Pripada središnjem dijelu srednjojadranskog praga. Morfostrukturno i geotektonski, prag se može podijeliti

u tri cjeline, uvjetno nazvane: *hvarski blok*, *blok Monte Gargano* i *žljebasto udubljenje* koje povezuje Jabučku s južnojadranskom kotlinom. Duljina praga je oko 80, a srednja širina oko 70 M.

Osim velikih višegodišnjih istraživačkih pothvata u području srednjeg Jadrana, organiziralo se i više manjih, a svi su doprinijeli novim spoznajama o oceanografskim značajkama srednjojadranskog praga, te potakli veliki broj teorijskih pitanja. Najznačajnija i najpoznatija istraživanja cijelog jadranskog bazena obavilo se u razdoblju od 1911 do 1914., brodovima *Najade* i *Ciclope*, na osam poprečnih presjeka i od 1974 do 1976., brodom *Andrija Mohorovičić.*

Rezultati koje polučilo je pet sezonskih istraživanja iz projekta *MOHO* dali su značajan doprinos elektrifikaciji obale i otoka, izgradnji vodovodnih i telekomunikacijskih ugradbi, izgradnji kolektora otpadne vode, hidrograđevnih, športskih, vojnih i turističkih objekata, zaštiti mora i morskog okoliša, označavanju plovnih putova, sigurnosti plovidbe, izradi navigacijskih zemljovida, priručnika i pomagala, ribarskoj privredi, pomorstvu i pomorstvenosti uopće. U *MOHO* – programu se multidisciplinarnost ostvarilo sudjelovanjem velikog broja oceanografa iz više znanstvenih institucija.

Ustanovilo se tijesnu međuovisnost strujnog sustava, hidrometeoroloških uvjeta i raspodjele fizikalnih, kemijskih i bioloških parametara. Uočilo se *zone hidrološkog diskontinuiteta.* Dijele jadranski bazen u nekoliko kinematičkih cjelina

U istraživanju srednjeg Jadrana se ni do danas ne koristi iste izvore podataka. To se drži stanovitom metodološkom neusklađenošću. Unatoč određenih mjernih presjeka, postaja i međupostaja, u obavljanju istraživačkih radova za isključivo namjenske potrebe, istražuju se prostorno ograničena područja, organizira ih se na pozicijama izvan dogovorenih, iako ih se studijski može vezati na referentna istraživačka područja.

Neprekidno se ističe pet *sezonskih MOHO* krstarenja. Sezone u oceanografiji nastupaju dvadesetak dana iza kalendarskih, a pregledom kalendara istraživanja može ustanoviti se da se samo 4. istraživanje obavilo sredinom sezone. O druga četiri je sa stručnog stajališta, teško govoriti kao *sezonskima.* Naravno, poznato je da sezonu određuju prevladavajuća vremenska stanja i da ih je dugoročno teško predvidjeti, međutim, valja voditi računa o tomu da se nepravilnosti u rasporedu i kolebanja vrijednosti oceanografskih parametara događaju na širokim prostorima, a njihov utjecaj na stanja u nekim mokrolokacijama prostorno može biti vrlo dalek. Stoga u izboru rokova za obavljanje oceanografskih mjerenja valja dosljedno voditi računa o ujednačenim ili približnim vremenskim prilikama. Sezonska bi se istraživanja moralo izvoditi u središnjem mjesecu svake sezone.

Za *MOHO* krstarenja je još problematično da su radovi vremenski trajali dugo, pa su se od mjerenja na prvoj do mjerenja na posljednjoj postaji, vremenska, a time i oceanografska stanja morske vode znatno mijenjala. Međutim, pozitivno je da su se usporedno s oceanografskim mjerenjima obavljala i mjerenja/određivanja vrijednosti klimatskih elemenata, tako da se u analizama moglo predstaviti meteorološko stanje u vrijeme istraživanja, kao i analiza vladajućeg strujnog polja u području.

Način kojim bi se moglo izbjeći sve negativnosti istraživanja na većim područjima (na prinjer srednjojadranskog praga), pri rasutom rasporedu mjernih postaja, odnosi se na plovidbu s tri brza, dobro *ekipirana* plovila i tehnički *kompatibilnim* instrumentarijem. Jedan tim obavlja radove na jednom presjeku, drugi na drugom, a treći na pomoćnim postajama. Cijeli se posao završava tijekom jednog dana u uvjetima ujednačenih vremenskih prilika. U takovim bi *briefinzima* valjalo isključiti suvišna i dugotrajna uzorkovanja, u skladu sa svrhom istraživanja. Također je nužna mogućnost vođenja točne navigacije. Strujomjere valja postavljati odmah na početku izvođenja radova, a podizati ih iz mora nakon svršetka. Ako ih se polaže na plovidbenim putovima/rutama ili u područjima u kojima obavlja se intenzivna ribarstvena dinamika, valja ih čuvati od mogućih oštećenja. Prije izvođenja bilo koje vrste istraživačkih radova, putom radio oglasa i obavještenja za pomorce, valja objaviti područje u kojemu se obavljaju aktivnosti, vrstu radova, vrijeme i proglasiti potpunu ili djelomičnu zabranu plovidbe. Na taj se način izvoditelj radova pravno i materijalno osigurava od nepoželjnih incidentnih situacija.