Coastal oceanographic observing and data in Montenegro

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Montenegro coast belong to the south-eastern part of the Adriatic Sea.

Geographical coordinates of the final points of montenegrin territory are 43° 32' N, 41° 52' N and 18°26' E, 20° 21' E.

The total area of the country is 13,812 km² of which 13,452 km² is land and marine maritime zone is 2540 km² (internal waters and territorial sea).

Total coastal line is 293 km.
Historical background of coastal observations in Montenegro

• The development of oceanography in the eastern Adriatic Sea is connected with historical changes and influences in this area.

• In the 1880’ first systematic oceanographic investigations of the open Adriatic Sea:
  Nautilus (1874), Deli (1875, 1876, 1877) and Nertha (1880).
  Organizational: Austrian naval authorities

• 1911-1914 cruises with Najade (12) and Cyclope (10)
  Organizational: The International Commission for Adriatic Sea (Italy, Austria)

• 1908-1909 Danish expedition Thor (Mediterranean Sea/South Adriatic)

Map of the 7th cruise of Najade (1)

Map of surficial currents in summertime Wolf and Luksch (1)

(1)Zore armanda: Annals of maritime studies. 38(2000[i.e. 2001]); pp 301-331
After II World War a lot of cruises were organized in the former Yugoslavia with domestic and foreign expeditions.

In 1961, the Institute of Marine Biology was founded in Kotor (Montenegro) with the main objective to study the marine food web in the southern Adriatic. Over time its activities has been expanded and now IMB in Kotor is the only institution in Montenegro dedicated to the research of the sea.

Establishment of the IBM enabled organized oceanographic investigation of the Montenegrin part of southern Adriatic for the first time in history.
Since 1975 the research and pollution monitoring along the eastern Adriatic coast has been organized at the national level.

In 1976, the Government of the former Yugoslavia signed and ratified in 1977, the Convention for the Protection of the Mediterranean Sea against Pollution (Barcelona Convention). Like part of the former common state SFRY, Montenegro was included into realization of this convention and its protocols from the start.

1975-1980, Montenegro has begun the realization of the monitoring programme - MEDPOL I phase
1983-1992 MEDPOL II Phase


Institute for Marine Biology, Kotor and Institute for Subtropical Cultures and Environment Protection, Bar (ISCEP-B) were included in this National Monitoring Program from 1985.

After the decomposition of former Yugoslavia in 90', Republic hydrometeorological Institute form Podgorica was formed the program of the coastal waters monitoring, in aim of inclusion in the MED POL phase II.

During several years (1994, 1996, 1997, 1998) HMI done the one day lasting researches of the water quality on the surface (0,5m) and on maximal depth, on 19 measure profiles along whole Montenegrin coast and in Boka Kotorska bay. The program has realized in cooperation with Hydrographic institute of the SRY Army (Tivat, Montenegro).

Due to objective reasons, in 1999. Medpol activities has stopped and a lot of important elements of coastal monitoring from Medpol III phase (1996-2005) has never realized.

From 1998-2003 Hydro-meteorological Institute (HMI), Centre for Eco-toxicological Research (CER) have implemented water monitoring programs including sea water quality (coastal waters).

Since 2003, the program continued (implemented by HMI) in limited form. In addition, CER (1998-2003, 2003-) and IMB (after 2003) took part in some monitoring activities.
After the independence, in October 2007 Montenegro has ratified Barcelona Convention and four of its Protocols.

In 2008 started the implementation of the Programme of Coastal Ecosystem Monitoring, harmonized with the criteria of the MED POL Programme and requirements of the European Environment Agency.

In 2009, the Programme of Coastal Ecosystem Monitoring was implemented as a part of the National Environmental Monitoring of Montenegro.

The following institutions are involved in its realization:
- Institute of Marine Biology Kotor
- Hydrological and Meteorological Service of Montenegro,
- Center for Eco-toxicological Research of Montenegro,
- Public enterprise for Management of Marine Zone "Morsko dobro"

Programme is consisted of the following complementary programmes:
- Programme of the general quality of coastal water,
- Monitoring of water quality of port sea surfaces,
- Monitoring of eutrophication,
- Water quality monitoring program for aquaculture and fish eco-toxicology,
- Monitoring of biomarkers,
- Monitoring of inputs through rivers and through effluents,
- Monitoring of bathing water quality.
• Research activities are reflected through the implementation of national and international projects.

• Within the ADRICOSM Partnership launched as a Type II Initiative at the World Summit on Sustainable Development (WSSD) in Johannesburg in September 2002, Montenegro took part in two projects:

  • **ADRICOSM EXTENSION** from 2005-2006. The Project was financed by the Italian Ministry of Foreign Affairs and implemented by IOC-UNESCO (Intergovernmental Oceanographic Commission).

  • **ADRICOSM-STAR** project from 2007 -2010 (Montenegro coaSTal ARea and Bojana river catchment basin) was supported by the Italian Ministry for Environment and Territory.

• **ADRICOSM 2** project 2014 - 2017

• The area of investigation was the Bojana river Delta and the whole Montenegro Adriatic coast

• Partners from Montenegrin side: Institute of Marine Biology Kotor, Hydrological and Meteorological Service of Montenegro, Center for Eco-toxicological Research of Montenegro.

• The coordinating Institution was the Centro Euro-Mediterraneo per i Cambiamenti Climatici and the scientific coordinator was Prof. Nadia Pinardi of INGV and University of Bologna
The Activities of the ADRICOSM-STAR Project included:

• Development of the ADRICOSM forecasting system for the Adriatic Sea and its coastal areas with particular emphasis for the Montenegro coastal area;

• Design and partial implementation of a monitoring system for the surface water cycle, the river runoff and the coastal area of Montenegro;

• Development and validation of modeling tools for the urban, surface, underground water and coastal currents in the Bojana river catchment and Montenegro coastal area, considering the trans-boundary nature of the system;

• Development of a short term (several days) forecasting capability for hydrology, coastal currents and river basin runoff;

• Develop the high resolution non-hydrostatic meteorological model and the modeling of the surface water cycle;

• Production of a IPCC climate change scenario impact studies for the next decades in connection with the water and sediment quality in the Bojana river and the Montenegro coastal area
Within ADRICOSM a near real time monitoring system and a near real time basin-shelf marine forecasting system have been implemented and run in operational mode for the Adriatic Sea. The Adriatic Sea Marine Forecasting System releases weekly forecasts of marine currents, temperature, salinity and other physical parameters.

3 different oceanographic models have been implemented in the coastal area of the Montenegrin and Albanian regions at different resolutions.

2 of them (AREG₂ and SHYFEM) are nested one into another, providing operational forecast at a regional and coastal scale.

3rd has been implemented for non operational purposes in the Bokakotorska Bay, mainly with water quality aims.
Several seasonal and mesoscale cruises has been carried out for physical, bathymetrical and seismological purposes, collecting important data on bottom topography, T, salinity, chlorophyll-a, CDOM, total suspended matter, turbidity and dissolved oxygen.

**Multibeam echo sounder** Simrad EM710 and EM3002D

**Chirp sub-bottom profiler** Benthos CHIRP (3.5Khz)
Sediment sampling
- box corer
- gravity corer
- grab

CTD probe with carousel
• Institute of Marine Biology was a member of MAMA project-Mediterranean network to Assess and Upgrade Monitoring and Forecasting Activity in the basin (2002-2005), funded under the EC Programme, and conducted by MedGOOS.

• MAMA has served to enable the sharing of experiences and the transfer of expertise, to reduce gaps in capacities for operational oceanography in the region, and provide a stepping stone towards an integrated plan and design of the initial ocean observing and forecasting system in the Mediterranean.

• EuroGOOS, UNESCO/IOC and UNEP-MAP – international institutions as participants of MAMA project

• Institute of Marine Biology was a scientific partner of the FAO-AdriaMed Project (Scientific Cooperation to Support Responsible Fisheries in the Adriatic Sea) from 2001-2011, funded by the Italian Ministry of Agriculture, Food and Forestry Policies and since 2007 by the European Commission.

• AdriaMed aims were: to contribute to enlarge the scope of information on the Adriatic Sea, related to shared fishery resources, to support international processes aimed at fishery management, to reinforce the scientific coordination among the different institutions interested in fishing activity, to establish a permanent network among the main institutions present in the Adriatic that are involved in fishery management activities.
Future perspectives for operational oceanography

• Beside routine measurements that are performed within national monitoring program, it can be say that other activities in the field of sea observation are provided only through international projects and collaborations with research institutions from abroad.

• Monitoring institutions have already participated in some international projects and monitoring programs relevant for coastal area, but there is no institutional network within which obtained data would be disseminated.

• Capacities of the existing institutions for ocean observing are limited in terms of human and technical resources, financial resources, knowledge and practical experiences.

• There is need to strengthen institutions in ocean research instruments, particularly for getting real time data.

• Institute of Marine Biology (IMB) has the potential to provide scientific and research functions. It has a long tradition in working with marine ecosystem.

OTT automatic station for water quality (provided within Ecoport 8 project 2009-2012)
• Institute participate in SEADATANET II project. The SeaDataNet infrastructure links 45 national oceanographic data centres and marine data centres from 35 countries riparian to all European seas.

• The data centres manage large sets of marine and ocean data, originating from their own institutes and from other parties in their country.

• A major objective of the SeaDataNet II is to provide an integrated and harmonized overview and access to these data resources, using a distributed network approach.

• It is expected for IMB to become NODC for Montenegro.

• Institute of Marine Biology has its own data base. This data base is suitable for storage of meta-data and in-situ measurements.

• The data base contain oceanographic data collected since 2002 in the area of south-east Adriatic.

• In order to make these data available, the web oceanography.me was developed and data are accessible by using various filters (spatial, temporal, by project and/or by sampling instruments).
IMBK has a number of marine data both historical and recent ones provided from international oceanographic cruises, national monitoring programmes and regular research activities in the Institute.

IMBK data base comprises marine data collected within 24 cruises from 2002 to 2010, and others data.

Most of data are physical data (in database MySQL), while chemical and biological data are archived in various files and formats (mostly .xls).

Entering chemical and biological data into the database is in progress.

Database is available online: [http://www.oceanography.me](http://www.oceanography.me)

Real time data provided by permanent sensors from OTT probe.
Institutional capacity

• Institutions have limited technical/financial capacities

Institute of Marine Biology Kotor (IBM)

• boat Nemirna II (12m, engine 280HP), one fast 7m long boat, CTD probe, water and sediment sampling equipment, laboratory equipment).
• IMB is situated in Kotor.
• IMBK has recently installed new OTT DS5X automatic station for water quality monitoring in the aquatorium of the Port of Bar (Montenegro).
• Station is equipped with GPRS communication, software and probes with sensors for T, depth, pH, conductivity, oxygen, ammonia, nitrates and chlorophyll, and supporting equipment. The data are read every 1h, for 8 parameters.

OTT Duo Sense 5X - Automatic water quality station
• Automatic water monitoring station provides results of the sensible parameters in the real time. Real-time data provided by permanent sensors are automatically collected and stored into database.

• Visualization of such data is provided on IBM developed web portal www.oceanography.me, as well as exchange with project data center.

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<th>Parameter</th>
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<tr>
<td>0002</td>
<td>pH</td>
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<tr>
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<td>0006</td>
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<td>0009</td>
<td>Voltage</td>
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**Plans:**

To equip and put into operation oceanographic buoy – in the first Montenegrin new protected marine zone.

To repair and get access to another automatic station in front of Institute, temporary out of function.
Hydrological and Meteorological Service of Montenegro (HMSM) -
(Department for hydrography and oceanography - DHO in Tivat):

- Hydrographic vessel 22.5m equipped for hydrographic measurements also for the open sea (portable and hull mounted single beam echosounders, high resolution Side Scan Sonar), survey equipment (CTD, ACDP current meter, sediment sampling equipment). DHO operates two permanent tide gauge stations (in port of Bar and in Kotor) and one mobile tide gauge.

- DHO set up graphical tide prediction software (portalTide T@bles) that visualize tide prediction for ports Bar and Kotor, allowing also correction by atmospheric pressure.

- HMI has laboratory in Podgorica.

Centre for eco-toxicological testing (CETI)

- CTD probe, OTT automatic station for sea water quality, equipment for water and sediment sampling, modern equipped laboratory for water and sediment analysis.
- CETI is situated in Podgorica.
• The activities that concern rapid transmission of observational data to data assimilation centers, proceeding data through numerical forecasting models, remote sensing data, rapid warnings of coastal floods, storm damage, harmful algal blooms and contaminants, prediction of ocean currents, ocean climate variability and others activities related to the operational oceanography almost doesn't exist at national level, except activities that are implemented through various international project.

• The further development of operational oceanography will depend on Government investments in the field of ocean research and monitoring, on participation of Montenegrin institutions in strategic projects, as well as on collaboration with oceanographic institutions, in the Adriatic or wider regional level.
Thank you for attention