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Promoting Technology Innovation in Environmental Monitoring and Modelling for Assessment of Fish Stock and Non-fish Resources

Situational analysis of the Monitoring and Assessment of Black Sea Fish and Non-fish Living Resources and recommendations to increase the efficiency of use of available methods and tools

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AUTHORS: V. Penchev/ BDCA, C. Makris / AUTh, V. Mihneva / IFR, S. Shukrieva / BDCA A. Kirova / BDCA, N. Beridze / NEA I. Navodaru / DDNI, V. Cotruta / RECM CONTRIBUTORS: F. Penchev, E. Petrova / IFR V. Baltikas/ AUTh, E. Bakradze / NEA M.Arabidze / NEA, M. Mgeladze/NEA, M.Tudor, O.Ibram , D.Bota/ DDNI J. Tochkov / IFR, T. Cozari / RECM	14.11.2020	1.0 Final

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ABBREVIATIONS

AUTh	Aristotle University of Thessaloniki, Greece
BDCA	Black Sea – Danube Association for Research and Development, Bulgaria
DDNI	Danube Delta National institute, Romania
IFR	Institute of Fish Resources, Bulgaria
NEA	LEPL National Environmental Agency, Georgia
RECM	Regional Environmental Centre, Moldova
SRIA	Strategic Research and Innovation Agenda (for Black Sea)
CFP	Common Fishery Policy (of the EU)
CMA	Common Maritime Agenda (for Black Sea)
CMEMS	Copernicus - Marine Environment Monitoring Service
DCF	Data Collection Framework
DDBRA	Danube Delta Biosphere Reserve Authority
DEKOSİM	Marine Ecosystem and Climate Research Center
EFCA	European Fisheries Control Agency
EMSO	The European Multidisciplinary Seafloor and water column Observatory
EAFA	Executive Agency of Fisheries and Aquaculture, Bulgaria
FAO	Food and Agriculture Organisation
GFCM	General Fisheries Commission for the Mediterranean
HCMR	Hellenic Centre of Marine Research
HNHS	Hellenic Navy Hydrographic Surveys
ICF	Indicator to Monitor and Evaluate Connectivity
ICT	Information and Communication Technology
IHF	Indicator to monitor and evaluate Mesohabitats
IO-BAS	Institute of Oceanology, Bulgarian Academy of Sciences
KPI	Key Performance Indicator
NARW	National Authority Romanian Waters
MONGOOS	Mediterranean Operational Network for the Global Ocean Observing System
MSFD	Marine Strategy Framework Directive
MSP	Maritime Spatial Planning
WFD	Water Framework Directive

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INTRODUCTION. BACKGROUND AND OBJECTIVES OF THIS STUDY

This report presents a Situational analysis of the Monitoring and Assessment of Black Sea Fish and Non-fish Living Resources, aiming to provide recommendations to increase the efficiency of the use of available methods and tools, in accordance with the TIMMOD BSB-1029 project work plan, within the Black Sea Basin Program 2014-2020. The report was developed as Deliverable DT1.1.1, within Group Activity T1, activity T1.1, in the period May-November 2020.

The report was developed as a collective effort of 6 partners from the Black Sea region, from the following countries: Bulgaria, Georgia, Moldova, Romania and Greece, focusing primarily on the characteristics of the state of monitoring and assessment of living resources of Black Sea in the above countries (considering Moldova gets to have a *de jure* international free port - Giurgiulesti on the Danube River, that allow it to ship goods to/from Black Sea). Some general characteristics on the topic for the other Black Sea countries - Turkey, Russia and Ukraine, are presented for the completeness of this report, as obtained from published information.

Consolidation of the individual reports by the project partners, as well as the editing and formatting of the final text of the report was accomplished by the team of the Group Activity T1 Leader, BDCA, in cooperation with the Lead Beneficiary IFR.

Section 1 of the report presents the main regulatory framework defining the activities for monitoring and evaluation of the Black Sea resources, including EU and international policies and regulations, as well as regional conventions. The main focus is on the current state of the Black Sea Ecosystem, Fish and Shellfish Resources, formulating the basic requirements for the scientific sector and marine surveyors to perform high-level marine research and improve coordination between countries.

Sections 2 and 3 present the individual reports of the Project Partners, providing details of existing organizational and human resources, as well as an Inventory of equipment, sensors, vessels; data platforms, numerical modelling and GIS tools. Information on available research vessels, measuring instruments and ICT/numerical tools has been collected and analyzed in order to determine the potential of the different countries in the Black Sea region, as well as to define their roles for further improvement of joint monitoring and data sharing.

Section 4 focuses on the challenges of transboundary cooperation, and emphasizes on the need for regional cooperation, presenting a specific SWOT analysis, and outlining the main challenges towards better planning of joint monitoring activities.

In conclusion, section 5 summarizes the results of the activities carried out by the international team of TIMMOD, presenting main conclusions and recommendations to increase the efficiency of the use of available methods and tools for environmental monitoring and assessment of fish and non-fish living resources of the Black Sea.

The analyses, conclusions and recommendations in this report are intended primarily for researchers, surveyors, decision makers, and all relevant stakeholders, but at the same time this report provides important information that can be used by a wider range of public institutions, industry companies and the general public.

1. ANALYSIS OF THE CURRENT STATE OF BLACK SEA FISH STOCK & NON-FISHING RESOURCES. NEEDS & DEMANDS OF ENVIRONMENTAL MONITORING

1.1 EU and International Water Environment and Fishery Policies and their Impact on the Black Sea Resources

1.1.1 EU Marine Water Environment Policies

EU Environment policies. Marine Water.

In 2007, the EU launched its Integrated Maritime Policy (IMP), which addressed the lack of coordination regarding maritime governance in Europe, promoting actions that encourage the EU Member States and regions to develop, introduce or implement integrated maritime governance. It also encourages the adoption of an integrated approach at the international level, considering the United Nations Convention on the Law of the Sea (UNCLOS) and other relevant international conventions. The IMP recognizes the need for increased marine knowledge, to identify the impacts of existing and planned activities on the marine environment, and to improve data collection and exchange through the implementation of the existing EU legislation (e.g. INSPIRE Directive[Infrastructure for Spatial Information in Europe – Directive 2007/2/EC of the European Parliament and of the Council of 14 March 2007 establishing an Infrastructure for Spatial Information in the European Community (INSPIRE)]). The IMP also seeks to develop increased economic growth in the marine area through the promotion of a 'Blue Growth' initiative, which was launched by the European Commission in 2012 and endorsed at Ministerial level with the Limassol Declaration in 2012. The objective of the Blue Growth strategy was to promote smart, sustainable and inclusive growth and employment opportunities in Europe's maritime economy. It is the maritime contribution to achieving the goals of the Europe 2020 strategy for smart, sustainable, and inclusive growth.

The Commission views the development of Maritime Spatial Planning as being central to the regulation of those activities, and to ensure their environmental sustainability. Maritime Spatial Planning is designed to ensure that decisions concerning human activities in the marine environment are based on sound scientific knowledge and that conflicts between different users of the marine environment are mediated and minimised.

The EU's Integrated Maritime Policy is based on actions at the level of each of the particular European marine regions and sub-regions and consequently, it looks to ecological boundaries rather than traditional territorial boundaries.

EU Coastal and Marine Policy. Relevant documents (MSFD, ICZM, MSPD)

The Marine Strategy Framework Directive (MSFD)

The aim of the European Union's ambitious Marine Strategy Framework Directive is to protect more effectively the marine environment across Europe. The Marine Strategy Framework Directive was adopted on 17 June 2008. The Marine Strategy Framework Directive aims to achieve Good Environmental Status (GES) of the EU's marine waters by 2020 and to protect the resource base upon which marine-related economic and social activities depend. It is the first EU legislative instrument related to the protection of marine biodiversity, as it contains the explicit regulatory objective "biodiversity is maintained by 2020", as the cornerstone for achieving GES.

In order to achieve its goal, the Directive establishes European marine regions and sub-regions based on geographical and environmental criteria. The Directive lists four European marine regions – the Baltic Sea, the North-east Atlantic Ocean, the Mediterranean Sea and the Black Sea – located within the geographical boundaries of the existing Regional Sea Conventions. Cooperation between the Member States of one marine region and with neighbouring countries, which share the same marine waters, is already taking place through these Regional Sea Conventions. To achieve GES by 2020, each Member State is required to develop a strategy for its marine waters (or Marine Strategy). In addition, because the Directive follows an adaptive management approach, the Marine Strategies must be kept up-to-date and reviewed every 6 years.

The Commission adopted a report on the first implementation cycle of the Marine Strategy Framework Directive in June 2020. This report shows that while the EU's framework for marine environmental protection is one of the most comprehensive and ambitious worldwide, it needs to be beefed up to be able to tackle pressures such as overfishing and unsustainable fishing practices, litter, excess nutrients, underwater noise and others types of pollution.

A major challenge in the implementation of the Marine Directive is to attain the necessary scientific knowledge of the elements that define the state of the marine environment. Increasing scientific knowledge on the marine environment and its processes is required to achieve the Directive's goal.

Good Environmental Status of Marine Water

The main goal of the Marine Directive is to achieve Good Environmental Status of EU marine waters by 2020. The Directive defines Good Environmental Status (GES) as "The environmental status of marine waters where these provide ecologically diverse and dynamic oceans and seas which are clean, healthy and productive". GES means that the different uses made of the marine resources are conducted at a sustainable level, ensuring their continuity for future generations. In general, the GES means:

- Ecosystems, including their hydro-morphological (i.e. the structure and evolution of the water resources), physical and chemical conditions, are fully functioning and resilient to human-induced environmental change;
- The decline of biodiversity caused by human activities is prevented and biodiversity is protected;
- Human activities introducing substances and energy into the marine environment do not cause pollution effects. Noise from human activities is compatible with the marine environment and its ecosystems.

Figure 1.1-1 Illustration on the "Good Environmental Status" approach

Integrated Coastal Management

Integrated coastal management aims for the coordinated application of the different policies affecting the coastal zone and related to activities such as nature protection, aquaculture, fisheries, agriculture, and industry, off shore wind energy, shipping, tourism, development of infrastructure and mitigation and adaptation to climate change. It will contribute to sustainable development of coastal zones by the application of an approach that respects the limits of natural resources and ecosystems, the so-called 'ecosystem-based approach'. Integrated coastal management covers the full cycle of information collection, planning, decision-making, management and monitoring of implementation. It is important to involve all stakeholders across the different sectors to ensure broad support for the implementation of management strategies.

In order to further promote sustainable development of coastal zones, the Commission adopted on the 12th of March 2013 a draft proposal for a Directive establishing a framework for maritime spatial planning and integrated coastal management.

The proposed instrument will require Member States to establish coastal management strategies that build further on the principles and elements set out in the Council Recommendation on Integrated Coastal Zone Management of 2002 and the Protocol to the Barcelona Convention on Integrated Coastal zone Management, ratified by the EU in 2010.

Maritime Spatial Planning Directive

The Integrated Maritime Policy is a holistic approach to all EU maritime activities and policies. The Framework Directive for Maritime Spatial Planning [Directive 2014/89/EU of the European parliament and of the council of 23 July 2014 establishing a framework for

maritime spatial planning (MSPD) is the main instrument for coordinating EU maritime activities to achieve ecological, economic and social objectives.

The main purpose of maritime spatial planning is to promote sustainable development and to identify the utilization of maritime space for different sea uses as well as to manage spatial uses and conflicts in marine areas. It contributes to a more efficient implementation of EU environmental legislation in marine and coastal waters. The 23 coastal EU Member States are obliged to develop a national maritime spatial plan at the latest by 31 March 2021, with a minimum review period of 10 years.

The MSPD lists several minimum requirements for maritime spatial plans, including reference to aspects such as:

- land-sea interactions;
- the ecosystem-based approach;
- coherence between Maritime Spatial Planning and other processes such as integrated coastal management;
- the involvement of stakeholders;
- the use of best available data;
- transboundary cooperation between the Member States;
- and cooperation with third countries.

The MSPD encourages EU countries to cover under their Maritime Spatial Planning the following activities and uses energy sectors at sea; maritime transport; fisheries and aquaculture; preservation, protection, and improvement of the environment, including resilience to climate change impacts; promotion of sustainable tourism; and the sustainable extraction of raw materials.

Interaction with Common Fisheries Policy (CFP)

The Water Framework Directive (2000) is closely linked to the Marine Directive. It sets a goal of achieving Good Status for all EU surface and groundwaters by 2015, tying in with the goal of Good Environmental Status under the Marine Directive. Following an adaptive management approach, it establishes a six-year planning cycle, during which Member States prepare River Basin Management Plans and develop actions and measures to achieve Good Status by 2015. Initial plans were published in 2009 and will be reviewed in 2015. Actions taken will reduce marine pollution from land-based sources and will protect ecosystems in coastal and transitional waters, which are vital spawning grounds for many marine fish species.

The Habitats and Birds Directives (1992 and 1979, codified 2009) are Europe's central laws on nature conservation, providing special protection for key sites (the Natura 2000 network), animal species, plant species and habitat types of European importance. This protection will be reinforced with the Marine Directive's Marine Protected Areas.

The Common Fisheries Policy sets out a collaborative approach to managing the EU's shared seas and fisheries. Among other things, it lays down rules to ensure Europe's fisheries are sustainable and do not damage the marine environment. The recent 2013 reform stresses that the Common Fisheries Policy shall ensure, among others, that fishing and aquaculture activities are environmentally sustainable in the long-term, thereby

contributing to the objectives of the Marine Strategy Framework Directive and the achievement of 'Good Environmental Status'.

The EU REACH Regulation (Registration, Evaluation, Authorisation and Restriction of Chemical substances), which entered into force on 1 June 2007, aims to improve the protection of human health and the environment through the better and earlier identification of the intrinsic properties of chemical substances, like the environmental risk they pose. It is directly related to Descriptor 8 (contaminants) and indirectly to Descriptor 9 (contaminants in seafood) and 10 (marine litter) of the Marine Directive.

Blue Growth Policy

Blue growth is the long-term strategy to support sustainable growth in the marine and maritime sectors as a whole. Seas and oceans are drivers for the European economy and have great potential for innovation and growth. It is the maritime contribution to achieving the goals of the Europe 2020 strategy for smart, sustainable and inclusive growth.

The strategy consists of three components:

1. Develop sectors that have a high potential for sustainable jobs and growth, such as - aquaculture (Fisheries website), coastal tourism, marine biotechnology, ocean energy, seabed mining

2. Essential components to provide knowledge, legal certainty and security in the blue economy - marine knowledge to improve access to information about the sea, maritime spatial planning to ensure an efficient and sustainable management of activities at sea, integrated maritime surveillance to give authorities a better picture of what is happening at sea.

3. Sea basin strategies to ensure tailor-made measures and to foster cooperation between countries - Adriatic and Ionian Seas, Arctic Ocean, Atlantic Ocean, Baltic Sea, Black Sea, Mediterranean Sea, North Sea

1.1.2 EU Fisheries Policy. Latest Developments & Challenges. Relevance to Black Sea.

EU Common Fishery Policy (CFP)

The CFP is a set of rules for managing European fishing fleets and for conserving fish stocks. Designed to manage a common resource, it gives all European fishing fleets equal access to EU waters and fishing grounds and allows fishermen to compete fairly. Stocks may be renewable, but they are finite. Some of these fishing stocks, however, are being overfished. As a result, EU countries have taken action to ensure the European fishing industry is sustainable and does not threaten the fish population size and productivity over the long term. The CFP was first introduced in the 1970s and went through successive updates, the most recent of which took effect on 1 January 2014.

The CFP aims to ensure that fishing and aquaculture are environmentally, economically and socially sustainable and that they provide a source of healthy food for EU citizens. Its goal is to foster a dynamic fishing industry and ensure a fair standard of living for fishing communities. The current policy stipulates that between 2015 and 2020 catch limits should be set that are sustainable and maintain fish stocks in the long term.

The latest report on EU Fisheries Policy was released in 2019. The main findings in the report are that is likely that not all CFP objectives will be met by 2020. The biggest challenge to meet the objectives is the slow transformation from unsustainable fishing practices, which could be explained by the lack of institutional capacity and still the lack of scientific capacity in terms of proper data reporting.

Data Collection Framework (CFP)

Since 2000, an EU framework for the collection and management of fisheries data is in place. This framework was reformed last in 2008 resulting in the Data Collection Framework (DCF). Under this framework the Member States (MS) collect, manage and make available a wide range of fisheries data needed for scientific advice.

The data is collected on the basis of National Programmes in which the MS indicate which data is collected, the resources they allocate for the collection and how data is collected. MS must report annually on the implementation of their National Programmes and the Scientific, Technical and Economic Committee for Fisheries (STECF) evaluates these Annual Reports.

Part of the data collected by the MS is uploaded in databases managed by the JRC in response to data calls issued by DG MARE. This data is analysed by experts of the STECF and forms the basis for scientific opinions and recommendations formulated in STECF reports. The resulting scientific advice is used to inform the CFP decision making process.

More details are available at: https://datacollection.jrc.ec.europa.eu/dc/fleet/dcf

DG Mare

DG MARE develops and carries out the Commission's policies on Maritime affairs and fisheries.

DG MARE works to ensure that the ocean resources are used sustainably and that coastal communities and the fishing sector have a prosperous future, promote maritime policies and stimulate a sustainable blue economy and promote ocean governance at international level.

The Black Sea is a sea basin with important potential, but also challenges with regard to sustainable use of its marine resources. The Commission has therefore taken the leadership in developing a new approach towards sustainability and development in the Black Sea fisheries and aquaculture. Together with the General Fisheries Commission for the Mediterranean and the Black Sea (GFCM), the Commission launched the preparation of a ministerial declaration of all Black Sea riparian countries (the Sofia Ministerial Declaration Search for available translations of the preceding link), as follow-up to the 2016 Bucharest Declaration. The new Declaration, signed on 7 June 2018, contains concrete and measurable actions and timelines for the Black Sea for the next ten years.

In October 2016, GFCM and the Food and Agriculture Organization of the United Nations (FAO), organised a High Level Conference on enhanced cooperation on Black Sea fisheries and aquaculture, bringing together representatives of Black Sea EU Member States and riparian third countries, the Commission and international organisations. The Conference adopted the Bucharest Ministerial Declaration, which underlines the need for collaborative approach to address Black Sea fisheries issues, including sustainability of marine resources,

better data collection and improvement of the scientific advice, sustainable development of aquaculture and compliance and fight against Illegal, Unreported and Unregulated (IUU) fishing.

Following an evaluation of the Bucharest Declaration, a Ministerial Conference was organised in Sofia on 6 and 7 June 2018, to take stock of the state of implementation and to adopt a concrete action plan for fisheries and aquaculture. The resulting Sofia Ministerial Declaration sets objectives and targets and requests actions. It has as objectives to commit all Black Sea riparian countries on the designed measures, provide ownership, enhance regional cooperation, create a culture of compliance and operationalize the political commitments given in the Bucharest Declaration. It is also aligned with the GFCM 2017-2020 mid-term strategies in fisheries and aquaculture.

European Fisheries Control Agency (EFCA)

The European Fisheries Control Agency is a European Union agency. The agency's mission is to promote the highest common standards for control, inspection and surveillance under the CFP. Its primary role is to organize coordination and cooperation between national control and inspection activities so that the rules of the CFP are respected and applied effectively.

The EFCA will function at the highest level of excellence and transparency with a view to developing the necessary confidence and cooperation of all parties involved and, in so doing, to ensure effectiveness and efficiency of its operations.

European Union governments agreed to establish the agency in the 2002 reform as part of the drive to instill a culture of compliance within the fisheries sector across Europe. In April 2005, they adopted the necessary legislation with Council Regulation (EC) No 768/2005.

The benefit of the work of the agency lies in its contribution to a European-wide level playing field for the fishing industry so that European obligations are observed by everyone and everyone in the sector is treated equally, wherever they might be operating. Secondly, it contributes towards sustainable fisheries by enhancing compliance with existing conservation and management measures to the benefit of present and future generations.

The Agency, in cooperation with the European Border and Coast Guard Agency and the European Maritime Safety Agency, each within its mandate, supports the national authorities carrying out coast guard functions.

Monitoring, Control and Surveillance (MCS). New monitoring technologies

- Vessel monitoring system (VMS)
- Electronic reporting system (ERS or 'e-logbook')
- Electronic monitoring (EM)

The EU system for fisheries controls is the vessel monitoring system (VMS), which is a satellite-based monitoring system, which at regular intervals provides data to the fisheries authorities on the location, course and speed of vessels. VMS is nowadays a standard tool of fisheries monitoring and control worldwide, but it was the EU which led the way, becoming the first part of the world to introduce compulsory VMS tracking for all the larger boats in its fleet. The EU legislation requires that all coastal EU countries should set up systems that are compatible with each other, so that countries can share data and the

Commission can monitor that the rules are respected. EU funding is available for Member States to acquire state-of-the-art equipment and to train their people to use it.

New control technologies become crucial nowadays to ensure effective monitoring and control of fishing fleets and streamlined management of qualitative and reliable fisheries data.

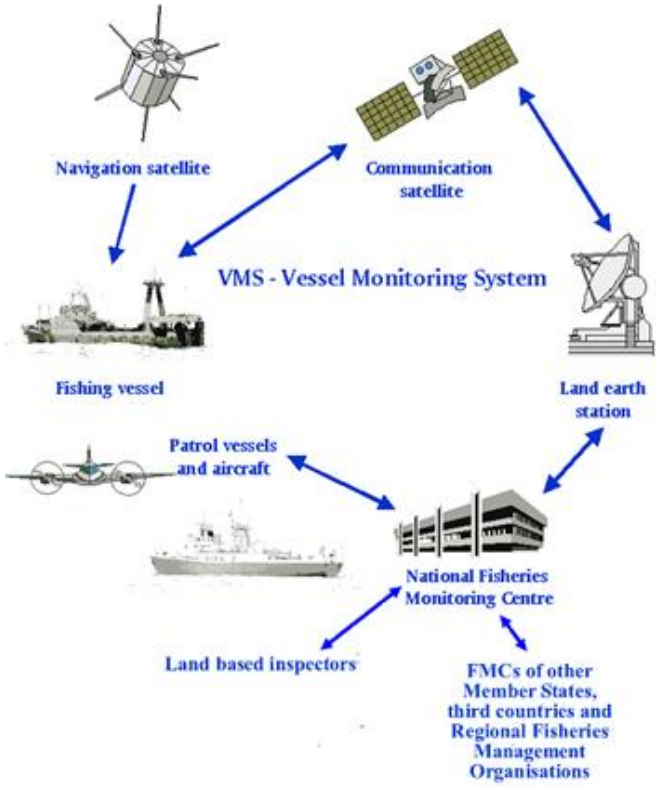


Figure 1.1-2 Electronic recording and reporting system (ERS)

The Electronic recording and reporting system (ERS) is used to record, report, process, store and send fisheries data (catch, landing, sales and transshipment). The key element is the electronic logbook where the master of a fishing vessel keeps a record of fishing operations. The record is then sent to the national authorities, which store the information in a secure data base.

1.1.3 International Fisheries Policy.

<u>Sustainable Development Goals</u>

Among the 17 SDGs that encompass the 2030 Agenda for Sustainable Development, adopted by the United Nations General Assembly in September 2015, a stand-alone goal seeks to address the need for, inter alia, the sustainable use and conservation of life below water: SDG 14, 'Conserve and sustainably use the oceans, seas and marine resources for sustainable development', seeks to prevent and reduce marine pollution; further the sustainable management and protection of marine and coastal ecosystems; address the impacts of ocean acidification; regulate harvesting and end overfishing, illegal, unreported and unregulated fishing and destructive fishing practices; conserve coastal and marine areas; increase the economic benefits to small island developing States and least developed countries from the sustainable use of marine resources; and strengthen the means of implementation, including increasing scientific knowledge, the transfer of

marine technology and implementation of international law[https://sdg-tracker.org/oceans] as reflected in UNCLOS.

The Report of the Secretary-General on the progress towards the Sustainable Development Goals 2019, about SDG 14, considers the expansion of protected areas for marine biodiversity and existing policies and treaties that encourage responsible use of ocean resources still insufficient to combat the adverse effects of overfishing, growing ocean acidification due to climate change and worsening coastal eutrophication.

According to the report, additional efforts and interventions are needed to conserve and sustainably use ocean resources at all levels. The alignment of the existing marine policies at international, EU and regional level could contribute to the achievement of SDG 14.

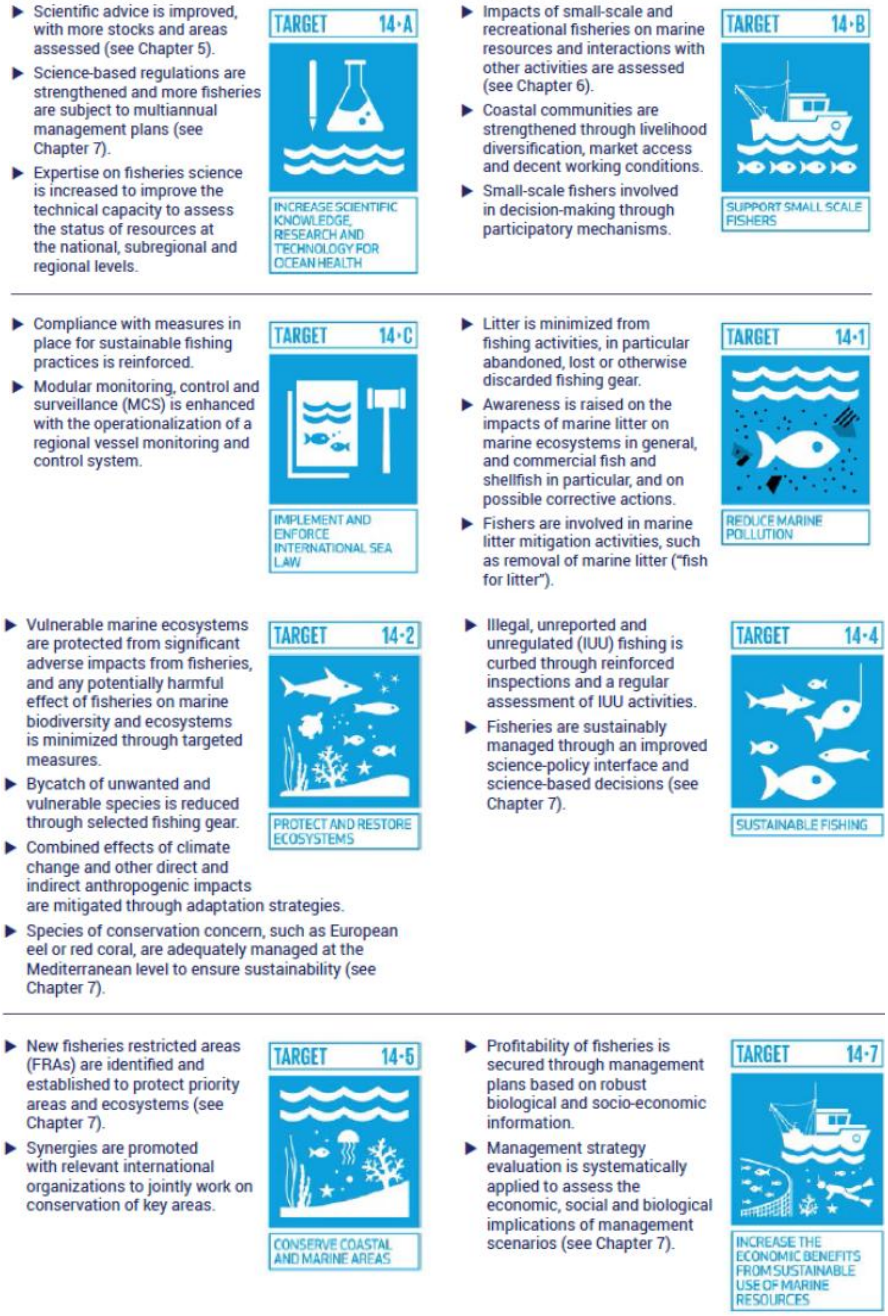


Figure 1.1-3 The midterm strategy's contribution to achieving Sustainable Development Goal 14 Target

FAO Fisheries Division (NFI)

The Division aims to make a significant contribution to the attainment of the Millennium Development Goals and the targets set by the World Summit on Sustainable Development and the World Food Summit.

General Fisheries Commission for the Mediterranean (GFCM)

The General Fisheries Commission for the Mediterranean (GFCM) is a regional fisheries management organization (RFMO) established in 1949 under the provisions of Article XIV of the Constitution of the Food and Agriculture Organization of the United Nations (FAO).

The GFCM is currently composed of 24 contracting parties (23 member countries and the European Union) and 5 cooperating non contracting parties (Bosnia and Herzegovina, Georgia, Jordan, Republic of Moldova, Ukraine).

The GFCM plays a critical role in fisheries governance in its area of application, having the authority to adopt binding recommendations for fisheries conservation and management and for aquaculture development. These recommendations can relate, among others, to the regulation of fishing methods, fishing gear and minimum landing size, as well as the establishment of spatial protection measures, fishing effort control and of multiannual management plans for selected fisheries.

One of the latest reports of the GFCM, the Report on "The State of Mediterranean and Black Sea Fisheries, 2018", provides an overview of status and trends, including fishing fleet, capture fishery production, socio-economic variables, bycatch and an analysis of the status of the stocks. The main finding of the report, concerning the Black Sea, is that the there is a slight improvement in terms of the stocks of industrial fish species, however more efforts are necessary to achieve a long-term sustainability of the fish resources.

The World Council of Fisheries Societies (WCFS)

The World Council of Fisheries Societies (WCFS) is a nonprofit, nongovernmental membership organization that aims to promote international cooperation in fisheries science, conservation and management. This includes encouraging sustainable management practices, encouraging excellence in fisheries research, and promoting the wise use of fishery resources.

The functions of the WCFS include:

- Facilitating, throughout the world, exchanges of ideas among Member Organizations and among the individual members of these organizations;
- Creating and maintaining contacts among Member Organizations and by encouraging the adoption of common practices and policies;
- Promoting the dissemination and application of all information;
- Cooperating with national and international scientific and technical fisheries organizations;
- Encouraging the introduction of uniformity of nomenclature and standardization in matters such as information storage and retrieval;
- Organizing meetings, particularly the World Fisheries Congress which will be the primary function of the Council;
- Recognizing outstanding contributions of scientists and professionals through various awards and scholarships;

1.1.4 Black Sea Regional Policies and Conventions

Review on Black Sea regional policies, conventions, initiatives, is presented here below in chronological order, starting from earlier documents, and reaching the present time.

Convention concerning Fishing in the Black Sea (1959, Varna)

The first Convention on the Black Sea dates back to 1959, when the Convention concerning Fishing in the Black Sea was signed in Varna, Bulgaria between Bulgaria, Romania and the Soviet Union. The Convention went into force in March 1960 and its primary goal is to provide for cooperation and assistance between the States Parties in the rational exploitation of the Black Sea fisheries, including research undertaken with a view to maintaining and augmenting their stocks. The Convention imposes certain limits on taking, especially establishing limits on the sizes of fish which may be taken. The Convention provides for the exchange of information as to the migration of 'industrial fish'. Such information includes the time and place of congregations of such fish, the direction of their movement, their density, and the hydrometeorological condition in which these migrations occur. The Convention also provides for the exchange of the results of scientific research more generally, especially in the fields of marine ichthyology, hydrobiology and fishing techniques.

The full text of the Convention may be found here - http://www2.ecolex.org/server2neu.php/libcat/docs/TRE/Full/En/TRE-000076.txt.

The Convention on the Protection of the Black Sea (1992, Bucharest)

The Convention on the Protection of the Black Sea Against Pollution, also known as the Bucharest Convention, was signed in 1992 in Bucharest, Romania, between all six Black Sea countries, eventually coming into force in 1994. The implementation of the Convention is managed by the Commission for the Protection of the Black Sea Against Pollution. The primary goal of the Convention is the prevention, reduction and control of the pollution in the Black Sea in order to protect and preserve the marine environment and to provide legal framework for cooperation and concerted actions to fulfil this obligation.

The full text of the Bucharest Convention may be found here - http://www.blacksea-commission.org/Official%20Documents/The%20Convention/Full%20Text/

Strategic Action Plan for the Environmental Protection and Rehabilitation of the Black Sea (2002)

This document represents an agreement between the six Black Sea Coastal states (Bulgaria, Georgia, Romania, the Russian Federation, Turkey and Ukraine) to act in concert to assist in the continued recovery of the Black Sea. The document provides a brief overview of the current status of the Sea, based largely on information contained within the 2007 Black Sea Transboundary Diagnostic Analysis (BS TDA), and taking into account progress with achieving the aims of the original (1996) Black Sea Strategic Action Plan (BS SAP). This SAP builds upon BS SAP signed in 1996 (updated in 2002), by reorganising the priorities and actions therein considering the progress in the region and the current state of the environment.

The updated version of the BS SAP, adopted in Sofia, Bulgaria, 17 April 2009, describes the policy actions required to meet the major environmental challenges now facing the Sea, and includes a series of management targets.

Full text of the document is available at:

http://www.blacksea-commission.org/_bssap2009.asp

Burgas Declaration, May 2018

The ministerial declaration, signed in May 2018, endorsed the Common Maritime Agenda for the Black Sea. Thus, the Black Sea region joined the rest of the sea basins bordering the EU in setting a basin-wide initiative for larger, and more sustainable, economic growth. The Declaration puts a strong focus on the general principle, that the United Nations Convention on the Law of the Sea, as well as the other relevant international conventions and customary international law related to activities in oceans and seas are fully considered.

The full text of the declaration may be found here - https://ec.europa.eu/maritimeaffairs/press/black-sea-ministers-endorse-common-maritime-agenda_en

Sofia Declaration, June 2018

The declaration was signed in Sofia on 7 June 2018 by the ministers and high-level representatives of Black Sea riparian countries in conclusion of the High-level Conference on Black Sea fisheries and aquaculture. The Sofia Declaration sets concrete objectives and actions that should help develop a comprehensive regional governance in the Black Sea. This should be achieved thanks to greater solidarity and coordination among all riparian countries in order to fight illegal unreported and unregulated fishing (IUU), improve data collection and science, improve fisheries management, and support sustainable small-scale fisheries and aquaculture. The many threats faced by the Black Sea, a peculiar marine basin with specific environmental conditions and human activities, need indeed to be properly addressed in order to secure the region's ecological and economic wealth and viable livelihoods for coastal communities.

The full text of the declaration may be found here - https://ec.europa.eu/fisheries/sites/fisheries/files/docs/2018-06-07-sofia-declaration_en.pdf

Common Maritime Agenda (CMA) for the Black Sea

The Common Maritime Agenda for the Black Sea (CMA) is a sea basin initiative that aims at supporting regional cooperation for a more sustainable blue economy in the Black Sea and it is developed in the broader framework of the Black Sea Strategy. Republic of Bulgaria, Georgia, Republic of Moldova, Romania, Russian Federation, Republic of Turkey and Ukraine, all BSEC Member States, are the participating countries.

The CMA is a unique framework of regional cooperation on blue economy and it was endorsed on 21 May 2019 at Ministerial level. It is complemented by its scientific pillar, the Strategic Research and Innovation Agenda for the Black Sea (SRIA), supported by the Directorate General for Research and Innovation of the European Commission (DG RTD).

The CMA sets 3 goals - 1. Healthy marine ecosystems; 2. Innovative blue economy; 3. Investment – and 10 priorities further declined into actions.

The Directorate General for Maritime Affairs and Fisheries of the EU Commission (DG MARE) accompanies the process as full member of the Steering Group where each of the seven countries is represented, while the political coordination is ensured by Ministerial meetings.

The CMA has recently launched its implementation. The 1st CMA Steering Group meeting took place on 10 February 2020 in Sofia, under the 2020 Bulgarian coordination. The second meeting was held online on 26 June 2020.

More info is available at:

http://www.bsec-organization.org/areas-of-cooperation/bsec-eu-cooperation/common-maritime-agenda

Strategic Research and Innovation Agenda for the Black Sea (SRIA)

The European Commission together with the Republic of Bulgaria, Georgia, Romania, the Russian Federation, the Republic of Turkey, Ukraine and the Republic of Moldova have launched a Strategic Research and Innovation Agenda for the Black Sea (SRIA).

The SRIA aims to advance a shared vision for a productive, healthy, resilient and sustainable Black Sea by 2030, while considering the special and unique ecosystem characteristics of it. In particular, its unique biodiversity, cultural heritage sites and the new local, national and transboundary policy measures.

It will focus on four key areas: to address fundamental Black Sea research challenges; to boost the Black Sea Blue Economy; to develop innovative infrastructures and to enhance blue workforce through education for new marine and maritime jobs and engaging citizens.

Research and innovation is crucial for a healthy and sustainable Black Sea by 2030.

The structure of the SRIA was set to pave the way for an effective and realistic implementation in close cooperation with experts and stakeholders from countries bordering the Black Sea.

More info is available at:

https://ec.europa.eu/newsroom/mare/document.cfm?doc_id=59035

1.1.5 Relevance to BSB JOP specific objectives

The Black Sea Basin Programme 2014-2020 is part of European Union's Cross-Border Cooperation (CBC) under its European Neighborhood Instrument (ENI). The Black Sea Basin ENI CBC programme 2014-2020 builds upon the previous cooperation framework, the Black Sea Basin ENPI CBC programme 2007-2013, under which 62 projects were awarded and implemented in 8 countries surrounding the Black Sea Basin. As a result of the completed analytical and consultation process, the Black Sea Basin programme focuses on a set of objectives and priorities, reflecting the countries' specific circumstances and requirements.

BSB CBC programme is the appropriate platform to accelerate the technological upgrade of monitoring and assessment of fish stock and non-fish resources in Black Sea. Promoting Innovation aims to utilize new tools, approaches and technology to assist implementation of EU policies and programmes.

The overall objective of TIMMOD is to improve joint environmental monitoring and modelling, by facilitating Technology Innovation, to improve the availability and quality of data, the cooperation in sharing of data for water quality, biodiversity statistics, assessment of fish and non-fish living resources of the Black Sea - in line with the EU's Marine Strategy Framework Directive (MSFD), Data Collection Framework (DCF), Blue Growth Strategy, Black Sea Convention on Environmental Protection, and other EU and regional policies and conventions.

TIMMOD will achieve the following results: New capacities for executing marine environmental surveys; Delivery and adaption of innovative tools and methodologies; A set of ICT tools developed and integrated in a Monitoring & Modelling Data Sharing Platform; New cross-border compatible environmental data for water quality parameters, fish and non-fish census count for the marine areas near Varna, and Batumi; Raising qualification of researchers, training and capacity building of decision makers.

All these results will directly **contribute to the Black Sea program Priority 2.1 expected result: Improved availability of cross-border compatible environmental monitoring data and information within the Black Sea Basin**. The relevant **programme result indicator R2.1: Level of availability of cross-border compatible environmental monitoring data and information - will be improved**, with new data collected, and new capacity created.

1.1.6 EU funded & other recent projects in the area of fisheries and environmental monitoring

Current and forthcoming projects

EMBLAS PLUS - Improving Environmental Monitoring in the Black Sea – Special Measures

This project is funded by the EU and is currently ongoing. Its main goal is to improve the protection of the Black Sea environment through further technical assistance focused on marine data collection and local small-scale actions targeted at reduction of pollution by marine litter, public awareness raising and education. The project works with key partners from research/scientific and educational institutions, and civil society organisations. The specific objectives are to Improve availability and sharing of marine environmental data from the national and joint regional monitoring programmes aligned with the MSFD and WFD principles and the Black Sea Integrated monitoring and Assessment Programme (BSIMAP), as well as to support joint actions to reduce river and marine litter in the Black Sea basin.

More details - http://emblasproject.org/

https://www.euneighbours.eu/en/east/stay-informed/projects/emblas-plus-improving-environmental-monitoring-black-sea-special

Black Sea CONNECT: *Black Sea Countries Come Together for Blue Growth!*

The H2020 Black Sea CONNECT CSA project has been funded under the coordination of Middle East Technical University (METU) – Institute of Marine Science, and started in late 2019 for three years. The project aims to carry out the development of the Black Sea Strategic Research and Innovation Agenda and implementation plan both at national and regional level.

Black Sea CONNECT is the first project in its own field for Black Sea. Fourteen organizations from nine countries are involved in the project; the Black Sea coastal countries, namely the Republic of Bulgaria, Georgia, Romania, the Russian Federation, the Republic of Turkey, Ukraine as well as Republic of Moldova and European Union countries Germany and France.

The overall objective of the Black Sea CONNECT is to coordinate the development of the Strategic Research and Innovation Agenda (SRIA), based on the defined principles in the Burgas Vision Paper and support the development of the Blue Growth in the Black Sea. The SRIA and its Implementation Plan will guide stakeholders from academia, funding agencies, industry, policy and society to address together the fundamental Black Sea challenges, to promote blue growth and economic prosperity of the Black Sea region, to build critical support systems and innovative research infrastructure and to improve education and capacity building.

More information at: https://ims.metu.edu.tr/slider/black-sea-connect

EU Framework Program HORIZON EUROPE.

Innovative research and international cooperation through the Horizon 2020 will continue with its successor HORIZON EUROPE. After launching a call for projects of 18 million targeting the Black Sea euro under Horizon'2020 in 2019, the forthcoming HORIZON EUROPE is looking at strengthening the Black Sea research cooperation, considering that:

- Issues such as climate change and its impact on, for instance, sea levels rising, declining fish stocks, as well as human-induced factors, are challenges that we need to tackle together, via common solutions.
- Research, innovation and cooperation between key stakeholders and countries play a crucial role in increasing the understanding of the Black Sea. Results of such cooperation and research feed into the development of evidence-based solutions and trigger innovation.
- The European Commission together with the Republic of Bulgaria, Georgia, Romania, the Russian Federation, the Republic of Turkey, Ukraine and the Republic of Moldova have launched a Strategic Research and Innovation Agenda for the Black Sea (SRIA).

HORIZON EUROPE can explore the synergies of Horizon Europe with the new European Maritime and Fisheries Fund (EMFF) and Invest EU programme on enhancing the transfer and uptake of research and innovation in the blue economy and development of project pipelines.

"*Action is needed at all levels. EU institutions, Member States and regions, neighbour countries, the Black Sea Economic Cooperation organisation, we all will have to be on board. Citizens, the young generations, businesses, social partners and the research and knowledge community will have to team up*" (EU Commisioner MariaGabriel, https://ec.europa.eu/commission/commissioners/2019-

2024/gabriel/announcements/speech-commissioner-mariya-gabriel-webinar-research-and-innovation-black-sea-empowering-next_en).

More information at: https://ec.europa.eu/info/horizon-europe_en

Completed projects

PRIDE

The PRIDE programme was carried out from 2015 until 2019, investigating the evolution and demise of lakes systems and biota in the Black Sea, Caspian Sea and surroundings.

PRIDE aimed to:

- raise awareness of the uniqueness of Pontocaspian biodiversity and the current biodiversity crisis and
- collect data on mollusk species in Northern Black Sea through the joint efforts of citizen scientists.

The programme combined climate-, geo- and bio- sciences and was conducted by 15 Early Stage Researchers. The PRIDE network contains 21 participating institutes, aiming to discover the unique mollusk fauna of the Black Sea

PRIDE presented the identification sheet to the most characteristic mollusk species of the Black Sea. Everybody was invited to participate in the PRIDE project by uploading observations to the iNaturalist portal.

More information at: https://www.pontocaspian.eu/

BLACKSEA4FISH

The BlackSea4Fish project was established in 2016 to contribute to the sustainable management of Black Sea fisheries, by providing scientific and technical support to the work of the GFCM in the region, coordinating priority activities of the GFCM Subregional Group on Stock Assessment in the Black Sea (SGSABS) and the Working Group on the Black Sea (WGBS). The project bridges gaps at the regional level, providing the WGBS with the necessary resources to efficiently execute its priority actions and supporting the implementation of the mid-term strategy (2017-2020) towards the sustainability of Mediterranean and Black Sea fisheries.

More details - http://www.fao.org/gfcm/activities/fisheries/blacksea4fish/en/

COMFISH - Strengthening the impact of fisheries related research through dissemination, communication and technology transfer

ComFish was part of the KBBE.2011-5 - Area2.1.4 of the FP7 Cooperation Work Programme with a focus on European fisheries. The project ran for three years from February 1, 2012 until January 31, 2015. The aim of the ComFish project was to identify important fisheries challenges in different fishing regions of the EU, propose possible solutions and, where appropriate, create content and engage in communication activities with fisheries stakeholders. ComFish took the view that it was not sufficient to focus, in isolation, on pressing issues in fisheries or on communication impasses between stakeholders (scientists - industry - policy makers). A broader approach was necessary, very much in line with the

ecosystem approach of the revision of the Common Fisheries Policy to be implemented in 2014.

More details - https://cordis.europa.eu/project/id/289610

Strengthening the Regional Capacity to Support the Sustainable Management of the Black Sea Fisheries

The project aims to facilitate the cooperation between Black Sea coastal states in the field of marine ecosystem and resource management. Knowledge sharing and research activities are a key element of the project implementation, serving to provide an objective analysis of fish stocks, as well as valuable strategic management advice. The project adopts a thorough approach that includes a harmonization of methods and tools to assess the present state of fish stocks, the use of analytic models to align the common methods for sampling, processing and interpretation data from fisheries, and awareness-raising with respect to the need to implement advice from research and joint-regional stock assessment in the management strategies for the fisheries; adding information sharing, knowledge and data base improvement by working visits, data survey, trainings and manuals translating in all partners languages.To describe population dynamics of fish stocks, different models have been developed, among the most often used models are Virtual Population Analysis (VPA), simple production model (Schaefer model) and Yield per Recruit model (Beverton and Holt model)

More information at https://www.msp-platform.eu/projects/strengthening-regional-capacity-support-sustainable-management-black-sea-fisheries

1.2 Current Environmental Status of the Black Sea with Reference to Fish and Non-fish Living Resources.

1.2.1 General characteristics of the Black Sea ecosystem

The Black Sea (BS) is a land-locked basin, bordered by six countries - Bulgaria, Georgia, Romania, Russia, Turkey and Ukraine (Fig.1).

Figure 1.2-1 Map showing the location of the Black Sea in Europe and Black Sea riparian countries
(redrawn from Llope et al., 2011)

The total surface of the catchment zone is ~ 2 million km^2, five times the surface of the BS itself (Ludwig et al.., 2009, EEA-Black Sea). Every year, ~350 km3 of river water enters the BS from an area covering almost a third of continental Europe and seventeen countries. The BS is characterized by a positive water balance that results in a net outflow into the Mediterranean through the Bosphorus. A compensatory inflow from the Mediterranean into the Black Sea is with high salinity, while the volume is roughly twice smaller. Through the Kerch Strait, the surface current flows from the Sea of Azov to the Black Sea, while the lower current flows in the opposite direction. Surface currents in the Black Sea are wind-generated, with the main current (Rim Current) running counter clockwise, i.e. cyclonic circulation and mesoscale eddies are formed along the periphery of the basin, as a part of the Rim Current dynamic structure.

The Black Sea is the largest meromictic and anoxic basin in the world. The oxygen rich surface waters, supporting sea life constitute ~13 % of the Black Sea volume. The water below 200 m depth are reach on H_2S and do not contain oxygen. The density boundary limits the vertical exchange between the oxygenated layer and the almost completely isolated anoxic deep water. Therefore, despite its substantial depth (2200 m), most of the biological activity (apart from bacteria) is hosted within the upper layer of 100 – 150 m (Llope et al., 2011).

The temperature trends in the Black Sea could be attributed to the variations in the overlying weather pattern (Shapiro et al., 2010). The atmospheric forcing across the Black Sea is not uniform: the northern and north-eastern parts of the sea are influenced by the Siberian anticyclone, which is the source of very cold winds from the NE in the winter. The southern and south-western parts are influenced by the milder Mediterranean weather system intruding from the southwest, and they belong to the sub-tropical climate zone with warm rainy winter and hot summer. The balance between the two weather systems is controlled by comparative strength of the westerly winds over Southern Europe, represented by the values of the North Atlantic Oscillation Index (NAOI). The weakening of the westerlies could arguably shift the balance towards greater influence of the Siberian anticyclone over larger areas of the sea, not only its NE areas.

At inter-annual and decadal scales, variations of air and water temperatures, as well as sea level are under global influence while changes of wind velocity, precipitations and salinity are subjected to substantial regional impact. The Black Sea's hydrodynamic characteristics change irregularly in time, with estimated frequency from several years to several decades (Ginzburg et al.., 2004; Oguz et al.., 2003; Oguz et al., 2006; Kazmin et al., 2010). This leads to differences in the estimates of long-term trends and, in some cases, the identified trends can differ by an order of magnitude apart (Miladinova et al., 2017).

Specific features of the Black Sea make it vulnerable to disturbances to its environment and ecosystems. The key regional ecological challenges, identified in the Transboundary Diagnostic Analysis (BSEP, 2009a) comprise: • eutrophication/nutrient enrichment; • changes in marine living resources (overexploitation); • chemical pollution (including oil); • biodiversity/habitat changes, including the introduction of non-native species.

Simultaneously, the Black Sea ecosystem has undergone different phases of eutrophication, caused by economical and lifestyle changes in the surrounding countries, including intensive animal farming and increasing use of agrochemicals and phosphate detergents (Llope, 2011; Yunev et al., 2016). Most nutrients, discharged into the Black Sea

come from the Danube River. From the 1950s–1960s to the late 1980s–early 1990s annual discharges of dissolved inorganic nitrogen and phosphate from the Danube River rose by factors of 5 and 3 (Zaitsev et al., 1993). These anthropogenically enhanced nutrient discharges resulted in increases in nutrients concentrations on the north-western shelf (Yunev et al., 2007). The nutrients introduced into the Danube originate from agriculture (chemical or organic fertilizer, irrigation etc.), metropolitan and industrial wastes, petroleum chemicals, lumber, wood-pulp industry and domestic sources. But the Danube is not the only pollution source. Dnieper (Ukraine), Dniester (Moldova), Kızılırmak, Sakarya, Yeşilırmak (Turkey), flowing into the Black Sea, are additional sources of pollutants. The excessive nutrient discharges have led to frequent algal blooms - "red tides" and formation of "dead zones" - large submerged areas with too little oxygen to sustain marine life in the coastal waters. Among the consequences from eutrophication was the process of gradual disappearance of the famous Phyllophora "Zernov field" (called also "the BS lungs") - a unique accumulation of unattached Phyllophora in the shallow North-western region.

The industrialization of the Black Sea region in 1970-1990s has led to other changes in the coastal areas which impacts biodiversity, such as chemical pollution, development of transport links (e.g. port facilities, coastal roads), recreational activities. (Hills et al., 2013). The most frequently cited pressure on Black Sea habitats is pollution, natural system modifications (mainly siltation rate changes from dredging and dumping activities) and from urbanisation and coastal development (Gubby et al., 2016). Fishing pressures, for example from beam trawling are current threats and coastal zone development will only further exacerbate threats to benthic habitats in the Black Sea (Gubby et al., 2016).

Important ecological challenge is related to the introduction of non-indigenous species (NIS) and invasive alien species (IAS). Typically, the BS flora and fauna are primarily with Atlantic-Mediterranean origin, as Ponto-Caspian elements are distinguished mainly in freshwater estuaries and river mouths. Presently, there is a progressive trend of arrival of new Mediterranean species (Ozturk, 2010). Phytoplankton, zooplankton, benthic and fish species, typical for Mediterranean, have been encountered not only near to Bosphorus, but in the northwestern and northeastern Black Sea (Boltachev et al., 2009; Shiganova & Ozturk, 2010). Species, native for Atlantic and Indo-Pacific fish species have been sporadically detected (Shiganova & Ozturk, 2010; Boltachev & Karpova, 2014; Turan et al., 2017). The total number of new species accounted ~ 150 (characterised with different level of colonisation and spatial distribution) and the invasion process was facilitated by both factors - rising seawater temperatures and increasing shipping intensity (Shiganova & Ozturk, 2010).

In conclusion, many evidence recognize that external forcing by climate change, alien invasions, cultural eutrophication, and overfishing trigger regime shifts, i.e. switches between alternative ecosystem states, with strong effects on ecosystem functioning. For example, fluctuating fish abundance could induce a lagged change in competitor jelly-plankton that cascades down to phytoplankton and influences water quality. Deprived of the stabilizing role of apex predators, the Black Sea's ecosystem is susceptible to both environmental and anthropogenic stresses, and increased fishing makes fish stock collapses highly probable (Daskalov et al., 2017).

1.2.2 Fish resources

Generally, the Black Sea is more productive than the Mediterranean Sea, but with lower biodiversity. About 200 fish species, more than 500 molluscs species and water plants – macrophytes (red and brown algae as well as marine floral plants) inhabit the Black Sea. Among this specific diversity, the greatest economic value had not more than two dozen of species producing about 98% of catch during the decades (Daskalov & Shlyakhov, 2008). The most common fish species caught in the Black Sea are:

- pelagic fish species: European sprat (Sprattus sprattus), Mediterranean horse mackerel (Trachurus mediterraneus ponticus), Grey mullet (Mugil cephalus), Atlantic bonito (Sarda sarda), Bluefish (Pomatomus saltatrix);
- demersal fish species: Red mullet (Mullus barbatus), Picked dogfish (Squalus acanthias), Thornback ray (Raja clavata), turbot (Scophthalmus maximus), Gobies (Gobiidae).
- anadromous fish species: pontic shad (Alosa pontica) and three sturgeon species (Acipenser gueldenstaedtii, Acipenser stellatus, Huso huso). Their life cycle consists of marine period (wintering and fattening) and river period (spawning and moving of newly born juveniles to the sea);
- In some countries the fishing fleet also exploits the rapana snail (Rapana venosa).

Figure 1.2-2 Biodiversity: Fish and shellfish species in the Black Sea

Currently, the small-scale fishery is the dominant fleet segment and small pelagic fishes are the major fishery object. Anchovy plays primary role in regional fisheries, with highest catches in Turkey. Overfishing is the most significant threat to marine living resources and many stocks are evaluated as overexploited.

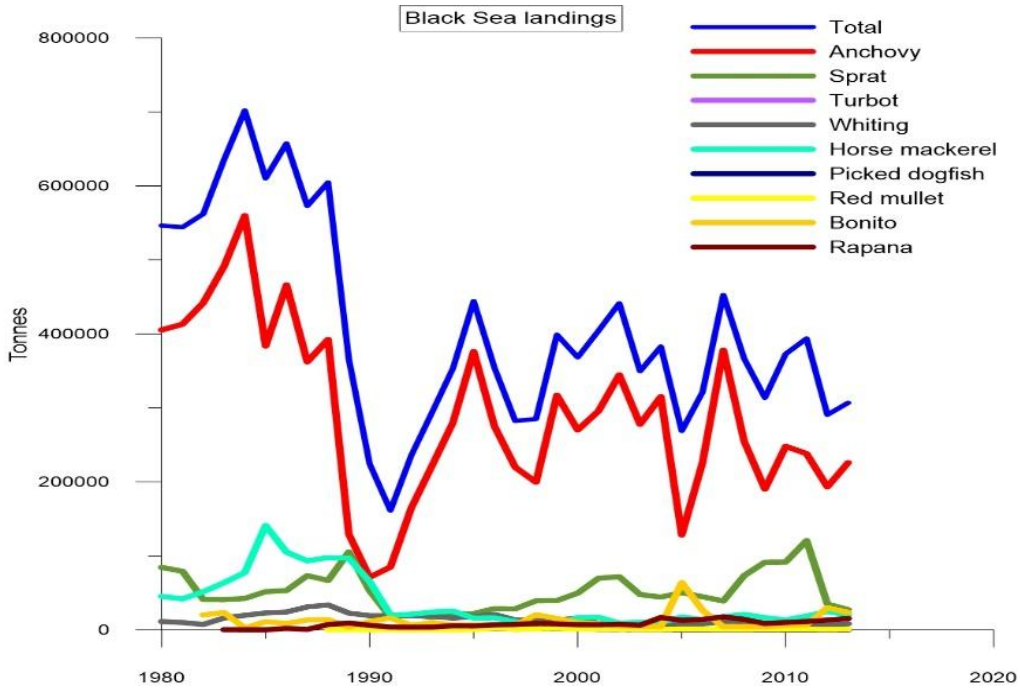


Figure 1.2-3 Black Sea landings: by different fish species and total in 1980-2014 (data source: STECF, 2017).

Prior to the 1970s the fish species were exploited mainly by artisanal fisheries (trap nets and beach seines) and the catches were low. The industrial trawl fishery for small pelagic species began in the early 1970s and has reached record levels during the 1980s (Fig.1.2-3). Thus, after reaching their maxima in the 1970s, the abundance trajectories of the small pelagic fishes go down for the early 1980s along with growing catch rates.

The maximal level of sprat (Sprattus sprattus) landings was registered in 1989 and reached 105 thousand tons. The whiting and spiny dogfish stocks declined. During the 1980s and 1990s, the fish stock status was worsened by outbreaks of local and invasive jelly plankton, that supplementary to the continuously high fishing effort provoked collapse of fisheries sector from early to mid-1990s with economical losses around 16.8 million USD (Knowler, 2005).

It is believed that a combination of favourable climate conditions and preceding overfishing on small pelagic fish, opened a window of opportunity for introduction of invasive ctenophore Mnemiopsis leidyi into the Black Sea. This species, competing with planktivorous fish for food and feeding on fish larvae became dominant component of the ecosystem in 1990s when sharp decline of anchovy (Engraulis encrasicolus) and sprat biomass occurred.

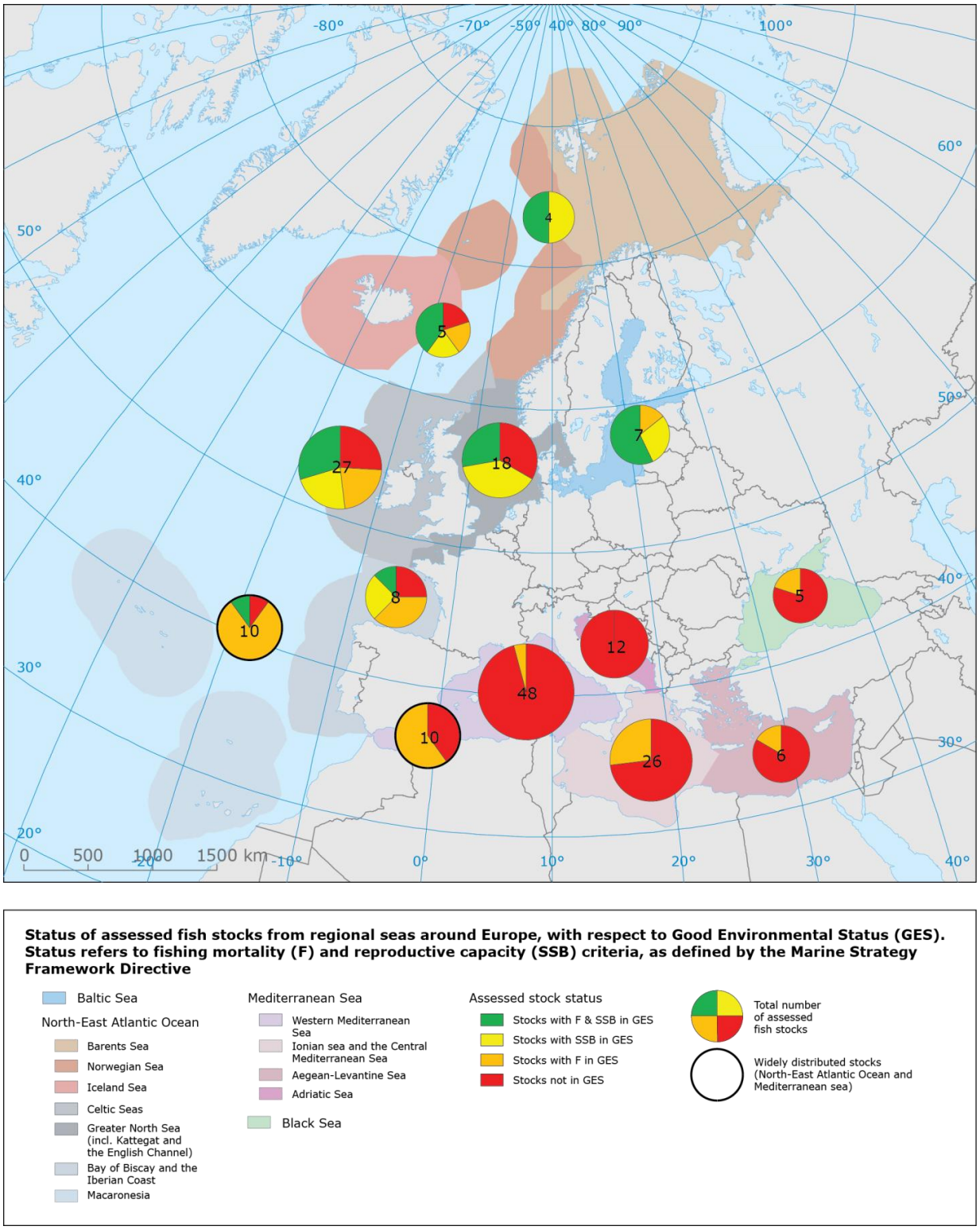


Figure 1.2-4 Status of assessed fish stocks from regional seas across Europe
(Source: https://www.eea.europa.eu/data-and-maps/indicators/status-of-marine-fish-stocks-4/assessment)

1.2.3 Non-fish living resources (shellfish, invertebrates; bycatch)

Shellfish

The primary non-fish resource in the Black Sea is the Rapana venosa, which is an invasive species. The rapana comes from the Pacific Ocean (Japan Sea) and was introduced into the Black Sea back in 1946, most probably from biofouling. The rapana population grew quckly

thanks to the high fertility rate and the relatively good adaptation to the local environmental conditions. The rapana started altering the marine ecosystem by predating shellfish species, i.e. the black mussel, which is its primary food. The commercial exploitation of rapana began first in Turkey and during the 1980s the catch reached up to 10 – 15 000 tons, however due to overfishing the current rapana catches are in the range of 6 to 9 000 tons. Thus, the rapana catch is forbidden jn Turkey during the breeding period (15 July – 31 Aug). Rapana venosa is being commercially exploited by all Black Sea countries.

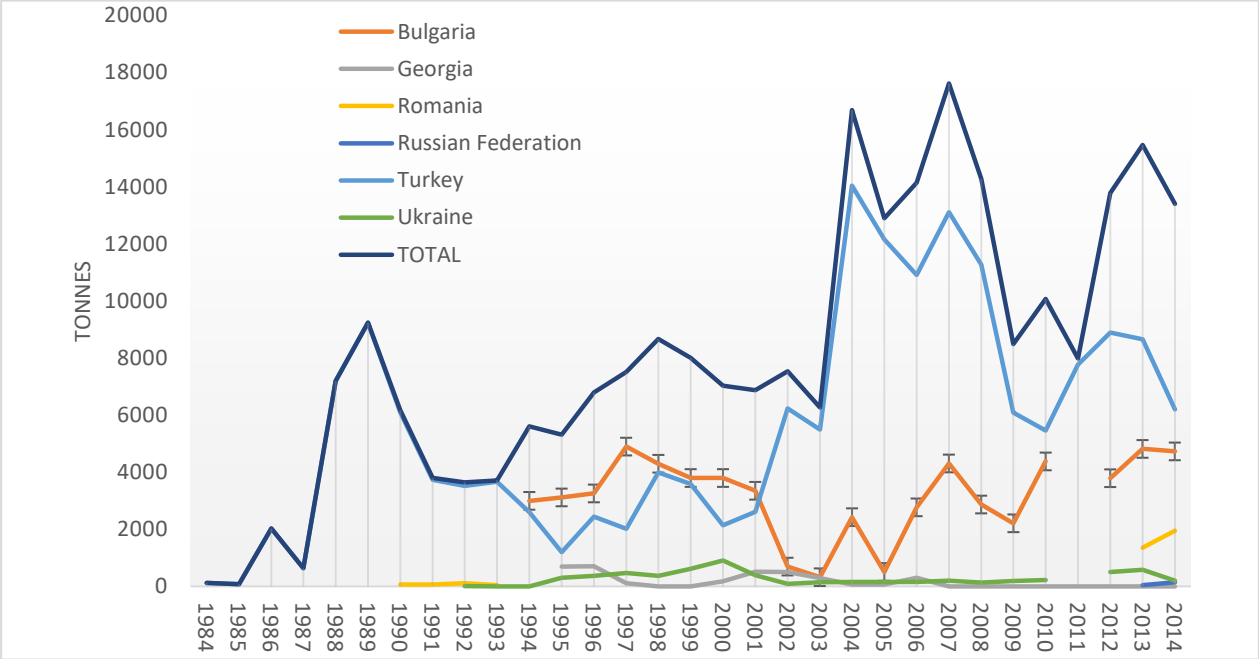


Figure 1.2-5 Rapana catch 1984 - 2014

Other important non-fish resources are the black and white mussel species. There is an increasing trend of the white mussel harvesting in the years after 2016.

Bycatch

The bycatch corresponds to incidental and unselective fishing catches of non-target species and individuals of the target species below the minimum conservation reference size, whether discarded or landed (Vasconcelos P et al., 2019). Bycatch appears a typical result of fishing operations since many species inhabit the vast fishing areas and fishing gears are not entirely selective (Clucas, 1997). The incidental catch could relate to an impact on species (including endangered and non-commercial species and commercially undersized target species) and on habitats and with effects on the food web and ecosystem energy pathways (Hall et al., 2000; Tudela, 2004; Sewell & Hiscock, 2005 and Ozdemir et al., 2014). The assessment of the bycatch by different types of fishing is among the priorities within the Mid-term strategy (2017-2020) towards the sustainability of Mediterranean and Black Sea fisheries, approved by the General Fisheries Commission for the Mediterranean and Black Sea (GFCM/40/2016/2). This strategy includes as a specific goal to "Minimize and mitigate unwanted interactions between fisheries and marine ecosystems and environment", aiming to assure reduced bycatch rates in the Mediterranean and the Black Sea fisheries and to improve the marine ecosystem status. Moreover, the Common Maritime Agenda for the Black Sea promotes research

providing new knowledge to mitigate the impacts of the multiple environmental and anthropogenic stressors on the Black Sea, among them the fisheries and bycatch related problems are key topics.

1.2.4 Climate change impacts

Sea level

The Black Sea sea level (BSSL) rise over the 20th century, with range from 1.5 to 2.5 mm/year (Tsimplis et al., 2004, Goryachkin and Ivanov, 2006), which agrees with 1.7 mm/year of the global MSL rise during the same period. The BSSL change encompass significant spatial variability, particularly, Vigo et al. (2005) and later Kubryakov and Stanichnyi (2013) showed that the coastal sea level is rising 1.5-2 times faster than the sea level in the basin center. During 1993-2014, the basin-mean sea level rise to 3.15 ± 0.13 mm/year, with significant spatial variations of the local rates - 1.5 - 2.5 mm/year in the central part and 3.5 - 3.8 mm/year at the basin periphery and over the north-western shelf and to 5 mm/year in the south-eastern part (Kubryakov et al., 2017).

The MSL rise in the Black Sea is mainly caused by the basin's freshwater budget and the thermal expansion of the water column due to warming during the last years of the XX century (Goryachkin and Ivanov, 2006).

Global mean sea level rise during the 21st century will very likely occur at a higher rate than during the period 1971– 2010. Process-based models project a rise in sea level in the range of 0.26–0.54 m for a low emissions scenario (RCP2.6) and 0.45–0.81 m for a high emissions scenario (RCP8.5) (Global and European sea level, 2016).

Sea Surface Temperature

The annual average SST in the Black Sea was assessed at ~15°C in 1982-2012 (Shaltout & Omsted, 2014), and to 15.98 ± 0.15 °C for 1960-2015 (Miladinova et al., 2017), while the overall mean temperature in the layer 0-200 m is calculated at 9.41°C for the same period. In winter, the most considerable cooling happens in the shallow north-western shelf zone, while the water temperature reached maximum of 9 - 10 °C in the southeast part of the sea. In summer, the surface layer is warmed to 23 - 26 °C.

The warming trend in the Black Sea was well pronounced since 1990-s (Shaltout & Omsted, 2014) and reached ~0.51 °C/decade, as the most rapid warming occur in 1992-2001 at a rate of 2 °C/ decade. The most affected zone in the Black Sea appears the shallow north-western shelf (Belkin, 2009).

As with other marine systems (i.e., Arabian Gulf and Baltic, Mediterranean, and Red Seas), longer data sets do not reveal a significant trend, most probably related to specific influence of recurrent weather systems such as NAO, Atlantic Multidecadal Oscillation (AMO), EAWR (Belkin, 2009). Over a 100-year period of 1900-2000, deep waters show cooling trend, with significant cooling detected during the first three quarters of the century, followed by warming in the last 15–20 years (Shapiro et al., 2010). The SST variability over the Western shelf does not show statistically significant trend for the same 100 years' period. In the deep sea, the general cooling trend of deep waters reached - 0.86 ± 0.3°C per 100 years (Shapiro et al, 2010). Miladinova et al., (2017) calculated a decreasing trend of - 0.13°C for 1960-2015. Due to significant inter-decadal SST variation, there is a high variance in the trends reported [Shapiro et al., 2010] and several authors suggest to cut the long periods into shorter intervals (with duration within 5-10 years),

that better represent the climate oscillations between warming and cooling phases. The first period is a relatively warm, with ASST in range of 15.4 -17.6°C. The second period is considered the coldest period, characterized by a ASST between 14.7-16.2°C, including five extremely cold years - 1976, 1985, 1987, 1992 and 1993. The third period is warm, with especially strong warming phases in 1998/1999 - 2001 and since 2009. During the last period, some severe winters were detected but the low winter temperatures could not balance higher summer temperatures and a steep positive ASST trend is calculated (Miladinova et al., 2017).

The teleconnections show clear impact on the Black Sea area (e.g. Oguz et al. 2006; Kazmin and Zatsepin, 2007) and a significant negative correlation of Black Sea SST (up to -0.65) to the North Atlantic Oscillation was established (Nardelli et al., 2010). At long timescales, the SST variations follow the NAO forcing with a relatively large time delay (between 2.4 and 3.5 years), indicating that the processes relating the SST to the atmospheric conditions are linked to the thermal and dynamical balance of the basin and not limited to the immediate response of its surface layers.

Different SST scenarios for a period 2000-2100, related to greenhouse gas emissions are elaborated (Shaltout & Omsted, 2014) and according the Representative Concentration Pathways 85 (RCP85) scenario, incorporating the highest greenhouse emissions, the SST in the Mediterranean may experience significant warming, peaking at 2.6 °C/century. The least warming was expected using the scenarios RCP26 (the lowest greenhouse emissions) and shows an increase of temperature with 0.5 °C. The Black Sea is projected to warm significantly, ranging from a maximum of 2.81 - 0.53 °C/century in summer to a minimum of 2.33 - 0.51 °C/century in winter.

Sea Surface Salinity

The main pattern of SSS distribution presents high salinity in the basin interior which is decreasing toward the coast and encompass salinity difference between the North-Western Shelf and the rest of the basin, due to fresh water inflow from the large rivers (Mildionova et al., 2017). The cyclonic circulation is predominantly driven by wind stress curl and modulated by the seasonal evolution of heat and freshwater fluxes.

There is an agreement, that the SSS displays gradual decrease over the last 50 years (Oguz et al., 2006; Kazmin et al., 2010; Belokopytov, 2011). Over 1954–2008, Belokopytov (2011) estimated decrease of SSS of 0.04 ‰ per decade, based on monthly data from the west half of the abyssal part of the Black Sea. Model study of Miladinova et al (2017) confirms a significant long-term decreasing trend with rate - 0.02 prom/year in the open sea. Though, that the model might overestimate the magnitude of the SSS trend, the trend is clearly present in the last 5–6 decades.

The tendency toward dilution of the upper layer is usually attributed to the increase of freshwater input. In fact, the freshwater input exhibits a weak increasing trend of 0.46 mm/yr, but at annual scale, a linear correlation between SSS and freshwater input was not found, nor with river runoff, evaporation or precipitation, thus a possibility of delayed response of the SSS to freshwater input due to hydrological conditions is considered (Miladinova et al., 2017). Oguz et al., (2006), Kazmin et al., (2010) suggested that a combination of stronger surface cooling and intensified wind stress in cold years usually lead to SSS increase, whilst mild years/winters are correlated with SSS decrease. The temporal variations of the upper 200 m layer-average salinity anomaly reflect well the

climatic signature in terms of phases and duration, and are inversely related to the temperature variations (Oguz et al.,2006).

The possible parallels between fluctuations of the surface circulation, the strength of the Rim Current and the variation of SSS on decadal or multi-annual scale were studied through model simulations (Miladinova et al., 2017, Fig.1). In summary, multi-decadal variability of the Black Sea surface circulation indicates consolidation and amplification of the main cyclonic motion in the recent decades as intensification of the anticyclonic motion is simulated in the periods of main current weakening. The latter dynamics well correspond with the decreasing trend of the SSS and increased density gradient in the North-western part of the sea.

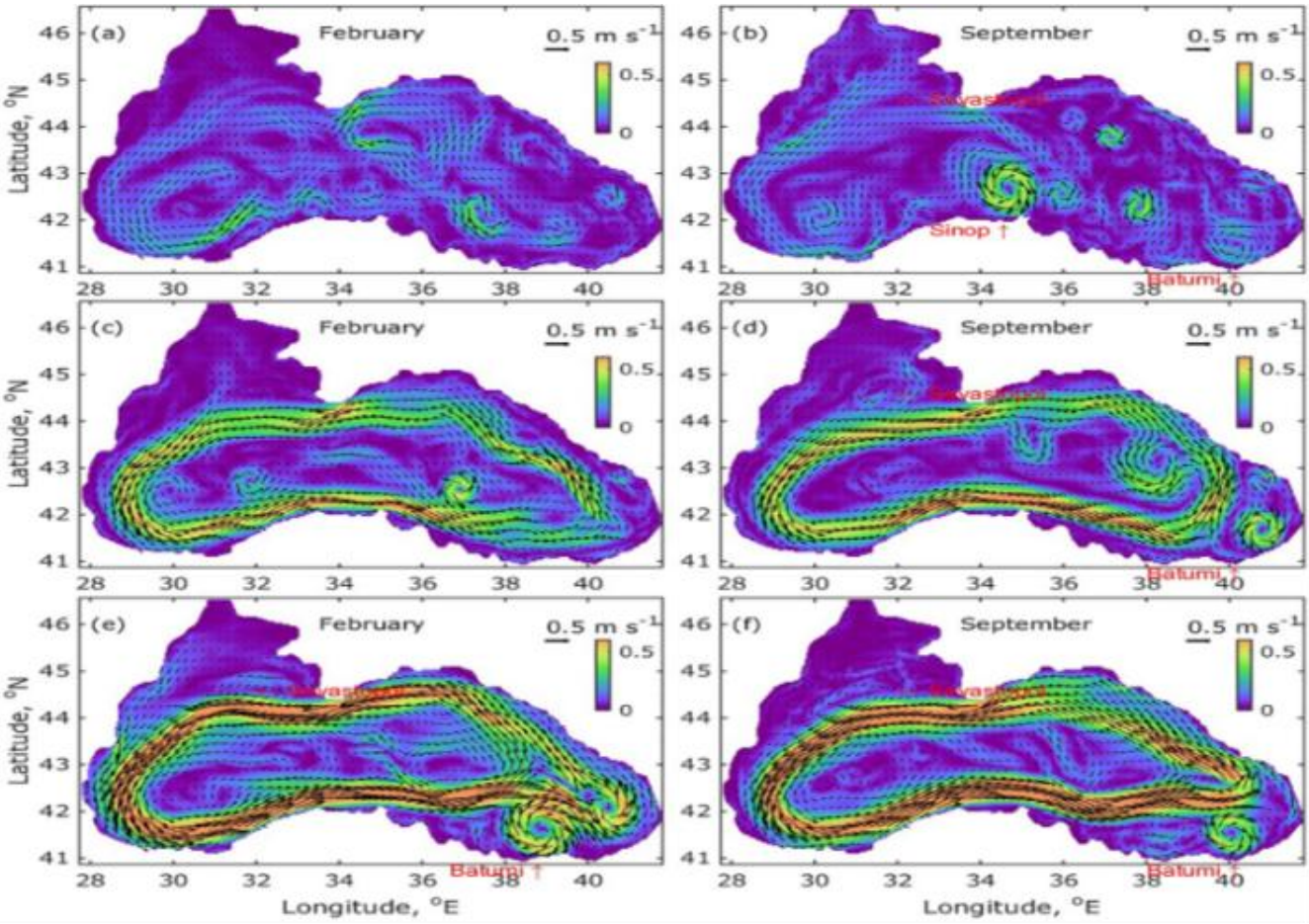


Figure 1.2-6 Climatological model surface circulations

(a) in February and (b) in September for the period I; (c) in February and (d) in September for II; (e) in February and (f) in September III. The colour bar represents the surface speed, while arrows show both speed and direction (from Miladinova et al., 2017).

Thermohaline structure

The most important variations of T/S occur in the upper zone of 250–300 m, as the deep-water masses possess almost vertically uniform S and T of about 22‰ and 9°C.

Temperature is seasonally variable at the surface, decreasing with depth until reaching minimum in the cold intermediate layer (CIL). The bounds of CIL are identified by the

location of the 8°C isotherm, and its lower boundary ranges from 40 m depth in cyclonic regions to 160 m depth in anticyclonic regions (Cannaby et al., 2014). The CIL is a major feature of the vertical termohaline structure (Carpet et al., 2016). it is formed by the processes of winter cooling and mixing (Stanev et al., 2014), followed by accumulation of the cold masses on top of the permanent halocline, where it persists throughout the year. In summer, the surface water layer is warmed to 23 - 26 °C, the seasonal thermocline develops between 20-30 m, the traces of the cold intermediate layer are detected at depths of 50 - 75 meters, while lower depths do not change from their winter levels. (Figure 1.2-7).

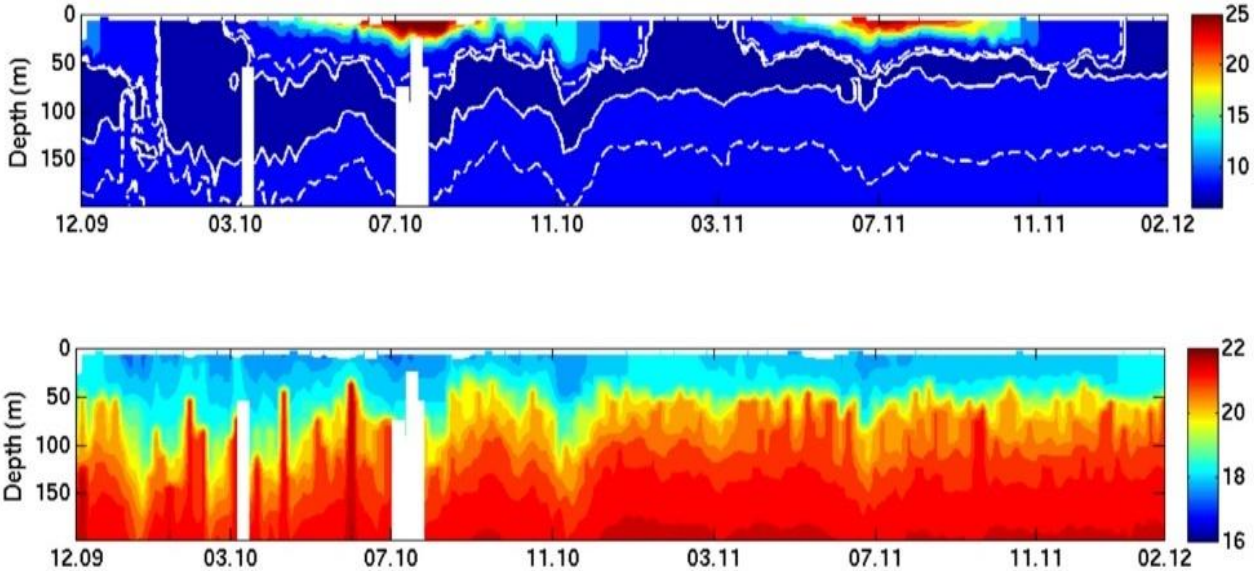


Figure 1.2-7 Temperature (top panel) and Salinity (bottom panel) evolution
(Stanev et al, 2010)

Seasonal variation of the near surface salinity is related to decreasing salinity of the mixed in summer-fall than in winter-spring. Vertically, a marked increase in salinity, up to 21 parts per thousand, occurs at depths of 50 - 150 meters, below which the salinity increase is gradual. The salinity is reaching max of ~33 parts per thousand at depth >1800 m. Salinity could increase to 38 parts per thousand at the Bosporus, where waters from the Sea of Marmara intrude.

While the temperature at the surface does not display an obvious linear trend, model studies exhibits a strong positive linear trend at 50 m depth, whereas at 200 m the trend is weaker and positive. Since the strongest positive trend is found at 50 m (approximately located at the core of the CIL), it is a signal of a warming of the intermediate layers. Analysis of salinity evolution at intermediate depths indicates a negative trend at 50 m depth, which weakens with depth and alters to a positive trend at 200 m.

Over the year, the main processes impacting the thermohaline structure include winter cooling and formation of a new CIL, horizontal and vertical mixing, summer warming and development of the seasonal thermocline, summer upwelling, convection and wind mixing in autumn-winter period. The CIL position depends on the surface water warming, vertical advection, and the turbulent diffusion of heat. Usually, the depth of CIL decreases due to

stronger heat loss and in seasonal aspect, from April to October, the CIL thickness decreases and its depth increases due to atmospheric heating.

The model simulations over the long period of 1960-2015 evidence that CIL temperature increases and less area is covered with intermediate layers of temperature ~ 8° C in the last decades (Miladinova et al., 2017). The warming of the Black Sea surface waters since the end of the 20th century has led to the warming of the CIL waters, disintegration and disappearing of the layer (Stanev et al., 2014). In several years through the last decade - 2001–2002 and 2013–2015, a significant disintegration of the CIL is found, as not only the area covered by CIL shrinks but also the CIL thickness decreases.

Oxic/anoxic zones boundaries

From 1955 to 2015, the inventory of oxygen in the Black Sea shows decreasing level and the basin-averaged oxygen penetration depth has decreased from 140 m in 1955 to 90 m in 2015, which is the shallowest annual value recorded during that period (Capet et al., 2016).

In the 1970s and 1980s, when the Black Sea faced severe eutrophication, enhanced respiration rates and reduced the thickness of the oxygenated layer. Re-increasing oxygen inventory in 1985–1995 was concomitant with a reduction of nutrient loads. More recently, atmospheric warming was shown to reduce the ventilation of the lower oxic layer by lowering cold intermediate layer (CIL) formation rates.

In the long run evidence is collected showing a significant shoaling of the oxic layer, and support the conclusion that the transient “recovery” of the 1990s was mainly a result of increased CIL formation rates during that period. Significant spatial variability of oxygen penetration depth was detected.

In the Black Sea, the upper (O_2 disappearance) and lower (H_2S onset) interfaces of this suboxic layer are controlled by different biogeochemical and physical processes (Stanev et al., 2014), and undergo uncorrelated vertical migrations (Konovalov and Murray, 2001).

Recently, atmospheric warming was shown to reduce the ventilation of the lower oxic layer (Capet et al., 2014, 2016). At deeper levels, the dense sinking plume formed by the Mediterranean inflow through the Bosporus, which entrains water from the overlying CIL, injects fingers of oxygenated water directly into the deeper part of the suboxic layer and upper sulfidic layer and thus acts to control the depth of the lower suboxic interface (Konovalov et al., 2006).

River inflow

The riverine inflow influence on the overall water balance and basin-scale circulation, as well as nutrient loading from human activities in surrounding land. Being an estuarine basin, the Black sea is very sensitive to variations in the freshwater input. This is because the resulting buoyancy flow, induced by the river runoff, is essential for establishing the basin circulation. Comparison between runoff data sets from different data centres has revealed similar climatological mean annual cycles for all rivers considered herein (Miladinova-Marinova et al., 2016b).

It is likely that there will be more severe and frequent droughts and heatwaves, an increase in winter river flows, a decrease in summer river flows and more intense rainfall events (Hills et al. 2013).

Acidification

Statistically significant century-scale acidification cannot be extracted in Black Sea. Decadal-scale reduction of pH has been observed in 1960's and between 1980 and 2000, however, the acidification of the upper layer is mostly due not to the rise of CO2 concentration in the atmosphere, but to natural quasi-periodical decadal-scale intensification of upward motions in the subsurface layer, transporting the water with low-pH to the surface (Polonski, 2012).

Ecological processes & Climate change

Climate may not act as a primary driver of ecological properties, but by affecting numerous chemical and biological properties of the Black Sea, it modulates the ecological changes.

In the deep-sea, the nitrate level increased between 1960s and early 1980s (Shaprio et al, 2010, Yunev et al., 2016), shaping the onset of ”eutrophication phase” coinciding with period of warming and thermic stability. Further, during the strong cooling of the deep sea in the 1980s, the nitrate concentration has stabilized at very high level and only moderate fluctuations were observed till middle 1990s (Yunev et al. 2007, Shapiro et al, 2010). While it is common to associate changes in the nutrient concentration with variations in river discharges, and particularly level of eutrophication due to the Danube river, there are evidence that physical factors, such as strength of the Rim Current may influence nutrients distributional patterns (Yunev et al., 2007, Shapiro et al., 2010). The winter convective mixing provides a flux of nitrate from deep stratums to the euphotic zone, which is approximately equal to the annual load of nitrogen from the Danube river (Cannaby et al, 2014). Hence primary production in the Black Sea may be equally sensitive to changes in both - advective processes and vertical mixing. Recently, the anthropogenic eutrophication decreased and the annual primary production (APP) is estimated to diminish by approximately 15 – 20 % in comparison with the peak eutrophication period (Yunev et al, 2016). The future (2080–2099) model simulation (Cannaby et al., 2014), based on ICPP A1B greenhouse gas emission scenario, show that changes to the advective distribution of nutrient rich river water could exert a stronger control on primary production variability than results from changes in the vertical supply of nutrients. Cannaby et al. (2014) suggested the increased retention of riverine nutrients within the euphotic zone under A1B climatic conditions and imply that climate warming may exacerbate the impact of eutrophication in the Black Sea.

The phytoplankton biomass and chlorophyll a level correlate with amounts of nutrients (Yunev et al., 2016). During the 1980s, phytoplankton biomass in the north-western shelf (May-September, 0-25 m) was approximately 8-9 times higher than in the 1950s-1960s (Yunev et al., 2007). Similarly, a tenfold increase in chlorophyll a concentration was observed for the same area. Apart from the regular two phytoplankton blooms for the temperate regions - early spring and autumn, in some years were additionally observed summer and autumn blooms, that can be attributed to the climate variability (Agirbas et al., 2010). Changes in the composition of phytoplankton species and domination of dinoflagellates are detected in parallel to frequent phytoplankton blooms (Shiganova & Ozturk, 2010). During the last decade, the increase in water transparency and accumulation of nutrients in sediments over the northwestern shelf has caused succession in the structure of seaweed communities of Zernov’s Phyllophora field. As a result, small

species of filamentous algae, which have 40 times higher biological activity than Phyllophora, have started to replace it.

The modelling of future scenarios (Cannaby et al., 2014), show climatic effects on the net primary production, that increased by ~5 %, with much spatial variability linked to advective processes. Phytoplankton biomass increased by 5 % and the higher nutrient environment of the future scenario caused a shift in species composition in favor of larger phytoplankton, while no significant change in zooplankton biomass was projected. It is expected that rare events such as exotic phytoplankton blooms will become more frequent in time due to the climate changes (Agirbas et al., 2010).

Some studies of higher trophic levels of marine food web documented similarities in the ecological trends between Black and North Sea, due to mass development of jelly-plankton and decreasing stocks of small pelagic fish, that indicate global forcing through complex climatic indexes such as North Atlantic Oscillation (Niermann et al.,1999). In late 1980s the high positive phase of NAOI has dominated, associated with high summer temperatures, creating favourable conditions for the outbreak of warm-water invasive ctenophore Mnemiopsis leidyis, that in combination with overfishing negatively affected the pelagic fish stocks.

The sea level rise, coastal erosion, water warming, hypoxia and anoxia events and increased upper boundary of the anoxic layer increase vulnerability of marine habitats, changing their characteristic properties. Analysis of the proportion of threatened habitats (Gubby et al., 2016) , show that Black Sea rank at third place with 13 %, after Mediterranean Sea (32%) and North-East Atlantic (23%). Of investigated 53 habitats, 13% are assessed as vulnerable to critically endangered and a further 2% as near threatened. Taking into account the large number of habitats, evaluated as data deficient, the share of vulnerable habitats would increase additionally.

2. INVENTORY ON EXISTING ORGANIZATIONAL AND HUMANN RESOURCES

2.1 Bulgaria

Basic facts on Marine Waters f Bulgaria:

- Territorial sea (12-nm zone from the baseline), including internal waters, approximately 6,358 km^2.
- Contiguous zone (12-nm zone from the territorial sea) approximately 5,200 km^2.
- Exclusive Economic Zone (EEZ) about 29 052 km^2.
- EEZ between Bulgaria and Turkey was agreed in 1997.
- Pending delimination of boundaries with Romania (TS, Continental Shelf and EEZ) There are no formal maritime spatial plans in Bulgaria yet. Nevertheless, pilot plans for MSP have been elaborated.

The EU Marine Strategy Framework Directive (MSFD) in Bulgaria

The MSFD has been transposed into the Bulgarian Water Act and into other relevant regulations (e.g. Ordinance for Environment and Sea Water Protection, No. 273/23th Nov. 2010) in November 2010. The Ministry of Environment and Water of Bulgaria (MOEW) is responsible for the implementation of the MSFD. In December 2016, the Council of Ministers adopted the Marine Strategy of the Republic of Bulgaria, and a Programme with measures for its implementation. The Strategy assesses the current status of the marine waters (in compliance with Article 8 of the MSFD), determines Good Environmental Status, and establishes environmental targets (in compliance with Articles 9 and 10 of the MSFD) in accordance with 11 descriptors. The main responsible bodies under the MSFD are:

- the Council of Ministers – Consultative and Coordination Council for Environmental Protection of Marine Waters in the Black Sea;
- the Minister of Environment and Water;
- the Director of the Black Sea Basin Directorate;
- the Minister of Transport, Information Technologies and Communications;
- the Minister of Agriculture and Food;
- the Minister of Foreign Affairs;
- the Minister of Regional Development and Public Works;
- the Minister of Energy; the Minister of Health;
- the Chairman of the Institute of Oceanology at the Bulgarian Academy of Sciences (IO-BAS).

Maritime Spatial Planning in Bulgaria

There are no formal maritime spatial plans in Bulgaria yet. Nevertheless, pilot plans for MSP have been elaborated. Bulgaria transposed the Directive 2014/89/EU by an amendment of the Act on Maritime Spaces, Inland Waterways and Ports of the Republic of Bulgaria. The Advisory Council on Maritime Spatial Planning has been working since 2018 on the development of the Plan that should be delivered by the end of 2020. Some general measures that cover MSP (and ICZM) are mentioned in the Development Strategies of the coastal districts (Burgas, Varna and Dobrich), in the National Strategic Plan for Aquaculture in Bulgaria (2014-2020) and in the National Regional Development Strategy (2012-2022).

Executive Environment Agency (EEA) - The National System for Environmental Monitoring (NSEM)

The National System for Environmental Monitoring (NSEM) is established and operated in accordance with Article 1, Clause 7 of the Environmental Protection Act (EPA) of Bulgaria. The system provides timely and reliable information on the elements of the environment and factors affecting it, on which base analyses, assessments and forecasts are performed to support the activities of preserving and protecting the environment from harmful effects. The system is managed by the Minister of Environment and Water through the Executive Environment Agency. ExEA administers the National Automated Syetem for Environmental Monitoring (NASEM) on the whole country, providing material-technical, methodological and software-information resources necessary for its operation and development. All measurements and observations are carried out by the structures of the ExEA in common, unified methods for sampling and analysis in accordance with the procedures ensuring the quality of measurements and data. All ExEA laboratories are accredited under the BS EN ISO/IEC 17025-General requirements for competence in testing and calibration from EA BAS.

ExEA maintains various databases at national and regional level. Databases at national and regional level are structured in components of the environment and using common nomenclatures.

Assessments of the state of environmental components and reporting of the data at national level is carried out by ExEA while the assessments done at regional level – by RIEW, and assessment and reporting of water resources at basin level – by the four Basin Directorates.

The system is organized in accordance with Chapter Eight of the EPA and includes the National monitoring networks for: air, water, land and soils, forests and protected areas, biodiversity, noise and non-ionizing and ionizing radiation. The Control and Information Systems on: emissions from harmful substances in the ambient air, waste water emissions in water bodies, waste information system, earth bowels protection information system are also included in the framework of NASEM.

Inquiries shall be made by components/environmental factors, Regional laboratories / Regional Inspectorates of Environment and Water and River Basin Directorates. They are elaborated on the base of the information received and/or introduced in the National Environmental database of ExEA from NASEM.

The overall management and coordination of the Maritime Spatial Planning related activities are performed by the Minister of Regional Development and Public Works, who is also responsible for development and maintaining of the Maritime Spatial Plan of Bulgaria. Furthermore, an Advisory Council on Maritime Spatial Planning is established as a subsidiary body to the Minister. The latter supports the cooperation and coordination between relevant stakeholders during the Maritime Spatial Planning process.

Institutional framework for fisheries

The Ministry of Agriculture and Forestry (MAF) is the main governmental institution responsible for the enforcement of the Bulgarian Fisheries and Aquaculture Act. In accordance with FAA, the Minister of agriculture and forestry has the power to regulate all administrative and organization procedures. All types of regimes - licensing, permitting

and registration regimes in the fisheries and aquaculture sector and the other activities and procedures are under the jurisdiction of the Minister of Agriculture and Forestry. He has the power to regulate the rights, obligations and functions of governmental bodies responsible for the implementation of the Fisheries and Aquaculture Act.

The Minister of Agriculture and Forestry jointly with the Minister of Environment and Waters determinate the rules and procedure for the accomplishment of fishing activities related to the species, included in Annex 4 from the Biodiversity Act, as well as the Ministers have the power to observe the rules and procedure for protection of fish population during the reproduction period and in dryness /insufficiency of water/. The Ministry of Agriculture and Forestry and the Ministry of Environment and Waters exercise the control on the preservation of the biological diversity of fish resources. The Ministry of Environment and Waters issues the relevant licenses for water use and for use of water basins for the inland water bodies, as well as for the Black Sea.

The National Executive Agency for Fisheries and Aquaculture (EAFA), which was established within the Ministry of Agriculture and Forestry, is responsible for the management of the whole fisheries sector. EAFA is an executive body of the central administration for both implementation of the National policy of fishery and aquaculture and for the application of the Law of Fisheries and Aquaculture. The Agency is financed by the national budget, fees from licensing and registration regimes and the collection of compensation for damage caused to fish and other water organisms. The management, observation and control of the fishery, aquacultures and trade with fish and other aquatic organisms is carried out by EAFA. There are 4 territorial units of EAFA across the country. The 27 Regional Fisheries Inspectorates of EAFA are responsible for field monitoring and control activities in place

In addition there are other structures of the Ministry of Agriculture, Food and Forestry that support the basic activities of the Agency.

Legal framework

The Law on Fisheries and Aquaculture (LFA), (published in State Journal No 41 from 21.04.2001, last amendment – State Journal No 91 from 2.11.2018), regulates the legal foundation for the management, conservation and utilization of fish resources, policy and resource storage programmes, and the structural and marketing organisation of the sector. The Law also regulates the liabilities for the overall management of the fishery sector, defines the obligations of EAFA, specifies the restrictions on controlling the fishing and angling by means of a system of licenses, as well as through the requirement for registration of aquaculture producers. Other relevant acts are:

- Water Act, https://www.lex.bg/laws/ldoc/2134673412 [in Bulgarian, consolidated version with all amendments]; http://www.bsbd.org/uk/page_9640752.html [In English, consolidated version with amendments until 2014];
- Environmental Protection Act, https://www.lex.bg/laws/ldoc/2135458102 [in Bulgarian, consolidated version with all amendments]; http://www.bsbd.org/uk/page_9640752.html [In English; consolidated version with amendments until 2014]
- Maritime Spaces, Inland Waterways and Ports of the Republic of Bulgaria Act, https://lex.bg/bg/laws/ldoc/2134907392 [in Bulgarian, consolidated version with all amendments] http://www.marad.bg/upload/docs/Sea_Spaces_Act.doc [In English];

- Ordinance for the Protection of the Environment in Sea Waters, http://www.bsbd.org/bg/page_5376710.html [In Bulgarian]
- Protected Areas Act, https://lex.bg/bg/laws/ldoc/2134445060 [in Bulgarian, consolidated version with all amendments] http://www.bsbd.org/uk/page_9640752.html [In English, consolidated version with amendments until 2014]
- Spatial Planning Act, https://www.lex.bg/laws/ldoc/2135163904 [in Bulgarian, consolidated version with all amendments]

Research and Education

The Bulgarian Research and Education Centres concerning fisheries are:

- Institute of Fish Resources - Varna;
- Institute of Oceanology – Bulgarian Academy of Sciences, Varna;
- Institute of Fisheries and Aquaculture, Plovdiv (specialized in research in the field of fresh water fish and aquaculture);
- Faculty of Biology, Department of Hydrobiology and Ichthyology at the Sofia University "St. Kliment Ohridski " (the main structure for higher education in fisheries);
- Institute of Zoology with a Natural History Museum in Sofia, Department of Hydrobiology and Ichthyology;
- Central Laboratory of General Ecology in Sofia;
- Thracian University, Stara Zagora;
- National Diagnostic Research Veterinary Medicine Institute which is part of the National Veterinary Service at Ministry of Agriculture and Food.

These research institutes support the activities of EAFA on the organisation and management of the fisheries sector in Bulgaria. EAFA also organises and/or participates in educational and training activities for its administration, professional organisations and people working in the sector. The Institute of Fish Resources and the Institute of Oceanology - Bulgarian Academy of Sciences (both located in Varna) carry out scientific research and give recommendations for the sustainable exploitation of the fish and other aquatic resources in the Black Sea.

Marine Water monitoring and fish stock assessment

The main marine research organizations in Bulgaria operating in the field of fish assessment and marine water monitoring are as follows:

- the Institute of Fisheries (IFR) -Varna.
- the Institute of Oceanology (IO - BAS) – Varna,
- the Institute of Biodiversity and Ecosystem Research (IBER) – Sofia and

Some fragmentary studies are carried by some organisations from the non-governmental sector, e.g. WWF - Bulgaria, Marine Cluster Bulgaria, BDCA. Incidental in-situ measurements are provided also by some private companies (e.g. Hydroremont A/G, CORES ltd, Sea Harmony ltd, and other).

Institute of Fish Resources (IFR -Varna) - https://edmed.seadatanet.org/org/191/

IFR is a state research institute, established in 1932, with departments of hydrobiology and ichthyology; and with a public Aquarium. The IFR is operating under the frame of the **Agricultural Academy, within the Ministry of Agriculture, Food and Forestry**. The main scientific research is focused on the Black Sea (BS) biodiversity; changes in the BS ecosystem due to anthropogenic and climatic factors; commercial fish stock dynamics and trophic base; fish biomass estimations; the Danube River impact on the nutrients level and on the living organisms in the Bulgarian sector of the Black Sea; outbreaks of invasive zooplankton and development of potentially toxic phytoplankton species. During the last years, IFR works in a close collaboration with NAFA (National Agency for Fisheries and Aquaculture) – Bulgaria, on the National Data Collection Program in the field of Fisheries.

The main scientific projects of IFR-Varna during the last years are:

2017-2023 - INFRASTRUCTURE FOR SUSTAINABLE DEVELOPMENT OF MARINE RESEARCH INCLUDING THE PARTICIPATION OF BULGARIA IN THE EUROPEAN INFRASTRUCTURE EURO-ARGO - (MASRI), http://masri.io-bas.bg/

2020-2022 - Research on white mussel species and proposal for new management measures (Whiteclam), funded by the Maritime and Fisheries Program

2020-2021 - Biological monitoring of landed *Rapana* catches by the fishing fleet of the Republic of Bulgaria, funded by the National Data Collection Program for Fishery

2020-2021 - Scientific study for assessment of the caught, stranded and landed quantity and collection of biological data for all species of fish and other marine organisms, through observers on board fishing vessels of the fleet of the Republic of Bulgaria, funded by the National Data Collection Program for Fishery

2020-2021 - Assessment of the stock of turbot (*Scophthalums maximus*) in the Bulgarian waters of the Black Sea, funded by National Data Collection Program for Fishery

2019-2021 - Biological activity and functional properties of Black Sea shellfish tissues (*Mytilus galloprovincialis, Chamelea gallina and Donax trunculus*) as sources of natural nutraceuticals, funded by Ministry of Education and Science

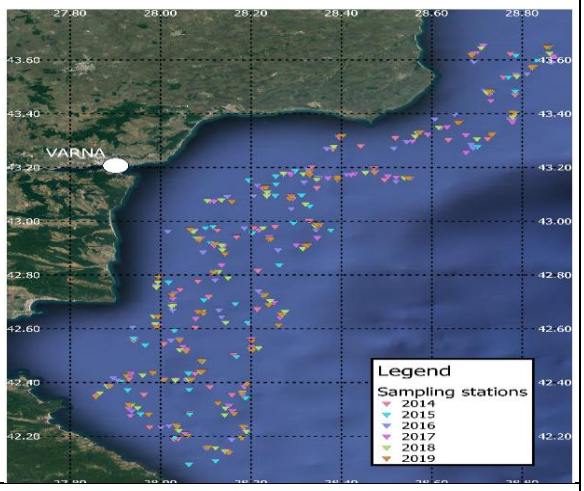
2018-2021 - State of the marine environment and non-fish marine resources off the Bulgarian Black Sea coast, funded by Agricultural Academy

2018-2021 - Status of industrially important fish resources off the Bulgarian Black Sea , funded by Agricultural Academy

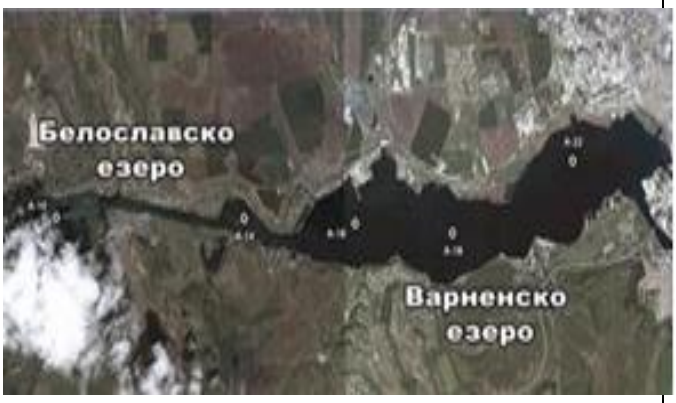
The monitoring areas of IFR – Varna

The major monitoring areas are presented on Figure 2.1-1

Hydrobiological sampling stations (plankton & benthos), from SEADATANET: https://cdi.seadatanet.org/search

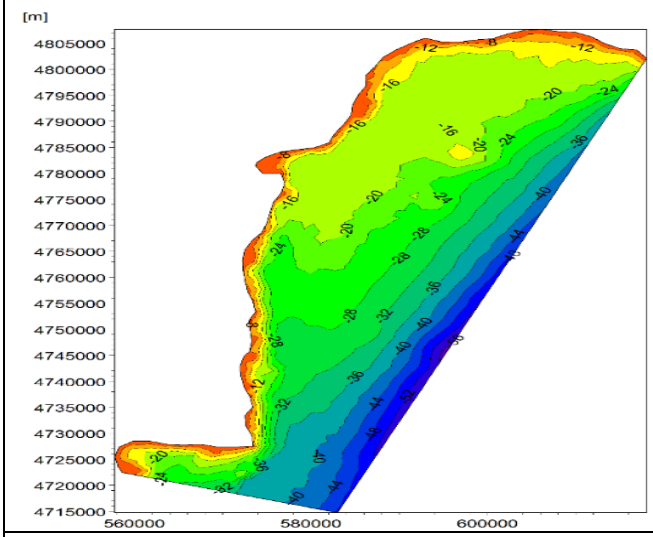


Sampling station of bottom trawl surveys (2014 - 2019)

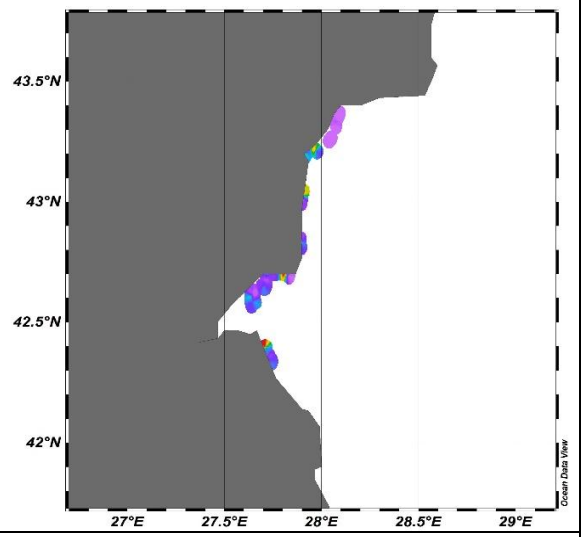


Sampling stations in Varna and Beloslav Lake

Sampling station in Varna Bay



Sampling region to study black mussels and *Rapana venosa*



Sampling stations for white mussels

Figure 2.1-1 Major study areas of IFR-Varna

Institute of Oceanology (IO -Varna); http://io-bas.bg/

The Institute of Oceanology, BAS, Varna is affiliated to the Bulgarian Academy of Sciences. The main research activities are focused on the field of coastal dynamics, marine physics, chemistry, geology, biology, ecology, and underwater investigations.

The research topics of IO- Varna are:

- Coastal zone Hydrodynamics (wind wave in deep sea and shallow water, wind wave climate, wind wave modelling, statistical wind wave models), Lythodynamics (sediment transport, contemporary bottom changes, beach dynamics and cadastre) and Coastal zone management;

- Marine Physics (marine hydrology, water circulation, currents, hydrophysical aspects of marine pollution, semi-enclosed and enclosed basins modelling - Black Sea, Caspian Sea, Mediterranean Sea);

- Marine Biology and Ecology (phytoplankton, zooplankton, macrophytobenthos and zoobenthos, fish-stock assessment, biodiversity, response to environmental parameters – eutrophication and pollution);

- Marine Chemistry (monitoring and analysis of hydrochemical components in the sea, rivers and lakes, indicators of marine environment ecological state: nutrients, oxygen, suspended matter, POC, heavy metals in sea water and sediments);

- Marine Geology and Archaeology (geological, geophysical and geo-chemical research, geological mapping, geomorphologic evolution and seabed processes, ancient sea coasts)

- Ocean Technologies (developing and application of oceanographic instrumentation, specialised and precise devices, deep diving and hyperbaric systems, hydro- and geo-acoustics)

The institute is hosting National Oceanographic Committee and National Oceanographic Data Centre.

Main research projects of IO-BAS

2019-2023 National Science Program "Environmental Protection and Reduction of Risks of Adverse Events and Natural Disasters", contract № Д01-322/18.12.2019, MOH

2017-2023 MASRI – Infrastructure for sustainable development of marine research including the participation of Bulgaria in the European infrastructure EURO-ARGO, contract № Д01-326/18.12.2019, MOH

2018-2023 National Geoinformation Center for monitoring, evaluation and forecasting of natural and anthropogenic risks and disasters, National Roadmap for Scientific Infrastructure 2017-2023, contract ДО1-161/28.08.2018; ДО1-282/17.12.2019

2020-2022 Pelagic trawl survey research of pelagic species in Bulgarian marine area, with target species: sprat, anchovy, horse mackerel, red mullet, whiting and picked dogfish, contract № 196/10/12/2019

2020-2022 Biological monitoring landings of commercially important species, contract № 197/10/12/2019

2019- 2022 Marine benthic diatoms as a tool for assessment of anthropogenic pressure in coastal areas of the Black Sea, contract № КП-06-Н31/9, 11.12.2019,

2020 Morphological mapping of areas along the southern Bulgarian Black Sea coast using unmanned aerial systems, № ПМС 203/19.09.18, MES

2019-2020 Support MSFD implementation in the Black Sea through establishing a regional monitoring system of cetaceans (D1) and noise monitoring (D11) for achieving GES

2019-2020 Benthic marine Antarctic diatoms in contrasting conditions: possible climate induced changes in communities, contract № 70.25-175/22.11.2019

2019-2020 Agreement between MOEW and IO-BAS for fulfillment of the obligations of IO-BAS, arising under art. 171, para 2, item 3 of the Water Act (WA) for implementation of the monitoring requirements of the Water Framework Directive (WFD) and the Marine Strategy Framework Directive (MFSD), № Д-33-28/26.07.2019, MOEW

2018-2021 Geothermal Evolution of marine gas Hydrate deposits – Danube paleodelta, Black Sea, contract № KP-06-OPR04/7, 18.12.2018,

2018-2020 Assessing the vulnerability of the Black Sea marine ecosystem to human pressures

Research area of IO-BAS Varna

The research area of IO-BAS Varna, based on different international and national projects is presented on Fig.2.1-2.

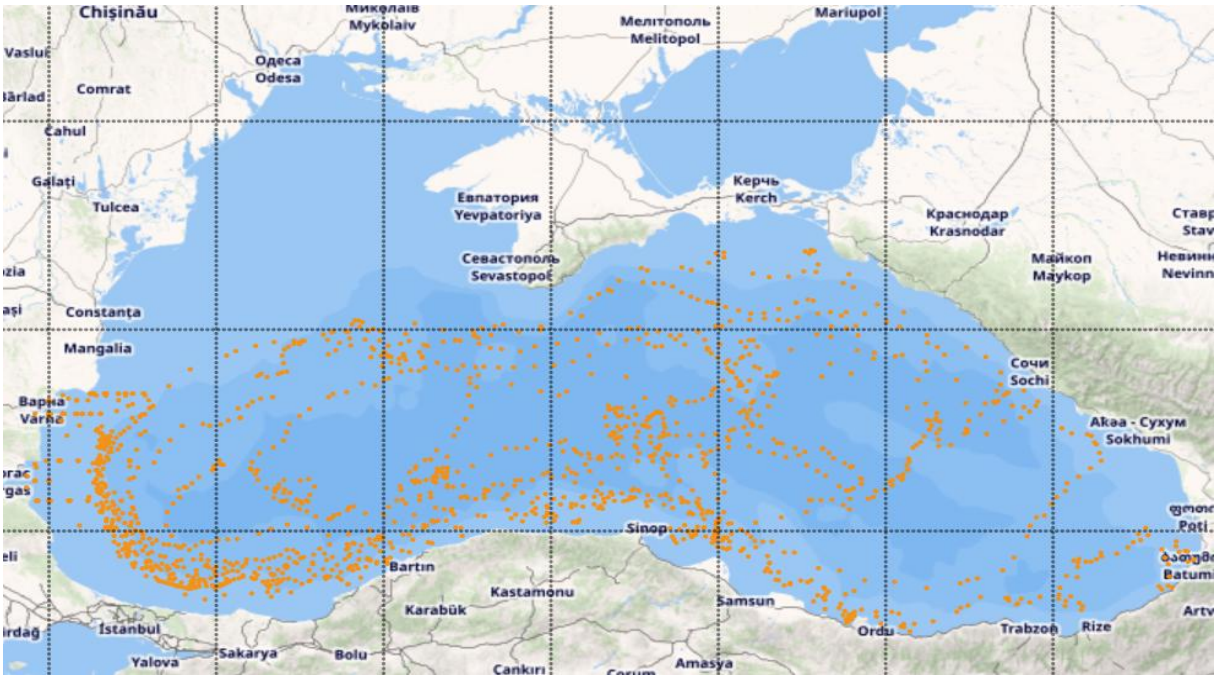


Figure 2.1-2 Research area of IO-Varna
(SEADATANET: https://cdi.seadatanet.org/search?step=~0101843)

Institute for Biodiversity and Ecosystem Research (IBER-Sofia)

The Institute of Biodiversity and Ecosystem Research (IBER) was established on 1 July 2010 after merging of Institute of Zoology, Institute of Botany and Central Laboratory of General Ecology based on resolution of General Assembly of Bulgarian Academy of Sciences from 23.03.2010.

Priority directions

- Structure and functioning of biotic communities, ecosystems and landscapes in the present and in the past.

- Diversity of organisms and their ecological and evolutionary relationships on all levels: from genetic and population to ecosystem level.
- Origin, development history and dynamics of biota and its components: flora, mycota and fauna.
- Scientific basis for conservation of living nature: identifying of threats and developing of methods for their removing or limiting.
- Approaches and methods for sustainable management of protected nature objects.
- Approaches and methods for sustainable management of biological resources, incl. studies on resource importance of species and communities not used before.
- Ecology and biology of species of economic and social importance, incl. approaches and methods for assessment; limiting the impact and regulation of density of invasive species, pests, parasites and other organisms of importance to medicine, nature protection, agriculture, forestry, fishery, hunting, managements of bio-resources and other human activities.
- Scientific basis of ecological risk assessment, the quality of environment and impact on it, elaboration of approaches and methods for biodiversity assessment, biomonitoring and safety systems.

The Institute has well-equipped laboratories for various floristic, faunistic and ecological studies: chemical, phytochemical, genetic, karyological, biotechnological, parasitological, ecological microbiology, light-microscope laboratory, GIS-center.

The Institute has several experimental field stations in Sreburna Biosphere Reserve, Kalimok Reserve, in the town of Sozopol, Atanasovsko Ezero Reserve, Beglika locality, Parangalitsa Biosphere Reserve, Plana Mt.

At the Black Sea, IBER disposes two main stations

- Laboratory of Marine Ecology of IBER, operates in Sozopol with the following main research topics:

- functional monitoring of marine coastal ecosystems and wetlands;
- anthropogenic impact assessment;
- development of scientifically based management approaches of marine coastal zone and of wetlands ecosystems.

- Ecological Station at the Atanasovsko Lake Reserve with the main research topics

- ornithological studies (observations on bird migrations and breeding populations)
- hydrobiology studies (zoobenthic communities, trophic structure, functioning of hyperhaline ecosystems)
- development of scientifically based approaches of conservation and management of the wetlands of the Reserve

Main projects of IBER-Sofia

2018-2023 - Center for Intelligent Solutions in Creative and Recreational Industries" (INCREA) (BG05M2OP001-1.002-0008-C01) (BG05M2OP001-1.002-0008-C01). Funded by the Bulgarian Operational Program "Science and Education for Smart Growth" 2014-2020, co-funded by the European Union through the European Structural and Investment Funds.

2019–2021 - Increasing understanding of alien species through citizen science (Alien CSI): Approaches to citizen science, data management and standards in Bulgaria (No КП-06-COST-13) co-funded by the National Science Fund of Bulgaria

2017-2019 - RECONNECT – Regional cooperation for the transnational ecosystem sustainable development; funded by Transnational Cooperation Program INTERREG Balkan-Mediterranean 2014-2020.

Study area of IBER-Sofia in the Black Sea

The main marine research area of IBER-Sofia in the region of the Sozopol Bay is presented on Figure 2.1-3

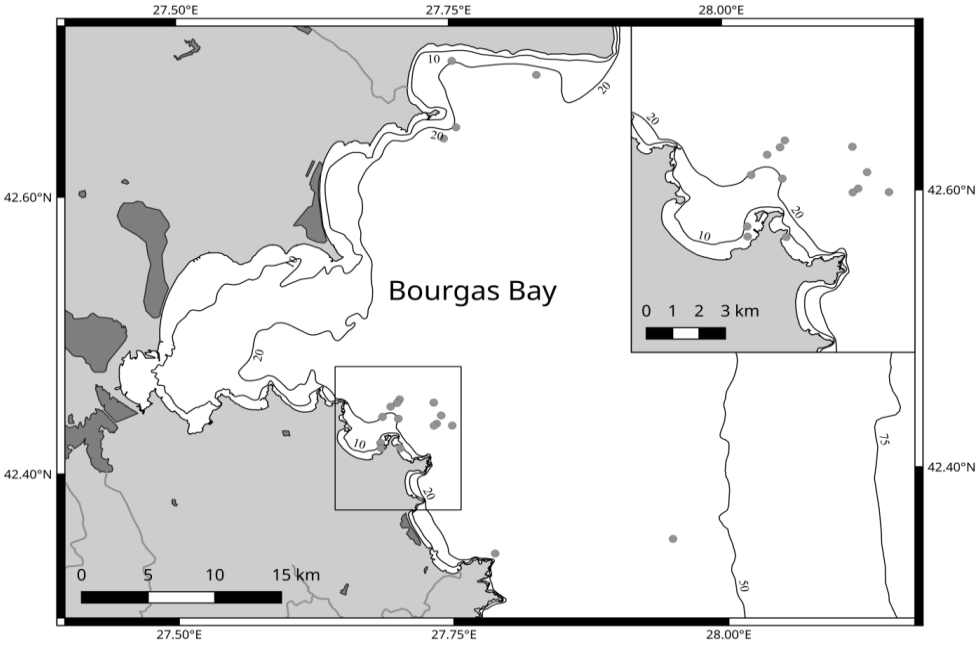


Figure 2.1-3 Map of the main research zones of IBER -Sofia
(I. Georgieva, PhD thesis, 2020)

2.2 Romania

The most influential on water quality of N-W Black sea is Danube river, the second largest river in Europe with 2,857 km long, up to 1,5 km wide and 8 m depth with 6550 m^3/s mean annual water volume discharge.

The Danube river basin drains 801,463 km^2 and it is the world's most international river basin, flowing through the territory of 19 countries. The ecosystems of the Danube River Basin are highly valuable in environmental, economic, historical and social terms, but they are subject to increasing pressure and serious threats of pollution from agriculture, industry and cities.

The Danube River and many of its tributaries form the spawning grounds for many fish, but they receive various degrees of treated wastewater from many different sources, which ultimately ends up in the Black Sea, affecting the nutrient levels in a large portion of its waters. In this sense, the River Danube is the single most important contributor to nutrient pollution in the Black Sea.

Monitoring of Environment especially for water is distributed at top level government policy by different ministries as: Ministry of Environment, Ministry of Water and Forest, Ministry of Transport. Monitoring of fisheries resources is coordinated by the Ministry of Agriculture and Rural Development. Research related to water that needs monitoring of environment and fisheries resources is coordinated by the Ministry of Education and Research. At operational level, monitoring of environment and fisheries resources is done by National Agencies or Authorities and at research level by Universities and National Research Institutes.

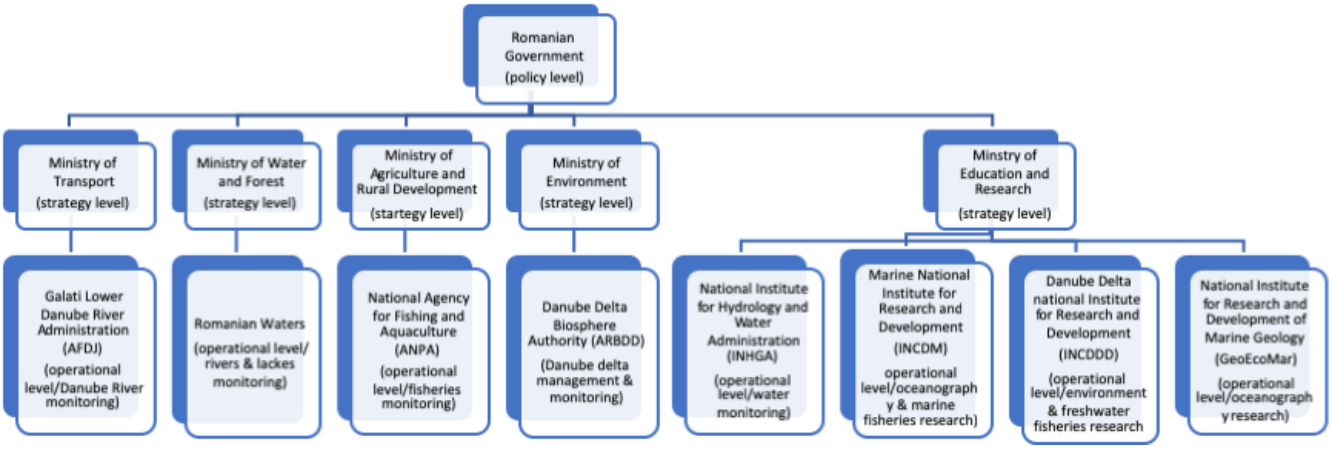


Figure 2.2-1 Organisational hierarchical diagram of environment and fisheries resources

In the South-East Region of Romania at operational level there are several entities which are dealing with environmental monitoring of main waters in the region, including lower Danube river, Danube delta and North-Vest of Black sea, some of which performs also assessment of fish stocks and non-fish living resources, which are described below.

Galati Lower Danube River Administration (AFDJ)

Lower Danube River Administration (https://www.afdj.ro/en) functions as an autonomous state control and is the waterways authority for the Romanian sector of Danube from the border line - km 1,075 to the river mouth in the Black Sea, on Sulina branch, in Sulina roadstead, on the shipping branches of the Danube, Borcea, Bala, Macin, Valciu, Caleia, on Chilia branch with its secondary branches, on Sfantu Gheorghe channel with the rectifications channels and on the secondary branches of the Sulina Channel, named the Old Danube.

The main task of the Autonomous State Control "River Administration of the Lower Danube" is the assurance of navigation conditions on Danube by means of dredging works, *topohydrographical survey*, coast and floating signalization, piloting on the maritime Danube sector between Sulina roadstead and Braila and in the Danube maritime ports, special transport on the river and maritime Danube, internal and international tugging etc.

Activity of interest for the project is "Danube level monitoring":

1) collecting and processing hydrometeorological data, elaborating forecasts on level variation of Danube waters on the Romanian sector https://www.afdj.ro/ro/cotele-dunarii;

2) daily forwarding data for the hydrometeorological bulletin of Danube, on "Romania Actualitati" radio station;

3) editing and spreading the hydrometeorological bulletin for Danube, with hydrological, weather data, minimal navigation depths, passage overall dimensions and other recommendations for difficult navigation sectors https://www.afdj.ro/sites/default/files/bhcote.pdf ;

National Institute of Hydrology and Water Management (INHGA)

The main objective of the National Institute of Hydrology and Water Management (INHGA), http://www.inhga.ro, is to provide services in the field of hydrology and water resources management to support activities and decisions related to the efficient management of water resources, both in situations of special hydrological events (floods, droughts), as well as in normal situations, by the decisional factors in the field: the National Administration "Romanian Waters" and the Ministry of Environment, Waters and Forests.

Activity of interest for the project is "Danube level water quality monitoring":

Daily hydrological bulletin: Hydrological diagnosis and forecast for the Danube at the entrance to the country and on the Romanian sector http://www.inhga.ro/diagnoza_si_prognoza_dunare .

Romanian Water National Administration (Romanian Waters)

The National Administration "Romanian Waters" is the National Authority, under the coordination of the central public authority in the field of water, which administers the goods in the public domain of the state of the nature of those provided in the Romanian Constitution, http://www.rowater.ro/default.aspx. Romanian Waters apply the national strategy and policy in the field of quantitative and qualitative management of water resources.

Activity of interest for the project is "Danube level & water quality monitoring":

Romanian Waters publishes Daily hydrological river situation, including for Danube river with data monitoring and forecast http://www.rowater.ro/Situaia%20hidrologic%20zilnic/Forms/AllItems.aspx .

Danube Delta Biosphere Reserve Authority (ARBDD)

The Danube Delta Biosphere Reserve Authority was created in 1990 to administrate the natural heritage of national interest from the **Danube Delta Biosphere Reserve (RBDD),** arbdd@ddbra.ro; http://www.ddbra.ro/en .

The main objectives of the ARBDD for the management of the Biosphere Reserve are: 1) Conservation and protection of the existing natural heritage; 2) Encouragement of sustainable use of the natural resources; 3) Provision of support, based on the results of research, for management, education, training and services.

Activity of interest for the project is "environmental and renewable resources monitoring and management":

Evaluate the status of *natural resources and their level of exploitation* (fish and other renewable resources) in accordance with their potential for regeneration and ecosystem support capacity. However, renewable resources estimation is externalized to Research institutes or academic entities, but DDBRA implements and regulates sustainable management of them.

The DDBRA performs an integrated monitoring program including following domains: 1. climate and air quality; 2. hydrology; 3. hydrobiology; 4. water quality; 5. soil quality; 6. biodiversity; 7. natural resources; 8. economic activities; 9. human population. The conceptual model of the integrated monitoring system involves 2 main components: data obtaining system (some from third-party) and data management system. For every one of these domains, key-parameters were identified and monitored in order to allow gathering information with maximum efficiency.

The "physics-chemistry" domain criteria include parameters describing ecosystems structure and reflect its possible evolution. "Biology" criteria indicate the levels of environmental productivity and the "social-economic" criteria indicate the level of human pressure.

Danube Delta Institute for Research and Development (INCDDD)

The Danube Delta National Institute for Research and Development (DDNI), http://www.ddni.ro was established in 1970 and its main objective is conducting fundamental and applied research for scientific support of the management of the Danube Delta and other wetland areas of national and international interest, with particular focus on biodiversity conservation and sustainable use.

Activity of interest for the project is "environmental and renewable resources research":

The research activities of the Danube Delta National Institute are oriented towards: 1) assessment of the physical-chemical parameter; 2) biological parameters (biodiversity & natural resources); and 3) the elaboration of biodiversity conservation measures through sustainable use of ecosystem services. There were envisaged hydrological and ecological models for harmonising socio-economic interest with the concept of conservation of natural capital.

National Institute for Marine Research and Development "Grigore Antipa" (INCDM)

National Institute for Marine Research and Development "Grigore Antipa" Constanta, ehttp://www.rmri.ro/Home/Home.html?lang=en, has as main activity scope conducting fundamental, applied and technological development research in

oceanography, marine and coastal engineering, marine ecology and environmental protection and management of living resources in the Black Sea and other marine areas of interest.

Activity of interest for the project is "environmental (oceanography) and renewable resources research":

Attributes for TIMMOD project of The INCDM are: 1) National Oceanographic and Environmental Data Center; 2) Early warning and mitigation tsunami system for Northwest Atlantic, the Mediterranean and the connected seas (IOC); 3) National operator of integrated physical, chemical and biological monitoring system of the marine environment; 4) National scientific responsible for the implementation of the Marine Strategy Framework Directive (MSFD); 5) Focal Points within the Black Sea Commission for: Biodiversity, Pollution, Land-based sources pollution, ICZM, Fisheries and other marine living resources; ACCOBAMS focal point; 6) Regional activity center for environmental aspects of fisheries and other marine living resources management; 7) National scientific responsibilities for fisheries data collection and marine living resources stock assessment; 8) National scientific responsible for the General Fisheries Commission for the Mediterranean (GFCM); 9) Coordinator of the International South-Eastern Europe Secretariat of the Balkan Environmental Association (B.E.N.A.);

The National Institute for Research and Development on Marine Geology and Geo-ecology (Geo-Eco-Mar)

Geo-Eco-Mar (https://www.geoecomar.ro/website/en/index.html) represents the focal point of national excellence in research and consultancy on marine, coastal, river and lacustrine geology, geophysics and geoecology, as well as a reference centre for Marine and Earth Sciences."

Activity of interest for the project is "geoecology research":

Main area of interest is knowledge of structure and functions of ecosystems characteristics for macrogeosystem Danube River-Danube Delta-Black Sea for modelling and forecast of ecological evolution of the system. Another activity refers to study of global changes, especially climatic, at sea level and of the impact of these changes to the environment.

National Agency for Fishing and Aquaculture (ANPA)

The Ministry of Agriculture and Rural Development is responsible for defining and implementing the policy regarding the conservation and management of living aquatic resources existing in natural fish habitats, aquaculture, processing and organization of fishery products, fisheries and aquaculture structures, through the National Agency for Fishing and Aquaculture (ANPA), http://www.anpa.ro.

The ANPA elaborates of the national strategy and of the regulations regarding the conservation and management of the living aquatic resources existing in the natural fish habitats, aquaculture, the organization of the fishery products market, the fishing and aquaculture structures, as well as the implementation and control of the application and their compliance.

Activity of interest for the project is "monitoring of fishing catch and implementing quota management of fish stock and other non-fish resources":

Manages the living aquatic resources from the natural fish habitats of Romania, except for those from the "Danube Delta" Biosphere Reserve, which are managed by the "Danube Delta" Biosphere Reserve Administration, in accordance with the law.

2.3 Georgia

To determine the status of the marine and coastal ecosystems, research is conducted by a considerable number of Georgia's Ministries and institutes, including:

- Environmental Pollution Monitoring Department of LEPL National Environmental Agency;
- Fisheries, Aquaculture and Water Biodiversity Department of LEPL National Environmental Agency;
- Department of Hydrometeorology of LEPL National Environmental Agency;
- Black Sea Protection Convention Division of the State Sub-Agency Department Of Environmental Supervision;

and a number of universities, like

- Ilia State University.

Apart from bilateral cooperation, cooperation with the other Black Sea countries exists within the framework of the Commission on the Protection of the Black Sea against Pollution and with the EU. As a result of international cooperation, the EMBLAS project started its implementation in 2013, inter alia aiming at developing harmonised and cost-effective chemical and biological monitoring programmes in Black Sea countries in line with the MSFD principles.

The Department of the Environmental Pollution Monitoring conducts chemical analyses of the Black sea waters. Chemical analyses are made on Nutrients and physical-chemical parameters every month in six points, as presented in Table 2.3.1

Table 2.3.1 Monitoring points of The Department of the Environmental Pollution Monitoring (NEA)

Station	**Coordinates**
Mtsvane Kontskhi	N 41°69.17'19" E 41°70.34'79"
Batumi Bartskhana	N 41°69.12'75" E 41°70.34'23"
Batumi Navsadguri	N 41°65.05'07" E 41°64.47'46"
Sarpi	N 41°52.67'28" E 41°54.80'94"
Jinvali Channel	N 41°63.30'69" E 41°60.25'55"
Pier Batumi	N 41°65.65'35" E 41°63.31'12"

The following parameters are measured:

- T (Temperature)
- Salinity
- pH
- O_2
- TSS (Total Suspended Solids)
- P (PO_4)
- P total
- N (NH_4)
- N (NO_4)
- N (NO_3)
- Si (SiO_4)

All planned parameters to be measured by the Department of the Environmental Pollution Monitoring are listed here below:

1. Transparency
2. Total Suspended solids
3. pH
4. Temperature
5. Carbonate
6. Carbon dioxide
7. Dissolved oxygen
8. Hardness
9. BOD_5
10. COD
11. Nitrite
12. Nitrate
13. Ammonia
14. Phosphates
15. Fluoride
16. Sulfate
17. Chloride
18. Hydrocarbon
19. Potassium
20. Sodium
21. Calcium
22. Magnum
23. Conductivity
24. Mineralization
25. Silicate
26. Iron
27. Zink
28. Manganese
29. Cupper
30. Nicel
31. Cobalt
32. Arsenic
33. Lead

34. Detergents
35. PAH
36. TPH
37. TDS
38. Microbiological analysis (E.Coli,Total coliforms, S.faecalis, Total viable counts)

The national monitoring at the Georgian Black Sea Coast

The Department of Fisheries, Aquaculture and Water Biodiversity Biodiversity and the Department Environmental Pollution Monitoring of the LEPL National Environmental Agency carries out monthly hydrochemical and hydrobiological monitoring in four permanent stations on the Black Sea coast of Georgia - Sarpi, Pier Batumi, Batumi Port, Green Cape. The stations Sarpi and Green Cape were selected as a reference water area, being relatively less anthropogenic influenced and Batumi and Batumi port – as having a more intensive municipal and industrial press.

Short description of monitoring stations is presented herebelow in Table 2.3.2.

Table 2.3.2 National monitoring stations at the Georgian Black Sea Coast

Monitoring station		Monitoring stations coordinates		Status of monitoring stations
1.	Sarpi	41.52674 N	41.54812 E	Referencing station
2.	Pier Batumi	41.65654 N	41.63324 E	Hazardous anthropogenic impact
3.	Port of Batumi	41.65173 N	41.64407 E	High anthropogenic impact
4.	Green Cape	41.69172 N	41.70345 E	Referencing station

Figure 2.3-1 Map of monitoring stations of LEPL/NEA, Georgia
The Department of Fisheries, Aquaculture and Water Biodiversity

The following parameters are measured **(Hydrobiological parameters /biological quality elements)**

- **Phytoplankton**– *List of species, total abundance, cells/l; total biomass, mg/m^3; Shannon-Index;*
- **Mesozooplankton**- *List of species, total abundance, ind/m^3, total biomass, mg/m^3; Shannon-Index, Biomass of Copepoda % in total mesozooplankton, %; Biomass of Noctiluca scintillans in total mesozooplankton, %.*
- **Macrophytobenthos-** *List of species; Morphfunctional parameters $(S/W)_{3Dp}$, m^2.kg^{-1}; $(S/W)_x$, m^2.kg^{-1}; SI_{ph},*
- **Macrozoobenthos** – *List of habitat; Total Abundance, ind/m^2; Total biomass, mg/m^2.*

The samples of phytoplankton were collected with use a bathometer (1,5l) in the upper layer of the sea and samples of zooplankton by small size Judy net. The Benthos samples were collected by Van Veen Grab from the depth of 5-7 m. Macrophyte samples were taken from the rocky coast of Sarpi, Green Cape and Castle (Tsikhisdziri) using diver.

The Department of Fisheries, Aquaculture and Water Biodiversity of the LEPL National Environmental Agency annually conducts research on fish stock assessment in the marine area of Georgia. They perform the following actions:

- Carrying out relevant scientific-research works (collecting and analyzing fish samples from commercial catch) in order to evaluate the main commercial pelagic fish species in the marine area of Georgia;
- Organizing expeditions within the marine area of Georgia for the research of the main commercial benthic-pelagic fish species. Fishing by the benthic-pelagic trawls in all defined areas at the different depths under the legislation of Georgia;
- Analyzing the samples of the main commercial fish - Identification of Species, determination of the number of each species in the catch, individual measurement, individual weighing, determination of weight-size variation, taking the scales and otoliths to determine the age-growth indexes;
- Collection of statistical information on the main commercial fish catches in the marine area of Georgia;
- Data collection on fishing vessel and gear nets in the marine area of Georgia.

2.4 Turkey

Governing regulations in Turkey

All fisheries and aquaculture activities are regulated by the Fisheries Law No. 1380, enacted in 1971 and amended by the Fisheries Law No. 3288 of 1986. Aquaculture is regulated through licensing, as well as, health and environmental regulations. More recently, the Aquaculture Regulation No. 25507 of 24 June 2004 came into force which addresses major issues related to the sector. Specific issues are regulated through ministerial decrees.

Article 13 of the Fisheries Law states that farmers are obliged to apply to Ministry of Agriculture and Rural Affairs (MARA) by informing the Ministry about the location, characteristics and management of the facilities, and submit the enterprise's project and plans. Permission is issued by MARA if there are no adverse effects, in terms of public health, the national economy, navigation or science and technology (Gozgozoglu, 2007).

The provisions of the last paragraph of Article 4 of the Fisheries Law 1380 are also applicable for production units to be established in the sea and inland waters. According to Article 13 of the Fisheries Law, the procedures and principles related to aquaculture are determined by the Aquaculture Regulation, which was issued in 2004. This regulation was amended in 2007 and 2009 and adds fish welfare issues.

This regulation covers and sets out rules for the following issues:

- Site selection for inland and marine farms.
- Application and evaluation procedures for fish farming licenses.
- Approving the projects and issuing licenses.
- Improving production capacity, species etc., site changes and sales.
- Other aquaculture activities (tuna fattening, organic farming, etc.).
- Importing broodstock fish, egg and fry.
- Compulsory technical staff employment.
- Fish health management.
- Environmental impacts and protection.
- Monitoring and control of farming activities.
- Fish welfare.

Institutional framework

Here below the institutional framework for fisheries and aquaculture in Turkey is presented in brief (*sources: Turkish fisheries report (2017), and FAO Fishery Report: National Aquaculture Sector Overview, by Deniz H. (2011*). As there is no responsible partner from Turkey within the TIMMOD project, this information may need to be further updated.

The Ministry of Agriculture and Rural Affairs (MARA) is the main state organization responsible for fisheries and aquaculture administration, regulation, protection, promotion and technical assistance through four general directorates: the General Directorate of Agricultural Production and Development (GDAPD), the General Directorate of Agricultural Research (GDAR), the General Directorate of Protection and Control (GDPC) and the General Directorate of Organisation and Support (GDOS).

Production, development and management of aquaculture and inland fisheries activities are implemented by GDAPD, while GDAR is responsible for research and GDPC for movements of live fish, diseases and fish as food issues. MARA has provincial directorates in 81 provinces responsible for implementing policies issued by its central office in Ankara. Most of the licensing and monitoring/control activities are carried out by these provincial directorates.

The Scientific and Technical Research Council of Turkey (TUBITAK) plays an important role in supporting high priority research projects, while the State Planning Organization has responsibility for the preparation of the Government's long-term development plans (5-year periods), annual programmes and coordination of the activities of various ministries and public institutions. Fisheries production data is gathered and evaluated by the State Statistics Institute in collaboration with the Ministry of Agriculture and Rural Affairs. A number of public institutions are also involved in the licensing process including the Ministry of Environment and Forestry, the Ministry of Culture and Tourism, the Navigation and Oceanography Department, the Under-Secretariat of Maritime Issues and the General Directorate of State Hydraulic Works (DSI).

Currently the services on fishing, infrastructure, quality control, processing and marketing are carried out by the relevant departments of the General Directorate for Protection and Control of the MARA, whereas the services related to freshwater and marine aquaculture production and statistics are carried out by the relevant departments of the Directorate General for Agricultural Production and Development of MARA. Research on fishery products is conducted by the Directorate General for Agricultural Research of MARA through 4 research institutes and 2 production stations. Support to fishery organisations (associations and co-operatives) is the responsibility of the DG for Institutional Support of MARA.

The institutions related with the fisheries and supports MARA are:

- Prime Ministry (State Planning Organisation (DPT), State Statistical Institute (SIS), DG Customs, Under secretariat of the Foreign Trade)
- Turkish Standardisation Institute (TSE)
- Ministry of Finance (DG Incomes)
- Ministry of Environment (4 DGs on environmental issues)
- Ministry of Interior (Coastguards)
- Ministry of Energy and Natural Resources (DG State Water Works)
- Ministry of Health (Institute of Public Health-hygiene and the sanitary of fish and fish products)
- Ministry of Forestry (DG Wildlife and National Parks)
- Municipalities (Quality control and conservation in the local open markets)
- Bank of Agriculture (Credits)

Fisheries legislative attempts has started during the second half of the 1800s, however later developments has not progressed as expected. In this respect Fisheries Law (No: 1380) of 1971 can be seen as the first major development or corner stone. Second main development or change took place early 1980s when the new legislative arrangements are enacted and got into force. As a result, a number of ministries and institutions established in the 1980's such as Ministry of Environment, Ministry of Forestry, Under Secretariat of Maritime etc. is involved in the decision making process regarding fisheries and aquaculture.

All activities in fisheries and aquaculture are based on the Fisheries Law No. 1380, enacted in 1971, as amended by Law No. 3288 of 1986. The main duties of MARA are:

- To undertake the duties as specified in Laws No. 1380 and 3288, and define and implement major fisheries policies (including for aquaculture).
- To assist the provision of subsidies by other Ministries for the fisheries and aquaculture sector.
- To establish and operate the Quality Control systems and organisations required to ensure and regulate that fish and other fishery products are captured, processed, stored, marketed and exploited in accordance with international quality standards.
- To establish and operate research activities relating to the sector and to provide support (in particular technical assistance) to the private sector wishing to undertake fisheries research.
- To design and implement model wholesale fish market,
- To prepare and implement extension and training programmes for fish farmers and fishermen.

- To collaborate with private agencies, universities, research institutions and international organisations to increase the productivity and conservation of natural stocks and to protect them from environmental hazards.

The collection and publication of statistics is undertaken separately by State Statistics institute (SIS) and the State Planning Organisation (SPO) is responsible for sector planning.

Conservation, control and resource management issues

Methods of controlling fishing activities in Turkey include certain seasonal, regional and size restrictions by the annual circulars issued by MARA. Temporal prohibition protects spawning stocks as it bans the use of trawl and purse seines between May and September. Zone restriction refers to the law against fishing within three miles from the coastline. The MARA has furthermore stopped the licensing of new fishing vessels with the exception renewal of old vessels and new established dam-lake vessels on inland waters.

Enforcement surveillance, inspection and control of the above measures is entrusted to both MARA and the Coast Guard (under the Ministry of Internal Affairs).

Marine aquaculture zones were determined by MARA along the all coastlines in 1988 and were provided moving of sea farms in these zones. After new Environmental Law come into force, new aquaculture zones were determined once again with consensus of all related institutions according to the Environmental Law and Notification on Defining Sensitive Enclosed Bays and Gulfs Areas in Coastal Waters where fish farms shall not be set up. After The Environmental Law was put into practice for implementing Articles related fish farms, inshore marine farms were moved to new offshore areas.

Great efforts have also been put into increasing species and product diversity, however, there has been no significant breakthroughs in these issues, at least on a commercial scale. Unless the above mentioned problems are eased it is unlikely that there will be a major change in species composition and production trends.

Applied research, education and training

Research and development activities are mainly performed by relevant faculties and departments of universities and research institutes, as well as, by the Production and Development Centre within MARA.

There are four research institutes associated with the Ministry, responsible for research and monitoring of fisheries, aquaculture and other aquatic issues. The Central Fisheries Institute is based in Trabzon on the north-eastern Black Sea coast of Turkey and is responsible for fishery, aquaculture and other aquatic research activities from Istanbul to the Georgian border including the Sea of Marmara and inland waters. The Institute has both trout and marine (turbot) hatcheries and grow-out facilities; this marine hatchery has been built as a part of Turkish-Japanese bilateral cooperation activities aiming to develop turbot larvae production. The Institute also has projects on developing sea trout and sturgeon farming and ranching.

A second institute was founded in 2004 on the Mediterranean coast, used as a marine aquaculture production and development centre founded in the late 1980s as part of a FAO project. The other two institutes concentrate mainly on inland fisheries with a small amount of aquaculture research; one is based in Egirdir-Isparta in the lakes region of south-western Turkey, while the other is situated in Elazig in the south-eastern part of the country.

Universities and in particular their fisheries faculties and departments, undertake aquaculture research projects as part of their M.Sc. and Ph.D. degree programmes. There are 13 fisheries faculties and five departments at agriculture faculties providing undergraduate and graduate education in fisheries (including aquaculture) and aquatic sciences, in addition there are number of fisheries programmes in vocational high schools. These fisheries faculties are mostly based in coastal areas. Fisheries and aquaculture related subjects are intensively covered within fisheries faculties, each year between 30–40 students graduate from each of these faculties. The Government of Turkey has just issued a decree imposing the compulsory employment of technical staff in aquaculture enterprises above a certain production capacity.

Training and extension activities are performed by the General Directorate of Agricultural Production and Development (GDAPD) within MARA, with occasional training programmes on aquaculture related subjects also being organized in cooperation with other research institutes or universities. There are also training and extension branches within the provincial directorates of MARA, however, extension services seem to be the weakest link in the support services for aquaculture development and are mostly supplied through farm visits, as well as, local/national radio and television programmes.

Turkey participates in the EU Framework Programmes, and is active in other international programmes such as Socrates/Erasmus, Leonardo da Vinci and the Marie Curie Actions.

Human recourses

Currently, Turkey has a significant level of know-how in the form of qualified manpower which is relatively cheap. There are 17 fisheries faculties and five departments in the agriculture faculties providing undergraduate and graduate education in fisheries (including aquaculture) and aquatic sciences.

Annually, over 300 students graduate from these institutions, however the numbers employed by the sector are still low and those who are employed are mainly in the marine aquaculture sector.

2.5 Ukraine

State Agency of Water Resources of Ukraine

The main tasks of the State Water Agency are:

1) implementation of state policy in the field of management, use and reproduction of surface water resources, development of water management and land reclamation and operation of state water facilities of complex purpose, inter-farm irrigation and drainage systems;

2) making proposals to ensure the formation of state policy in the field of water management and hydraulic reclamation of land, management, use and reproduction of surface water resources.

Ukrainian Scientific Center of Ecology of the Sea (UkrSCES)

The Ukrainian Scientific Center of Ecology of the Sea (UkrSCES), Ministry of Environment and Natural Resources of Ukraine, was founded in January in 1992 based on the Odessa Branch State Oceanographic Institute. It is the main institution of the

Ministry of Environmental Protection of Ukraine in the field of marine ecological research. UkrSCES – is a unique institution of all state ecological systems of monitoring within the Black and Azov Seas, which provides a whole complex of tasks of the ecological monitoring.

The main task of UkrSCES is scientific and practical providing of realization of public policy of Ukraine in relation to the protection, rational use and rehabilitation of natural resources of the Black and Azov Seas basin, and also providing implementation of international obligations of Ukraine, in relation to marine aspects. We are ready for collaboration with national and foreign partners.

The Centre has great experience of oceanographic and ecological investigations in various regions of the World Ocean, fulfilling marine expeditions and providing safety navigation. In 1968-2000 UkrSCES fulfilled more than 400 expeditions in the Atlantic, Pacific and Indian oceans, Black and Azov seas. The ships participated in various national and international complex cruises. All history of oceanographic information that was obtained by scientific-research vessels was stored in UkrSCES Data Bank. UkrSCES according to international agreements has a copy of the World Ocean Oceanographic Database, more than 1 473 588 stations. Now UkrSCES has Data Bank with information of the state of the Black and Azov seas around 100 years (European Directory of Marine organisations (EDMO) https://edmo.seadatanet.org/report/1167, accessed 5.10.2020)

Institute of Marine Biology of the NAS of Ukraine, http://www.imb.odessa.ua

The fundamental foundations of the structural and functional organization of marine ecosystems, estuaries and prehistory territories in conditions of climate change and anthropogenic loading development of scientific principles for monitoring marine ecosystems, management of the quality of the marine environment and ecological management biological diversity and assessment of the biological resource potential of the Azov-Black Sea basin, justification of the methodological aspects of the formation of the marine ecological network of Ukraine

Danube Biosphere Reserve, http://www.dbr.org.ua/

The Danube Biosphere Reserve is an independent nature protection and research institution. Located in the extreme southwest of Ukraine, in the Kiliya district of Odessa region. The directorate and the main base are located in Vilkove. The reserve has a nature protection service, scientific and ecological-educational subdivisions, an economic part and, in part, a self-financing service managed by the administration. The reserve is subordinated to the National Academy of Sciences of Ukraine.

The main tasks:

- complex investigations of ground and water ecosystems, including the biodiversity and updating the periodical "Chronicles of Nature"
- development of scientific basis of environmental protection and sustainable development
- scientific analysis of the state of environment affected by anthropogenic activity

2.6 Russia

Background

Prior to the 1990s, most scientists (Russian or otherwise) were unable to access, analyse, or publish official water quality data of the former Soviet Union. In the past, the only legal entity for long-term monitoring and assessment was Roshydromet. In 1997 monitoring responsibility was officially allocated both to Roshydromet and to the Ministry of Natural Resources. The exact jurisdictional boundaries between the two organizations are often unclear. Federal Law No. 113-FZ of the Russian Federation enabled monitoring by other organizations (e.g., institutes and individuals) that are licensed for such activities. However, this law focuses almost exclusively on long-term monitoring of the type historically associated with Roshydromet, and it's not possible to find official use of evaluation data obtained by other organizations. For effluents, 1991 Federal Law "On environmental protection" granted monitoring rights to individuals and nongovernmental organizations and gave them access to environmental protection information. In retrospect, it is easy to understand how monitoring was developed to facilitate the evaluation of status, trends, and aquatic response to remedial interventions on a large scale but not to the provision of data that are needed for day-to-day operational management of water quality at the local level. There is a gap and the lack of an appropriate institutional response that has been the Achilles heel of water quality management both formerly and presently in the Russian territory.

Water legislation, water strategy, water policy and implementing mechanisms

Legislation

Russia has a federal legal system with environmental matters regulated at both the federal and regional level. At the federal level, this takes the form of codes, laws and subordinate regulations approved by the government and other state bodies. These are supplemented further at the regional level.

Codes and federal laws cover matters such as:

- Environmental protection, including environmental expert assessment and so on.
- Use of natural resources (including land, subsoil, forests, water and so on).
- Sanitation and epidemiology.
- Waste management.
- Wildlife protection.
- Activities on the continental shelf and in the territorial sea.
- Nuclear power.

Many aspects of environmental law, for example, industrial emissions, are regulated in government decrees and federal authorities' orders.

Finally, there are also technical regulations on specific aspects of the environmental protection and pollution control regimes. These include:

- Sanitary and hygiene standards and requirements (SANPIN).
- Hygienic norms (GN).
- Technical regulations.
- Construction rules (SP).

- Construction norms and rules (SNIP).
- State standards (GOST).

Main legislative acts governing water management are the following regulatory instruments:

- ✓ Water Code of the Russian Federation No. 74-FZ of 3 June 2006
- ✓ Inland Water Transport Code of the Russian Federation No. 24-FZ of 7 March 2001
- ✓ Federal Law on Hydrotechnical Structures Safety No. 117-FZ of 21 July 1997
- ✓ Federal Law on Fishing and Conservation of Aquatic Biological Resources No. 166-FZ of 20
- ✓ December 2004
- ✓ Federal Law on Environmental Protection No. 7-FZ of 10 January 2002
- ✓ Federal Law on Water Supply and Sanitation No. 416-FZ of 7 December 2011
- ✓ Federal Law on Lake Baikal Protection No. 94-FZ of 1 May 1999
- ✓ Federal Law on Melioration No. 4-FZ of 10 January 1996.

Federal executive authorities

Ministry of Natural Resources and Environment and subordinated agencies and services

The Ministry of Natural Resources and Environment of the Russian Federation (Minprirody of Russia) is a federal executive authority. It makes policies and regulations for the study, use and protection of water resources and specific water bodies; hydrometeorology and related areas; and environmental protection. It also monitors the natural environment and pollution.

The ministry co-ordinates and supervises the activities of five subordinate agencies which are the:

- Federal Service for Supervision of Natural Resource Usage (*Rosprirodnadzor*).
- Federal Agency for Water Resources (*Rosvodresursy*).
- Federal Forestry Agency (*Rosleskhoz*).
- Federal Agency for Subsoil Use (*Rosnedra*).
- Federal Service for Hydrometeorology and Environmental Monitoring (*Rosgidromet*).

The Federal Service for Hydrometeorology and Environmental Monitoring (Roshydromet) is a federal executive authority that manages state property and provides public services in the area of hydrometeorology and related areas, as well as monitoring of environment and its pollution. Roshydromet's functions include, among others:

- ✓ maintain state accounting for surface waters and state water cadastre with regard to surface water bodies;
- ✓ maintain common state data fund on environmental status and pollution;
- ✓ set up, and ensure the operation of, the state observation network, including setting up and terminating operation of stationary and mobile observation stations;
- ✓ conduct state monitoring of surface water bodies and monitor the unique environmental system of Lake Baikal;
- ✓ conduct state monitoring of continental shelf as set by the legislation of the Russian Federation (within its terms of reference);

- ✓ ensure operation on the territory of the Russian Federation of hydro-meteorological observation stations and of a system to obtain, collect and disseminate hydro-meteorological information.

There are a number of environmental NGOs that actively participate in major environmental projects and initiatives, including with respect to improvement of the Russian environmental legislation.

Some of these organisations are well-known and operate worldwide, such as Greenpeace and the World Wildlife Fund. Other NGOs are national, such as the Russian National Committee for Supporting UNEP, or regional, such as Baikal Research Centre.

Scientific Institutions

Central level - VNIRO – All Russian Scientific Institute for Fisheries Research and Oceanography

VNIRO (Russian Federal Research Institute of Fisheries and Oceanography) plays a leading role in fisheries science and serves from the studies of abiotic and biotic ambient conditions of commercial species to evaluation of biological and fishery productivity of water bodies, to the identification of regularities in the distribution patterns and reproduction of aquatic living resources, forecast of the state of their stocks and estimation of the allowable catch, protection of interests of national fisheries at the international level.

Basin level - TINRO – Far Eastern Scientific Institute for Fisheries Research & Oceanography Regions- KamchatNIRO, MagadinNIRO, SakNIRO

North Pacific research institutes include the TINRO-Center in Vladivostok (as a center fishery scientific institute for the Far Eastern Fishing Basin), KamchatNIRO in Kamchatka, SakhNIRO in Sakhalin, and MagadanNIRO in Magadan. These scientific institutes operate under the FFA Department of Science and Education.

The Federal State Budgetary Institution of Science of **P. P. Shirshov Institute of Oceanology of the Russian Academy of Sciences** provides marine research in all Russian seas. It owns a number of research vessels operating and maintained by the shipping company P.P. Shirshov of the Institute. The Company is comprised of the Scientific Expeditions and Fleet Department of the Institute and the Fleet Departments of the Atlantic Branch and the Southern Branch

In Russia there is already a well-established, comprehensive legal and policy framework aimed at developing sustainable fisheries. Russian fisheries management is organized through a common coordinating agency - the Federal Fisheries Agency (FFA) that operates under the Ministry of Agriculture (MoA).

Fishery Sector Institutions

Until 2004, management of fisheries as the use of a state property (including governance, interagency coordination of “rational use”, monitoring and research, protection of stocks and their environment, and stocks replenishment was a responsibility of the State Committee for Fishery. In 2004, the State Committee for Fishery was abolished and the function of governance of fisheries became the responsibility of the Ministry for

Agriculture and Fisheries, and the affiliated Federal Agency for Fisheries and Fisheries Directorate of the Federal Service for Veterinary and Phytosanitary control (Rosselkhoznadzor). The Department of Fishery of the Ministry develops policy and prepares regulations. Within the frame of this Ministry there was the Federal Agency of Fishery, which had a mandate for conducting government policy with regard to fisheries, including regulation of access to resources, monitoring, research and representation of the Russian Federation in international fisheries agreement and regional fishery organizations. The Fisheries Directorate of the Rosselkhoznadzor had a watching role. In October 2007, a new reform removed the Agency of Fishery and Fisheries Directorate of the Rosselkozndazor from the Ministry of Agriculture. The State Committee for Fishery was re-established as an institution directly under the Federal Government. It will combine the functions of the Department for Fisheries (policy and development), Federal Agency of Fishery (management on behalf of the state), and the Fisheries Directorate of the Rosselkhoznadzor (control). Further structural changes are expected, in particular at the regional level, so providing an organigram is currently unrealistic. In addition, coordination of enforcement of marine biological resources is the task of another federal body, the Border Service, Pogranichnaya Sluzhba (PS). Since 2003, this service is subordinated to the Federal Security Service (FSB).

The Ministry of Agriculture is responsible for developing high-level policies and fishing industry strategic development. The FFA provides operation management of fisheries.

FFA has the following key functions:

- Development of orders and regulations related to the fisheries management and environment protection measures
- Organizing of scientific research and survey for fisheries;
- Total Allowable Catch (TAC) setting process;
- Quota allocation among quota types, fishing zone, and companies;
- Perfoming of fisheries control, monitoring and enforcement functions to ensure implementation of Fishing Rules and environmental regulations;
- Providing operational management of fisheries through FFA regional divisions;
- Advocating the right for public participation in the fishery management process through supporting public and industry councils schemes.
- Through CFMC Operating of the Fishery Monitoring System for monitoring and data collecting;

The Federal Agency for Fishery (Rosrybolovstvo) is a federal executive body responsible for:

- ✓ control (oversight) in fisheries and conservation of marine biological resources in Russia's inland waters, excluding internal sea waters and the Caspian and Azov Seas until their status is determined, and government oversight of merchant shipping in terms of ensuring the safe navigation of fishing vessels in fishing areas;
- ✓ government services and state property management in fishing, the protection, sustainable use, study, preservation and reproduction of marine biological resources and their habitats, as well as fish farming (aquaculture), commercial fisheries, the

production of fish and other products from marine biological resources, the navigational safety of fishing fleets and safety of search-and-rescue operations in fishing areas while fishing, as well as production activities on board fishing vessels and at seaport terminals designed for the comprehensive servicing of fishing vessels.

The Fishery Monitoring System (FMS) provides a central platform for data storage, analysis, and dissemination of fisheries data and statistics. FMS is designed to collect, process, store and represent data of the fishing and transport vessels and information on production activity of the vessels and fishery companies. It is available to FFA, FSB, fishery scientific institutes like VNIRO and TINRO, Customs, users plus others approved by the FFA.

According to the regulations, each vessel (fishing trawler or transport vessel) and fishing company is obliged to register in the FMS, with unique FMS code being assigned to the vessel (company) which is needed for such vessel's (company's) reports processing.

Data of vessels' activity is based on the Daily Vessels Report (DVR). All information is transmitted by satellite or radio communication channels.

DVR includes information on:

- vessel's unique code;
- vessel's status and position coordinates at the moment of report;
- port of destination and estimated date of arrival;
- daily catch regarding each species of the caught aquatic biological resources;
- data on catching operations performed (fishing (catching) gear), total quantity of harvest (catch), number of operations and time spent, average depth of the operations, fishing grounds, etc.);
- total volume of the fish and other products produced from each species specifying the source of raw materials (caught or bought at the sea);
- detailed information on accepted on board and transhipped fish products;
- volume of each type of cargo/store on board;
- data on out-of-operation maintenance (type of out-of-operation maintenance, actual date of its start and estimated date of its completion);
- time spent for each type of activity performed by the vessel; etc.

The CFMC also performs satellite tracking of fishing vessels with mandatory installations onboard each vessel. Each vessel (fishing or transport) with output at least 55 kW and tonnage at least 80 tons must be equipped with satellite control equipment (VMS). Information from the VMS is transferred through satellite communication (by means of Agros and Inmarsat systems) to the earth station of the telecom provider and further to the FMS. The CFMC is planning to introduce an electronic logbook system for the pollock fisheries within the Far East in 2016.

FFA coordinates a network of fishery scientific institutes which annually accomplish a wide range of scientific research in the north-western part of the Pacific, including surveys of walleye Pollock stocks in the West Bering Sea, the Sea of Okhotsk and the Japan Sea.

The Russian Federal Service for Hydrometeorology and Environmental Monitoring (Roshydromet) (Russian: Федеральная служба по гидрометеорологии и

мониторингу окружающей среды России (Росгидромет)) is a service in the Ministry of Natural Resources and Environment (Russia) which carries out the functions of state property management and provision of public services in the field of hydrometeorology and related areas, monitoring of environmental environment pollution, public oversight of the work on modification of meteorological and other geophysical processes.

Responsibilities:

- State oversight of the work on modification of meteorological and other geophysical processes on the territory of the Russian Federation;
- Licensing of certain activities within the competence of the Service in accordance with the laws of the Russian Federation;
- State records of surface water and maintenance of public water inventory in terms of surface water bodies;
- Maintenance of the Uniform State Fund data on the state of the environment and its pollution;
- The formation and maintenance of the state monitoring network, including the organization and the termination of fixed and mobile observation points and the determination of their location;
- State monitoring of ambient air.

2.7 Moldova

Having as its basis the DECISION of the Parliament of the Republic of Moldova, no. 88-XIII of 28.04.94, for the ratification of the Convention on the Black Sea Countries on Cooperation in the Field of Culture, Education, Science and Information, and the Convention on the Protection of the Black Sea against Pollution of 21.04.1992 signed in Bucharest by the 6 Black Sea Countries Black, the Republic of Moldova has rights and obligations to assume the risks and benefits offered by the Black Sea.

Aware that only through cooperation and joint actions with all countries bordering the Black Sea can progress be made in protecting the environment, conserving biological resources and maintaining an ecological balance in the Black Sea.

It is proven that the pollution of the Black Sea marine environment also results from land sources in other European countries, especially through rivers, so it has been requested that countries with watercourses that flow into the Black Sea to join initiatives, programs , projects to reduce the impact / pollution of Black Sea water.

The Republic of Moldova through the water transported by the rivers Nistru, Prut, Ialpug, Cogâlnic, Cahul, Cirghij-Citai, Sărata, Caplani, Khadzhyder, and Gealair contributes directly or indirectly to the pollution of the Black Sea water.

Based on the provisions of the above-mentioned Conventions and national strategies and policies, the Republic of Moldova aims to improve both the management of water resources and their quality.

For these purposes, the Government has designated institutions responsible for both hydrological, hydrochemical, hydrobiological, and biological monitoring, as well as for the elaboration and implementation of policies for the protection and management of water and biological resources.

In the Republic of Moldova, the national system responsible for the elaboration and implementation of policies in the field of aquatic resources and fish resources, are divided into:

- monitoring functions,
- control functions,
- management functions,
- research functions.

The monitoring functions of surface waters and fishery resources are assigned to the following institutions:

- *State Hydrometeorological Service (SHS),*
- *Environmental Agency.*
- *State Fisheries Service*

The control functions for surface waters and fishery resources are assigned to the following institutions:

- Moldovan Waters Agency,
- State Ecological Inspectorate,
- Environmental agency,
- State Fisheries Service.

The functions of water and fisheries management are assigned to:

- Moldovan Waters Agency
- State Fisheries Service

The research functions of water resources and fishery resources are assigned to:

- Institute of Geography and Ecology,
- Center for Research on Aquatic Genetic Resources "ACVAGENRESURS",
- Institute of Zoology,
- universities,
- Civil Society (NGO)

The success or failure of any community in achieving sustainable / sustainable policies in the field of environment, water and fishery resources is based on the information collected objectively, operatively and truthfully. To this end, the Government of the Republic of Moldova has established and developed institutions empowered to manage monitoring systems for various fields and purposes.

The State Fisheries Service is the national institution empowered both for policies in the field of monitoring, control and management of fishery resources.

Currently, the State Fisheries Service does not have a system for monitoring fishery resources, this activity is carried out periodically and episodically in order to assess the quantity and quality of fish species present in different river sectors.

In the cases of updating the Red Book, control and evaluation tests are made of the number of species present or extinct in the natural waters of the country.

At the same time, the fish resources available in the waters of the Republic of Moldova are a source of food for the country's population. Currently, in the structure of the annual menu of the country's population, fish as food is 11.9 kg/year, including 3.0 kg of domestic

production, which indicates the need to increase fish consumption by at least 1.5-2.0 times, the norm biological consumption of fish per capita on the globe being 20.0 kg/year.

Habitats for multiplying and increasing fish resources in the Republic of Moldova from year to year are becoming smaller in area and more endangered in quality, so it is required to develop and implement policies to improve the situation.

In order to develop and implement sustainable strategies, programs and projects, it is necessary to organize, develop and equip the national fish quality and migration monitoring system, according to the requirements of national conventions and strategies, to know how much, where, what quality and quantity of fish. Fish arranges the habitat, as it is distributed in time and space.
The Republic of Moldova needs support in developing and equipping itself with stationary installations and mobile equipment for quantitative and qualitative monitoring of cave resources, which are currently lacking.

Research studies on fishery and aquaculture are carried out mainly by two institutes:

- ✓ the Laboratory of Ichthyology and Aquaculture, and the Laboratory of Hydrobiology and Ecotoxicology within the Institute of Zoology of the Academy of Sciences of Moldova and
- ✓ the Chisinau Branch of the State Enterprise on Research and Production of Water Bio-resources Aquaculture – Moldova.

The first institute concentrates its activities in two main fields: the study of ecological and biological aspects of the functioning of fish populations and managing population abundance; and the elaboration of eco-industrial methods for reproduction, acclimation and re-acclimation of valuable, vulnerable, endangered and critically endangered aquatic species.

The second institute conducts its research in the field of creating new fish breeds, lines, hybrids and in developing new reproduction and breeding technologies, as well as the conservation of gene pools of valuable fish species (recently of spiny lobster).

Legislation and official bodies in the fisheries sector in the Republic of Moldavia

The main legal regulation of the Republic of Moldavia on the fisheries sector is Law no. 149 of 08.06. 2006 on the Fisheries Fund, Fisheries and Fish culture. The law establishes the legal framework in the field of fisheries fund, fisheries and Fish culture, regulating the way and the conditions of creation and protection of the fishery fund, reproduction, growth and acquisition of hydrobionets, improvement of the aquatic fishery objectives and development of fish farming. This legal provision establishes the principles of the activity of the central and local public authorities empowered with the management of aquatic biological resources, the scientific cooperation with the Academy of Sciences of Moldavia and with the specialized institutions. There are also mentioned aspects regarding industrial and amateur fishing, protected areas, state bodies authorized to monitor and control the national fisheries sector (Parliament of the Republic of Moldavia, 2006).

In the framework of the pre-accession negotiations with the European Union, the harmonization of the national legislation also includes the correlation between the rules

specific to the national fisheries sector and the European one (Center for Harmonization of Legislation, 2010). At the same time, the association agreement between the Republic of Moldavia and the European Union has created prerequisites for cooperation in various fields and allows connecting the political, economic and ecological systems of the Republic of Moldavia to the values and standards of the European Union.

In 1995, the Republic of Moldavia ratified the Convention on Biological Diversity, which aims at preserving biological diversity, the sustainable use of its elements and the fair and equitable sharing of benefits arising from the use of, and access to, genetic resources, taking into account all rights on those resources and through adequate funding for biodiversity conservation measures.

In cross-border areas (Prut and Nistru rivers), cross-border agreements on the protection of fishery resources are also applicable. Thus, the Cooperation Agreement to Ensure Environmental Protection and Rational Use of Fishery Resources and Regulation of Fishing in the Prut River, signed in 1 August 2003 by the Governments of Romania and the Republic of Moldavia, regulates the protection of fishery resources on the border areas (the Prut River and Costești Stânca reservoir). At the border with Ukraine, the fish stocks in the Nistru are permanently diminishing due to the regularization of the course through the construction of the Nistrean hydropower complex. Although the Agreement between the Government of the Republic of Moldavia and the Cabinet of Ministers of Ukraine on cooperation in the field of sustainable protection and development of the Nistru River Basin was signed in Rome as early as 29 November 2012, so far it has not entered into force because it has not been ratified by the Ukrainian side. (Mihaela Munteanu (Pila) and Silvius Stanciu, Monitoring the Fisheries Sector in the Republic of Moldova)

According to the FAO Fisheries and Aquaculture Circular No. 1055/3, there are only a few fishery and aquaculture institutions of in the Republic of Moldova:

- ✓ the Chisinau Branch of the State Enterprise on Research and Production of Water Bio-resources Aquaculture – Moldova, which is the successor of the Biological Experimental Station for Fisheries (1945–1990) and the Fisheries Scientific Research Station (1990–2007);
- ✓ the Institute of Zoology of the Academy of Sciences of Moldova;
- ✓ the Piscicola Association, which is subordinated to the Ministry of Agriculture and Food Industry;
- ✓ the Fishery Service, which is subordinated to the Ministry of Agriculture, Regional Development and Environment;
- ✓ the Society of Hunters and Fishers of the Republic of Moldova;
- ✓ Aquatir Ltd.

There are also a few NGOs with the necessary potential to carry out projects in the fisheries and aquaculture sector:

- ✓ Society of Bioremediation of Aquatic Ecosystems and Anthropogenic Amphibians
- ✓ EURIBIONT;
- ✓ Association of Ecotoxicologists of Moldova ECOTOX;
- ✓ Society of Hydrobiologists and Ichthyologists of Moldova Argonaut.

International cooperation in fisheries and aquaculture development and management

The Republic of Moldova has signed a range of international conventions and agreements in the field of environment. These aim both directly and indirectly to protect natural fish resources and their habitats (below). As stated above, the Dniester and Prut Rivers are transboundary rivers, and the Government of the Republic of Moldova has signed some regional agreements (below) that support environment protection in the region and the management of the waters and biological resources of the Dniester and Prut Rivers.

International conventions and agreements

Below are few international conventions and agreements signed by the Government of the Republic of Moldova on environment and fisheries:

- ✓ Convention on Environmental Impact Assessment in a Transboundary Context (Espoo, 1991). Joined by Parliament Decision No. 1546-XII of 23 June 1993.
- ✓ Convention on Access to Information, Public Participation in Decision-making and Access to Justice in Environmental Matters (Aarhus, 1998). Ratified by Parliament Decision No. 346-XIV of 7 April 1999.
- ✓ Convention on the Protection and Use of Transboundary Watercourses and International Lakes (Helsinki, 1992). Joined by Parliament Decision No. 1546- XII of 23 June 1993.
- ✓ Convention on Biological Diversity (Rio de Janeiro, 1992). Ratified by Parliament Decision No. 1546-XII of 23 June 1993.
- ✓ Convention on Cooperation for the Protection and Sustainable Use of the Danube River (Sofia, 1994). Ratified by Parliament Decision No. 323-XIV of 17 March 1999.
- ✓ Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal (Basel, 1989). Joined by Parliament Decision No. 1599-XIII of 10 March 1998.
- ✓ Protocol on Civil Liability for Damage and Compensation for Damage Caused by Transboundary Effects of Industrial Accidents on Transboundary Waters (Kiev, 2003) to the Convention on the Transboundary Effects of Industrial Accidents and to the Convention on the Protection and Use of Transboundary Watercourses and International lakes. Signed on 21 May 2003.

Regional agreements

The regional agreements relating to fisheries and aquaculture are:

- ✓ Agreement between the Government of the Republic of Moldova and the Government of Romania concerning Cooperation on the Protection and Sustainable Use of Prut River and Danube River Waters (Chisinau, 2010).
- ✓ Agreement between the Government of Romania and the Government of the Republic of Moldova with Regard to the Cooperation in the Area of Protection of Fish Resources and the Regulating of Fishing in the Prut River and Stanca-Costesti Artificial Lake (Stanca-Costesti, 2003).
- ✓ Agreement between the Ministry of Waters, Forests and Environmental Protection of Romania, the Ministry of Environment and Territorial Development of the Republic of Moldova, and the Ministry of Environment and Natural Resources of

Ukraine Concerning Cooperation in the Zone of the Danube Delta and Lower River Prut Nature-Protected Areas (Bucharest, 2000).

- ✓ Agreement between the Ministry of Waters, Forests and Environmental Protection of Romania and the Department of Environmental Protection of the Republic of Moldova Concerning Cooperation in Environmental Protection and Sustainable Use of Natural Resources (1997).
- ✓ Memorandum of Understanding on Cooperation in the Field of Sustainable Use and Protection of Dniester River Basin between the State Department of Environmental Protection and Natural Resources of the Republic of Moldova and the Ministry of Environmental Protection and Nuclear Safety of Ukraine (1997).
- ✓ Memorandum of Understanding on Cooperation at River Prut and Danube River between the National Administration Apele Romane and Apele Moldovei (1995).
- ✓ Agreement between the Government of the Republic of Moldova and the Government of Ukraine on Joint Use and Protection of Transboundary Waters (1994).
- ✓ Protocol between the Government of the Republic of Moldova and the Government of Ukraine on cooperation in the field of environmental protection (1993)

Cooperation with the European Union (Member Organization)

The Republic of Moldova has considerable possibilities to cooperate with other countries in economic, social and environmental fields. It also has the potential to develop its fishery and aquaculture sector in the frame of European Neighbourhood and Partnership Instrument (ENPI) of the European Union (Member Organization). The Republic of Moldova was and/or is eligible for the following transnational and crossborder programmes of the European Union (Member Organization):

- ✓ Joint Operational Programme Romania–Ukraine–Republic of Moldova (www. ro-ua-md.net);
- ✓ South East Europe Transnational Cooperation Programme (www.southeasteurope. net);
- ✓ Black Sea Basin Joint Operational Programme (www.blacksea-cbc.net).

In accordance with the Regulation on the monitoring and systematic highlighting of the status of surface waters and groundwater, GD no. 932 of 20.11.2013, the monitoring of surface water quality is performed at national level within the State Hydrometeorological Service (SHS), by the Environmental Quality Monitoring Directorate, which performs systematic monitoring on the pollution status of environmental factors (surface waters). , aquatic alluvium, air, soil, radioactive bottom) on the territory of the Republic of Moldova and provides the state bodies and organizations interested in information on the state of environmental pollution (Annexes 7, 8, 9).

This activity is regulated by a series of normative and legislative acts, among which the most imported can be nominated:

Laws of the Republic of Moldova:

1. Water Law no. 272 of December 23, 2011;

a) Regulation on quality requirements for surface waters, GD no. 890 of November 12, 2013;

b) Regulation on the monitoring and systematic evidence of the state of surface waters and groundwater, GD no. 932 of November 20, 2013;

2. Law on hydrometeorological activity, no. 1536-XIII of February 25, 1998;

3. Law on environmental protection, no. 1515-XII of June 16, 1993;

4. Law on water protection zones and strips, rivers and water basins, no. 440-XIII of April 27, 1995;

5. Law on natural resources, no. 1102-XIII of February 6, 1997;

6. Law on drinking water, no. 272-XIV of February 10, 1999;

7. Law on access to information, no. 982-XIV of May 11, 2000.

Decisions of the Government of the Republic of Moldova:

1. Regarding some measures regarding the regulation of the use of water basins, no. 1202 of November 8, 2001;

2. Regarding the elaboration and approval of the water use and protection schemes in the complex, no. 747 of November 3, 1995;

3. Regarding the measures for establishing the riparian zones and strips for the protection of river waters and water basins, no. 32 of January 16, 2001.

2.8 Short overview on Mediterranean Sea region

The situational analysis of existing institutions, research organizations involved in monitoring strategies/programs is divided in two levels: local scale (Greek TIMMOD partner of the Black Sea), and regional scale (Mediterranean Sea).

A. Greece (Aegean and Ionian Seas):

The main responsible research institution for marine water quality monitoring and modelling is the *Hellenic Centre for Marine Research* (HCMR; https://www.hcmr.gr/en/) is a governmental research organisation operating under the supervision of the General Secretariat for Research and Technology (GSRT) of the Ministry of Education, Research and Religious Affairs. The HCMR comprises three Research Institutes (Figure 2.8-1):

a) the Institute of Marine Biology, Biotechnology and Aquaculture (IMBBC),
b) the Institute of Marine Biological Resources and Inland Waters (IMBRIW), and
c) the Institute of Oceanography (IO).

The overall scientific mission of IO (https://io.hcmr.gr/) is the multidisciplinary study and the long-term monitoring of physical, chemical, biological, and geological processes that govern the structure, functioning and evolution of pelagic and benthic ecosystems including:

- The interaction of the hydrosphere with their physical boundaries, the atmosphere, the coastal zone, the seabed, and the related geodynamic processes and hazards.
- The operational long-term monitoring and forecasting of the marine environment.
- The study of the dynamics of water masses, the climatic variations, the biogeochemical cycles, the food webs, the biodiversity, and their interaction.

HCMR's IO explores the marine and underwater energy resources and geohazards, the anthropogenic impact on the marine environment, and implements integrated coastal zone

management actions. It is active in the fields of operational oceanography and marine renewable energy. It also organizes and manages integrated marine observatories and develops marine technology. Individual activities of IO Research team comprise the production of "useful" knowledge in the context of "blue growth", technology, training, and social information-awareness-education. The major thematic research axes of IO refer to integrated ocean observatories and forecasting systems, marine ecosystems research, health and environmental status, coastal processes, integrated coastal zone management, long-term ocean dynamics and kinematics.

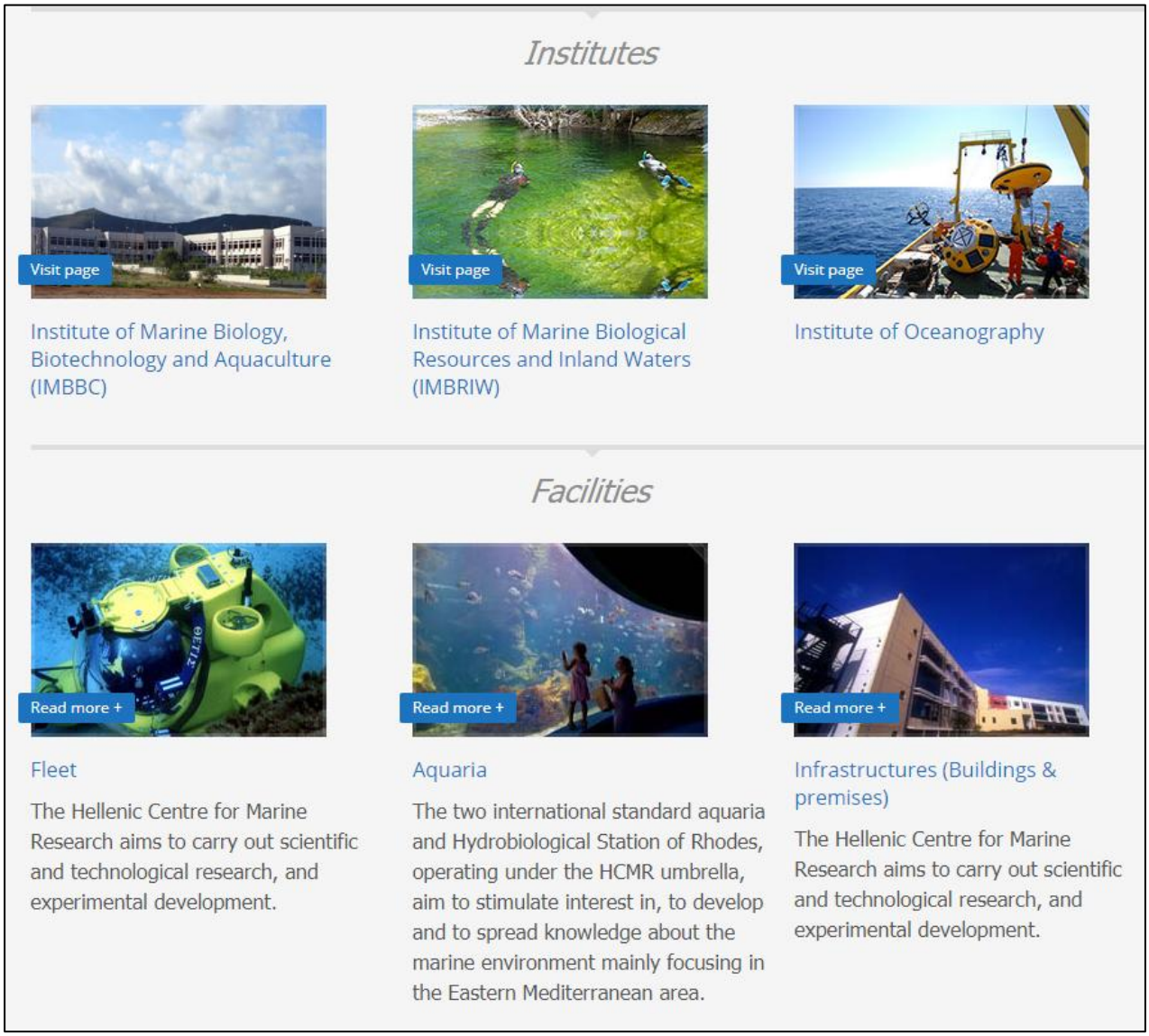


Figure 2.8-1 HCMR's Institutes and facilities, presented online on https://www.hcmr.gr/en/

HCMR's IO has an instrument maintenance and management laboratory in its oceanic physics department that is responsible for hosting, servicing, and managing of all equipment used for field deployments and operations. Their inventory of field equipment consists of (amongst others):

- SeaBird Electronics SBE911plus CTD unit + 24 & 12 Niskin bottles carousels. The CTD unit is fully equipped with pressure, temperature, conductivity, oxygen, fluorescence, and optical sensors.

- SeaBird Electronics SBE19plus portable CTDs
- SeaBird Electronics SBE37 microCATs
- Aanderaa current meters (RCM9, RCM11, Seaguard)
- RDI Workhorse LADCPs and ADCPs
- IXSEA acoustic releasers
- Guildline 8410A salinometer for precise salinity measurements and inter-calibration.
- Marine Environmental Radioactivity Laboratory (MERL) with a HpGe detection system (laboratory broad energy Germanium detector) for measuring radioactivity
- In-situ KATERINA II (low-resolution) autonomous subsea gamma spectrometer for marine applications (like radioprotection, submarine groundwater discharge, submarine volcanos/faults and rainfall studies).
- In-situ GeoMAREA (medium resolution) to support mapping activities and site characterization in areas that potential radioactive leaks may appear.
- 11 Seawatch Buoys + 5 Wavescan Buoys with installed computers (acquiring, storing, and sending data from sensors by telecommunication).
- ARGO Floats.

HCMR's research vessels and underwater vehicles are (Figure 2.8-2):

- The manned submersible THETIS (by COMEX S.A.) with great potential for a wide range of scientific activities.
- The MAX ROVER used in the Aegean Sea reaching depths of 1854m.
- ROV Super Achilles which is a remote operated underwater vehicle with 1000m diving ability.
- ROV Seabotix supporting research in shallow water (about 300 m).
- R/V AEGAEO for scientific operations in the Eastern Mediterranean.

F/R PHILIA operating throughout the Aegean and Ionian Seas.

The monitored parameters include:

- Air Temperature
- Air pressure
- Wind speed and direction
- Precipitation
- Relative humidity
- Current speed and direction
- Wave height and direction
- Sea temperature conductivity
- Dissolved oxygen
- Chlorophyll-a and turbidity
- Solar radiation (0.285-2.8 nm) PYRANOMETRO PSP
- Solar radiation infrared (3.5-50 nm) PYRANOMETRO PIR
- Solar radiation at 7 wavelengths (irradiance)
- Radiation from the sea at 7 wavelengths (radiance)
- PAR (Photosynthetically Active Radiation)

Figure 2.8-2 HCMR's research vessels, ROVs and underwater vehicles

The laboratory infrastructure includes:

- Chemical Laboratories for scientific analyses and services related to:
  - nutrients,
  - organic chemistry and biogeochemistry,
  - trace metals,
  - marine litter,
  - ocean acidification parameters,
  - N, C, P, S,
  - biogeochemical processes
  - dissolved gases: O2, H2S

- greenhouse gasses – CO2, CH4
- Aliphatic and polycyclic aromatic hydrocarbons (PAHs) and petroleum hydrocarbons
- Organochlroninated compounds including polychlorinated biphenyls (PCBs)
- Pesticides and insecticides
- n-alkanes, sterols, aliphatic alcohols, fatty acids
- Methane
- Marine biotoxins
- Phytoplankton pigments
- Aminoacids
- Antibiotics

IO's Chemical Laboratories are certified by the Hellenic Accreditation System SA – ESYD for the methodologies of the analysis of nutrients in seawater, polycyclic aromatic hydrocarbons in seawater and sediments, major elements and trace metals in sediments and soil according to ELOT EN ISO/IEC 17025:2005.

The Biological Oceanography department is separated in four Laboratories for:

- Plankton Ecology
- Benthic Ecology
- Ecotoxicology
- Operational Ecology,

The Geology Department is separated in four Laboratories for:

- Geology and Geophysics
- Sedimentology
- Geochemistry and Mineralogy
- Geotechnics
- Sediment Trap

all incorporating a vast variety of laboratory and field sampling equipment.

From 2016, the Institute of Oceanography and especially the department of Marine Chemistry is operating a fully equipped mobile laboratory (https://io.hcmr.gr/infrastructure/mal/mobile-lab/) aiming at upgrading coastal works and improve the sample collection and analyze basic analytical biotic and abiotic measurements in-situ. The mobile lab has been effectively used in fast response actions such as the recent (September 2017) oil spill accident in the Saronikos Gulf that impacted the coasts of Attica.

The available monitoring strategies/programs in Greece are many, yet mainly refer to what is described here below

The main strategic priority of HCMR is to play a decisive role in the future integrated research issues in the Mediterranean Sea and beyond by participating in major networks, such as the European infrastructure network ESFR Infrastructures:

- LIFEWATCH (https://www.lifewatchgreece.eu/)
- EMSO-ERIC (http://emso.eu/)
- EMBRC (https://www.embrc.eu/),
- EUROARGO-ERIC (https://www.euro-argo.eu/)

HCMR's IO is currently running the Hellenic National Oceanographic Data Centre (HNODC) with an Online Data Access Service which provides an Online Search & Download Service database (http://mapserver.ath.hcmr.gr/) that comprises physical, chemical, and biological parameters in the water column. Through web, one can select and add the data of interest into a basket. If requested datasets are of public domain then one can directly download them in MEDATLAS format, otherwise the requested datasets will be automatically sent to the administrator (Figure 2.8-2).

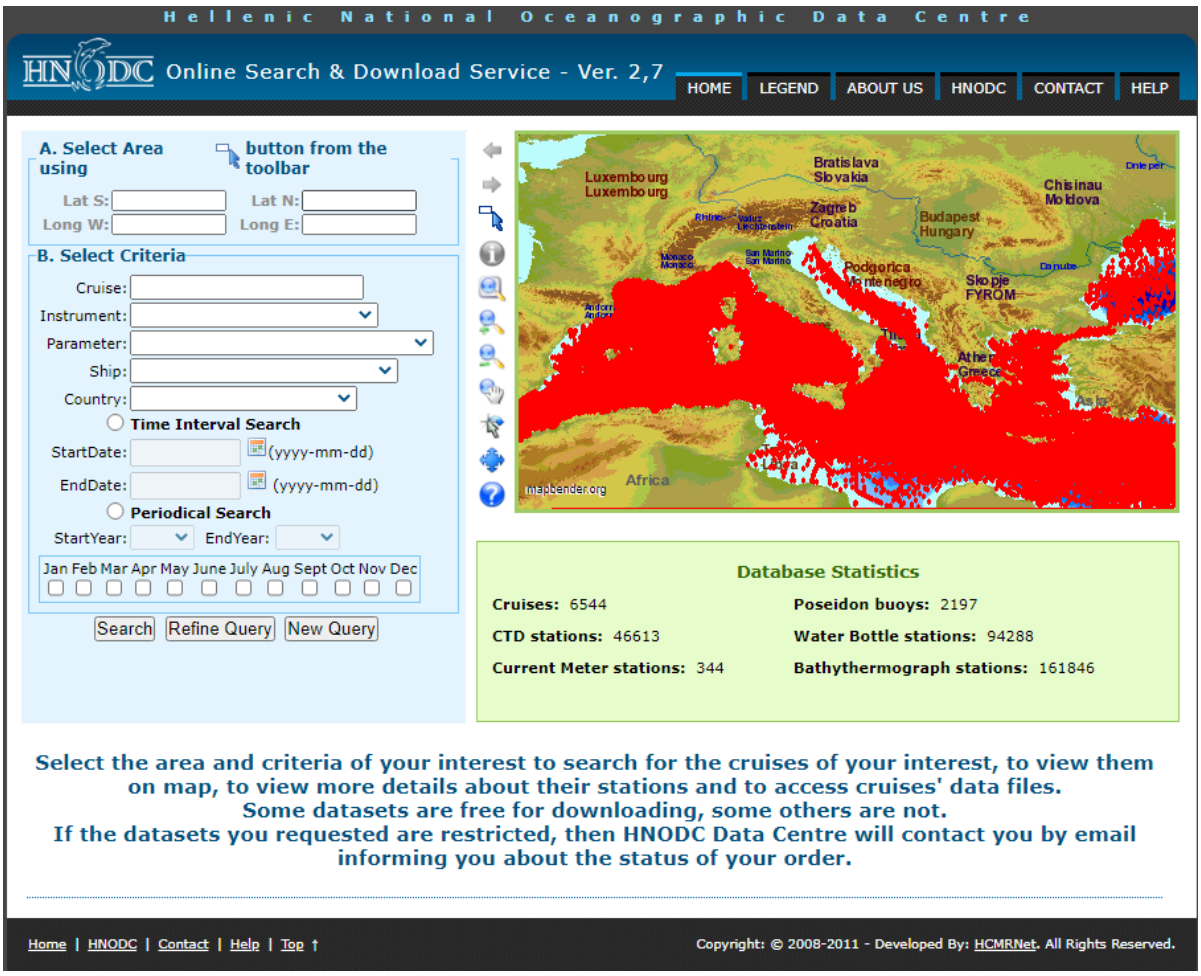


Figure 2.8-3 HCMR – IO – HNODC Online Data Access with Online Search & Download Service database

One of the most significant services of HCMR is the Poseidon System (https://poseidon-new.hcmr.gr/), which is a comprehensive marine monitoring, forecasting and information system for the Hellenic Seas and the only operating European network of its kind in the eastern Mediterranean Sea (http://poseidon.hcmr.gr/). It is composed by:

a) the monitoring system based on a network of oceanographic buoys, a fleet of autonomous profiling floats and a Ferry Box system,

b) the forecasting system based on a suite of numerical models,

c) the operational center for data analysis and processing as well as for the dissemination of the synthetic information to the public.

Poseidon provides important services and contributes among others in the safe shipping, the protection of the marine ecosystem and the improved management of environmental

threads. The system delivers quality-assured information products to end users including policy makers, the maritime economy sector, and users of the sea in general. It is also a major infrastructure that promotes marine research and delivers new knowledge of our seas. The POSEIDON API (https://api.poseidon.hcmr.gr/swagger/) lets one access the data of their database. The data sources come from observational platforms (Figure 2.8-3). Being in operation for over two decades, the POSEIDON system has been evolved from the initial founded buoy network into a multi-node integrated observatory, adjusting to the leading trends of marine science and technology, which can make use of data come from several platforms, providing the capabilities for ocean monitoring on multiple scales, ranging from ocean state to ocean variability.

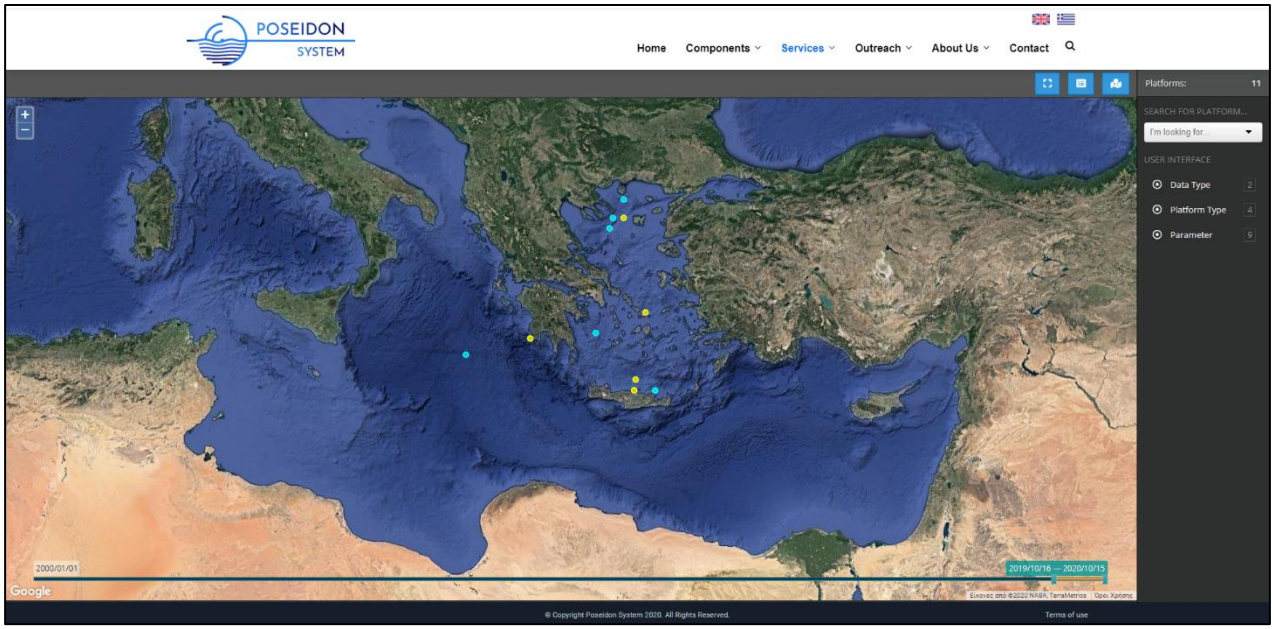


Figure 2.8-4 HCMR's Poseidon System for in situ ocean data

Other research organizations involved in marine water quality monitoring comprise several schools and departments of the Greek Universities operating under many EU and nationally funded research projects. Indicatively within AUTh (TIMMOD PP3) the main players are:

- AUTh School of Civil Engineering, Division of Hydraulics and Environmental Engineering, Laboratory of Maritime Engineering and Maritime Works http://tytp.civil.auth.gr/index.php/features/maritime-engineering-and-maritime-works
- AUTh Biology Department (https://www.auth.gr/en/bio)
- AUTh School of Geology (http://www.geo.auth.gr/)
- AUTh School of Rural and Surveying Engineering (https://www.auth.gr/en/topo)
- AUTh School of Chemistry (https://www.auth.gr/en/chem)

Other agencies include the following:

The Hellenic Navy Hydrographic Service (HNHS; https://www.hnhs.gr/en/) offering several nautical products and services (Figure 2.8-4).

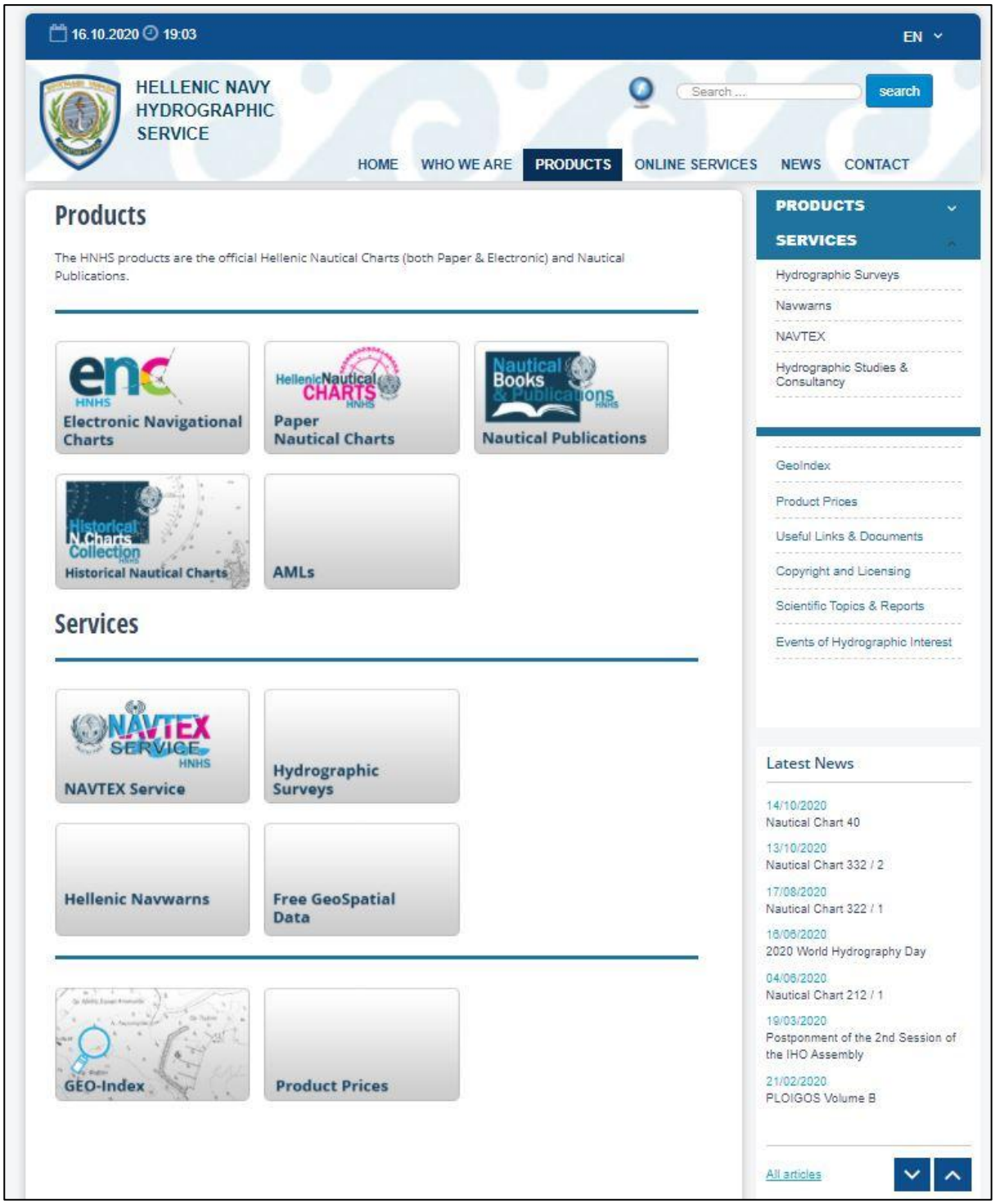


Figure 2.8-5 HNHS nautical products and services

B. Mediterranean Sea:

The **ISPRA** Italian National Tide-gauge Network (https://www.mareografico.it/) has employed many stations within the hydrographic service and national Mareografico (SIMN) hydrographic sector platform in the maritime field. The national tide-gauge network composed 36 measuring stations uniformly put on the Italian territory located inside port areas prevalently. In terms of seawater characteristics only water level and temperature, and sea level pressure are provided. Data are given both in paper and digital form.

The **Mediterranean Operational Network for the Global Ocean Observing System** (MONGOOS; http://www.mongoos.eu/) has been established in 2012 to further develop operational oceanography in the Mediterranean Sea (Figure 2.8-5). MONGOOS is promoting partnerships and capacity building for GOOS (https://www.goosocean.org/) in the Mediterranean Sea (Figure 2.8-6). MONGOOS is creating a continuous working framework with EuroGOOS and GOOS Africa, in order to define common roles and activities in the Mediterranean Sea, and foster collaboration with Black Sea GOOS and global ocean GOOS initiatives.

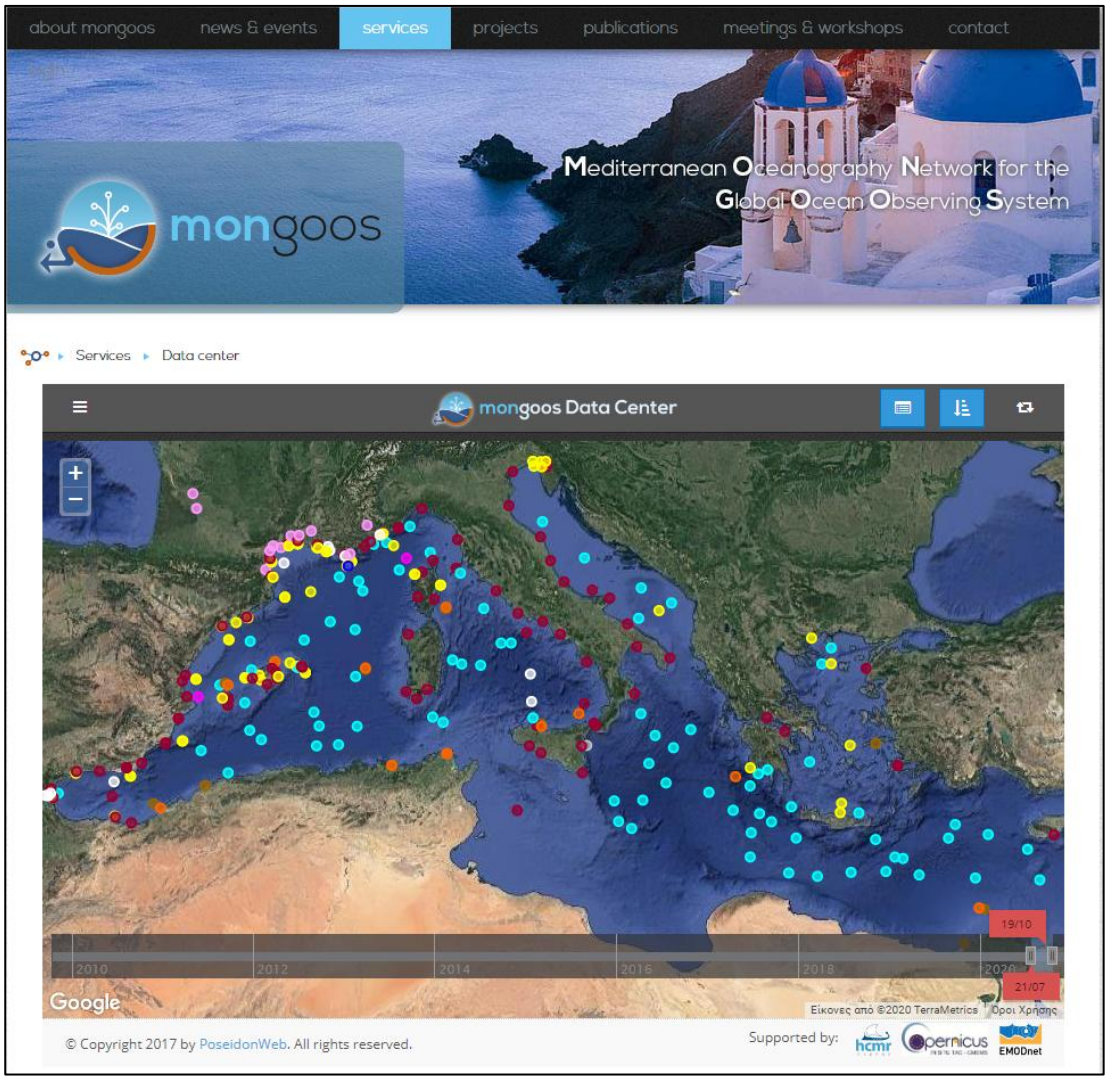


Figure 2.8-6 MONGOOS Data Center GIS platform for products and services of in situ observations in the Mediterranean Sea

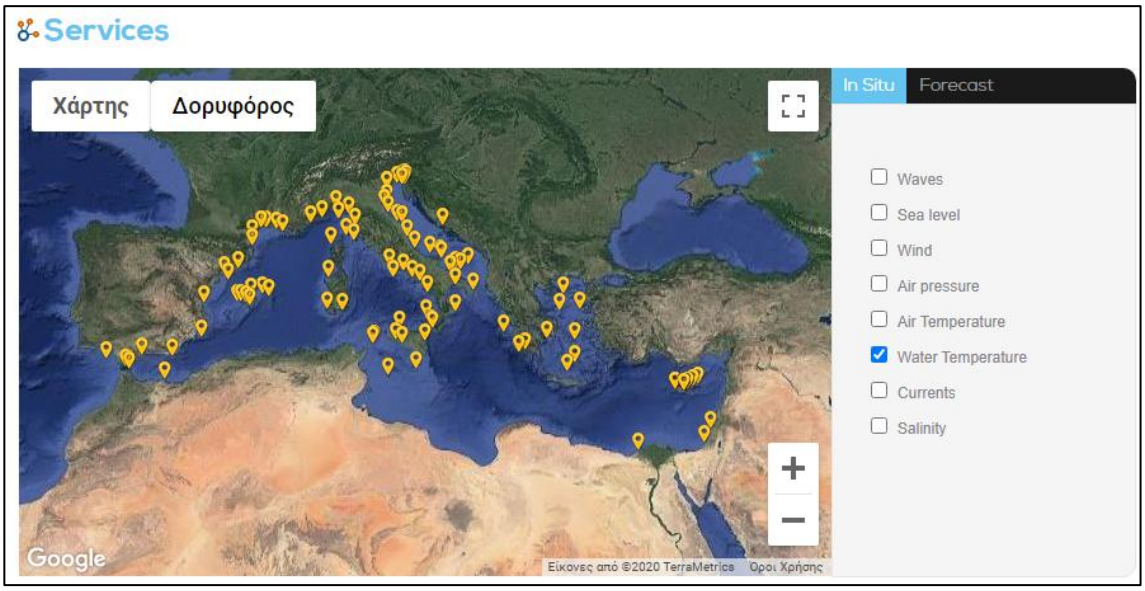


Figure 2.8-7 MONGOOS service of in situ observations (e.g. water temperature) in the Mediterranean Sea

Open Ocean Fixed Oceanographic Stations in the Mediterranean Sea has a service called Operational Oceanography (OO) that can be defined as "the activity of systematic and long-term routine measurements of the seas and oceans and atmosphere, and their rapid interpretation and dissemination" (within the EuroGOOS initiative). OO includes "a routinely collection, interpretation and presentation of data from the ocean and atmosphere with the purpose of giving a reliable description of the actual conditions of the ocean including its living resources, establishing a marine database from which time series and statistical analysis can be obtained for descriptions of trends and changes in the marine environment including consequences for the living conditions in, on and around the sea and providing prognoses for the future developments of the conditions in the sea" (Buch and Dahlin, 2000). In general terms, systematic observation includes remote sensing facilities (satellite, radar, etc.) and local and in-situ attended systems (moorings, ships of opportunity, regular research vessel cruises, etc.), together with autonomous or semiautonomous devices (sea level, buoys, drifters, gliders, profilers).

The term "fixed oceanographic stations" was defined as "oceanographic stations at which observations are taken continuously and periodically for periods of one year or more" (Landis, 2004). They consist in many different types of observations as CTD profiles with additional sensors, water samples at different levels for biogeochemical analysis (for nutrients, contaminants, chlorophyll-a, pH, alkalinity, phytoplankton abundance), plankton-net samples (for biomass and taxonomic composition), neuston net samples (for microplastics). An oceanographic station could also consider benthos samples, velocity profiles, deep moorings, etc. The following map (Figure 2.8-7) shows the known Open Ocean Fixed Oceanographic Stations that are in operation in the Mediterranean Sea.

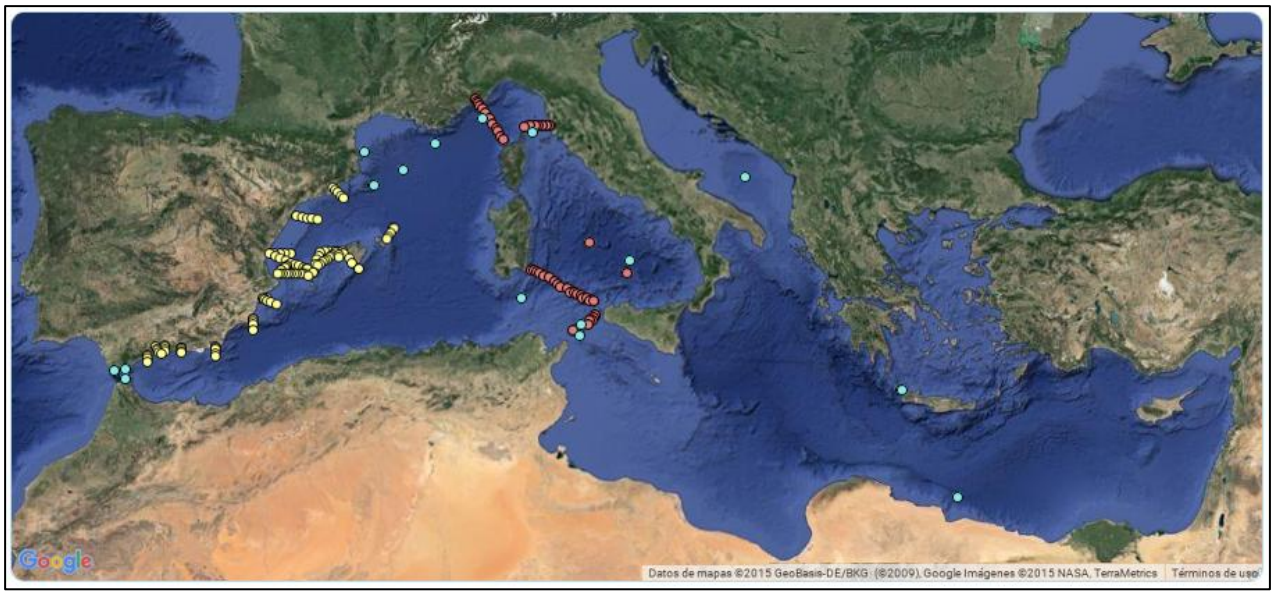


Figure 2.8-8 MONGOOS Data Center GIS platform for products and services of in situ observations in the Mediterranean Sea,

The **MedArgo** (http://nettuno.ogs.trieste.it/sire/medargo/active/index.php) main responsibility is the overall coordination of profiling float operations in the Mediterranean and Black Seas. As such, MedArgo serves as a Delayed Mode Operator (DMO) for the delayed-mode processing of the Argo data with specific QC tailored for the Mediterranean and Black Seas. In addition, MedArgo is a component of the North Atlantic Argo Regional Centre (ARC) and conducts the following activities:

- the coordination of float deployments in the Mediterranean and Black Seas,
- the preparation and distribution of Mediterranean and Black Sea Argo products and services,
- and the comparison of the Mediterranean and Black Sea Argo data with ancillary hydrographic data and model products.

MedArgo is the official Argo Regional Centre (MED-ARC) for the Mediterranean and Black Seas. It is part of the Italian "Gruppo Nazionale di Oceanografia Operativa" (GNOO). Partial support is provided by the EuroArgo, Copernicus and Argo-Italy projects (Figure 2.8-8).

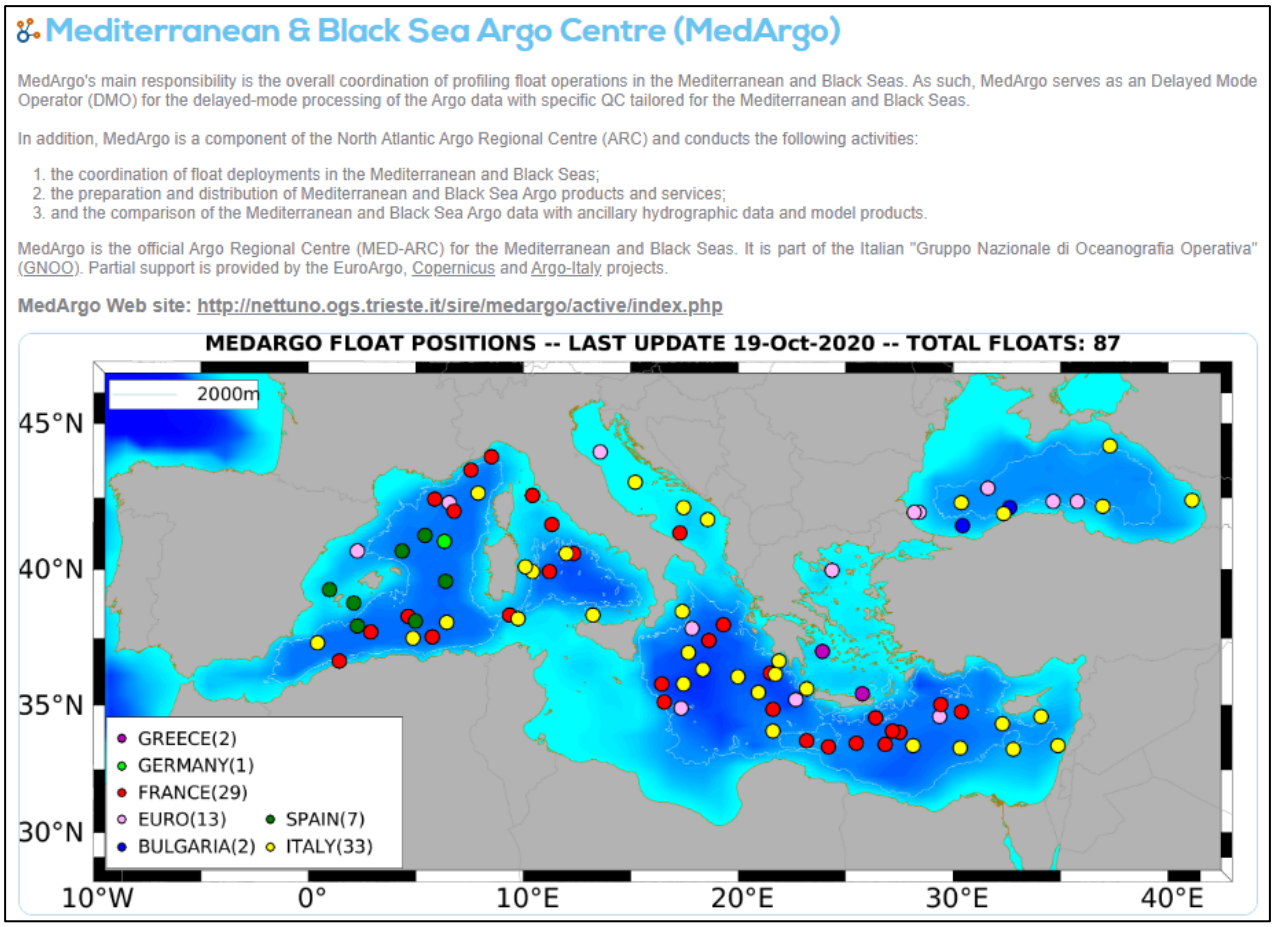


Figure 2.8-9 MedArgo Float online platform within MONGOOS service for in situ Lagrangian observations in the Mediterranean Sea

The **Med Sea Re-analysis** (http://medsearr.bo.ingv.it/) platform provides post-processed oceanographic datasets for the Mediterranean Sea. Ocean synthesis or ocean reanalysis provides a temporally continuous and spatially gridded four-dimensional estimate of the ocean state for better studying and understanding the thermodynamic processes as well as their spatial and temporal variability (Figure 2.8-9).

For the Mediterranean Sea, the products disseminated are the former **MyOcean** NextData Reanalysis (now within Copernicus system):

- 3-D monthly mean fields of Temperature, Salinity, Zonal and Meridional velocity, and
- 2-D monthly mean fields of Sea Surface Hight, Heat, Water and Momentum fluxes, Temperature, Salinity, Zonal and Meridional velocity for the period 1987-2014.

NextData is the nominal dataset of 60 years ocean reanalysis for the Mediterranean Sea, composed by:

- 3-D, daily and monthly mean fields of Temperature, Salinity, Zonal and Meridional Velocity,
- 2-D, daily and monthly means of Sea Surface Height
- 2-D, 6hr snapshot and monthly mean fields of Heat, Water and Momentum fluxes, Temperature, Salinity, Zonal and Meridional velocity for the period 1955-2014.

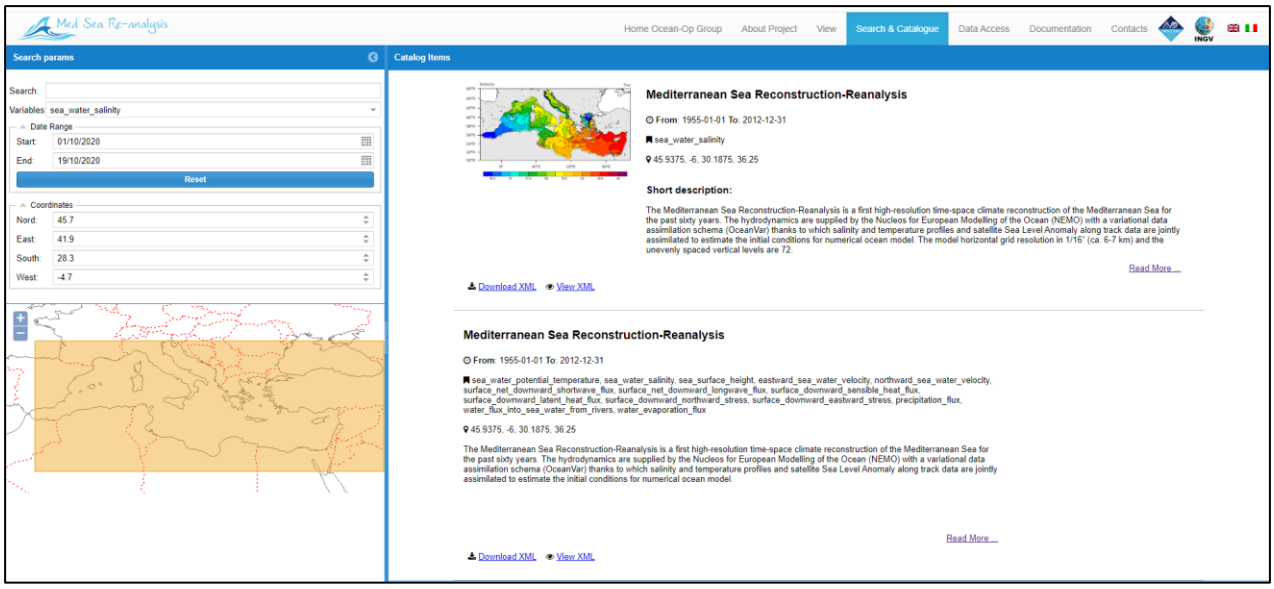


Figure 2.8-10 Mediterranean Sea physics reanalysis datasets provider platform within the Med Sea Re-analysis service

3. INVENTORY ON EQUIPMENT, SENSORS, VESSELS. DATA PLATFORMS, NUMERICAL MODELLING AND GIS TOOLS.

3.1 Bulgaria

An inventory of Equipment, sensors, vessels, data platforms and numerical simulation software is presented here below for the three Bulgarian research organizations providing environmental monitoring and surveys for assessment of marine living resources.

Equipment, sensors, vessels, data platforms and numerical simulation software at IFR-Varna

The main parameters, studied by IFR, include - temperature, salinity, water transparency, nutrients – N- and P-forms, oxygen content, oxydizability; phytoplankton (taxonomy, abundance and wet biomass), chlorophyll-a, meso- and macrozooplankton (taxonomy, abundance and wet biomass), benthos (taxonomy, abundance and wet biomass), planktonic larval fish. Fisheries investigations include fish length, weight, age and sex structure, growth, recruitment, fish stock assessment, catches statistics. Marine mammals – sightings, stranding, pathology, ecology.

For hydrological data, the main sampling devices is CTD (Sea&Sun Technology) and in situ measurements include conductivity, temperature, pressure, pH, oxygen and chlorophyll a concentration. Derived parameters are salinity, depth, density, dissolved oxygen saturation. For **hydrochemistry data** (nutrients content in sea water) the specific equipment includes - Spectrophotometer HITACHI Model U-2001 UV / Vis, analytical scales Precisa XT 220A, etc.

The phytoplankton sampling is performed by Niskin bottles of 1l or 5 l volume at standard depths (0, 5, 10, 25, 50, 100, 150m) or surface-bottom at shallow stations.

Mesozooplankton is collected by two devices - vertical hauls of ring net (opening diameter D=36 cm) and mesh size 150 μ, or by closing "Juday" plankton net (D=36 cm, mesh size 150 μ). The first device is used at shallow regions - Varna Bay, Varna Lake, and the Bourgas Bay, while "Juday" net sampling is used at open sea transects and at standard depths: 5-0, 10-5, 25-10, 50-25, 100-50, 150-100 m.

The macrozooplankton and ichthyoplankton are sampled by "Bongo" net, with opening diameters d=2x0.60m and mesh size of 300 μ and 500 μ. The net is provided with flowmeter to register the volume of filtered water and with depth-meter to identify the maximal depth of sampling. The weight for the net is 20 kg. The sampling is performed by the method of 'oblique tows" at a towing speed of around 2.5 knots (1.25m/sec). The abundance, linear size and bio-volume of different gelatinous species are defined onboard ships. The laboratory operates also with video equipment" Panasonic", 2003, for underwater photography.

Macrozoobenthos - The sampling was carried out by "Van-Veen" grab, with opening mouth 1/10 m and the collected samples were preserved in 4% formaldehyde. The taxonomic identification of species composition, determining the quantitative characteristics was completed in laboratory conditions.

Research on shellfish species - *Rapana venosa*, black mussels, white mussels - analysis of species composition, quantities per unit area, determination of stocks by the method of areas, recommendations for sustainable use of stocks, etc.

Ichthyological data: The important part of data collection programs includes accomplishment of trawl surveys on fishing boats/or research vessels. The trawl surveys allow applying "swept area" method for biomass estimation, population parameters collection, establishment of some important characteristics as catch per unit effort, CPUA, maturity, fish stomach content analysis, establishing MSY and TAC (quota), and estimations on the composition and parameters characterization of "by catch" species. Direct methods for evaluation of fish stock include also application of daily eggs and larvae production method (DEPM) to establish spawning potential, and hydro-acoustical method that provide immediate data about the characteristics of the available for fisheries part of the fish stock. In the Black Sea region, however, these two methods are not widely applied.

Additionally, in order to study fish population parameters, the method of random extracted samples is used – regular collection of samples, which represent a share of the whole population and provide sufficient information for population characterization. Usually, the sample, extracted to study biological parameters of small-sized pelagic species, must have at least 200 individuals. The sampling frequency must be at least one sample per week. Shlyakhov et al. (2006) explained all procedures related to this method: Determinate length frequency: counting, biometry (measurements), gravimeter (weightings), and sampling of otholits for aging, determination of sex and gonads maturation. The characteristics determined by biometry measurements are as follows: plastic characters (length, weight, thickness), and meristic characters (radii, scales, branchial spines). Within these analyses, the following elements important for growth parameter assessments are used: - the structure of length and age classes; the weight of length and age classes; sex ratios. In the fishery studies the most utilized method refers to the measurement of linear dimensions of the fish or its different parts. Among numerous measurements, which can be made, the easiest one is to measure the fish total length. Other parameters, such as weight and age, correlate with the total length, so each of them can be determined by the length data. Measurements for determination the lengths frequency of the fish populations are used for assessment of their population stock. Determination of fish age: The material used for age determination is represented basically by the otholiths. Establishment of gonads maturation degree and weight of gonads. Determination of spawning intensity: Establishment of ichthyoplankton abundance by using of special plankton nets (BONGO net) for sampling and calculations based on areas methods.

Cetaceans Data: *Phocoena phocoena*, bottlenose dolphin (*Tursiops truncatus*), common dolphin (*Delphinus delphis*)

Research on the monitoring and conservation of Cetaceans dates back to 1992, and studies have also been conducted on by-catches of cetaceans. An observation program for the assessment of incidental by-catches of cetaceans was carried out for the first time in Bulgaria in 2010-2011 in accordance with the resolutions, the priority tasks set out in the Work Program of ACCOBAMS (Agreement on the Conservation of Cetaceans of the Black Sea, Mediterranean Sea and Contiguous Atlantic Area), Monaco and the recommendations

of ICES (International Council for the Exploration of the Sea) and EC. It covers the 30-mile zone of the central part of the Bulgarian coast and takes place during the spring and autumn seasons.

The data recorded during the expeditions are: location, geographical coordinates, depths, fishing effort: number and length of inspected nets, net operation in kilometers and hours and number of turbots caught. A chronological record of the monitoring conditions, the speed of the vessel and the behavior of the cetaceans around the fishing vessel shall be kept. All cetaceans entangled in nets are recorded, and dead animals are taken on board whenever possible to be identified, morphological data, length, sex, and externally examined.

Stranded Cetaceans

The network for stranded cetaceans in Bulgaria was established in 1997-1998 and was developed according to the priorities of ACCOBAMS. An analysis of the monthly distribution of stranded dolphins, geographical distribution, species, size, and sex composition was performed. Based on the obtained results, the relevant conclusions for critical habitats, risky fishing activities and seasons are derived, and relevant recommendations are prepared to improve research, to reduce the negative impact of fishing on cetaceans, etc. Practical recommendations for sampling have been prepared. For research and conservation of cetaceans, Methodology in Bulgaria for monitoring of stranded cetaceans.

Bycatch data from scientific observations on the marine fishing fleet

Scientific observers on board of fishing fleet are dispatched on a random principle to fishing vessels using the following gears: (1) gill nets, (2) pelagic trawls, (3) beam trawls for Rapana, (4) polyvalent gears. The sampling design follows the recommendation of FAO, 2019: “Monitoring discards in Mediterranean and Black Sea fisheries: methodology for data collection” and “Monitoring the incidental catch of vulnerable species in Mediterranean and Black Sea fisheries: Methodology for data collection”.

***Rapana* venosa data from ship landings at ports**

Measurements for *Rapana* landings are based on data from beam trawls and scuba diving. Data collected by both geras are analyzed separately and then compered. The main parameters estimated include - Total weight of the target species, landed at a port, number of collected specimens in the biological sample; Total weight shell weight (TW, g); Shell length (Shell length, SL, mm); Shell width (Wd, mm); Aperture shell length (Aperture length, AL, mm).

Data for the available long-term database of IFR-Varna, are presented in Table 3.1.1

Table 3.1.1 Long-term data base of IFR-Varna

Name of the data base	Link	Start of the dataset	Type of data files
Abiotic data set	https://edmed.seadatanet.org/report/1062/	1953	Excel
Biotic data set	https://edmed.seadatanet.org/report/1063/	1953	Excel
Ichthyological data	https://edmed.seadatanet.org/report/1064/	1925	Excel
Marine mammal's data	https://edmed.seadatanet.org/report/5400/	1992	Excel

Specific equipment of IFR-Varna

- CTD "Sea & Sun technology" – measured parameters in situ: conductivity, temperature, pressure, pH, oxygen and chlorophyll concentration, salinity, depth, density, oxygen saturation.
- RDCP 600 – "Doppler flow meter for bottom mounting"
- SEAGUARD RCM – Device for measurement of sea follows – direction and speed
- Spectrophotometer HITACHI Model U-2001 UV / Vis
- Bathometers – Niskin type with volume – 1l and 5 l (Fig.5)
- Bongo plankton net (d = 2X 0.6 m, eye size 300 µm & 500µm) (Fig.5)
- Plankton net (d = 0.36 m, eye size – 150µm)
- Juday Plankton Net (d = 0.36 m, mesh size 150 µm)
- Van-Veen grab (opening = 0.1 m^2) (Fig.5)

Scientific software of IFR-Varna

MIKE 21& Ecolab - MIKE 21 Flexible Mesh develops hydrodynamic models for the currents and velocity fields, based on several input data – bathymetry, boundary conditions, bed resistance, viscosity, wind, temperature, salinity, and wave radiation stress. The ecological module EcoLab allows the MIKE 21 hydrodynamic model to simulate different physical, chemical, and biological processes that occur in water environment.

PRIMER - calculation of biological indices - Shannon, Pielu, frequency of distribution, equalization, AMBI benthos index, M-AMBI benthos index, etc.

XLSTAT - data research, tests, modeling and visualizations, integrated with ECXEL and allows performing parametric and nonparametric tests, modeling (ANOVA, regressions, GLM, mixed models, etc.), methods for forming clusters (Agglomerative Hierarchical Clustering, K -means), classification systems, etc.

Brodgar & R - univariate analysis methods - linear and nonlinear models, multivariate analysis - PCA, CCA, RDA, time series data analysis - ARIMA models, etc.

GRAPHER - a software package for technical graphs, which allows the generation of quality graphs for publishing and presenting scientific data.

SURFER - a grid-based program that interpolates irregular spatial XYZ data, allows the construction of different types of maps - contour, vector, 3D maps, diverse interpretation of data and selection of the most appropriate methods for analysis. Surfer allows determination of areas and volumes, differentiation of polygons and formation of sections by profiles.

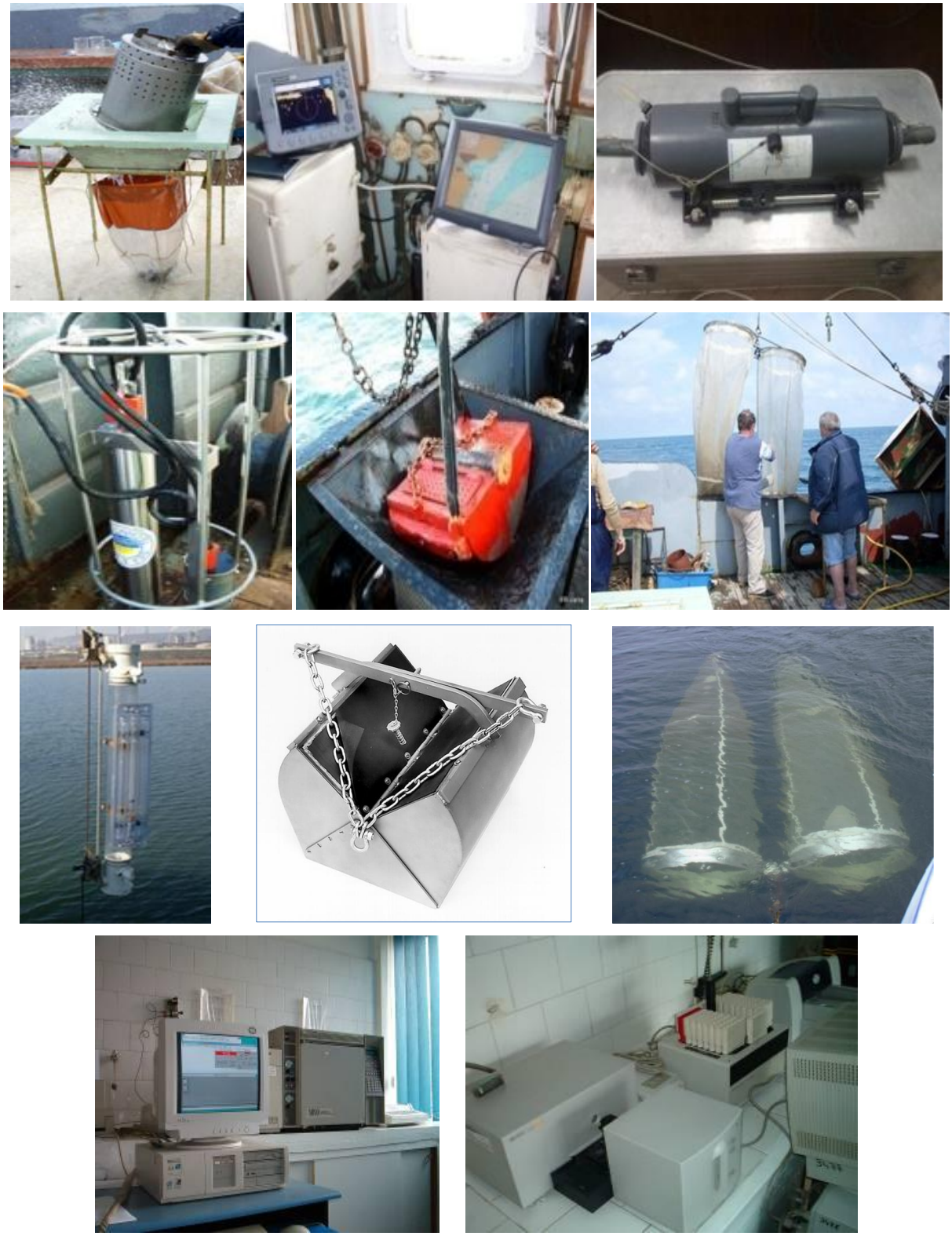


Figure 3.1-1 Field and laboratory equipment for plankton and benthos studies in IFR-Varna

Equipment, sensors, vessels, data platforms and numerical simulation software at IO-BAS, Varna

The main parameters studied in IO-Varna

- Density of the water column
- Electrical conductivity of the water column
- Nitrate concentration parameters in the water column
- Nitrite concentration parameters in the water column
- Nutrients in sea water – N- and P-forms, Si, etc.
- Pesticide concentrations in water bodies
- Dissolved metal concentrations in the water column
- Dissolved oxygen parameters in the water column
- Phosphate concentration parameters in the water column
- Salinity of the water column
- Secchi disk depth
- Temperature of the water column
- Variable fluorescence parameters
- Biodiversity indices
- Chlorophyll pigment concentrations in water bodies
- Concentration of other organic contaminants in the water column
- Concentration of polycyclic aromatic hydrocarbons (PAHs) in the water column
- Macroalgae and seagrass taxonomy-related counts
- Organometallic and organometalloid species concentration parameters in water bodies
- Phytoplankton taxonomic abundance in water bodies
- Phytoplankton taxonomic biomass in water bodies
- Zoobenthos generic abundance
- Zoobenthos non taxonomy-related wet weight biomass per unit area of the bed
- Zoobenthos taxonomic abundance
- Zoobenthos taxonomy-related wet weight biomass per unit area of the bed
- Zooplankton taxonomy-related abundance per unit volume of the water column
- Zooplankton biomass
- Cetacean abundance
- Cetacean mortality

Data bases in IO-Varna

EU-SEASED :
(https://www.bodc.ac.uk/resources/inventories/edmed/results/1843/originated/)

Catalogues: http://eugrant.io-bas.bg:8080/geonetwork/srv/eng/catalog.search?node=srv#/search?resultType=details&from=1&to=20&sortBy=relevance

Research bases and vessels, monitoring systems and equipment

Research base "Shkorpilovtsi" - Research base "Shkorpilovtsi" is located on the coast near the village of Shkorpilovtsi, 50 km south of Varna and belongs to the IO-BAS. The research base consists of a laboratory complex and research pier, with conditions for work and living of 25 persons. The pier is 230 m long, 7m high and is used for mounting of

research gauges for studying wave break, beach dynamics and interaction between the sea and the shore. Several scientific instruments have been recently installed: sea level station, weather station installed at the pier, UV index meter. The base has been used in several national and international coastal experiments.

R/V "Akademik" (owned by BAS, operated by IO-BAS) is a Regional type Oceanographic Research vessel. The main characteristics are Length – 55,5 m, Beam – 9,8 m. Draught – 4,8 m; Displacement: 1125 t, Max. speed: 10,5 knots.

Name	Owner/ Operator	Year built
R/V "Akademik"	Bulgarian Academy of Sciences, operated by IO-BAS	1979

Main features
Length 55,5 m Beam: 9,8 m Draft: 4.8 m Max Speed: 10.5 kn Gross tonnage: 905 GT Crew: 22 Scientific staff: 20 Endurance: 35 days Range: 7500 n mi

Deck equipment § facilities	Scientific Equipment
• Hydraulic A-frame – 2.5 t; Stern A-frame: 7 t; L-frame – 2 t • Crane HIAB 360: 8 t; FOOD CRANE: 1.7t • 1 Wet lab: 9.5 m^2 ; 2 Wet lab: 22.5 ^{m2} • Dry lab: 14 m^2 + 3.2 m^2	• CTD System SBE 911 plus • pressure , temperature, conductivity, • Sampling: SBE 32 carosel - 12 x 5 lt

Figure 3.1-2 Research vessel "Akademik", IO-BAS

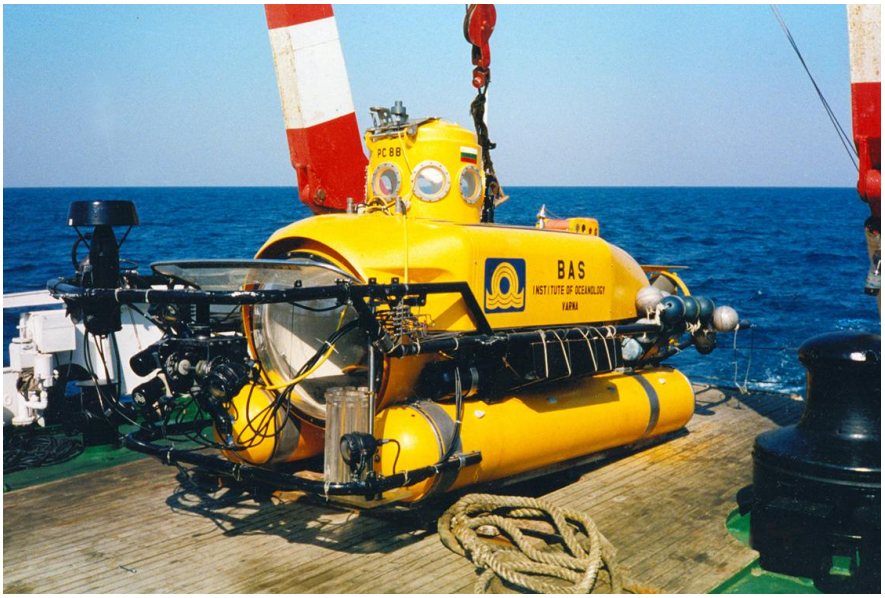


Figure 3.1-3 Research Submersible PC-8B, IO-BAS

BulARGO is developed as a project supported by Bulgarian National Science Fund, Ministry of education, youth, and science. The purpose of the project was to develop a new national marine research infrastructure for in situ observation in Black Sea based on autonomous profiling floats as a Bulgarian component of the Euro Argo network. The main objective of the BulArgo project was to deploy and make operational an array of 4-5 floats during the 3 years of project execution. The Bulgarian contribution to the establishment of the future Black Sea Argo system consist now of 4 drifting buoys deployed during the project implementation: 3 floats in year 2011 and one float in 2013. It is planned to deploy two ARGO floats during 2019, one of them with Dissolved oxygen sensor.

Sea Level Monitoring System - Systematic sea level measurements have been started in Bulgaria in the beginning of 20th century and nowadays there are 16 coastal sea level stations in operation. Operators of sea level stations are: National Institute of Meteorology and Hydrology (NIMH) – 6 stations, Geodesy, Cartography and Cadastre Agency (CA) – 4 stations and Institute of Oceanology, Bulgarian Academy of Sciences (IO-BAS) – 6 station. Six of them are able to provide real time data. The sea level observations in the network of NIMH, performed at six main Bulgarian ports using standard poles, started in 1910. The program, implemented on the NIMH stations, includes daily measurements of the sea level with water gauges (poles). The position of a zero mark of the water gauge is checked once per year. The sea level network of the CA consists of 4 stations: Varna and Burgas (operational since 1928), Irakly and Ahtopol (since 1971). These stations ware equipped with stilling-well tide gauges and with mechanical writing devices which draws sea level changes on paper.

Moorings network - Moored buoys that provide long time series are one of the most important sources of marine data. The national network of moored buoys includes two of them, one located in the Bay of Varna and the other in the Bay of Burgas, which measure and provide in real time the parameters of the marine environment and the surrounding atmosphere such as: wind velocity and direction, air temperature, atmospheric pressure , relative humidity, height and period of sea waves, sea water temperature and salinity, oxygen concentration, chlorophyll concentration, color dissolved organic matter and turbidity. Data obtained from moored buoys are used to assess the status of the marine environment, analyze climate change, model assimilation and forecast verification.

Equipment, sensors, vessels, data platforms and numerical simulation software at IBER, Sofia

Main research parameters studied at IBER-Sofia

- Nutrients (NH4+, NO3-, NO2-, N tot, PO43+)
- Chlorophyll a
- Suspended matter
- Primary production
- Transparency
- Temperature
- Salinity
- Dry Biomass of Chlorophyta, Rhodophyta, Phaeophyta
- Wet biomass of Chlorophyta, Rhodophyta, Phaeophyta
- Horizontal projected cover of Chlorophyta, Rhodophyta, Phaeophyta

- Surface to Weight index of Chlorophyta, Rhodophyta, Phaeophyta
- Ecological Evaluation Index of Chlorophyta, Rhodophyta, Phaeophyta
- Ecological Evaluation Index – Continuous

Scientific collections of IBER-Sofia http://www.iber.bas.bg/?q=en/node/737

- Mycological Collection (SOMF)
- Paleobotanical Collection
- Herbarium SOM
- Palynological Collection
- Ex situ Collection of Living Plants
- Protozoological Collection
- Helminthological Collection
- Nematological Collection
- Malacological Collection
- Millipede Collection
- Entomological and Arachnological Collections
- Fossil Mammals Collection
- Recent Mammals Collection

Marine research equipment by private companies:
In situ measurements and marine research in coastal zone in Bulgaria has been carried also by some private companies (e.g. Hydroremont A/G, CORES ltd, Sea Harmony ltd, and other). Here below an example is presented for an Unmanned Surface Vehicle used for hydrographic survey and water quality parameters measurements owned by CORES ltd, associated member of The European Marine Observation and Data Network (EMODned, www.EMODned.eu).

Name	Owner/ Operator	Year built
USV-CORES A1	Coastal Research and Engineering Center CORES Ltd.	2013

Unmanned Surface Vehicle – Floating Monitoring Station	**Main features**
	Length: 1.9 m Beam: 1.35 m Height: 1.2 m Max. Draft: 0.6 m Displacement: 150 kg (max) Speed: Max 6 kn; operating 3-4 kn Unmanned – direct control mode Range/Communications: UHF up to 2000 m Endurance: autonomous, with solar charged batteries

Facilities & Scientific Equipment	
A set of measuring sensors and equipment for river and coastal waters survey:	
• Remote control, GPS navigation system • Bottom sonar (echo-sounder) • Water sampler (up to 3 bottles x 1 lt)	• Turbidity measurements (OBS) • Water Temperature • On-board and underwater cameras

Figure 3.1-4 Unmanned Surface Vehicle (marine drone) operated by CORES, Bulgaria

3.2 Romania

Here below inventory on vessels, equipment, sensors, data platforms, used at Romanian marine research organisations is presented.

Galati Lower Danube River Administration (AFDJ)

All systems measure at certain time intervals the water level and temperature and send the data via GPRS or where is the case satellite modem to a central software installed on a server.

The data are analyzed and processed using the software, are stored, and can be viewed on graphs or tables.

The monitoring equipment is to improve hydrological services for sound decision management while creating important synergies between the waterway administrations.

- 4 surveying vessels (bathymetric measurements);
- 12 systems for monitoring the water level and temperature with GPRS communication, type Watermanager STS, installed at Turnu Severin, Orsova, Bazias, Moldova Veche, Drencova, Calarasi, Harsova, Cernavoda, Galati, Braila, Isaccea, Tulcea;
- 10 systems for monitoring the water level (dual sensors systems) and temperature with GPRS and satellite communication, type DTM.OCS/S and Amazon Bubbler 300, installed at Harsova, Capidava, Cernavoda, Rasova, Izvoarele, Corabia, Bechet, Rast, Gura Jiului, Gradistea.

National Institute of Hydrology and Water Management (INHGA)

The National Institute of Hydrology and Water Management has following equipment such as:

- 633 automatic hydrometrical stations (water level, air and water temperature and precipitation sensors)
- 247 supplemental rain gauge automatic stations;
- 70 hydrometrical stations with water quality sensors (dissolved oxygen, conductivity, pH, turbidity, etc)

National Administration „Romanian Waters" (NARW)

- 51 automated stations with sensors for monitoring water quality; (WATMAN project)
- A laboratory vessel with equipment for quantitative and qualitative measurements of water,
- sensors to monitor and drilling, equipment for gauging stations and laboratory equipment for the common area of the Danube (Romania-Bulgaria)

Figure 3.2-1 The laboratory vessel with equipment operated by NARW

Figure 3.2-2 Monitoring equipment used by NARW

N. A. "Romanian Waters" have automatic stations with sensors for measuring the snow layer and hydrometric stations for tributary flows prevention/mitigation of floods through controlled management of water during floods. These sensor stations are (Danube WATER project):

- 14 stations for measuring solid and liquid precipitation;
- 9 hydrometric stations on tributaries;
- 21 Equipment for measuring important catchments (for a catchment coefficient higher than 0.2);
- 12 stations for measuring the discharge level in case of deviations of watercourses;
- 17 dams category A and B monitored for structural safety parameters in an automated system, provided with anti-theft monitoring system;
- 3 category C dams monitored for structural safety parameters in an automated system.

Danube Delta Biosphere Reserve Authority (DDBRA)

- one RiverSurveyor S5/M9 - measurements of open channel hydraulics - with Acoustic Doppler Current Profiler sensor.

Figure 3.2-3 Monitoring equipment used by DDBRA

Danube Delta Institute for Research and Development (INCDDD)

The DDNI equipment and sensors for monitoring hydrological and environmental factors

- One high-quality multisensor EXO 2 Sonde with operating: Temperature, pH, Dissolved Oxygen, Conductivity and Total Algae (Chlorophyll+Blue-Green Algae);

Figure 3.2-4 Multisensor EXO 2 Sonde used by DDNI

Fish resources estimation from Danube delta

The Danube Delta National Institute (INCDD) assists the ARBDD in developing policies for the sustainable management of stocks through a research programme to assess maximum sustainable yield and corresponding fishing effort. The programme uses fish stock assessment models. Analytical models (Virtual Population Analysis), production models (Schaefer±Fox) and yield per recruit (Y/R) models have been applied.

The DDNI owned 2 slowly (Antipa and Merisor) and 3 speedy (Glastron, Deltaica and Marina) river & lake vessels that are used for survey of freshwater ihtiofauna and commercial catches from landings points. For ichthyofauna sampling is used outboard small aluminium boats (type John 1648 and Linder) and fibreglass fisherman boats. Main gear used for freshwater fish sampling are Nordic gillnets, research seines, ichthyoplankton bongo nets and electric fishing (Samus and Deka 7000). The samples are standardised at Catch per Unit Effort (CPUE) and recorded in Excel database.

Figure 3.2-5 Research vessel "Marina" operated by DDNI

Main data recorded are data, GPS coordinates, water physical parameters, fish species, length-weight and it is collected scales for age estimation.

The following ecological parameters are calculated: Constance, Dominance, Ecological significance, and Shannon-Wiener diversity index.

The biodiversity parameters are analysed for ichthyofauna conservation status estimation.

For fisheries the Maximum Sustainable Yields (MSY) are estimated for fish stocks management. A suite of models is used for fish stock estimation, mainly VPA, based on length frequency, von Bertalanffy growth education parameters, fishing and natural mortalities parameters, and Thomson-Bell prediction model.

National Institute for Marine Research and Development "Grigore Antipa" (INCDM)

Fish resources estimation from Black sea

The INCDM is national scientific responsibilities for fisheries data collection and marine living resources stock assessment. For this task annually is surveyed catch fisheries from industrial fishing and complementary is performing sampling of fish by trawling. A marine vessel trawler type (Steaua de Mare 1) it is used for trawling survey.

Figure 3.2-6 Research marine trawler vessel "Steaua de Mare 1"
(25 m length, 570 HP, 134 tons, 12 m² Drylab)

The method of fishing surfaces / swept area is a method of primary estimation of marine fish biomass. The method involves fishing an area known with a trawl. Another method is estimation of spawning biomass (Sette and Ahlström) that is based on ichthyoplankton net (Bongo net) survey of fish eggs. From eggs samples are calculated/estimates spawner biomass.

Hydroacoustic laboratory

The Hydroacoustics Laboratory gives support to R&D projects and performs the acoustic characterization of the marine environment.

The main objectives are: 1) seawater sound velocity and underwater noise measurements from natural and anthropogenic sources; 2) interdisciplinary research and applications in the marine environment acoustics – seawater sounds propagation, noise perception and effects on the marine ecosystem; 3) Thematic maps and charts on underwater noise: minimum, average and maximum noise levels in the western Black Sea to define the value of good environmental status and environmental objectives as required by the Marine Strategy Framework Directive (2008/56 / EC) Descriptor 11: Energy incl. Underwater Noise "Introduction of energy, including underwater noise, is at levels that do not adversely affect the marine environment".

Equipments

<u>Hydrophones for Monitoring system for vibro-acoustic parameters</u>

Bruel&Kjaer Monitoring system for vibro-acoustic parameters caused by anthropogenic factors in marine environment propagation: - 4-ch Input Module LAN-XI 52 kHz (Mic, CCLD, V); - LAN-XI Front panel, Charge input, detachable, 6 ch. Gain: 1mV/pC; HPF: 0.1Hz - 6 x TNC(F); - Battery Module for LAN-XI, including ZG-0469 mains charger and ZH-0686 adaptor; - LAN-XI Stand Alone Recorder, Single Module

(https://www.bksv.com/en/products/data-acquisition-systems-and-hardware/LAN-XI-data-acquisition-hardware/modules/type-3050)

SWiFT - SVP

Sound Velocity Profiler SWiFT SVP (Sound Velocity /Temperature/ Pressure/ Salinity /Conductivity /Density)

(http://www.valeport.co.uk/Products/Sound-Velocity/Sound-Velocity-Details/ProductID/47)

GoPro Hero 5 Black Edition

The Hero 5 features a 2-inch touchscreen and a waterproof housing up to a depth of 10 meters. The camera shoots at a 4K quality with 30 frames per second, and the photos are shot at a resolution of 12 megapixels. The maximum video resolution of 3840 x 2160. An advanced background noise cancellation is also present, the incorporation of three microphones cameras surface. The Hero5 is also equipped with a GPS sensor and allows you to shoot in RAW format. The camera can be triggered by voice commands

Multiparameter HI98194

Multiparameter HI98194 pH/ORP/EC/TDS/Salinity/DO/Pressure/ Temperature Waterproof Meter 40m cable length Scope: monitoring the physical and chemical sea water characteristics during the underwater noise measurements The HI98194 is a rugged, waterproof multiparameter meter that monitors up to 12 different key water quality parameters. A backlit, graphic LCD provides easy to read resolution even in low-lit areas and a combination of dedicated and soft keys allows easy operation. The powerful logging capability and digital probe make this multiparameter meter a great tool. CAL Check™ electrode diagnostics system alerts you to potential calibration problems so that you know your results are trustworthy every time. The HI98194 meter, probe, and all accessories are supplied in a rugged carrying case designed to provide years of use. The inside compartment of the carrying case is thermoformed to securely hold and protect all of the components.

COSMOMAR

Constanta Space Technologies Competence Centre Dedicated to the Romanian Marine and Coastal Regions Sustainable Development National Institute for Marine Research and Development "Grigore Antipa" The main component of COSMOMAR is to develop a multidisciplinary remote sensing center for the coastal surveillance as a main tool of ICZM implementation (governance, environmental conservation and protection) on the Romanian coastal zone.

Equipments

Singlebeam Hydrographic Echosounder

Odom Hydrographic provides an extensive range of hydrographic level single beam echo sounders with the flexibility of frequency agility supporting existing transducer installations. Models include modern PC screen-based interfaces as well as support for tried and tested thermal record printing. Maximum depth range varies based on a number of factors including maximum transmit power, water conditions and vessel installation.

Teledyne RDI ADCP Workhorse Sentinel 600Teledyne RDI ADCP Workhorse Sentinel 600

An Acoustic Doppler Current Profiler (ADCP or ADP) is a sonar that attempts to produce a record of water current velocities for a range of depths. They are made of ceramic materials, and contain transducers, an amplifier, a receiver, a mixer, an oscillator, a clock, a temperature sensor, a compass, a pitch and roll sensor, and computer components to save the information collected. ADCPs can be configured in many ways: side-listening, into rivers and canals for long term continuous discharge measurements, downward-listening and mounted on boats for instantaneous surveys in the ocean or rivers, and mounted on moorings, or the seabed for long term current & wave studies. They can stay underwater for years at a time, and have a battery back for an energy source. The sonar is used for oceanography, estuary, river and stream flow measurement, and weather forecasting.

Workhorse Monitor ADCP 1200

The Monitor is Teledyne RD Instruments' most popular direct-reading Acoustic Doppler Current Profiler. The unit is typically bottom frame-mounted and hard-wired to shore to provide real-time monitoring of coastal currents. The Monitor's high data accuracy and reliability make it a favorite for deployments in high-volume traffic areas such as ports and harbors, where the data is often integrated into a Vessel Traffic Monitoring System.

ECM Valeport 880 Current meter

ECM Valeport 880 provide real time relative water velocity information. The electromagnetic sensors use the Faraday Principle to measure the water speed. As a conductor (water) moves through an electromagnetic field (generated by the sensor), it generates a voltage that is measured by the sensor electrodes. Modern day signal conditioning electronics and filtering techniques allow highly accurate measurements to be made, and there is a choice of sensor shapes and sizes to suit the application. The solid state sensors and standard titanium/ polyurethane construction provide excellent corrosion resistance, and depth ratings up to 5000m

Hemisphere GPS S320 GNSS Survey Rec

The S320 is Hemisphere's multi-GNSS, multi-frequency, smart antenna, quality survey product for GIS, construction, mapping, and land or marine surveying. The S320 provides performance and high precision in a compact and rugged package. With multiple wireless communications ports and an open GNSS interface, the S320 can be used in a variety of operating modes. Use the S320 as a precise base station sending RTK to an existing rover network. The built-in web user interface can be used to control and manage the receiver status and operation.

GPS Trimble GeoXH 2005 Series

The GeoXH ™ Handheld is a high precision GIS data collection tool. The GeoXH Handheld delivers the 30 cm precision required for scientific research and other areas such as electrical and gas utilities, water and sanitation, agrarian reform projects and other applications where site positioning is crucial.

GPS Trimble GeoXH 6000 Series

GeoXH™ handheld delivers real-time decimeter (10 cm / 4 inch) accuracy positioning, high quality photo capture, and integrated Internet connectivity options. Together with the latest field software enhancements and GNSS innovations including Trimble Floodlight™

satellite shadow reduction technology the GeoXH handheld establishes a new standard for GNSS system performance and handheld data capture

Turbidimeter OBS-3A Campbell

The OBS-3A combines OBS probe with pressure, temperature, and conductivity sensors in a battery-powered recording instrument. Batteries and electronics are contained in a housing capable of operating at depths of up to 300 meters—depending on the pressure sensor installed. (OBS® is a registered trademark of Campbell Scientific.) The heart of the OBS-3A monitoring system is an OBS sensor for measuring turbidity and suspended solids concentrations. This sensor detects near infrared (NIR) radiation scattered from suspended particles. A fast-response, stainless steel-clad thermistor monitors temperature. Pressure is measured with a semiconductor piezoresistive strain gage, and conductivity is measured with a four-electrode conduction-type cell. Working depths of the pressure sensor are selected as an option. The monitor uses HydroSci software running under Windows XP, 7, and 8.

STS-VIS Modular Spectrometer

High performance spectrometers ideal for embedding into OEM devices. The STS models are attractive option for applications such as LED characterization, absorbance, and transmission measurements. Life sciences, materials identification, environmental monitoring, quality control and process monitoring are among some of the applications where the STS has played its role of a powerful performer in a small footprint. The STS delivers optical resolution, sensitivity and stability associated with larger, more expensive spectrometers.

OpenROV v2.8 - Underwater Robot

OpenROV is an open source robotic submarine designed to make underwater exploration possible for everyone.

MetPak Weather Station

The MetPak Weather Station is a professional weather station with Integrated WindSonic ultrasonic wind sensor for high accuracy wind speed and direction measurement. It is capable of monitoring barometric pressure, air temperature, humidity, and dew point. The unit features an on-board high accuracy barometric pressure sensor and a Rotronic Hygroclip HC2-S3 temperature/humidity probe housed in a naturally aspirated radiation shield.

Sky Hero Spyder X8 ARF

Sky Hero is the representative of new copters. It works & flies with all the gear: flight controller, power supply, telemetry, video camera and TX, gimbal. Sky Hero is suitable for any application from classical topographic measurements to military applications, security and monitoring, environmental protection.

Aquacopter - Bullfrog

Ready-to-Fly (RTF) is a complete kit built, tuned, and test flown for functionality. The standard configuration comes in white with a Naza-M V2 w/GPS flight controller, waterproof equalization vent, balance charger, and (2) 4000 mAh batteries with parallel adapter (to run both batteries at the same time). In addition, the Bullfrog incorporates an external power plug for easy power-up's and (2) rear orientation lights which are

extremely bright and can been see day or night. Optional upgrades are listed below, please select the options you desire to see the configured price.

9320 C-Series | Analog Thermal Infrared Camera

The ICI 9320 P-Series Infrared Camera is an real time temperature measurement tool for many applications including: surveillance, maritime, long distance, firefighting (on aircraft), research & development, military, space, medical, petrochemical, electrical, and process control and monitoring. The 9320 C-Series not only integrates into the Sensor Control Module for UAV applications but also it can be mounted to a number of available ICI enclosures which meet NEMA 4 – NEMA 9 specifications; these housings provide protection from harsh weather environments.

The National Institute for Research and Development on Marine Geology and Geo-ecology – Geo-Eco-Mar

The Geo-Eco-Mar owned 3 research vessels, one for marine/oceanographic research (Mare Nigrum) used in Black Sea, one for Danube river research (Istros) and one for the Danube delta waters (Halmiris).

Figure 3.2-7 Research oceanographic vessel "Mare Nigrum"

Technical characteristics:

- Length: 82 m;
- Draught: 5 m;
- Displacement: 3200 t;
- Main propulsion: 2 SKL 8 NVD 48A- 2U from 1160 HP each;
- Main power: 2x320 kVA, 1x350 kVA, 1x50 kVA;
- Telecommunications: NERA Fleet 55 satellite communication; Inmarsat C - GMDSS by VHF radiotelephone FM 8500 and facsimile Furuno D Fax;
- Navigation systems - Kelvin Hughes 5000 t 6000 A and Nucleus 5000 radar-two units; gyrocompass Vega 2 M; log Furuno DS70; echosounder LAZ50 ; Ninas integrated navigation system.

Laboratories:

- Tomography;
- Hydrology;

Gase mesurements;

- Biology;
- Geochemistry;
- Geophysics;
- Computer room;
- Seismo - acoustics;
- Photo;
- Wet lab.

Personal onboard:

- Crew: 25 persons;
- Scientists: 25 persons;

Marine equipments:

- Multibeam bathymetric system SEABEAM 1050 Elak Nautik;
- Seism - acoustics CHIRP Star Full Spectrum;
- Magnetometer Geometrics G-87;
- On-board (GMNKM) and bottom (GDK) gravimeters;
- ROV (1000 m water deep);
- Sub-bottom profiler;
- Side Scan sonar.

Geochemical, Geoecological and Sedimentological equipments:

- CTD SBE 25 Sealogger ;
- Gravity and piston corers;
- Multi-corer Mark II-400;
- Grab samplers;
- Nets for biology;

Deck equipments:

- Hydraulically Winch 10 tf;
- Electrical Winch 8 tf;
- CTD Winch;
- ROV winch;
- Grab sampler winch;
- Crane 3 tf/15 m;
- A – Frame on aft ship.

Figure 3.2-8 Research river vessel "Istros"

Technical characteristics:

- Length: 32 m;
- Breadth: 6,90 m;
- Draught: 1,25 m;
- Displacement: 175 t;
- Main propulsion: 2 engine with 420 HP each;
- Main power: 2x35 kVA;

Laboratory:

- Geochemistry;
- Geophysics;
- Multifunction lab;

Personal onboard:

- Crew: 7 persons;
- Scientists: 10 persons;

Marine equipments:

- Multibeam bathymetric system SEABEAM 1050 Elak Nautik;
- DGPS Sea Star 3200 LR 12;
- Magnetometer Geometrics G-877;
- On-board (GMNKM) and bottom (GDK) gravimeters;

Geochemical, Geoecological and Sedimentological equipments:

- Gravity and piston corers;
- Grabs samplers;

Deck equipments:

- A-Frame on aft ship;
- Side crane;
- Hydrological winches;
- 2 hand cranes;

Figure 3.2-9 Research river laboratory ponton "Halmiris"

Technical characteristics:

- Length: 32 m;
- Breadth: 6,60 m;

- Draught: 0,60 m;
- Displacement: 90 t;

Laboratory:

- Geochemistry;
- Biology;

Facilities:

- Electrical power generator;
- Air condition installation;

Other facilities:

- 14 cabins (single and doubles);
- Conference room (30 – 40 persons)
- Boats.

National Agency for Fishing and Aquaculture (ANPA)

The ANPA is national responsibilities for fisheries data collection, marine living resources stock assessment and reporting to European Commission (EC). In this respect, ANPA coordinates and funds an annual programme for fisheries collection data by a multiannual auction contract with research entities. The ANPA reports annually on the implementation of their National Programmes for Romania and the Scientific, Technical and Economic Committee for Fisheries (STECF) evaluates these Annual Reports. Part of the data collected is uploaded in databases managed by the Joint Research Center (JRC) in response to data calls issued by DG MARE. JRC is assembling the data, storing it in databases, analysing its quality and coverage and making it available to the STECF working groups. This data is analysed by experts of the STECF and forms the basis for scientific opinions and recommendations formulated in STECF reports. The resulting scientific advice is used to inform the CFP decision making process.

3.3 Georgia

Main organisation authorised to perform marine research is LEPL National Environmental Agency (NEA). NEA does not possess a dedicated research vessel. Instead, a fishing seiner is regularly rented, as follows:

Vessel Characteristics

Vessel Name: BESHUMI

LOA (m): 20m

ID Code (Marine code): 445404250

Figure 3.3-1 Photo of the fishing seiner "BESHUMI"

BioSonics scientific echosounders is suitable for a wide range of fisheries and oceanographic assessment applications including fish stock assessment.

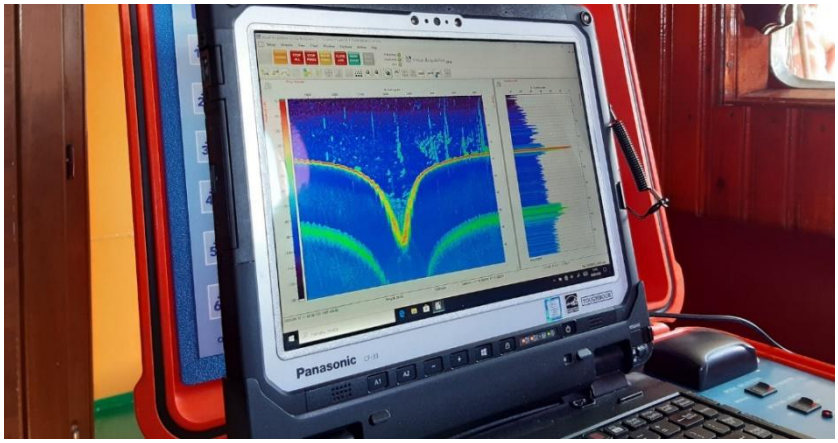


Figure 3.3-2 BioSonics scientific echosounder used by NEA

EXO Multiparameter Sonde is an extremely versatile instrument, allowing the user to automatically configure a sonde with different sensors for different applications in minutes: *Conductivity/Temperature; Dissolved Oxygen; fDOM; ISEs (Ammonium, Chloride, and Nitrate); pH (guarded and unguarded); pH & ORP (guarded and unguarded); Total Algae (Chlorophyll + Phycocyanin and Phycoerythrin); Turbidity*

Figure 3.3-3 EXO Multiparameter Sonde used by NEA

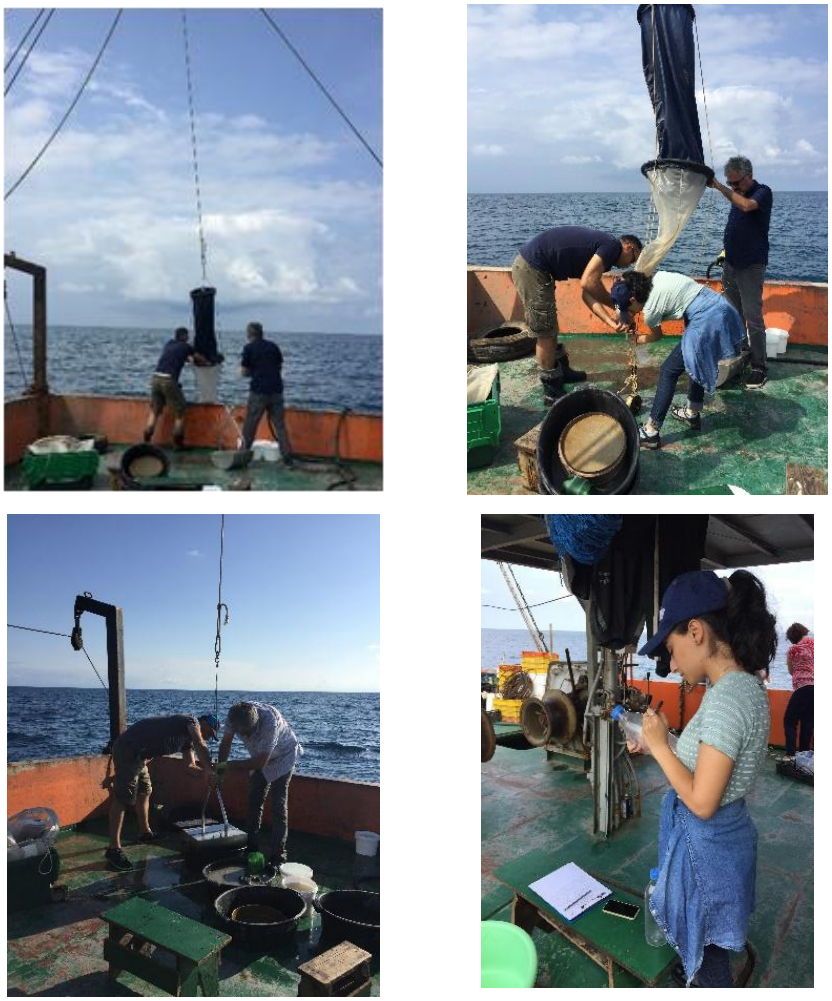


Figure 3.3-4 Photos from Hydrobiological survey of the Black Sea Georgian coast on the fishing seiner "BESHUMI"

3.4 Turkey

Here below an inventory of marine research vessels of Turkey operating in Black Sea is presented, with details on the on-board monitoring equipment (sensors, winches, data loggers, etc.). An overview on remote sensing and GIS experience is given, as well as some examples for the numerical modelling in the area of eco-hydraulics in coastal zone and open sea.

The following research vessels are presented below:

1) R/V MTA Oruç Reis, owned by General Directorate of Mineral Research and Exploration (MTA), Ankara, built in 2015
2) R/V TUBITAK Marmara, owned by TUBITAK-Marmara Research Center, built in 2013
3) R/V Seydi Ali Reis, owned by Sinop University Fisheries Faculty, built in 2012
4) R/V Derinsu, owned by DERINSU Underwater Engineering and Offshore Services company, built in 2006
5) R/V Karadeniz Araştirma, T.C. Recep Tayyip Erdoğan University, Faculty of fisheries and aquatic sciences , built in 1995
6) R/V Alemdar II- owner Istanbul University, Institute of Marine Science and Management- built in 1966
7) R/V Bilim2 - owner Middle East Technical University, Erdemli, built in 1983
8) R/V Lamas-1- owner Middle East Technical University, Erdemli, built in 1981
9) R/V Piri Reis- owner Institute of marine Sciences and Technology - Izmir, built in 1978
10) R/V Denar 1- owner Karadeniz Technical University, Faculty of Marine Sciences, Trabzon, built in 1992
11) RV Denar 2- owner TOMA Maritime S.A. Istanbul (NGO), operated by 2E Maritime, Istanbul, built in 1974
12) R/V Sismik 1- owner Istanbul Technical University, Faculty of Maritime, built in 1976
13) R/V Cesme- owner Turkish Navy, Department of Hydrography, Oceanography and Navigation, Istanbul, built in 1965
14) R/V Cubuklu- owner Turkish Navy, Department of Hydrography, Oceanography and Navigation, Istanbul, Istanbul, built in 1986
15) R/V Mesaha 2- owner Turkish Navy, Department of Hydrography, Oceanography and Navigation, Istanbul, built in 1994
16) R/V Surat Arastirma 1 - owner Central Fisheries Research Institute – Trabzon, built in 1984
17) R/V Aurelia - owner Sinop University Fisheries Faculty, Sinop, built in 1988

Table 3.4.1 Characteristics of Turkish marine research vessels operating in Black sea

Name	Owner/ Operator	Year built
R/V MTA Oruç Reis	General Directorate of Mineral Research and Exploration (MTA), Ankara	2015

Main features

Length: 87m
Beam: 23 m
Draft: 6 m
Gross tons: 4575 GT
Crew: 27
Scientists: 28
Endurance: 35 days

Deck equipment & facilities	Scientific Equipment
• Wet and dry labs • Dredge crane • A-frame • Oceanographic winch- MacArtney Cormac 5 – depth-3000m- 6.4mm wire • ROV operating room	• Seismic system Sercel Inc. • Meteo stat. Long life Air Gun 1900-LLXT • ROV – capacity 150kg, depth 1500m, with 2 camera and robotic hands • CDT Seabird SBE25 • Teledyne RDI ocean surveyor OS1138- depth 800-1000m • Mini water sampler-chemical sensors- PH, dissolved oxygen, PAR, OPR,metan H2S, Nitrate • Geological sampler- Piston Corer OSIL- depth 3000m

Name	Owner/ Operator	Year built
R/V TUBITAK Marmara	TUBITAK -Marmara Research Center	2013

Main features

Length: 41.20 m
Breadth: 9.55 m
Draught: 4.50 m
Load displacement: 497 t
Operating cruis. speed: 14 kn
Crew: 12
Scientific staff: 11
Endurance: 15 days

Deck equipment and facilities	Scientific Equipment
• Aft deck space: 65 m^2 • Laboratory space: 62 m^2, 5 labs (wet, dry, biology, computer, and heat-controlled) • A-frame (aft): hydraulic, 3 ton, 4 m clearance, 45° inward/outward • Knuckleboom crane (aft): 3 ton capacity, 9 m range • Winches: 2 (3000 m data cable, 2000 m steel cable)	• SEA BEAM 1050D - 3000 m maximum depth • Single beam hydrographic survey sounder (HydroStar 4900 – 3000 m maximum depth) • 2 x hull deep water ADCPs (Teledyne RDI Ocean Surveyor; 75 and 150 kHZ) • CTD (SBE 25plus with a transmissometer, pH, fluorometer, turbidity, PAR, and DO sensors) • Carousel water sampler (SBE 32C, 12 x 8 lt) • Thermosalinograph (SBE 21)

Name	Owner/ Operator	Year built
R/V Seydi Ali Reis	Sinop University Fisheries Faculty	2012

Main features

Length: 22,14 m
Breath: 7,5 m
Gross Tons 150 GT
Max. speed: 14 kn
Crew 7
Scientists 5
Endurance: 10 days

Deck equipment & facilities	Scientific Equipment
• Crane 360° - 6 m - 2 ton • Winch 1 - 600 m wire, 600 kg • Winch2- 300 m wire, 80 kg • A-Frame 4.20 m, 3 ton, 120 cm outboard • Wet lab • Cool storage for samples	• Water sampler • CDT • Current meter, Teledyne RD Instruments, Sentinel ADCP, 300/600 kHz, depth-150m • Multichannel Teledyne RD, Model Workhorse (H-ADCP), 300 kHz • Operational depth 600 m • Sonar CMAX Model CM 2 Digital Tow Fish, 100-325 kHz / 325-780 kHz, depth 0-1000 m • Depth Profiler – Knudsen Model Chirp Rack System, 3,5-210 kHz, depth 5000 m • ROV- depth-50m

Name	Owner/ Operator	Year built
R/V Derinsu	DERINSU Underwater Engineering and Offshore Services company	2006

Main features

Dredger
Length: 45 m
Beam: 15 m
Draft: 4.1 m
Tonnage: 612 GT

Deck equipment & facilities	Scientific Equipment
• Offshore survey - capable of conducting research work in depths up to 3,000 m	State-of-the-art instruments and equipment for : • hydrographic, geophysical, geotechnical, oceanographic and marine environmental surveys • All kinds of ROV surveys

Name	Owner/ Operator	Year built
R/V Karadeniz Araştirma	T.C. Recep Tayyip Erdoğan University, Faculty of fisheries and aquatic sciences	1995

Main features

Length: 25 m
Breath: 8 m
Draft: 2 m
Gross tons: 183 GT
Max. speed: 12kn
Endurance: 10 days
Crew: 4
Scientists: 8

Deck equipment & facilities	Scientific Equipment
• Wet lab: 5 m^2 • Crane: Teleskobik, 360-2.5m/3 tons-4m/7tons • Hydraulic trawl 50tons • 2 labs • Cool room for samples	• CDT depth-600m temperature, salinity, conductivity, pH, dissolved oxygen etc • Rosette Sampler- Niskin bottles12x 5lt • Li-193 SA Spherical Quantum Sensor, Li -1400 data logger, • Li-190SAT surface Quantum Sensor, C-14 incubator • Topograhic instruments-Topcon HiPer V, AML Oceanographic BASE-X • Fitoplankton & zooplankton monitoring sieves and nets

Name	Owner/ Operator	Year built
RV K. Piri Reis	Dokuz Eylül University, Institute of Marine Sciences and Technology, İzmir	1978

Main features

Length: 36 m
Beam: 8.05 m
Draught: 3.4 m
289 GT
Speed: 9 kn
Crew: 10
11 scientists
Endurance: 20 days

Deck equipment and facilities	Scientific Equipment
• a laboratory to carry out research work in various fields like oceanography, marine biology, undersea geology, geophysics for oil and gas exploration and earthquake engineering	• Sea-Bird SBE / CTD Rosette • GO Rosette Sampler • Niskin Bottle 10 l x 12 • Winch (2 x 3.2 Ton)

Name	Owner/ Operator	Year built
R/V Alemdar II	Istanbul University, Institute of Marine Science and Management	1966

Main features

Lenght: 63.40m
Width: 11.0 m
Max. Draught: 5.20 m
Max. Speed/Dead Slow: 13 kn/6 kn
Gross tonnage: 967
20 Crew + 18 pers.

Deck equipment and facilities	Scientific Equipment
• A Frame swl 5tons • Crain, swl 2t, 12m. • 3 pieces mataforas (for oceanographic equipments) • Winches for multi purpose • Laboratory (60m2): Computer room • Wet laboratory Instrumental analysis loboratory • Multipurpose conference room	• Currentmeter vessel mounted, 150kHz BBADCP (Broad Band Acoustic Doppler Current Profiler) • CTD, Conductivity, temperature and depth system. • Rosette sampler 12x5lt • Gravity Core • Van Veen Grab (Hydro-bios, 0.1m^2) • Plankton Nets, Trawl Nets

Name	Owner/ Operator	Year built
R/V Lamas-1	Middle East Technical University, Erdemli	1981

Main features

Length: 16 m
Gross tons: 28 GT
Net tons: 7.65
Max speed: 12 kn
Crew: 3
Scientists: 4

Deck equipment and facilities	Scientific Equipment
• Trawler, used mostly in biological and fisheries surveys • Oceanographic winch	• capable of oceanographic investigations • Sentinel Workhorse ADCP (300kHz)

Name	Owner/ Operator	Year built
RV Bilim-2	Institute of Marine Sciences - Middle East Technical University, Erdemli	1983

Main features

Length: 40.36 m
Beam:9.47 m
Draft: 3.8 m
Gross Tons: 433 GT
Range: 5600 n mi Speed Cruise: 9.5 kn
Speed Max: 11.5 kn
Endurance: 45 days
Crew: 12
Scientists: 14

Deck equipment and facilities	Scientific Equipment
• Area Wetlab: 15 m^2 • Area Drylab: 40.0 m^2 • Free Deck Area: 20m^2 • Computer room for collection and processing data • hydrographic winch with a cable	• CTD+Rosette System A- Seabird 911 plus: Sensors; Pressure, Conductivity, Temperature, Dissolved Oxygen, Chlorophyll Fluorescence, Turbidity. 12 Niskin Bottles (12 L capacity), Depth: 3000 m • Argo Profiling Floats • Buoy Systems • Dietz-La Fonde grab • Van Veen grab • Gravity Corer • Partical Size Analyzer • Grain Size Analysis,Sieving method,Laser diffraction method (< 0.25 mm)

Name	Owner/ Operator	Year built
R/V Denar 1	Karadeniz Technical University, Faculty of Marine Sciences, Trabzon	1992

Main features

Length 32,47 m.
Breath 9,60 m.
Freeboard 4 m.
Draft 2,5 m.
Gross tons 384
Area Wetlab: 20 m^2
Range: 500 n mi
Speed Max: 12kn
Endurance: 10 days
Crew 4
Scientists 7

Deck equipment & facilities	Scientific Equipment
• Winch 15 tons (2x500m 10 mm) • A-frame 10 tons • L-frame 1 Ton • all chemical, biological sampling equipment	• CTD Sea & sun Tech Multiparameter probe CTD 75M (2000 m) SEABIRD SMP-37-ODO (1500 m) • Optical Sensors- Li-Core PAR Sensor Li-192 SA • Satlantic Hyperspectral Radiospectrofotometre (Free falling Profiler) • Floresan Sensors WETLAB Eco FL (Chl-a) • Chelse Unilux (Chl-a) • Wave gauges AquaDrop-300M • Plankton nets 20 µm, 75 µm (Calsico closing net), 100 µm (Hydro-Bios closing net), 200 µm, 300 µm (Hydro-bios eggs net), 500 µm • Bongo net 20 µm-200 µm (Φ=57 cm) • Gravity Corer (1,5 m); Gravity Core (50 cm) • Piston Core (50 cm Hydro-bios), Orange Peel Type Sampler • Van-veen grap (40x30)

Name	Owner/ Operator	Year built
RV Denar 2	TOMA Maritime S.A. Istanbul (NGO), operated by 2E Maritime, Istanbul	1974

Main features
Length 78.80 m LBP: 75.00 m Breadth: 13.25 m Depth: 6.00 m Summer Draft: 4.16 m Max Speed: 11 kn DWabt.: 1400 Gross tonnage: 2033GT Scientific crew: 37

Deck equipment § facilities	Scientific Equipment
• Crane 1 -10 tons; Crane 2- 3,5 tons • Crane 3 - 4,5 tons; A-Frame- 20 tons • Free Deck Space • 21m x 13 m excl. hatch cover • Wet lab	• ROV TRV-HD diving up to 1,000 m carrying payloads up to 136 kg • Image-class ROV (Saab Seaeye Falcon) with diving capability of up to 300 m (cameras -2) • Orange Peel Type Sediment Sampler, • HydroBios Box Type Sediment Sampler • Piston Corer • RBR TGR-1050 HT Tide Gauge • HyroBios Niskin Type Water Sampler, • DAVIS Vantage Pro2 Plus Automatic Meteorological Station

Name	Owner/ Operator	Year built
R/V Sismik 1	Istanbul Technical University, Faculty of Maritime	1976

Main features

Length: 56.45 m
Beam: 8.80 m
Max. draft: 3.90m
Gross tons: 720 GT
Speed: 12 kn
Crew 23
Scientists 12
Endurance: 25 days

Deck equipment § facilities	Scientific Equipment
• ship serves as training ship • Wet laboratories (total area): 40m2 • winches for sampling: Steel Wire,2500 Meter,3 Ton	• fitted with up to date technology equipment for subsea geophysical exploration • Core Grab KAHLSICO Type 214WB250 • Core Gravity Head weighs 750 Kg, 1,5 m length and 42 cm diameter. Core pipes of 8,6,4,2 and 1 m can be mounted on the head (103 kg and 68 kg respectively

Name	Owner/ Operator	Year built
R/V Cesme	Turkish Navy, Department of Hydrography, Oceanography and Navigation, Istanbul	1965

Main features

Length: 87 m
Freeboard: 3 m
Draft: 4.6 m
Gross Tons 2900GT
Range: 8000 n mi
Speed Max: 15kn
Endurance (days) 50.0

Deck equipment and facilities	Scientific Equipment
• Wetlab (m2) 30.0 • Area Drylab 150.0 • Winches : 4.0 • Crane Max Load: 2.5 tons	• CTD SBE-25, SBE-19 • CTD SeaBird 19 -Towable , Oxygen Sensor, Conductivity, Sensor, Fluorometer, Rosette • Core Grab with Coring Capabilities • Velocitymeter Teledyne RD Instruments Inc. Model ADCP 300, 300 Khz, depth 200 m • Water sampling SBE 25

Name	Owner/ Operator	Year built
R/V Cubuklu	Turkish Navy, Department of Hydrography, Oceanography and Navigation, Istanbul	1986

Main features

Length: 40.41m
Freeboard: 1.2m
Draft (m) 3.95
Gross Tons 660 GT
Range: 5000 n mi
Speed Max: 11.5kn
Endurance: 30 days
Crew: 11+5
Scientists: 8

Deck equipment and facilities	Scientific Equipment
Area Wetlab (m2) 6.0 Area Drylab 30.0 • Winches (number): 4 • Crane Crane Location: Stern • Crane Max Load: 1 ton	• CTD Make SBE-25, SBE-19, Towable: Oxygen Sensor, Transmissivity Sensor, Fluorometer • CTD Rosette Sampler • Coring Capabilities • Core Grab • Core Piston

Name	Owner/ Operator	Year built
R/V Mesaha 2	Turkish Navy, Department of Hydrography, Oceanography and Navigation, Istanbul	1994

Main features

Length: 21,28 m
Beam: 5,07 m
Freeboard: 1,8 m
Draft: 1,8 m
Gross tons: 68 GT
Max. Speed : 10 kn
Crew 11
Endurance 12 hours

Deck equipment & facilities	Scientific Equipment
• 1Crain • Oceanographic winch: Lister – Peter Disel	• SeaBeam 1180, 180 kHz, depth 600m • Mobile water sampling instrumentation • Mobile CDT Capabilities temperature salinity conductivity, sigma-t, pH, DO, chlorophyl-a, light transmission • diving equipment for 4 person, diver tube, compressor

Name	Owner/ Operator	Year built
R/V Surat Arastirma 1	Ministry of Agriculture and Rural Affairs, Central Fisheries Research Institute – Trabzon	1984

Main features

Length: 22m
Freeboard: 10m
Draft: 1,75m
Gross Tons 76,38GT
Free Deck Area (m2) 60
Speed Max: 10kn
Crew 6
Scientists 10

Deck equipment & facilities	Scientific Equipment
• Crane 1 150 kg electric • Crane 2 1500 kg hydrolic • Trawl winch 1 12 tons • Trawl winch 2 12 ton • A-frame 12 tons kg (hydraulic)	• CTD Seabird-25 Capabilities temperature salinity conductivity, sigma-t, pH, DO, chlorophyl-a, light transmission • ADCP Current meter, 600 kHz, depth 200 m • Carousel (SBE-33) 12x5lt • Oxygen Sensor YSI, Transmissivity Sensor VET LABS, Fluorometer • Diving Capabilities diving equipment for 4 person,diver tube, compressor • Grab, Kor

Name	Owner/ Operator	Year built
R / V Aurelia	Sinop University Fisheries Faculty TR57000 Sinop	1988

Main features

Length: 11 m
Depth: 1.1m
Width: 3.7
Crew 2
Scientists: 5
Gross Tonnage: 10,62GT Wooden

Deck equipment & facilities	Scientific Equipment
• Hydraulic Winch • Wet lab: 7 m^2 • 1 bottom trawl • 1 beam-trawl	• YSI CTD Sonda : 1 • Hydrobios Van Veen Grab • Nets for biology: 3 • Hydrobios Sediment corer :1 • YSI multiparameter :1

Remote sensing and GIS centres in Turkey

TÜBİTAK MAM, the Environment and Cleaner Production Institute, Remote Sensing and GIS Laboratory, Gebze, Kocaeli; *Geographical Information Systems and Remote Sensing Laboratory*

The Remote Sensing and GIS Laboratory conducts studies in appropriate data models preparing, collecting, analyzing, visualizing, and sharing of the geographic data needed for the institute's multi-disciplinary projects. These studies are carried out under 2 main categories; Building the GIS Infrastructure needed for the monitoring of environmental change and GIS - based decision support applications for environmental management. GIS - based data produced for the projects since the year 2006, support decision-makers complex analyses and help determine the possible needs for institute projects. Remote Sensing and GIS is used as an effective decision support tool for especially the projects intended for the solution of environmental problems and planning activities.

ITU Research and Application Center for Satellite Communications and Remote Sensing (CSCRS), Istanbul Technical University

ITU-CSCRS is one of the forecoming institutions around the world with a highly capable ground receiving station unit and is the first ground receiving station in Turkey. It is also the first center and satellite ground receiving station established in Turkey to conduct application oriented projects in remote sensing and satellite communications technologies.

ITU-CSCRS has the capabilities of:

- acquiring images from remote sensing satellites,
- processing these images in different levels,
- processing these images in different levels,

Station is capable of establishing a link with Communication Satellites via 2.4m and 4.6m VSAT antennas and has an advanced capability in remote sensing via 13m X/Ku band antenna within the 3000km diameter coverage area for the direct downlink including the areas from Sweden to South Sudan and from Kazakhstan to England.

Starting from 2002 ITU-CSCRS has downlinked data from various Remote Sensing Satellites with medium, high and very high resolution imagery and has the most extensive remote sensing satellite image archive in Turkey. ITU-CSCRS archived telemetry include Radarsat-1 between 2002-2012, ERS-2 between 2002-2005, NOAA 14,15,16,17 between 2002-2005, SPOT-2 between 2002-2009, SPOT-4 between 2002-2013, SPOT-5 since 2009 to present and SPOT-6 since 2011 to present. An agreement has been made for the SPOT-7 and Pleiades 1A-1B satellite telemetry and image archiving has begun since March 2014.

Institute of Marine Sciences - Middle East Technical University, Erdemli

The capabilities of the remote sensing laboratories of the Institute have significantly improved recently through acquisition of HRPT images from NOAA satellites. The Institute’s HRPT station is one of the authorized stations to receive SeaWiFS data since September 1997. The Institute remote sensing data flow has reached to a considerable volume together with the data received from METEOSAT satellite through SSB radio.

The following satellite data acquisition and data processing systems are currently in operation.

Receiving:

- US NOAA TIROS-N HPRT-AVHRR receiver: real time HRPT images from NOAA satellites
- METEOSAT SDUS receiver: SDUS WEFAX data transmitted by EUMETSAT through Meteosat-5
- Automatic Picture Transmitter (APT) receiver: real-time coarse-resolution infrared/visible images from TIROS-NOAA series, METEOR satellites and US GSFC HRPT SeaWIFS receiver:real time HRPT images from SeaStar satellite.

Processing:

- apiX Ocean AVHRR processing unit
- SEAPAK processing unit
- SEADAS processing unit

In situ data acquisition systems

Marine Ecosystem and Climate Research Center (DEKOSİM), Institute of Marine Sciences, Middle East Technical University, Erdemli

The Argo floats in the Black Sea, along the coastline of Turkey have been placed in 2002 within the cooperation between Institute of Marine Sciences - Middle East Technical University (METU), Marine Hydrophysical Institute (Sevastopol/Ukraine) and Washington University (ABD). In this period, seven Argo floats were placed, of which four Argo floats were placed in the Black Sea for measuring the long-term physical parameters of the sea.

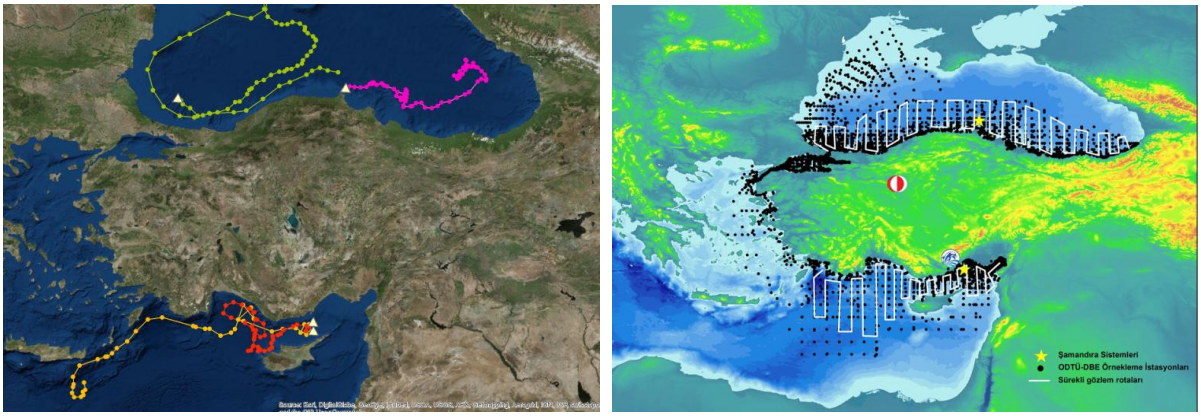


Figure 3.4-1 DEKOSİM Argo float positions (Institute of Marine Sciences, METU)

Numerical Modeling

There are many research and academic institutions in Turkey performing numerical simulation of hydrodynamic and eco-hydraulic processes in coastal zone and open seas, listed here above in this report in Section 2.4.

Here below two examples are given for the case of Marine Ecosystem and Climate Research Center (DEKOSİM), Institute of Marine Sciences, Middle East Technical University, Erdemli as well as for DERINSU Underwater Engineering and Offshore Services company.

A comprehensive ecosystem model is in operation in Institute of Marine Sciences at METU, based on data collected within the DEKOSİM projects.

The elaborated Ecosystem model of Black Sea is illustrated on Figure 3.4-2.

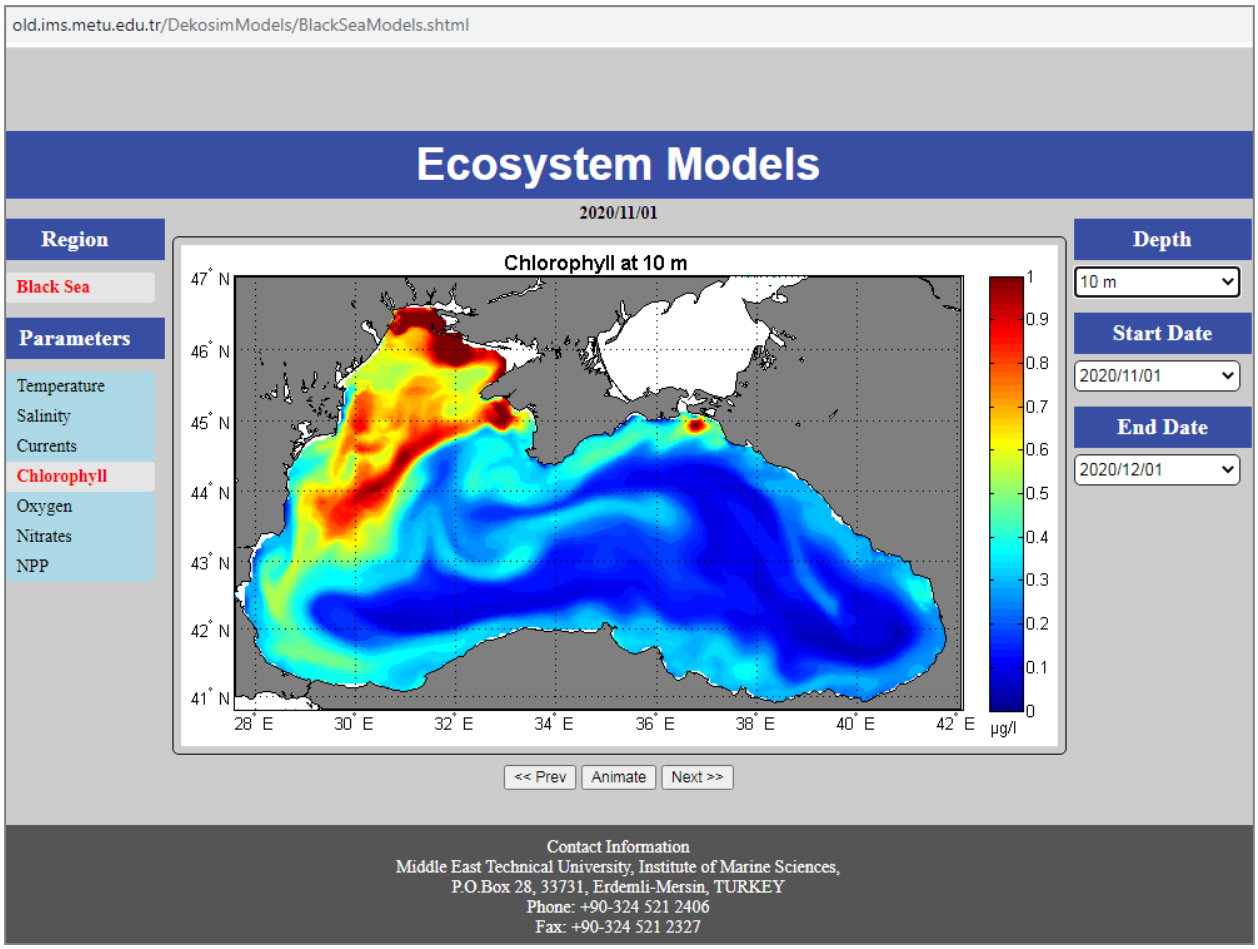


Figure 3.4-2 Black sea Ecosystem model, developed by DEKOSIM, METU

DERINSU conducts both 3D Recirculation and Dilution Model analysis for Offshore Discharge systems of Power Plants, Factories & etc. and 2D Wave Model analysis for ports and harbors. The required data (Bathymetry, Ambient Water Temperature, CTD values, Current Measurements, Wind Wave characteristics, Meteorological Conditions, Discharge Quantities, Diffuser Ports and Intakes General Layout) shall be collected prior to the numerical modeling studies. After all data is analyzed and processed, it is used as input data for the three-dimensional hydrodynamic numerical model for the recirculation and dilution studies. Related software used are;

- MIKE3 by DHI (3D hydrodynamic numerical modeling software)
- MIKE21 BW by DHI (2D numerical wave modeling software for ports and harbors)

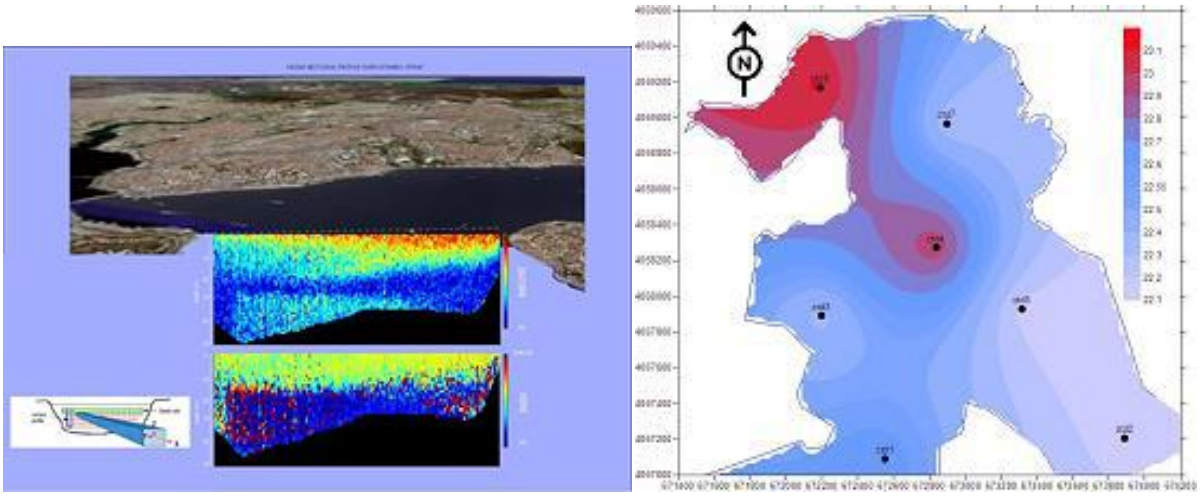


Figure 3.4-3 Illustration of a 2-D numerical model at Turkish coast (DERINSU)

3.5 Ukraine

Herebelow a short overview on Ukrainian research vessels and equipment is presented.

Vessels

The Ukrainian Scientific Center of Ecology of the Sea (UkrSCES)

Major units of infrastructure:

- Marine Information and Analytical Centre
- Department of Analytical Studies and Organisation of Monitoring
- Department of Scientific Investigations of the Marine Environment
- Department of Scientific Fundamentals of Nature Use, Ecological Expertise and Audit
- Department of Scientific Investigations and Protection of Marine Biocenosis
- Department of Scientific and System Information Support

Research vessels and research equipments on vessels:

1. Research vessel **"Vladimir Parshin"**, year build: 1989, Length: 50 m, With: 10 m

   Data Processing Equipment: Computers/printers;

   Navigational equipment: Furuno, GPS.Sounder, gyro compass

   Communications: Radio Station Reid Navigation receiver – Rumba

   Laboratories: Meteo; Oceanographic: Hydrochemical; Biological; Photo lab; Computer.

   Research Equipment: System continuous temperature and salinity registration of the surface layer while the vessel is going with reference coordinates for satellite system 4 deep Winch - 4-6 thousand meters cable; STD-Probe, Gydrozond, Snapper – Ocean, Geological tube; Niskin samplers; system for photographing the sea bottom; Plankton nets; Colemer GM-65, I-130 ionomer, Photocolorimeters KFK-3 (Diagnostic Report II, EMBLAS, 2013)

Figure 3.5-1 Research vessel "Vladimir Parshin", Ukraine

2. Research boat **"Ecocontrol"**, Length: 20 m

Without laboratories.

Research Equipment (Diagnostic Report II, EMBLAS, 2013):

- 1 winch - 30 m cable CTD- robe "Indromar",
- Bottom grabs Peterson;
- Geological tube;
- Niskin samplers;
- Plankton net ;
- Colemer GM -65,
- I- 130 ionomer,
- Photocolorimeters KFK-3 ()

3.6 Russia

The Federal State Budgetary Institution of Science of P. P.Shirshov Institute of Oceanology of the Russian Academy of Sciences owns 6 vessels operating and maintained by the shipping company P.P. Shirshov of the Institute. The Company is comprised of the Scientific Expeditions and Fleet Department of the Institute and the Fleet Departments of the Atlantic Branch and the Southern Branch.

The ships are equipped with modern navigation systems, scientific instruments and equipment for complex oceanographic research, inclufing environmental monitoring and fish stock assessment. However, none of these research vessels is refered as operating in the Black Sea.

According to published information (https://en.wikipedia.org/wiki/List_of_active_Russian_Navy_ships) the Black Sea marine research in Russia is now concentrated in research vessels owned by Russian Navy, Armed Forces of the Russian Federation. Here below some illustrative information is presented for such oceanographic research vessels. As there is no responsible partner from Russia within the TIMMOD network, this information may need to be reviewed and/or updated.

Figure 3.6-1 Photo of Research vessel Ladoga, Russian Federation
built for the Main Directorate of Deep-Water Research (GUGI) of the Ministry of Defense.
(https://en.wikipedia.org/wiki/List_of_active_Russian_Navy_ships)

Figure 3.6-2 Photo of Research vessel Ilmen, Russian Federation
(https://en.wikipedia.org/wiki/List_of_active_Russian_Navy_ships)

Figure 3.6-3 Photo of Research vessel Seliger, Russian Federation
(https://en.wikipedia.org/wiki/List_of_active_Russian_Navy_ships)

3.7 Moldova

<u>The national environmental monitoring system in the Republic of Moldova.</u>

The State Hydrometeorological Service (SHS), Hydrological Center (CH) is the national institution authorized to organize and perform quantitative hydrological monitoring of surface waters, this activity is regulated by the World Meteorological Organization (WMO) Guide to Practical Hydrology; No. 168, 2011 edition, and is carried out through the National Hydrological Monitoring Network (RNMH), composed of 2 Hydrological Stations and 56 Hydrological Stations, of which 20 stations are automated, the remaining 36 are classic with the involvement of observers.

Automated P / H

Automated Hydrological (P / H) stations are complemented by PLS (Pressure Level Sensor), SBS (Compact Bubbler Sensor), RLS (Radar Level Sensor) sensors from the OTT HydroMet manufacturer, which are only used to collect water level and temperature data every 15 minutes.

Figure 3.7-1 Automated station for hydrological observations, SHS Moldova

Figure 3.7-2 Classic station for hydrological observations, SHS Moldova

The classic Hydrological stations have employees, observers (individuals) who perform systematic hydrological observations, twice a day, at 8 am and 8 pm, with the transmission of information, from the operational stations once a day, and from the regime once a month.

Classic P / H

At the classic Hydrological Posts, observations are made daily on:

- water level, data read on the fixed hydrometer or piles,
- water and air temperature using a portable thermometer,
- ice formations, visual observations (periodically every 5 days or as appropriate),
- thickness of the ice with the graduated cup (periodically every 5 days or as the case may be),
- water flow, with hydrometric grinders GR-21 and GR-55 for small rivers, and for the Dniester and Prut rivers with ADCP Stream-Pro (periodically every 10 days or as the case may be),
- sludged alluvium with slow filter bathometer.

Currently, SHS does not have in the RNMH any hydrological station arranged and equipped with automated equipment necessary for flow measurements and no mobile equipment for maximum flow measurements of the Rio-Grande Q-ZBOAT model 1800.

As the Dniester River and the Prut River have a cross-border flow, SHS under the bilateral Agreements with Romania and Ukraine, with the relevant institutions in Ukraine and Romania annually develops and approves Joint Plans on Water Flow Measurements with Ukraine on the Dniester River in 2 sections and with Romania on the Prut River in 4 sections.

Figure 3.7-3 National Network for hydrological monitoring, Moldova

The Environment Agency, the Water Quality Laboratory (LCA) fulfills the role of national laboratory for water and monitors surface water quality in over 50 sections, located on 16 large and small rivers, 6 reservoirs and 2 natural lakes, where they are analyze more than 70 hydrochemical parameters (physicochemical indicators, oxygen regime indicators, biogenic elements, heavy metals, organic pollutants, organochlorine pesticides and polyaromatic hydrocarbons) and 6 groups of hydrobiological elements (phytoplankton, including chlorophyll "a", zooplankton phytobenthos, macrozoobenthos, macrophytes and aquatic microbiology), thus implementing the European directives: DCA 60/2000 and Directive 2013/39 / EU.

In accordance with the Bilateral Agreement between the Republic of Moldova and Romania (National Administration "Romanian Waters"), the Water Quality Laboratory conducts investigations on water quality r. Prut in 7 monitoring sections, established by mutual agreement, after 26 hydrochemical indicators and 3 groups of hydrobiological elements.

The same goes for the Bilateral Agreement between the Republic of Moldova and Ukraine, which monitors and exchanges information on water quality in the Prut River (Lipcani section) and the Dniester in 2 cross-border sections - Otaci and Palanca.

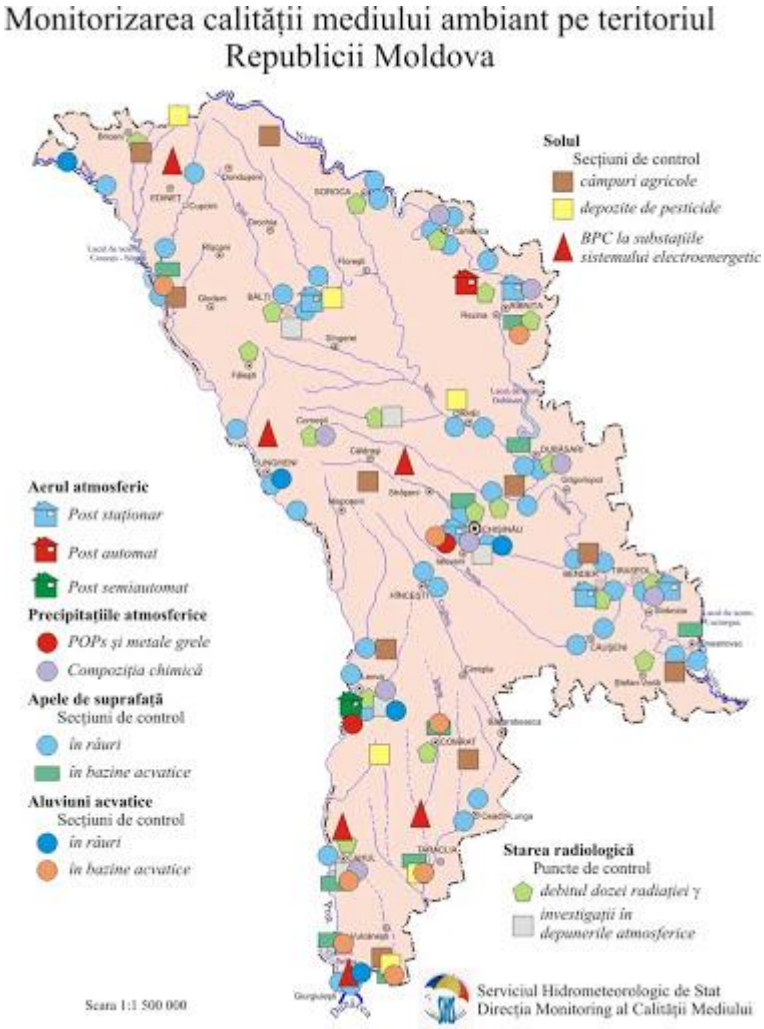


Figure 3.7-4 National network of Moldova for monitoring of environmental components (soil, air, water, precipitations, radiology)

Within the Convention on Cooperation for the Protection and Sustainable Use of the Danube River, monitoring is carried out in 5 established sections of the Transnational Monitoring Network according to 73 hydrochemical parameters and 5 hydrobiological indicators.

Figure 3.7-5 Use of mobile sensors in daily monitoring routines

For the purpose of warning about transboundary pollution in the Danube, the AEWS (Accident Emergency Warning System) alert system has been set up, which is viable, active 24/24 hours and is effective in the event of a risk of pollution of transboundary watercourses in the hydrographic district of fl. The Danube, as well as when the hazard levels or the maximum permissible concentration for dangerous substances are exceeded. AEWS sends international warning messages to downstream countries that may be at risk of pollution. This intervention supports the authorities to take urgent measures to protect the environment and the population. AEWS operates a network of Alert Information Centers (PIACs) in each of the participating countries.

In order to monitor the quality of surface water are used both internationally approved international ISOs and methodological works included in the collection "Rucovodstvo pohimicescomu analizu poverhnostnîh vod suşi", ed. A.D.Semionova, Ghidrometeoizdat Leningrad 1977, as well as other methodological guidelines accompanying the specialized equipment.

Surface water samples are sampled in accordance with ISO 5667 and DCA guidelines.

The monitoring program (Annex 1) which includes the monitored parameters and its frequency was included in the Regulation on the monitoring and systematic highlighting of surface water and groundwater status, GD no. 932 of November 20, 2013, WFD 2000/60 and European Guide no. 7 - Rally monitoring with the Water Framework Directive.

The in-situ analysis is carried out once a month or as the case may be, involving the expeditionary group at the following indicators; Water temperature, pH, conductivity, dissolved oxygen concentration, as well as its saturation are determined using the Multi 350i portable multifunctional analyzer, and in order to ensure quality, the results obtained in field conditions are periodically compared with those obtained in the laboratory. potentiometric, using the Inolab pH meter.

Organoleptic parameters:

The transparency is determined by the method of reading through the water layer in the Snelen cylinder, the special text fixed at 4 cm from it.

The coloration is determined by the method of visual comparison with the standard solution.

The smell is determined by the organoleptic method and is rendered in points.

The suspended substances are determined by filtration or centrifugation, and the obtained residue is dried to a constant weight at 105 ° C.

Dissolved oxygen is determined by the iodometric method, based on the evaluation of the amount of dissolved oxygen in the water currently taken (Winkler Method) in accordance with MS SR EN 25813: 2011.

Biochemical oxygen consumption at 5 days (CBO5) is determined by the iodometric method, based on the evaluation of the amount of oxygen dissolved in water after storage of the sample, for 5 days in the incubator, where a temperature of 200 C is maintained.

Chemical oxygen consumption (CCOCr) is determined by applying oxidation with K2Cr2O7 in an acid medium in the presence of the Ag2SO4 catalyst. Excess K2Cr2O7 added to the water sample is titrated with the solution of ammonium-iron (II) Mohr salt (double sulfate).

Nutrients:

Ammonium ions are determined by reaction with Nessler reagent, which is treated with Seignette salt solution.

The intensity of the yellow color is determined by measuring with a spectrophotometer at the wavelength - 425 nm. The spectrophotometric method for the determination of nitrites is based on the reaction of the nitrated sulfanilamide with N- (1-naphthyl) ethylenediamine dehydrochloride as a result of which a specific red compound is obtained. The method for the determination of nitrates is based on MS SR ISO 7890-3: 2006, namely on the spectrometric measurement of the absorption of the yellow compound formed by the reaction of sulfosalicylic acid with nitrate, followed by treatment with alkaline solution. The method of determining orthophosphates is based on their reaction with ammonium molybdate, in an acid medium with the formation of ammonium phosphomolybdate, which subsequently under the action of ascorbic acid, forms a blue complex known as molybdenum blue. The method of determining total phosphorus is based on the redox reaction between phospho-organic compounds and ammonium persulfate in an acid medium with phosphate formation, which are then determined by the spectrophotometric method.

Heavy metals:

The total iron content is determined according to SM SR ISO6332: 2001 with orthophenanthroline and the absorption of the complex colored in red-orange is measured with the UV-VIS Carry 100 spectrophotometer - wavelength of 510 nm, mg / l.

Heavy metals (copper, cadmium, nickel, lead and zinc) are determined by measuring the atomic absorption value of the analyzed sample according to the methodological indications set out in MS SR ISO 8288: 2006, at the Solaar 969 atomic absorption spectrometer, using cathode lamps concerned. The results are expressed in µg / l.

Mineralization:

Mineralization (sum of Cl -, SO42-, HCO3-, Ca2 +, Mg2 + Na +, K + ions), is determined by evaluating the sum of cations and anions that make up the mineral base, analyzed water sample, mg / l.

Calcium is determined by the reaction of calcium ions with Trilon B in an alkaline medium according to MS SR ISO 6058: 2012, mg / l.

Magnesium is determined by the method of evaluating the difference between the total hardness and the ion content, according to MS SR ISO 6059: 2012, in mg / l.

Chlorine ions are determined by the titration method for the purpose of dosing chlorine ions with silver nitrate solution, in the presence of potassium chromate as stipulated in MS SR ISO 9297: 2012, mg / l.

Sulphate ions are determined by spectrophotometric measurement of the turbidity of the water sample analyzed in the presence of barium salts, mg / l.

The silicon content is determined by the reaction between tartaric acid and ammonium molybdate, then the optical density of the yellow solution obtained by UV-VIS Carry 100 spectrophotometer (wavelength 410 nm), mg / l is determined.

The alkalinity (mol / l) and HCO3 ions (mg / l) are determined by titration of the water sample, using the special equipment BAT-15, with hydrochloric acid solution after the turning points pH 4.5 and 4.2. The turning points are determined by the potentiometric method using the ionometer ЭВ –74.

Sodium and potassium are determined by the flame photometric method, using the gas complex: air-propane-butane, mg / l.

The total hardness of the water is determined by titrating the water sample with ethylenediaminetetraacetic acid (Trilon B) in an alkaline medium with the black chromogenic indicator, mg · ech / l.

Organic substances:

Anionic surfactants (anionic-active detergents) are determined by the method based on their action on methylene blue (MBAS) and the subsequent measurement of the absorption value, which is performed on the Carry100 UV-VIS spectrophotometer - wavelength 650 nm, mg / l.

Volatile phenols on distillation are determined by their reaction with 4-aminoantipyrine in an alkaline medium (pH 9.3). The measurement of the absorption value is performed with a Carry 100 UV-VIS spectrophotometer - wavelength 460 nm, mg / l.

Petroleum products are determined by their extraction with N-hexane or cyclohexane. After concentration, the extract is analyzed with the Carry 100 UV-VIS spectrophotometer - wavelength 255 nm, mg / l.

Organic micropollutants:

Organochlorine pesticides are determined in accordance with SM SR EN ISO 6468: 2006 and the After concentrating the components with a low degree of volatility and after all purification steps, the analysis by gas chromatography is applied, using the chromatograph HP 6890 - the electron capture detector, the results are reported in µg / l.

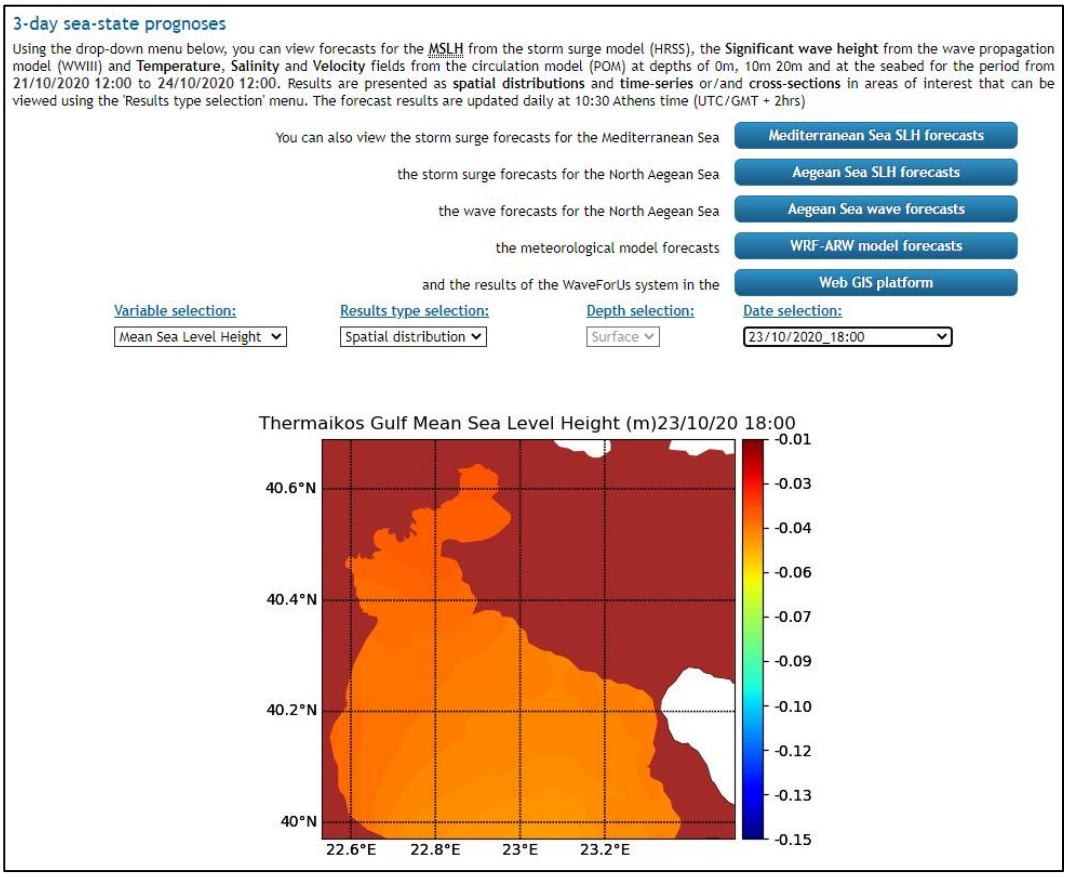
Polyaromatic hydrocarbons are determined by the standardized methods SM SR EN ISO 17993: 2012 and SM SR EN ISO 15680: 2012 by gas chromatography after liquid-liquid extraction.

3.8 Marine water quality forecast platforms for Mediterranean region

On a regional scale, e.g. focusing on the Mediterranean Sea and other aquatic bodies around the European continent, there are several local forecast systems and services, such as **WaveForUs** (http://wave4us.web.auth.gr/; Krestenitis et al., 2014, 2015, 2017; Makris et al., 2020), **POSEIDON** (https://poseidon-new.hcmr.gr/; Kalaroni et al., 2020a,b; Korres et al., 2019; etc.), Balearic Islands Coastal Ocean Observing and Forecasting System (**SOCIB**; http://www.socib.eu/), and several others usually covering ocean forecast needs on a national level (Makris et al., 2020).

Within the WaveForUs forecast system 3-day sea-state prognoses are provided (Figure 3.8-1; see also http://coastal.web.auth.gr/ssm_Med_forecast.htm and http://coastal.web.auth.gr/ssm_Aeg_forecast.htm). By using the drop-down menu, one can view daily-renewed forecasts for the mean Sea Surface Height from the storm surge model HiReSS, the significant wave height from the 3rd generation irregular wave propagation model WaveWatch-III, and temperature, salinity and velocity fields from a

coastal circulation implementation of POM model at several depths for a future 3-day period. Results are presented as spatial distributions and time-series or/and cross-sections in areas of interest.



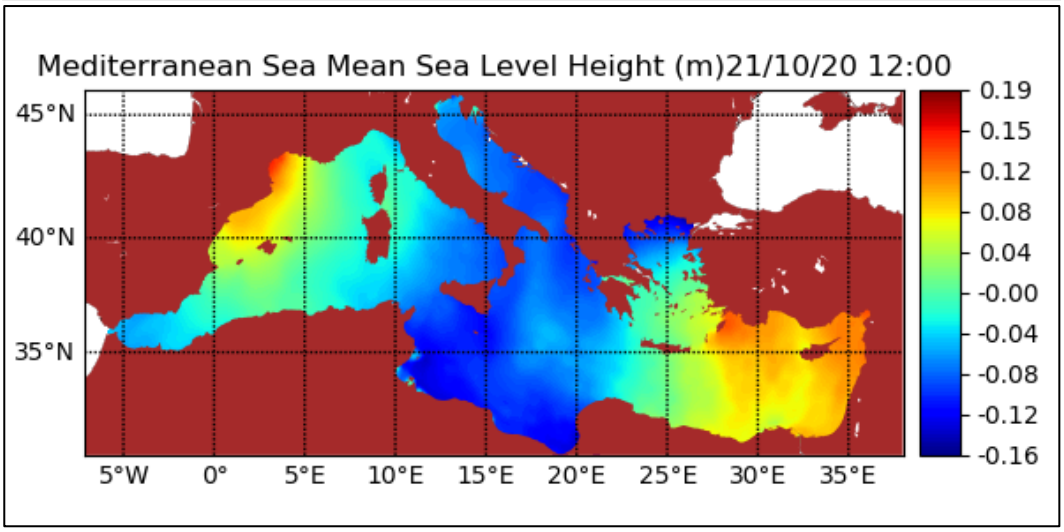


Figure 3.8-1 Online data sharing tool of marine forecast data by the Wave4Us System in Thermaikos Gulf and Mediterranean Sea; Ocean Forecast Parameter: sea surface height (m)

The forecast results are updated daily at 12:30 EET (UTC + 2hrs). Results refer to several forecasting scales discretely presented for the Mediterranean Sea, the central and northern parts of the Aegean Sea, and a high-resolution representation of sea-states in Thermaikos Gulf.

The POSEIDON system (see also HCMR's operational system of monitoring Greek maritime areas and the Mediterranean Sea basin in Section 3.8 - Greece; Figures 3.8-2 and 3.8-3) formulates the Greek ocean observatory and is a long-term infrastructure dedicated to multiple in-situ observations, from sea surface to the ocean bottom and the water column. The latter are maintained over long timescales and can provide critical data for delivering marine weather and ocean services, to ensure safe and efficient maritime operations, and improving response efficiency for extreme events and emergencies. Moreover, they can increase understanding of ocean processes, deliver further insight into ocean variability, provide scientific assessments to enable environmental prediction and adaptation to climatic change and contributing to a sustainable management of the oceans and coastal areas. POSEIDON's infrastructure refers to Eastern Mediterranean basin, for the monitoring and forecasting of the marine environment, supporting the efforts of the international and local community and replying to the needs and gaps of science, technology and society in the EU and globally.

The POSEIDON general aims are: (a) to establish a sustainable marine observing network in the Eastern Mediterranean, (b) to provide quality and validated forecasts of the marine environment, (c) to provide scientific knowledge and support on the study of the ocean mechanisms and their variability, as well as to address the sensitivity of marine ecosystem and biodiversity to combined natural forcing factors and anthropogenic pressures, and (d) to provide a technology test bed and services to marine policy-makers and the society. The system is being developed in accordance to the policy frameworks suggested by IOC/GOOS, EuroGOOS, MonGOOS and GEO, while it maintains a balance between the operational and research character of the infrastructure through the integration of methodologies and tools developed in relevant EU initiatives and projects.

The POSEIDON forecast system consists by a suite of numerical models that provide atmospheric, wave, hydrodynamic and ecosystem forecasts for the next five days in daily basis (Figures 3.8-2 -- 3.8-6). It also cooperates with HCMR's data management and dissemination unit, which collects and process the data from the monitoring network and distributes the observing and forecasting products to the linked European Infrastructures and to the public.

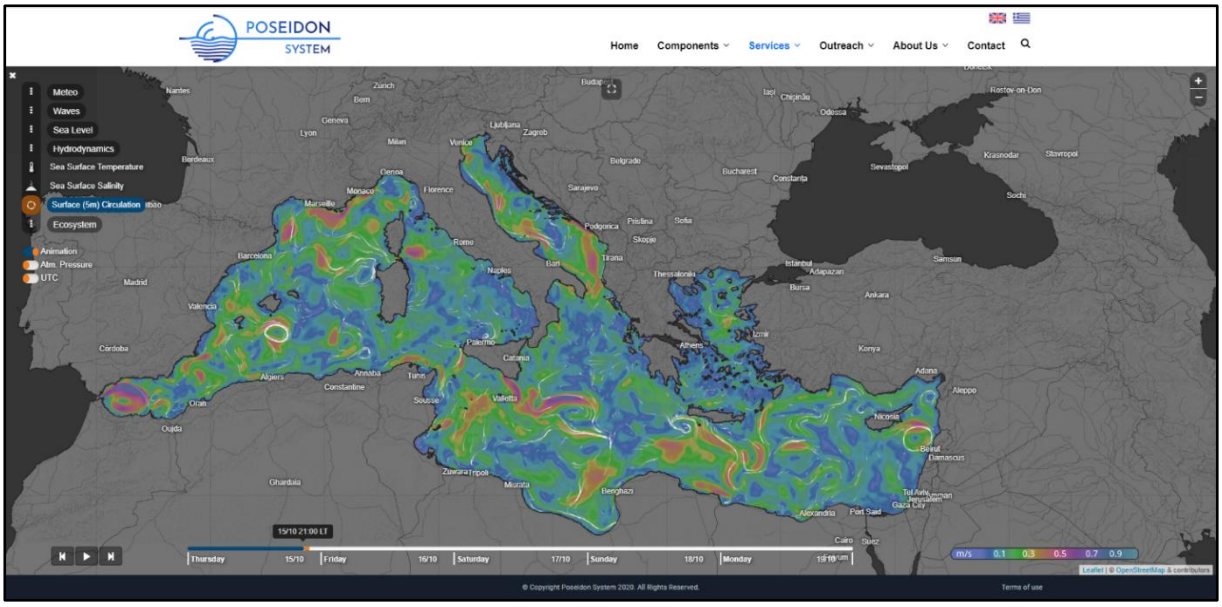


Figure 3.8-2 Online data sharing tool of marine forecast data by the POSEIDON System in the Mediterranean Sea

Ocean Forecast Parameter: sea surface current (circulation; in m/s).

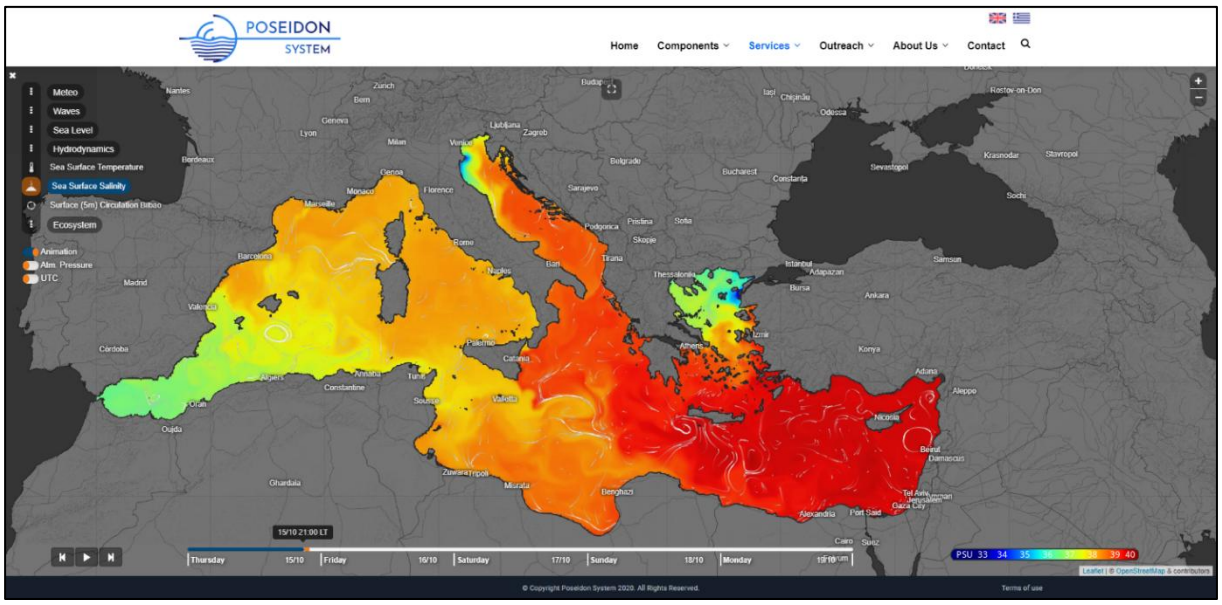


Figure 3.8-3 Online data sharing tool of marine forecast data by the POSEIDON System in the Mediterranean Sea;

Ocean Forecast Parameter: sea surface salinity (in PSU).

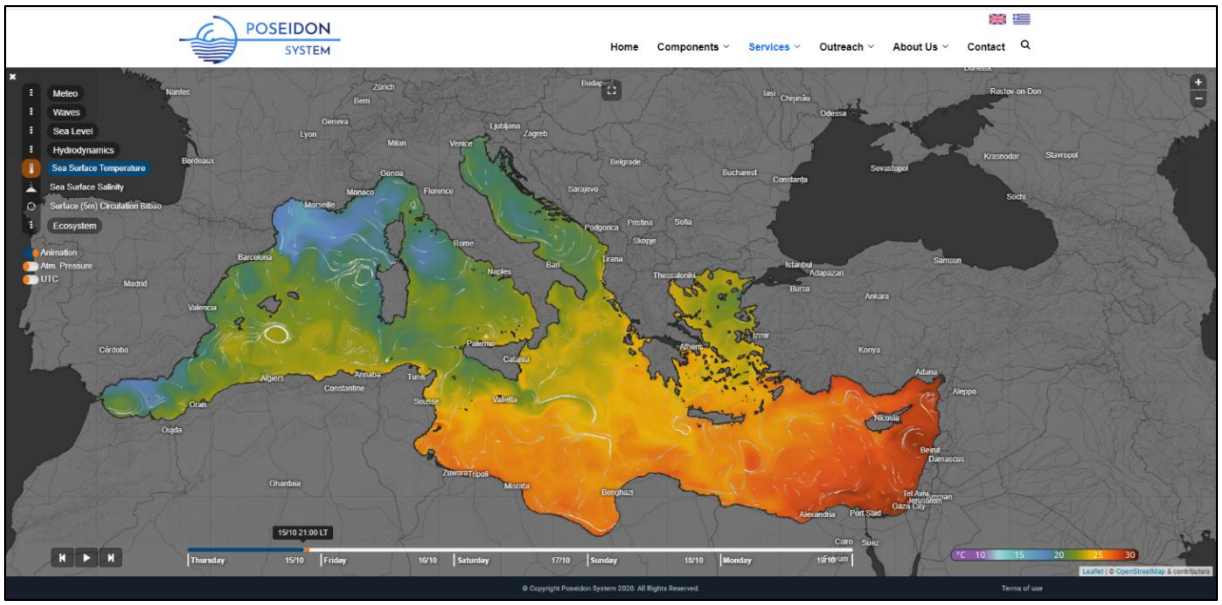


Figure 3.8-4 Online data sharing tool of marine forecast data by the POSEIDON System in the Mediterranean Sea;
Ocean Forecast Parameter: sea surface temperature (in °C).

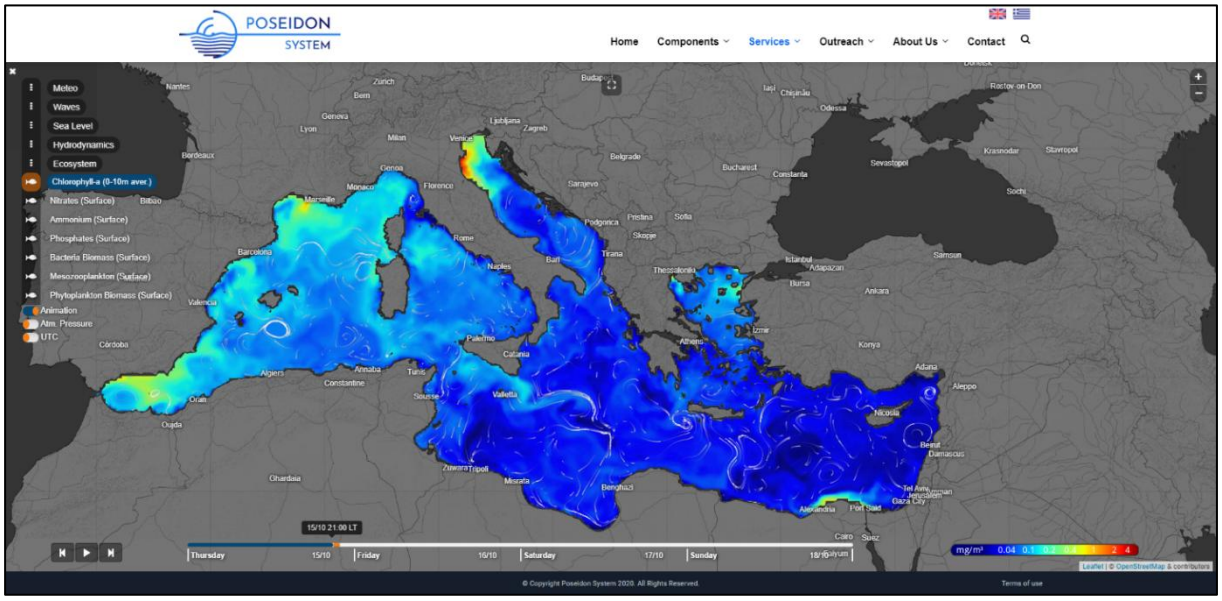


Figure 3.8-5 Online data sharing tool of marine forecast data by the POSEIDON System in the Mediterranean Sea;
Ocean Forecast Parameter: chlorophyll-a (in mg/m^3).

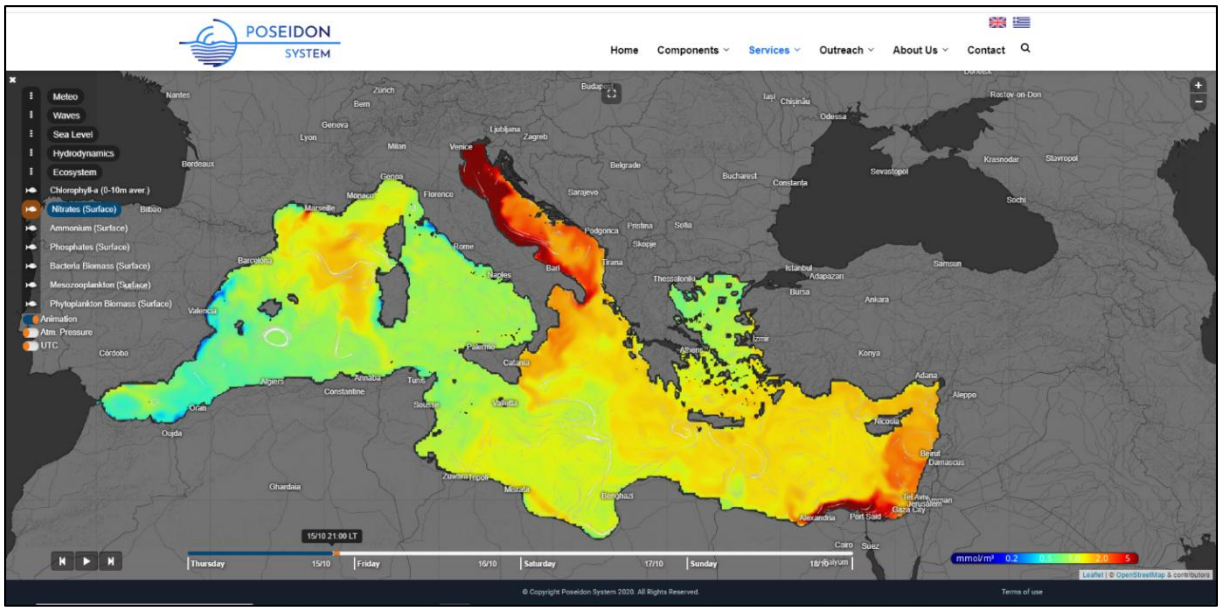


Figure 3.8-6 Online data sharing tool of marine forecast data by the POSEIDON System in the Mediterranean Sea;
Ocean Forecast Parameter: nitrates (mmol/m^3).

SOCIB is a Coastal Ocean Observing and Forecasting System located in the Balearic Islands, a new facility of services open to international access. SOCIB responds to a paradigm shift in the forecasting and observation of our oceans and coasts, issues that have evolved from being centered on a unique platform, the oceanographic ships with data availability being delayed in time, to an observation now based on multi-platform and integrated systems (using buoys, satellites, ships, autonomous underwater vehicles, HF radar, ARGO profilers, etc.), also assuring quasi real time quality controlled data availability for both researchers and society.

SOCIB is a multi-platform distributed and integrated system that provides streams of oceanographic data and modelling services to support operational oceanography in a European and international framework, therefore also contributing to the needs of marine and coastal research in a global change context. In line with EuroGOOS, the operational oceanography initiative includes both the systematic long-term measurements of the seas and their interpretation and dissemination, and also the sustained supply of multidisciplinary data to cover the needs of a wide range of scientific research and societal priorities. This allows a quantitative increase in our understanding of key questions on oceans and climate change, coastal ocean processes, ecosystem variability, sea level rise, etc., and further drives towards a more science based coastal and ocean management. The research activities are being carried out by IMEDEA, COB/IEO and UIB, among other organisations, in close coordination to SOCIB.

SOCIB is composed by three major subsystems: (1) an observing sub-system (Observing Facilities), (2) a forecasting and modelling sub-system (Forecasting and Modelling Facility, Figure 3.8-7), and (3) a data management sub-system (Data Centre Facility). A combination of these three components forms the Systems Operation and Support Division (SOS Division).

The Engineering and Technology Development Division (ETD Division) provides the engineering and technical backbone to develop and operate the facilities of the SOS Division and is also responsible for the application, development and testing of new technologies for future observing systems and for developing new analytical tools for the effective management of new, high volumes, of observational data and modelling output. Mobile apps and applications for modern web browsers are also offered within well-known App Galleries/Platforms (Figure 3.8-8).

The third Division, the Strategic Issues and Applications for Society (SIAS Division), develops applications and operational tools for science-based management of the coastal and marine environment, within the general frame of sustainability science, thus supporting the development and transfer of strategic knowledge to meet the needs of society in the context of global change. It is important to consider that the sound management of the coastal zone is of utmost importance in the Balearic Islands and elsewhere to guarantee both the quality of life of residents and the competitiveness and sustainability of the economic activity in the Balearic Islands.

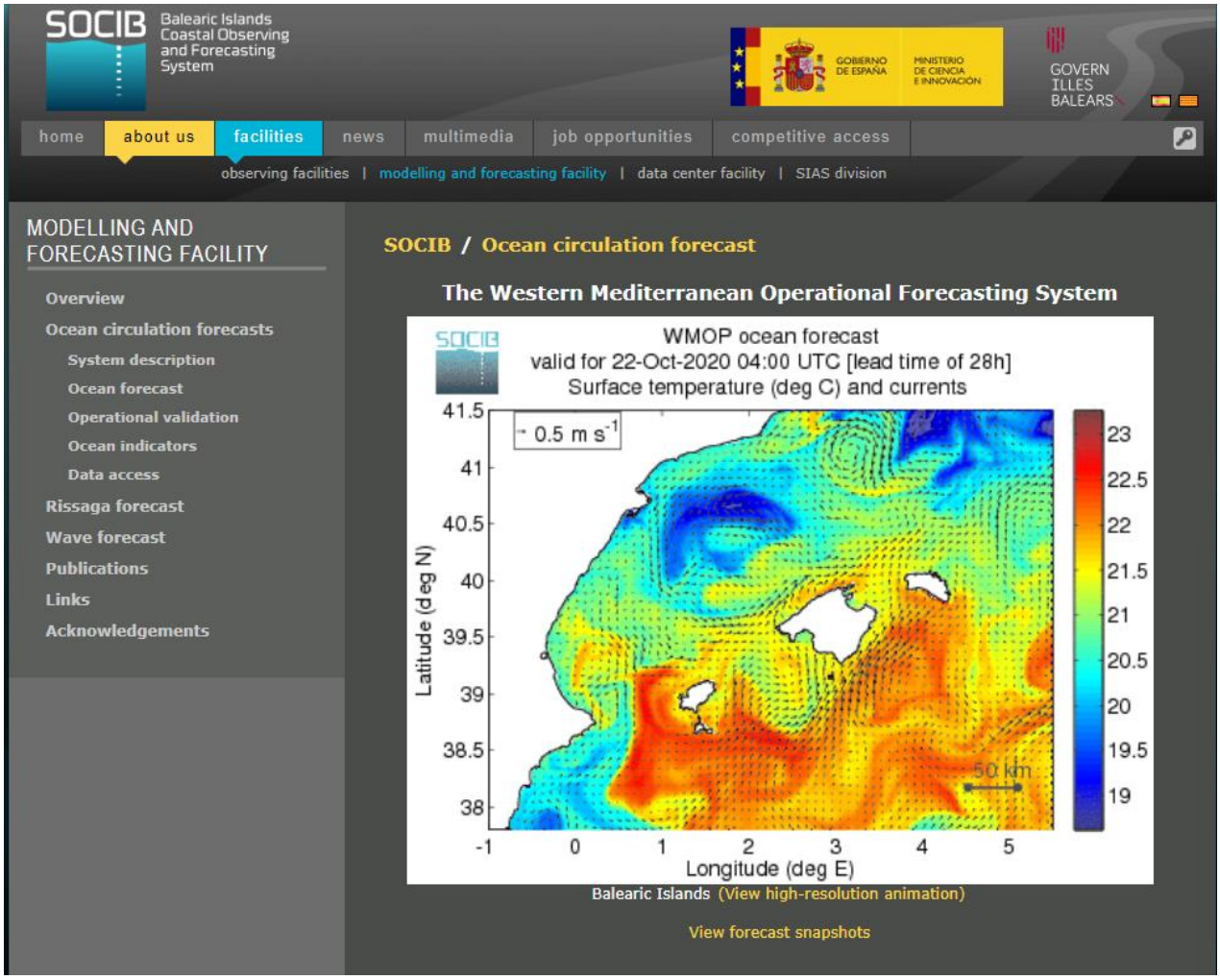


Figure 3.8-7 Online data sharing tool of marine forecast data by the SOCIB System in the western Mediterranean Sea around the Balearic Islands;
Ocean Forecast Parameter: sea surface temperature (in °C).

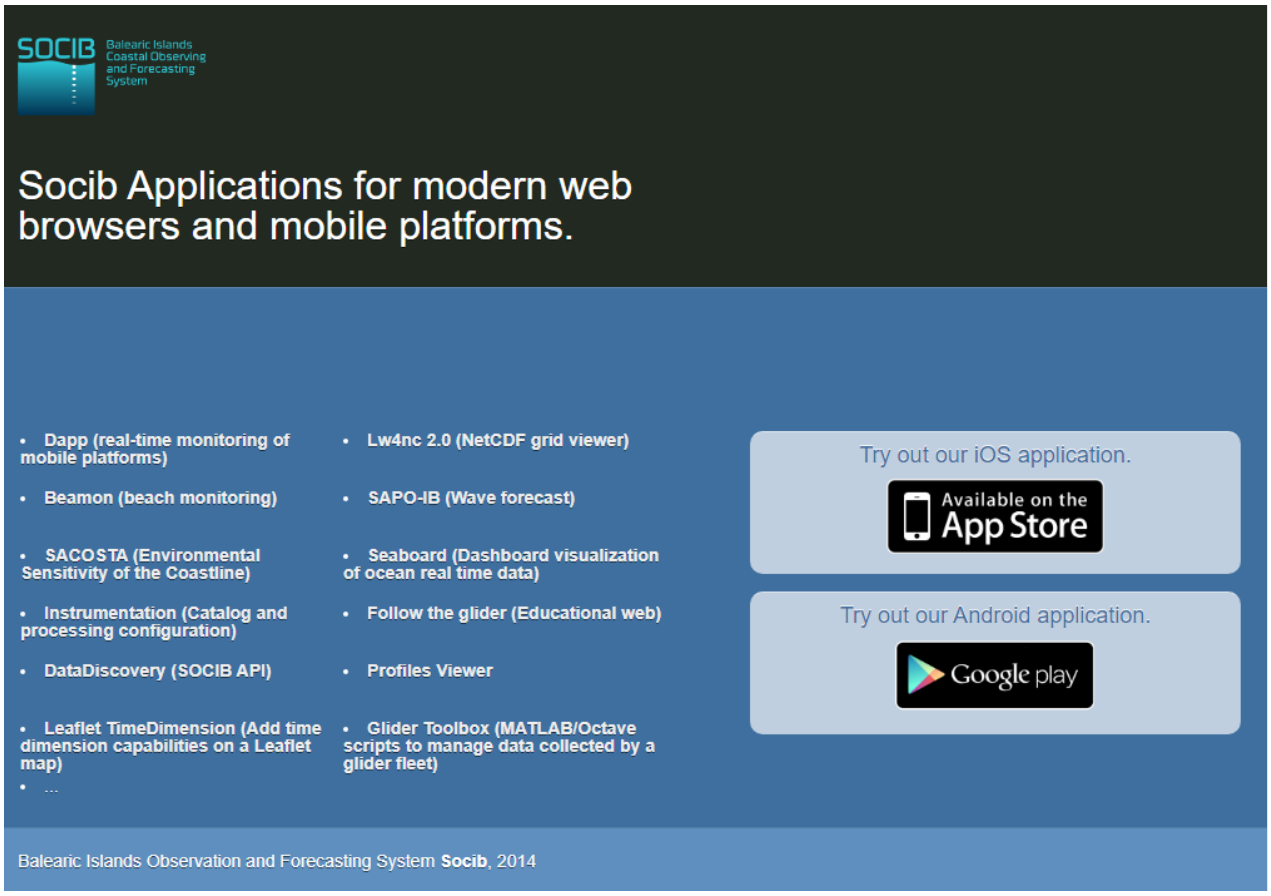


Figure 3.8-8 Available SOCIB mobile apps and applications for modern web browsers.

The Mediterranean Forecasting System (MFS) is a numerical ocean prediction service that produces analyses, re-analyses and short-term forecasts for the entire Mediterranean Sea (Figure 3.8-11). MFS became operational in the late '90 and was developed within the VI and VII EU Framework programs, the national program Ritmare and it has finally become part of the Copernicus Marine Service in 2015. The service is available 24 hours a day, all year around. Two different implementations of the system are available (Figure 3.8-12):

- COSMO MFS: the system is forced by the analyses and forecasts from the Limited Area Model forecasting service with a horizontal resolution of 1/16 degrees (6.5 Km, approximately).
- ECMWF MFS: the system is forced by the analyses and forecasts from the global ECMWF service with a horizontal resolution of 1/8 degrees resolution (12.5 km, approximately).

The Mediterranean Forecasting System is a coupled hydrodynamic-wave model with data assimilation components. The model horizontal grid resolution is 1/16° (6-7 km, approximately) and it is resolved over 72 unevenly spaced vertical levels. It is nested to the Atlantic ocean through the Copernicus global ocean analyses and forecasts (http://marine.copernicus.eu).The wave model uses 24 directional bins (15° directional resolution) and 30 frequency bins (ranging between 0.05Hz and 0.7931 Hz) to represent the wave spectra distribution.

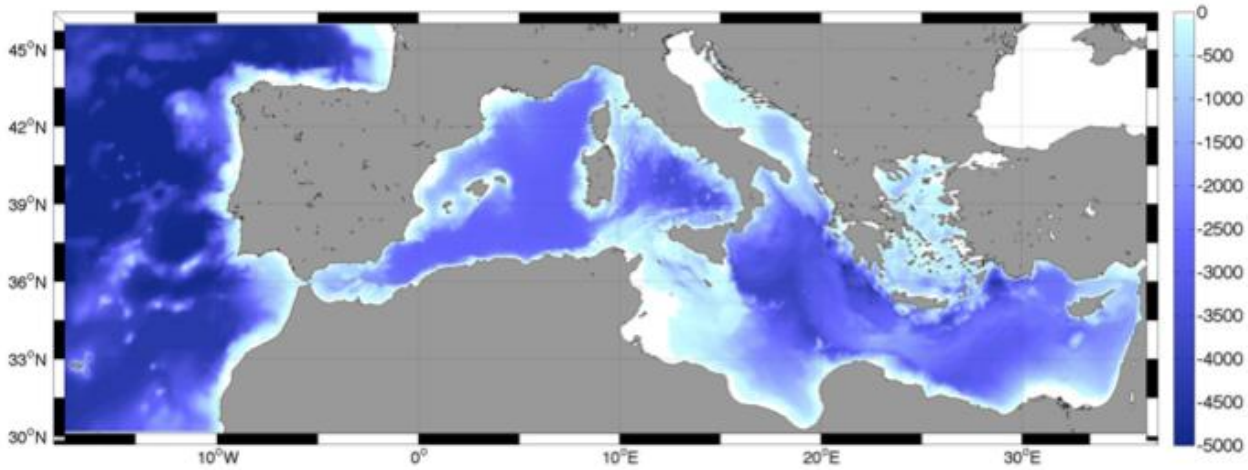


Figure 3.8-9 Bathymetry of MFS study area.

The Nucleus for European Modelling of the Ocean (NEMO,http://www.nemo-ocean.eu) is used for the hydrodynamics component and WaveWatch-III (http://polar.ncep.noaa.gov/waves/index2.shtml) for the wave component.

Ocean measurements from satellites (SLA) and in situ (temperature and salinity from ARGO floats, CTD and XBT) are assimilated on a daily basis, following a weekly cycle of assimilation.

The NEMO code solves the primitive equations using the linear free surface formulation and it uses vertical partial cells to best fit the bottom topography. Seven rivers are considered as volume input: Ebro, Rhone, Po, Vjose, Seman, Bojana and Nile, moreover the Dardanelles Strait is closed but considered as a river in terms of net volume source.

The WWIII model solves the wave action balance equation in slowly varying depth domain, considering a superposition of the following source/sink terms: wind input growing action based on Janssen's quasi-linear theory of wind-wave generation, a dissipation source term, white-capping theory and nonlinear resonant wave-wave interactions modelled using the Discrete Interaction Approximation (DIA). The spectral discretization is obtained through 30 frequency bins ranging from 0.05 Hz (20 s) to 0.79 Hz (1.25 s) and 24 equally distributed directional bins.

- Data Assimilation
  - The data assimilation system is a variational schemedeveloped with a specific background error correlation matrix formulation. The assimilated data include sea level anomaly, in situ temperature profiles from VOS XBTs (Voluntary Observing Ship-eXpandable BathyThermograph), in situ temperature and salinity profiles from ARGO floats, and in situ temperature and salinity profiles from CTD and gliders. Satellite objectively analyzed Sea Surface Temperature is used for the correction of surface heat fluxes.
  - All the assimilated observations are provided by the Thematic Assembly Centers of Copernicus (http://marine.copernicus.eu/).

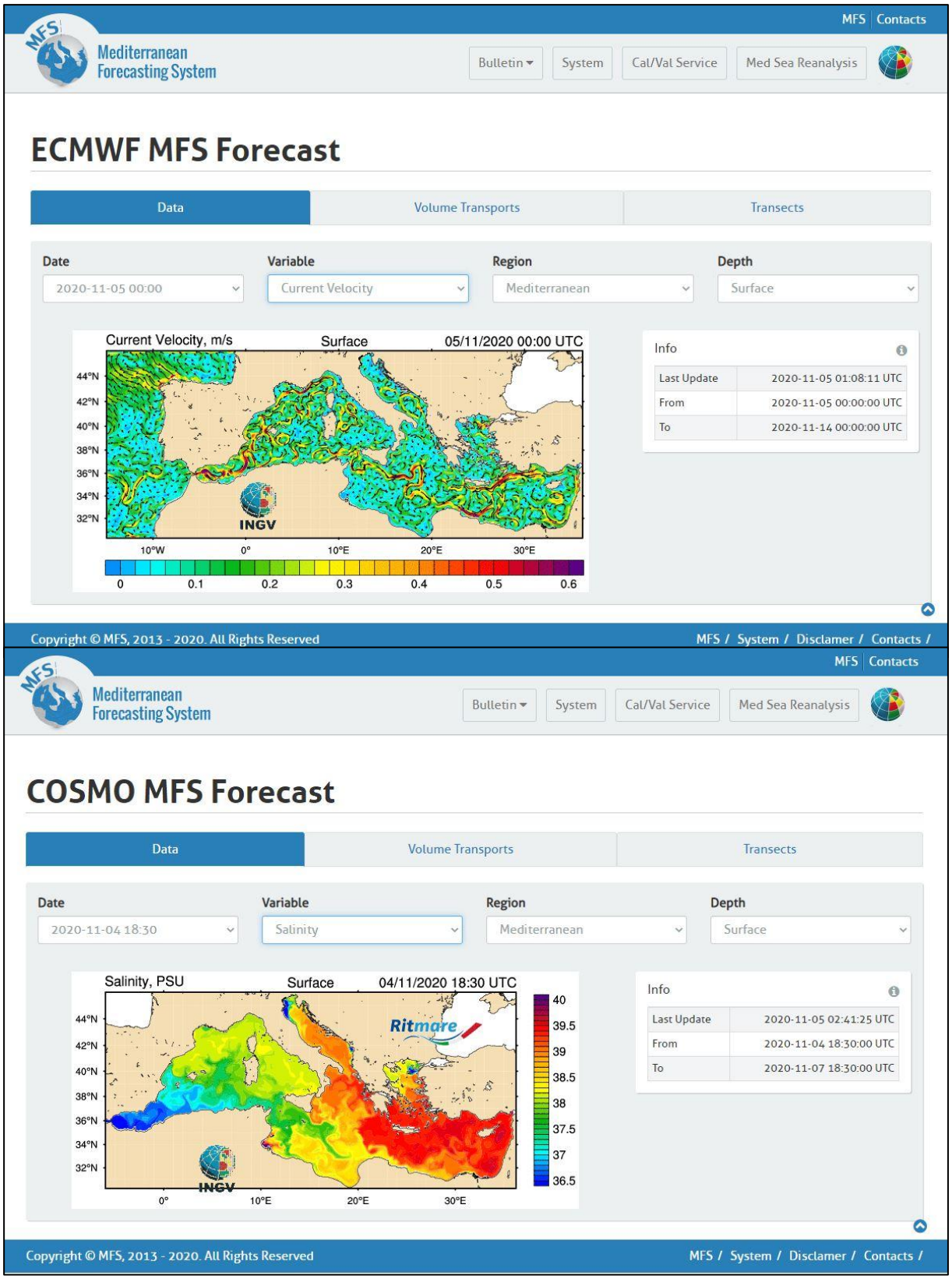


Figure 3.8-10 ECMWF and COSMO MFS forecast dissemination environment: 2-D horizontal maps.

- Cal/Val system
  - The quality assessment of the system is monitored weekly by the calculation of the root mean square statistics of difference between observations and model background fields (so-called misfits): http://medforecast.bo.ingv.it/mfs-copernicus-evaluation/
  - The systems performance is also evaluated by considering independent data at fixed stations around the Mediterranean Sea and results are displayed here: http://calval.bo.ingv.it
- Production Cycle
  - Analysis are produced weekly, on Tuesdays, for the previous 14 days. The assimilation cycle is performed on a daily basis and it runs in filtered mode. In the ECMWF MFS two products are available with a different frequency of output. A 10-day forecast is produced as daily means whereas a 5-day forecast has an hourly output frequency. In the COSMO MFS a 3-day forecast is produced both with hourly and daily output.
  - Each forecast is initialized by a hindcast every day except for Tuesday, when the analysis is used instead. The production cycle of ECMWF MFS is represented here below.

Results are provided in 2-D horizontal maps, but also in timeseries graph format and cross-sectional 2-D vertical depictions (Figure 3.8-13).

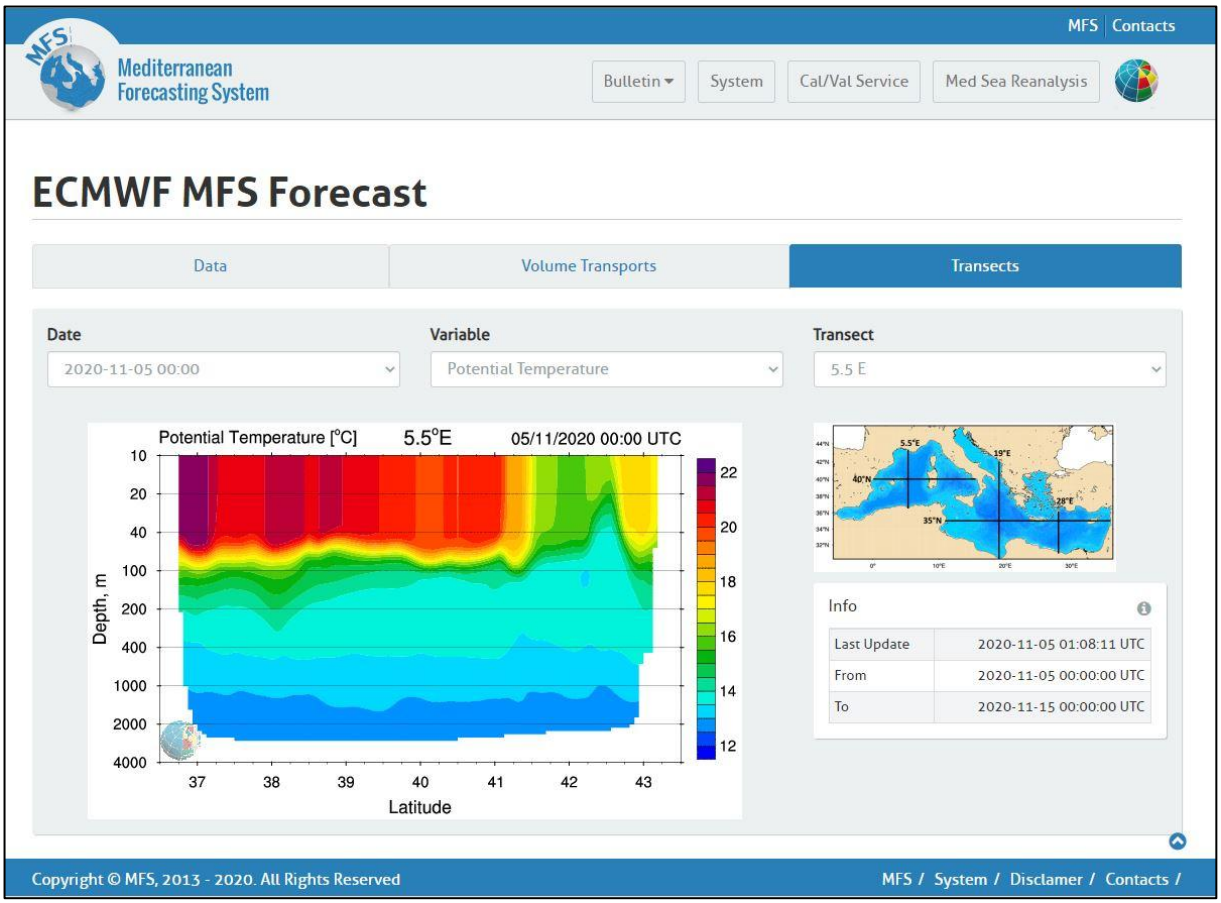


Figure 3.8-11 ECMWF MFS forecast dissemination environment: oceanographic cross-sections.

4. BLACK SEA REGION TRANSBOUNDARY ISSUES. NEED OF REGIONAL COOPERATION.

4.1 Overview on cross-border cooperation. Transboundary issues. Need of regional cooperation

Isolation from the flushing effects of the open ocean, coupled with its huge catchment, has made the Black Sea particularly susceptible to eutrophication (the phenomenon that results from an over-enrichment of the sea by plant nutrients). Eutrophication has led to radical changes in the Black Sea ecosystem in the past three decades with a major transboundary impact on biological diversity and human use of the sea, including fisheries and recreation.

Prior to the 1990s, little or no action had been taken to protect the Black Sea. Political differences during the Soviet era, coupled with a lack of general knowledge of the environmental situation resulted in an absence of effective response.

In response to increasing demand for fisheries products coastal countries are now trying to benefit from their own new opportunities by investing in a contemporary fishing fleet and processing factories. Since the late 1980s it became evident that fish resources would not be able to keep pace with rapid and, in most cases, uncontrolled exploitation, immediately requiring the introduction of new methods for fisheries management or an ecosystem approach aimed at conserving biological resources and the state of the environment.

In 1992 the Black Sea countries signed the Bucharest Convention followed closely by the first Black Sea Ministerial Declaration (the Odessa Declaration) in 1993. This inspired the GEF and other donors, particularly the European Union, to provide more than US$17 million support to the region to help implement the Odessa Declaration and to formulate the longer-term Black Sea Strategic Action Plan (BS SAP).

The Sofia Ministerial Declaration was signed in Sofia, Bulgaria on 7 June 2018 by the ministers and high-level representatives of Black Sea riparian countries in conclusion of the High-level Conference on Black Sea fisheries and aquaculture. The Sofia Declaration sets concrete objectives and actions that should help develop a comprehensive regional governance in the Black Sea. This should be achieved thanks to greater solidarity and coordination among all riparian countries in order to fight illegal unreported and unregulated fishing (IUU), improve data collection and science, improve fisheries management, and support sustainable small-scale fisheries and aquaculture. The many threats faced by the Black Sea, a peculiar marine basin with specific environmental conditions and human activities, need indeed to be properly addressed in order to secure the region's ecological and economic wealth and viable livelihoods for coastal communities.

The need of regional cooperation comes from the multiple EU and International policies, as presented above in Section 1. The practical aspects of such cooperation and coordination of monitoring activities comes directly from the MSFD requirements, despite for the non-EU Member States, Russia, Ukraine, Georgia and Turkey, which have 86% of the Black Sea's coastline length, the EU directives are not obligatory. There is obvious need of unique approach of collecting, and common data formats to exchange data regarding Qualitative descriptors for determining Good Environmental Status (4.1.1)

Table 4.1.1 Qualitative descriptors for determining Good Environmental Status (MSFD)

Qualitative Descriptors for determining Good Environmental Status (MSFD, Annex I)		International tools	EU policies
D1	Biological diversity is maintained. The quality and occurrence of habitats and the distribution and abundance of species are in line with prevailing physiographic, geographic and climatic conditions.	• BWMC Ballast Water Management Convention • Convention on Biological Diversity (CBD) • Ramsar Convention[1]	• EU Biodiversity Strategy • Birds and Habitat Directives • Water Framework Directive (WFD) • EIA and SEA Directives
D2	Non-indigenous species introduced by human activities are at levels that do not adversely alter the ecosystems.	• BWMC • CBD	• EU Biodiversity Strategy • Birds and Habitat Directives • WFD • Regulation No. 708/2007 • Regulation 1143/2014
D3	Populations of all commercially exploited fish and shellfish are within safe biological limits, exhibiting a population age and size distribution that is indicative of a healthy stock.		• Common Fishery policies[2] • Regulation No. 2347/2002[3]
D4	All elements of the marine food webs, to the extent that they are known, occur at normal abundance and diversity and levels capable of ensuring the long-term abundance of the species and the retention of their full reproductive capacity.	• BWMC • CBD • Ramsar Convention	• EU Biodiversity Strategy • Birds and Habitat Directives • WFD • EIA and SEA Directives
D5	Human-induced eutrophication is minimised, especially adverse effects thereof, such as losses in biodiversity, ecosystem degradation, harmful algae blooms and oxygen deficiency in bottom waters.	• MARPOL	• WFD • Nitrates Directive • Urban Wastewater Treatment Directive
D6	Sea-floor integrity is at a level that ensures that the structure and functions of the ecosystems are safeguarded and benthic ecosystems, in particular, are not adversely affected.	• BWMC • CBD • Ramsar Convention	• EU Biodiversity Strategy • Birds and Habitat Directives • WFD • EIA and SEA Directives
D7	Permanent alteration of hydrographical conditions does not adversely affect marine ecosystems.		• WFD • Nitrates Directive • Urban Wastewater Treatment Directive • EIA and SEA Directives • MSFD • Habitat and Birds Directives
D8	Concentrations of contaminants are at levels not giving rise to pollution effects.	• MARPOL	• WFD • Nitrates Directive • Urban Wastewater Framework Directive • Port reception facilities Directive 2019/883
D9	Contaminants in fish and other seafood for human consumption do not exceed levels established by Community legislation or other relevant standards.		• WFD • EU Regulation No. 1881/2006 on contaminants in foodstuff[4]
D10	Properties and quantities of marine litter do not cause harm to the coastal and marine environment.	• MARPOL	• Urban Wastewater Treatment Directive • Port reception facilities Directive 2019/883 • Waste Framework Directive[5] • Directive 2019/904 on the reduction of plastic products
D11	Introduction of energy, including underwater noise, is at levels that do not adversely affect marine environment.	• MARPOL (2011 amendment)	• EIA, SEA, Birds and Habitat Directives

[1] Convention on Wetlands of International Importance especially as Waterfowl Habitat - www.ramsar.org
[2] https://ec.europa.eu/fisheries/cfp_en
[3] Council Regulation (EC) No. 2347/2002 establishing specific access requirements & associated conditions applicable to fishing for deep-sea stocks
[4] Commission regulation (EC) No 1881/2006 of 19 December 2006 setting maximum levels for certain contaminants in foodstuffs https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2006:364:0005:0024:EN:PDF
[5] Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain Directives (Text with EEA relevance) - https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32008L0098

The main challenges to the regional cooperation can be considered as follows:

- Reduce eutrophication/nutrient enrichment
- Preserve changes in marine living resources
- Fight Chemical pollution (including oil)
- Preserve Biodiversity/ prevent habitat changes, including alien species introduction

There are a number of positive trends in the region that need to be mentioned:

The major strength in the Black Sea monitoring is the regional cooperation of all Black Sea countries. At Regional Sea level in the framework of the Bucharest Convention (Convention on the Protection of the Black Sea Against Pollution, Black Sea Commission), there is the regional monitoring programme BSIMAP (Black Sea Integrated Monitoring and Assessment for years 2017-2022) based on national monitoring programmes and financed by the Black Sea States. There is solid base of the regional cooperation, set in the Sofia Ministerial Declaration (2018).

Most of the monitoring activities are based on EU/NATO/UNDP funded projects.

Several inter-comparison exercises have been organized and collaboration within recent WFD/MSFD supporting projects (SESAME, PERSEUS, CoCoNet, MISIS, EMBLAS, EMBLAS-II, EMBLAS Plus) contribute to generating new data and advance application of harmonized approaches and indicators.

In the same time, there are some barriers for the coordination of marine research activities and improving of regional cooperation:

For the non-EU Member States, Russian Federation, Ukraine, Georgia and Turkey, which have 86% of the Black Sea's coastline length, the EU directives are not obligatory, which is a potential threat for the integrated regional monitoring activities. The lack of integrated monitoring could generate difficulties in identifying the most adequate cause/effect relationships and formulation of proper management options.

In spite of accomplished standardizations in data collection, analysis and assessment methods and representativeness of different water bodies of the Black Sea, a serious deficiency in spatial and temporal resolutions in the areas monitored is apparent.

Poor geographical coverage: measures do not reflect all monitoring activities being carried out by the six countries (Bulgaria, Romania, Ukraine, Russia, Georgia, Turkey) surrounding the Black Sea. All countries have their own national programmes concerning monitoring of particular biodiversity.

The monitoring activities are not planned to cover all seabed and water column habitats of the region especially for the non-EU waters and the Sea of Marmara.

The regional programmes do not adequately address pressures except for nitrogen, phosphorus and organic matter enrichment and there is poor simultaneous monitoring of pressures within monitoring programmes.

Although, monitoring data are used in Ukrainian legislation for the designation of MPAs for integrated coastal zone management, the data are poorly used in legislation regarding the identification of operational objectives and development of measures for

marine management. The Ukrainian marine policy is currently being reformed in line with MFSD.

In general, there is insufficient financial support of monitoring and poor coordination between responsible authorities.

Despite the Black Sea regional initiatives such as Black Sea GOOS (ARGO floats and other drifters in the Black Sea), as well as participation in the MyOcean program, the bio-ecological operational oceanography is still poorly developed.

Infrastructure improvements and effective introduction of less applied approaches (such as remote sensing, underwater video surveys, side-scan sonar techniques, satellite imagery should be considered as overarching and critical issues for implementation of the MSFD.

There is a lack of a fixed network of sampling stations with regular and long-term observations.

There is also lack of efficient data exchange and integrated outputs (intercalibration between different networks) stands as an obstacle for data management and quality issues in intergovernmental levels.

All the above claims for further efforts to improve the coordination of marine research activities and improving of regional cooperation in environmental monitoring for assessment of fish stock and non-fish living resources.

4.2 Towards better planning of joint monitoring activities. SWOT Analysis.

Here below a SWOT analysis is presented, to serve as a strategic planning technique used to help TIMMOD consortium, and all involved stakeholder organizations, to identify Strengths, Weaknesses, Opportunities, and Threats related to joint monitoring and modelling for assessment of fish stock and non-fishing resources of Black Sea.

This analysis is based on the SWOT analysis on the Black Sea monitoring developed by Patrício J. et al. (2016) - *European Marine Biodiversity Monitoring Networks: Strengths, Weaknesses, Opportunities and Threats*, now updated with fish assessment aspects, as per latest developments of EU policies and regional activities in the subject, and reflecting the view point of the TIMMOD network.

Table 4.2.1 SWOT Analysis on joint monitoring and modelling for assessment of fish stock and non-fish living resources

STRENGTHS	***WEAKNESSES***
There is now common understanding and good will for joint actions, as the six Black Sea countries (Bulgaria, Romania, Ukraine, Russia, Georgia, Turkey) have joined the Common Maritime Agenda (CMA), and the Strategy Research and Innovation Agenda (SRIA) for Black Sea, with the support of the EC. At Regional Sea level in the framework of the Bucharest Convention (Convention on the Protection of the Black Sea Against Pollution, Black Sea Commission), there is the regional monitoring programme BSIMAP (Black Sea Integrated Monitoring and Assessment Program for years 2017-2022) based on national monitoring programmes and financed by the Black Sea States. Joint monitoring is supported by GFCM initiates - for example the joint survey for the Rapana venosa in autumn 2020, that started in Bulgaria, Romania, Ukraine, Tureky and Georgia. It can be expected that joint monitoring wll be boosted also by the Sofia Ministerial Declaration (2018). Most of the marine monitoring activities are based on EU/NATO/UNDP funded projects. Five of the national programmes monitor three or more biodiversity components simultaneously. Among the biodiversity components, phytoplankton, zooplankton and benthic invertebrates are monitored in all areas, being monitored by 4 (EU waters), 3 (non-EU waters) and 3 (Sea of Marmara) programmes. Nitrogen, phosphorus and organic matter enrichment are the pressures covered by highest proportion of monitoring networks in the region. Monitroing programs encompass significant part of seabed habitats, but large part of them remained data deficient, or only partly studied. Manuals on sampling and analysis, including guidelines on equipment, site selection, abundance, biomass, blooms and taxonomic identification have been developed and used for soft-bottom macrozoobenthos (Todorova & Konsulova, 2005), zooplankton (Korshenko & Alexandrov, 2006) and phytoplankton (Moncheva, 2010; Moncheva & Parr, 2010).	Poor geographical coverage: measures do not reflect all monitoring activities being carried out by the six countries (Bulgaria, Romania, Ukraine, Russia, Georgia, Turkey) surrounding the Black Sea. All countries have their own national programmes concerning monitoring of particular biodiversity; only Bulgaria, Ukraine and Turkey reported for the catalogue. Several descriptors of the GES, according to MSFD are not fully addressed by the monitoring programs in the region and many indicators (of the MSFD descriptors), concerning food webs, NIS, sea floor integrity, etc need further development. The proportion of monitoring programmes that address a single descriptor is high. Marine bacteria & viruses are not fully studied, thus the process and changes in the marine microbiome remained widely unknown. The monitoring activities are not planned to cover all seabed and water column habitats of the region especially for the non-EU waters and the Sea of Marmara. Several Black Sea specific habitats (i.e. gas seepages, mud volcanoes, oxic/anoxic layer, deepsea oceanic waters) are insufficiently monitored and studied. Different pressures on marine ecosystem are not fully addressed by the regional monitoring programs.. According with the information reported in the catalogue, the EU Black Sea waters are the least well covered by pressure related monitoring activities. Although pressure related data are collected, the link with the biodiversity components is not clear and the monitoring is not carried out in the MSFD context. modern data exploitation tools and models are not sufficiently applied or not fully used in many of the regional scientific studies. Capacity development is a key requirement in the region, Level of data sharing within and among the countries is low. Databases with open access (especially for biological parameters of the ecosystem) are rarely found.

There has been significant recent progress in compiling monitoring manuals for meiobenthos and microzooplankton (not finalized), for harmonization of assessment methodologies, analytical techniques, reporting formats, application of unified set of indicators (protocol of 17th Meeting of Advisory group for Biodiversity Conservation). Several inter-comparison exercises have been organized and collaboration within recent WFD/MSFD supporting projects (SESAME, PERSEUS, CoCoNet, MISIS, EMBLAS, EMBLAS-II, EMBLAS Plus) contribute to generating new data and advance application of harmonized approaches and indicators. A regional database (known as Mnemiopsis) hosted by the Black Sea Commission was developed in 2008 (BlackSeaScene infrastructure Project) but needs further updating. An interoperable GIS enabled Regional Pollution Data Base, hosted by Regional Activity Centre (RAC) Pollution Monitoring Assessment (PMA) is being developed in the framework of Baltic2Black (BSC and HELCOM) Project. A common tool for assessment of eutrophication (BEAST) has been adopted (Baltic2Black Project).	Marine spatial planning and integrated coastal-zone management practices are in the inception phase in the Black Sea region. Despite the positive trends for enhancement of the Black Sea regional cooperation within CMA and SRIA, it could be mentioned that Russia is not included in some programs under EU cooperation mechanism (e.g. the Black Sea CBC programme) that could be counted as a weakness, together with some political tension between some Black Sea countries. Although, monitoring data are used in Ukrainian legislation for the designation of MPAs for integrated coastal zone management, the data are poorly used in legislation regarding the identification of operational objectives and development of measures for marine management. The Ukrainian marine policy is currently being reformed in line with MFSD. There is insufficient financial support of monitoring and poor coordination between responsible authorities. Despite the Black Sea regional initiatives such as Black Sea GOOS (ARGO floats and other drifters in the Black Sea), as well as participation in the MyOcean program, the bio-ecological operational oceanography is still poorly developed. Lack of advanced genetic and genomic methodologies for taxonomic revisions including microbes and viruses. Lack of a fixed network of sampling stations with regular and long-term observations. Lack of efficient data exchange and integrated outputs (intercalibration between different networks) stands as an obstacle for data management and quality issues in intergovernmental levels.
OPPORTUNITIES The GFCM and National programs for data collection in the filed of Fisheries (in the EU countries) support data collection, data exchange and scientific advice in the field of BS fisheries. New opportunities for cooperation in marine research for fisheries and aquaculture appear after the six Black Sea countries joined their efforts within the framework of the Common Maritime Agenda (CMA), and the Strategy Research and Innovation Agenda (SRIA) for Black Sea. Infrastructure improvements and effective introduction of less applied	***THREADS*** For the non-EU Member States, Russian Federation, Ukraine, Georgia and Turkey, which have 86% of the Black Sea's coastline length, the EU directives are not obligatory, which is a potential threat for the integrated regional monitoring activities. The lack of integrated monitoring could generate difficulties in identifying the most adequate cause/effect relationships and formulation of proper management options. In spite of accomplished standardizations in data collection, analysis and

approaches (such as remote sensing, underwater video surveys, Continuous Plankton Recorders, side-scan sonar techniques for habitat mapping, Ship of opportunity / FerryBox systems) should be considered as overarching, and thus as a good opportunity for cooperation for implementation of the MSFD. The descriptors catalogue provides evidence for various sampling frequencies within the Black Sea monitoring networks. This leads to the necessity to address scales (temporal and spatial) as a crucial issue for adequate monitoring efforts.The descriptors catalogue assesses the gaps of existing QA/QC procedures and thus provides opportunities to further addressing the issue towards improving the reliability of the assessments. There is increasing cooperation between the Black Sea countries and progress on the integration of monitoring with EU directives. This opportunity enhances the state-of-art of monitoring in the region. Turkey, with almost 35% of coastline length coverage, is a candidate state and proceeds efforts to reorganize its monitoring activities to be integrated with the EU directives. The Sea of Marmara, although not an EU Regional Sea, is the connection between the Mediterranean and Black Sea. Integrating the local ongoing monitoring programmes within the regional networks can improve the MSFD implementation in the neighbour regional seas. Opportunities lies also in development of institutional coordinating mechanisms, especially between national and local authority levels; provision of stable financial resources to support innovative, transparent, and robust local development; linking maritime spatial planning and infrastructure development strategic planning; innovation in smart infrastructure development.	assessment methods and representativeness of different water bodies of the Black Sea, a serious deficiency in spatial and temporal resolutions in the areas monitored is apparent. The deficiency of monitoring for some of the descriptors for the MSFD affects the level of knowledge that might be crucial for adequate understanding of the ecosystem processes. Integrating the Sea of Marmara monitoring activities in the international networks it is not straightforward because it is an inland sea of Turkey.

The above SWOT analysis can be used as a tool for evaluation of the possible role of Black Sea states and relevant marine research organisations in establishing the joint monitoring mechanism of the Black Sea ecosystem.

It is intended to contribute to identify the internal and external factors that are favorable and unfavorable to achieving the main objectives of the TIMMOD project – raise quality and improve regional cooperation in monitoring and modelling, by promoting innovative technologies, towards improving joint activities and data sharing platforms in fish stock and non-fish living resources assessment.

5. CONCLUSIONS AND RECOMMENDATIONS TO INCREASE THE EFFICIENCY OF USE OF EXISTING (AVAILABLE) METHODS AND TOOLS

In accordance to the considerations and analyses presented here above in this report the following main conclusions can be drawn:

- The present report provides baseline information upon the situation analysis of environmental monitoring and assessment of fish stock and non-fish living resources of Black sea, that will serve to contribute on the enhancement of joint environmental monitoring and modelling, and to improve the availability and quality of marine data. This information will help to improve the cooperation in sharing of data for water quality, biodiversity statistic - in line with the EU's Marine Strategy Framework Directive (MSFD), Data Collection Framework (DCF), Blue Growth Strategy, Black Sea Convention on Environmental Protection and other EU and regional policies and conventions.
- Within the analysis in Section 1, it was found, that in marine fish stock assessment monitoring (in EU, and in Black Sea in particular), focus is put on (illegal) catchment control, rather than to environmental/preventive monitoring. This finding claims for further efforts in raising preventive role of environmental monitoring of Black Sea ecosystem, for providing detailed spatial coverage and temporal resolution of data required to preserve eco-systems and provide sustainable use of resources.
- As a result of this study, it was found that at present very little (or almost no) advanced monitoring tools to provide data on the marine environment and fish stocks (such as satellite images, sea drones, gliders, high-generation multi-beam sonars) are used by the key monitoring performers along the Black Sea. Such tools are widely used in the practice of providing marine data for Copernicus, EMODnet and others big data platforms.
- It should be stressed that the present study shows that there is a sharp disparity between the quantity and quality of monitoring equipment (and in particular of number of research vessels), available in the different Black Sea countries. While in some countries (Turkey, Ukraine) there are many research vessels equipped at a modern level, in other countries (Georgia, Bulgaria) the number of such ships is quite limited, and is reduced to 1-2. This issue needs to be properly addressed if a cooperation on equal terms and in mutual interest is pursued. The above situation is similar with the operation and access to large databases and platforms for data interchange (such as Copernicus, EMODnet, etc.) and in particular to data related to fisheries and aquaculture - where the EU member states - Romania and Bulgaria - have some advantages with guaranteed access and full membership.
- Existing observations at Black Sea mostly lack the spatial coverage and temporal resolution required to determine the state of the marine environment and changes within it. To overcome these problems, the use of "ships-of-opportunity" such as

ferries or other ships on regular routes offer a cost-effective and reliable possibility to obtain regular observations on near surface water parameters. Based on the analyses in the present report, it can be concluded that there is a clear trend towards changing the classic approach to the environmental monitoring of the Black Sea - from the use of specialised research vessels or classic buoys, to the use of the FerryBox systems on "ships-of-opportunity" with corresponding sensors and data loggers. Such systems can be operated with lower costs and have better performance with regard to biofouling.

Based on the findings of the present report and on the above conclusions, the following recommendations are suggested for continuing activities within the TIMMOD project, as well as for involving key stakeholders for improving regional cooperation in marine environment monitoring:

- A special report on inventory of advanced monitoring technologies for assessment of fish stock and non-fishing living resources will be elaborated within TIMMOD activity GA T1, Activity 1.2. It is recommended that this study shall cover in depth such advanced tools as satellite images, sea drones, gliders, high-beam sonar, hydro-acoustic measuring devices, etc., including investigation on compatibility of data between the Black Sea surveyors, as well as with the major European marine data portals Copernicus and EMODned.
- It is recommended to make maximum use of the forthcoming TIMMOD Thematic Transboundary Meetings (TTM) for training of partners, as well as other researchers and surveyors, on the use of someadvanced monitoring techniques, as wel as for dissemination of project results, familiarization of key stakeholder with main project findings, in order to promote regional cooperation, including through joint participation in new projects funded by the EU and other sources.
- Specific targeted actions are needed to facilitate access to large databases and platforms for interstate exchange (Copernicus, EMODned). This may include initiating of training events in order to raise capacity of researchers and surveyors involved in the topic, within the TIMMOD network, or using other cooperation instruments outside the project framework.
- Considering the analyses in Section 2.8 and 3.8 of this report, the following principles to base the future pilot TIMMOD monitoring platform are recommended:
  - One-time data collection and multiple times use;
  - Develop standards across disciplines as well as within them;
  - Process and validate data at different scales and levels. The structures are already developed at national level but infrastructure at Black Sea basin is needed;
  - Provide sustainable financing at an EU cross-border level to extract maximum value from the efforts of individual Member States;
  - Build on existing efforts where data communities have already organized themselves;
  - Develop a concise decision-making process for priorities that are user-driven;

- Accompany data with statements on rights of use, accuracy, precision, etc.;
- Recognise that marine data is a public good and discourage cost-recovery pricing from public bodies;
- Capitalize on already established knowledge about marine data handling (Copernicus, EMODnet, etc.).

- Access to marine data is of vital importance for marine industries, decision-making bodies, and scientific research. TIMMOD efforts shall be focused to contribute to an effective Black Sea marine data infrastructure that will:
  - enable effective and efficient marine spatial planning and legislation for environment and fisheries;
  - reduce uncertainty in our knowledge and ability to forecast the behaviour of the Black Sea waters;
  - improve offshore operators' efficiency and costs in gathering and processing marine data for operational and planning purposes;
  - stimulate competition and innovation in established and emerging maritime sectors.

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Section 4

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