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

Deliverable D.T1.3.1

Recommendations on adoption of appropriate technology innovation and promotion of best practices for marine environmental monitoring at Black Sea

TIMMOD

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INTRODUCTION

This report presents tailor-made recommendations on spread-out and adoption of identified appropriate technology innovation and best practices for water environmental monitoring and collecting data for non-fish and fish stock assessments (e.g., stock structure, age / size composition).

The report is Deliverable DT1.3.1 "*Recommendations on adoption of appropriate technology innovation and best practices for marine environmental monitoring at Black Sea*", elaborated within Group Activity T1, activity T1.3, in the period February 2021-September 2021, in accordance with the work plan of TIMMOD BSB-1029 project within the Black Sea Basin Program 2014-2020.

The report is developed as a collective effort of the 6 TIMMOD partners from the Black Sea region, from Bulgaria, Georgia, Moldova, Romania, and Greece, under the coordination of the Group Activity T1 Leader, BDCA, in cooperation with the Lead Beneficiary IFR.

The recommendations on adoption of appropriate technology innovation and promotion of best practices for marine environmental monitoring at BS cover:

- various equipment/platforms, i.e., vessels, boats, buoys, satellites, autonomous surface vehicles, remote operated vehicles;
- new-generation sensors, by technology (e.g., acoustics, infrared); and by type (e.g., turbidity sensor, nitrate sensor, fish-count sensor, etc.);
- various methodologies of data collection/sampling/measurements, including methods/ tools of real-time measurements, advanced tools for water sampling for lab analysis, etc.;
- ICT tools / software for data handling/transmission technologies, e.g., radio telemetry, satellite transfer, etc.; software tools for data handling and visualization, including recent cloud technologies and web base solutions.

Data on non-fish and fish stock assessment are essential in order to be able to give advice on potential harvesting on commercial living resources (fish and shellfish), while preserving environment, and ensuring sustainable use of marine resources. This deliverable is using findings of previously developed technical reports DT.1.1. and DT1.2. and recommendations provided during the project thematic transboundary meetings (TTM-1, TTM-2, TTM-3). The technical report includes the following sections:

In Section 1 of this report a review on major barriers and enablers for introducing technology innovations in fishery research in Black Sea is presented. National aspects from the 5 countries represented in TIMMOD are discussed, while short reference to other Black Sea countries is also presented. Various regulatory and financial barriers are identified in the different countries. On the other hand, raising capacity and public awareness, including role of TIMMOD project is highlighted as an important enabler for technology advancement.

Section 2 of the report provides a more in-depth analysis of the environmental impact of the technical solutions already discussed in DT1.2.1. Key factors such as preserving marine environment, avoiding technologies generating water, air or noise pollution, are considering when assessing the possibilities for practical application of presented sensors, equipment, platforms.

Another key factor - the economical assessment of innovative technologies and good practices under consideration - is discussed in Section 3 of the report. A quick Market research (estimated price review based on internet investigation) and preliminary analysis on economical efficiency (estimated costs versus expected benefits) is presented.

Finally, based on the analysis of existing resources and potential presented in DT1.1.1, the detailed technological review presented in DT1.2.1, and the quick assessment of environmental impacts and economical efficiency given in this report, a selection of innovative solutions and relevant best practices for water quality monitoring, fish stock and non-fish resource assessment for the conditions of Black Sea is presented in Section 4. The list includes

- 12 advanced technological solutions applied in EU or world-wide (in-situ and remote operated sensors and instruments, sensor carrying platforms, numerical simulation and data handling software, GIS and other ICT tools (Table 4.2)
- 6 Best practices, operated by research organizations or private industries within the Black Sea and Mediterranean area, with potential for further replication and up-scaling in the Black Sea region (Table 4.4)

Recommendations on the Indicative roadmap for replication and up-scaling of suggested innovative technologies is also presented.

1. REVIEW ON REGULATIONS, NON-TECHNOLOGICAL BARRIERS AND ENABLERS FOR INTRODUCTION OF TECHNOLOGY INNOVATIONS BASED ON FINDINGS OF T.1.1. AND T1.2. AND RECOMMENDATIONS PROVIDED AT TTM-1 AND TTM-2

1.1 Regulatory, financial, and other barriers, that can hamper putting into operation innovative technologies and good practices considered in D.T1.1.1 and D.T1.2.1

1.1.1 Review for Bulgaria

Policy and regulatory barriers

The Bulgarian Government's intentions in each policy area are detailed in the full version of the National Development Programme "BULGARIA 2030", which includes a detailed indicative financial framework, a preliminary impact assessment and a mechanism for controlling and monitoring the implementation of the strategic documents".

The following main barriers, that can hamper putting into operation innovative technologies in all areas of the national economy are highlighted in the National Development Programme, as follows:

- Low funding innovation activities,
- Low internal potential of enterprises, absence of the adequately qualified staff, insufficient qualifications of the management, lack of strategic planning, etc.
- High investment risk in new technologies,
- Slow/Tough legal provisions and administrative procedures,
- Low public support

The above barriers are fully valid also regarding introduction of innovative technology solutions for marine survey, water quality monitoring, assessment of fish stock and non-fish resources.

In the meantime, in Bulgaria - being an EU-member state - the implementation of the technological upgrade processes has to be set in accordance with the MSFD, DCF, EU Blue Growth policy, BS-SAP and other EU and regional policies and conventions.

In that sense, it can be stressed that there are no real regulatory and legislative aspects than can hamper both:

a) Introduction of new, innovative, economically efficient technological solutions, and
b) transboundary cooperation and data-sharing ability,

concerning water quality monitoring, fish stock and non-fish resource assessment.

Nevertheless, the process of introducing advanced innovative technologies still need stronger political and regulatory support from the central government, providing facilitating mechanisms, preference terms and conditions.

Financial aspects

Considering the financial aspects, it is known that Bulgaria is the EU state with lowest GDP, lowest incomes, and restricted potential for investments in (high risk) innovative technologies.

In Bulgaria, research and innovation funding is concentrated mostly through the Bulgarian National Science Fund at the Ministry of Education and Science and through the European structural and investment funds. The National Operational Programme "Competitiveness" provides some funding for innovative projects, however the available funds are insufficient, and therefore the number of granted innovative projects is very low.

It should be stressed therefore that each delivery of any monitoring equipment or/and software by public funding shall be accompanied by a very detailed and comprehensive cost - benefit analysis, in particular, when concerning delivery of environmental monitoring equipment relevant to water quality monitoring and fish stock, or non-fish resource assessment.

According to a Eurostat database analysis, the key barriers to innovation activities, identified based on the percentage of innovative enterprises' indications to high importance of specific barriers (top 3 positions), are associated with cost factors; among the 3 most important barriers to innovation activities, 3 or 2 cost barriers are listed in 8 and 10 EU countries, respectively, and, in addition, the high costs barrier groups as many as 10 countries presenting high indication percentage of all enterprises in the range [24,8% - 36,05%]. It is worth noting that the "Lack of collaboration partners" is top rated in

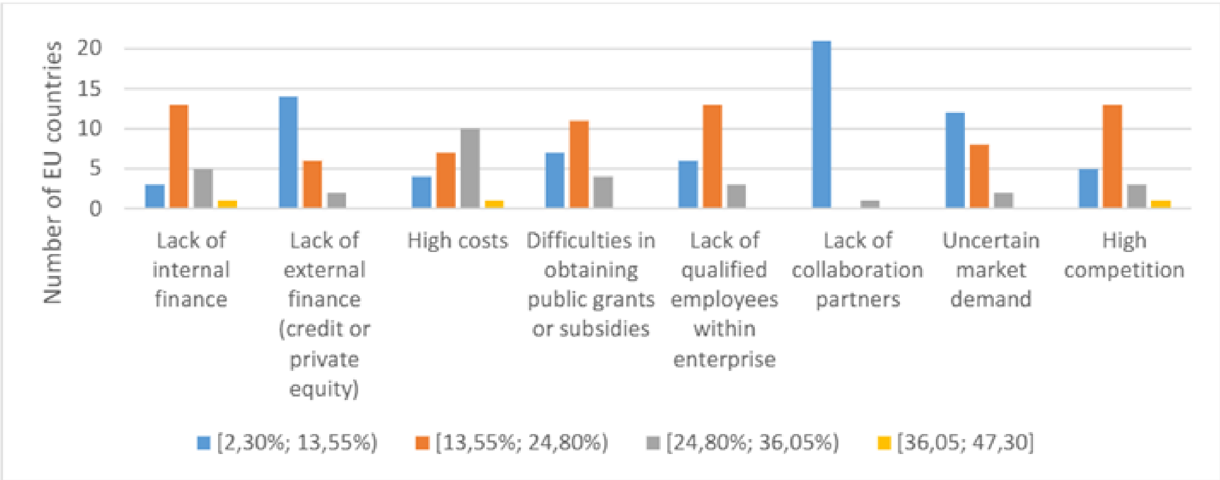

Figure 1-1The histogram of innovative enterprises' indications identifying significant barriers to innovation activities in EU countries
(source: compilation from Eurostat database)

Cost barriers to innovation activities can be mentioned as a key barrier also for Bulgaria, the EU country with lowest potential for investment in high risk innovative developments.

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1.1.2 Review for Romania

Policy and regulatory barriers

The national strategy for the sustainable development of Romania 2030, was adopted by the Romanian Government in the meeting of November 9, 2018, by GD no. 877/2018.

Romania's 2030 Sustainable Development Strategy is the "lighthouse " that guides the implementation of the UN's 2030 Agenda in all sectoral policies that can promote sustainable development at the national level. Under Objective 14 - Aquatic life, of those 17 sustainable use objectives of UN's 2030 Agenda, Romanian 2030 strategy ”aims to prevent and reduce marine pollution, manage and sustainably protect marine ecosystems, conserve coastal areas and ensure sustainable fishing”.

The vision regarding the Research Development and Innovation (RDI) system and the identification of the internal needs in economic and political context were materialized in the RDI Strategy 2014 - 2020 approved by GD 929/2014.

The RDI strategy is implemented through a number of instruments, mainly through the National Plan for Research, Technological Development and Innovation 2014-2020 (PNCDI III) and through the Operational Program "Competitiveness" - the priority axis "Research, technological development and innovation to support business and competitiveness ".

In 2020, Romania has reached only 3 targets out of the 16 officially assumed 7 years ago in the "National Strategy for Research, Development and Innovation 2014-2020" - according to an analysis conducted by INACO on the state of implementation.

"The June 2020 study published by McKinsey , ”Innovation in a crisis; Why it is more critical than ever” shows that the innovation bet is the answer to the post-COVID-19 economic recovery. But very few big business leaders are prepared to face this challenge. Romanians are creative individually. Organizational? Last place in the EU. Why? Because we are only talking about innovation and research, but we are confining them to a bureaucratic system that is suffocating them (INACO).

Obstacle to environmental innovation are mainly linked to uncertainty and associated costs of innovation activities (Pinget A & R. Bocquet 2014). The major barriers to innovation in European firms related to the education system and skilled labour, the effect of venture capital and banks on financing innovation, and the influences of norms, legislation, and public bureaucracy. The firms postponing projects are more prone to face obstacles linked to economic risk, lack of skilled personnel, innovation costs, lack of customer responsiveness, lack of information on technologies, and organizational rigidities. These obstacles constitute four groups, related to risk and finance, knowledge, the knowledge-skill outside the enterprise, and regulation. The lack of internal human capital (skilled personal) complements all other obstacles in almost all industries. At the European level, in an action plan, ETAP (the European Commission’s Environmental Technologies Action Plan) pointed several barriers to environmental innovation: economic barriers, some regulations or standards inappropriate, insufficient and weak research system, and a lack of market demand (European Commission, 2004). Regulations, as opposed to supply chain partners (contractors), are a significant source of coercive pressures, reflecting the effectiveness of regulatory efforts in guiding green behaviours. Environmental regulation is one of the main driven factors for SMEs to introduce environmental innovation but large Enterprises have more mature environmental strategies towards innovation.

Rumania - as an EU-member state – must to implements the environmental innovation in accordance with the MSFD, DCF, EU Blue Growth policy, BS-SAP and other EU and regional policies and conventions.

Financial aspects

Romanian finances environmental technologies and innovation mainly through the National Plan for Research, Technological Development and Innovation 2014-2020 (PNCDI III) and through the Operational Program "Competitiveness" - the priority axis "Research, technological development and innovation to support business and competitiveness ". However, theological and innovation transfer from RDI entities to the industry is rather low effectiveness.

1.1.3 Review for Georgia

Policy and regulatory barriers

The monitoring activities are not covering all seabed and water column habitats of the region, especially for the non-EU waters. . 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.

For the non-EU Member States, the 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.

Inconsistencies within the water-related legislation are the main challenge for taking the proper steps towards the establishment of a modern water management system at the national level. The AA sets obligations for Georgia on the approximation of its legislation with the EU Water Framework Directive (WFD) and other water quality-related regulations. Although the draft Water Law and some draft secondary legislation, reflecting EU approaches, is in place, further efforts are needed to, first of all, adopt these pieces of legislation and second, ensure their effective implementation (e.g. THIRD NATIONAL ENVIRONMENTAL ACTION PROGRAMME OF GEORGIA setting the proper institutional scheme for achieving integrated river basin management). Therefore, the development of a water resources management system is one of the priorities in the coming years. Although as mentioned above the trend of monitoring network extension has been well-noticed in recent years, additional efforts are needed. The establishment of a reporting, data management, and use system is also crucial for planning and implementing these adequate measures. Considering the above-mentioned data the following long-term goal (2030) and three five-year targets have been identified in water resources management.

There are several positive trends in the region that need to be mentioned. The major enabler in the Black Sea monitoring is the regional cooperation of all six countries. However, a rapid increase in the range, capability, and accessibility of new technologies, which is the main challenge for the water monitoring sector. Infrastructure improvements and effective introduction of less applied approaches (such as remote sensing, underwater video surveys, Continuous Plankton Recorders, side-scan sonar DT4.1.1. Technical report Page 75 of 83 techniques for habitat mapping, Ship of opportunity / FerryBox system) should be considered as overarching and critical issues for implementation of the MSFD. · 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.

Financial aspects

Georgia is not an EU member state so it needs more investments in innovative technologies.

In Georgia, research and innovation funding is concentrated mostly through the Georgian National Budget Fund from the Ministry of Environment Protection and Agriculture and donors such as EU, UNDP etc.

It should be noted that in recent years the amount of funding for the LEPL National Environment Agency (NEA) of the Ministry of Environment Protection and Agriculture allocated to environmental monitoring has increased significantly. In 2018 New laboratory infrastructure were built in Tbilisi which is equipped with state of art model equipment and is accredited by ISO -17025:2018, In -2021 the NEA started construction of the new laboratory building in Batumi which will be equipped with the state of the art equipment for the Black Sea surveys. The infrastructure will be fully in line with the international standards and requirements for the laboratories

Despite the above-mentioned fact in general, there is the insufficient financial support of monitoring and poor coordination between responsible authorities in the direction of implementing innovative technologies.

1.1.4 Reference to Moldova, and other Black Sea countries (Turkey, Ukraine, Russia)

As there are no representatives of Turkey, Ukraine and Russia, no any special considerations regarding Barriers and Enablers are analysed in this report. However, it is planned to fill-in this gap and provide some basic information through the mechanism of capitalisation of CBC Black Sea Program, exchanging information, experience and findings with other BSB projects

As long as Moldova has no real access and operation in marine waters, the applicability (and modifications) of the recommended technological solutions presented in this report will be discused in details during the national validation workshop in Moldova, planned February 2022, and will be included in the final updated version of this deliverable.

1.1.5 Review for Greece (Aegean / Mediterranean)

Fisheries and mariculture have been vital activities for the Greek island and coastal communities for thousands of years. Over the past couple of decades, however, marine resources have been over-exploited in the east-central Mediterranean region, often due to destructive practices. If drastic measures shall not be taken, the local fishing industry faces the risk of collapse; this will induce major socio-economic and ecological consequences, regionally, affecting the southern EU countries.

The primary causes of the drastic declines in fish stocks are overfishing, habitat destruction, the increasingly common use of destructive and illegal techniques, pollution, and climate change. The Mediterranean Sea is among the most overfished bodies of water in the world. According to the European Environment Agency, over 65% of the region's fish stocks are below the safe ecological limits. Catch levels in the Mediterranean have declined by 30% in the last 10 years. Although stock and catch assessments regarding the Greek seas are limited, research in the eastern Aegean Sea (e.g., Archipelagos; https://archipelago.gr/en/our-work/marine-conservation/fisheries/) has indicated a decline of up to 50% in catch levels of small-scale fisheries during 2009-2011. As a result of decades of unsustainable national and EU fishing policies, fishermen are now using larger and faster boats, employing greatly improved methods for finding and catching various species, using longer-ranged equipment, and traveling over larger distances. Despite all this increased effort, small-fish catch levels continue to decline.

Policy and regulatory barriers

The EU and Greek Government's policy and regulatory actions towards financing of the Fisheries sector

Vlachopoulou et al. (2013) have reported on the disconnects in EU and Greek fishery policies and practices in the Aegean Sea in tandem with its impacts on Posidonia oceanica meadows. The found barriers refer to disconnects in the application of fishing legislation between EU and Greek laws, socio-economic and institutional obstacles to fisheries enforcement, and a lack of habitat baseline information. The recommendations focus on seagrass conservation through direct engagement of the coastal artisanal fishing communities in the management of local fisheries protection areas (FPAs) to support long-term survival of seagrasses ecosystems, which in turn sustain local fishing livelihoods today and for the future. For example, the EU supports the protection of Posidonia oceanica meadows under the Habitats Directive and through the Common Fisheries Policy (CFP). Application of the CFP in Greek coastal zones would define the destructive fishing practices (e.g., dynamite fishing in nearshore waters, trawling within 1.5 nautical miles of member state shorelines, etc.) formally as Illegal, Unreported and Unregulated (IUU) fishing practices.

Piroddi et al. (2020) comment on the heterogeneity of the Mediterranean Large Marine Ecosystem (Med-LME), which despite its oligotrophic nature, has high diversity of marine species and high rate of endemism, making it one of the world hotspots for marine biodiversity. Existing legislation for the protection of the Med-LME basin lacks in addressing the potential impacts of combined multiple stressors, such as fishing pressure, habitat loss and degradation, climate change, pollution, eutrophication, and the introduction of invasive species. The complexity of Med-LME in its structure/function and dynamics, its vicinity and interaction with the Black Sea, the Atlantic Ocean, and the Red Sea, combined with the socio-political framework of the region make management of its marine resources quite challenging. The goal should be to demonstrate the importance of a holistic framework, based on fish stock assessment and ecosystem-based modelling approaches, to be adopted locally, e.g., in the northern Aegean Sea or regionally, e.g., the central Mediterranean – Ionian and Adriatic Seas, in support of management and conservation measures for the preservation and sustainable use of the Med-LME resources.

Several regional/international organisations, agreements and initiatives are involved in the protection of the Med-LME marine biodiversity and in the maintenance of a sustainable economic development. Most notably, the Convention for the Protection of the Marine Environment and the Coastal Region of the Mediterranean (Barcelona Convention) – which includes the United Nations Environment Programme (UNEP)'s Mediterranean Action Plan (MAP) -, the Agreement on the Conservation of Cetaceans in the Black Sea, Mediterranean Sea and contiguous Atlantic area (ACCOBAMS), the Food and Agriculture Organization (FAO) with several sectoral agreements and initiatives - such as the FAO Compliance Agreement, the General Fisheries Commission for the Mediterranean (GFCM) and the International Commission for the Conservation of Atlantic Tunas (ICCAT) – and the Convention on Biological Diversity (CBD). Within Europe, three main legislations exist to preserve and sustainably use the Mediterranean Sea marine resources: the Common Fishery Policy (CFP, Regulation (EU) No 1380/2013), which aims at ensuring that fishing is environmentally, economically, and socially sustainable; the Marine Strategy Framework Directive (MSFD, 2008/56/EC), which aims to achieve or maintain Good Environmental Status (GES) by 2020; and the EU Biodiversity Strategy to 2030 (COM (2020) 380) which aims to halt the loss of biodiversity and ecosystem services. Recently, under the CFP, a first multiannual plan for fisheries exploiting demersal stocks in the western Mediterranean Sea has been enforced by the European Union (Regulation (EU) 2019/1022 of the European Parliament and of the Council of June 20, 2019, amending Regulation (EU) No 508/2014), with strict spatial and temporal regulations and restrictions, to avert the overexploitation of marine resources that has led to bad stock status in the area. In relation to fisheries, one of the main issues is that most policy measures and European regulations are designed and developed for single species fishery (e.g., the landing obligation) and do not consider the mixed nature of the Mediterranean fisheries (and the dynamics among the stocks). Mixed and multispecies fisheries result in large numbers (and quantities) of by-catch species for which data are scarce and their status is not being routinely evaluated (Froese et al., 2020).

Because fisheries and other anthropogenic pressures are expanding at fast pace in the Med-LME, the move towards a holistic approach to ecosystem marine management in the basin seems to be necessary. Ecological and socio-ecological modelling tools, including stock assessments, have been recognized to be essential in addressing this issue (Hyder et al., 2015; Heymans et al., 2018). Currently, for example, ecosystem models (Piroddi et al., 2011; Dimarchopoulou et al., 2019) and stock assessments (Froese et al., 2018), developed for different areas of the Med-LME, predict that true effort reductions (i.e., accounting for effort creep and hauling time) through confinement of fleet numbers and days at sea should be accompanied by permanent spatial restrictions of trawling on essential fish habitats (nursery and spawning area), while the coastal zone should be reserved for small-scale coastal vessels and selective fisheries (nets, longlines) (Dimarchopoulou et al., 2018).

The following main barriers, i.e., overfishing, IUU fishing and destructive fishing practices (direct stressors), and the negative effects of anthropogenic activities on commercial fish stocks, preventing the management of resilient and sustainable fisheries in the EU can be reported, due to their pernicious impacts on local coastal economies and national capacity (indirect stressors).

More precisely:

- **Overfishing**. The most serious threat to the conservation of marine living resources in the Mediterranean Sea to the extent that it seriously puts at risk the socio-economic well-being of coastal communities in littoral States. The Mediterranean region has been strengthening collaboration towards the common management of fisheries resources. Enormous progress has been made in improving the knowledge and conservation of the region's living marine resources. Action has also been taken by the GFCM to trigger the adoption of management plans to reverse the trend of the most critically and unsustainably exploited commercial stocks and to protect their most vulnerable habitats. Although improvements are being made, much is still to be done, including to secure investments in the fishery sector at the country level. One of the principal management challenges for Mediterranean fisheries remains the implementation of adaptive plans capable of adjusting fishing capacity to realistic estimates of ecosystem productivity and encompassing adequate monitoring and control measures. This is complicated further by the fact that most of these fisheries are small-scale and data-poor, a constraint which undermine the performance of all-encompassing assessments of stock status. However, new methods for improving data collection, as well as assessing and managing data-poor fisheries, are emerging and should be applicable to the Mediterranean region. The proposed project will support the capacity building needed to reduce overfishing and improve understanding at country level of data-limited stocks for improved fisheries governance and biodiversity conservation outcomes. Since weak enforcement of the management regimes is also known to contribute to overfishing of many commercial stocks, future projects should aim at leading to improvements and updates in the regulatory frameworks of the GEF eligible Mediterranean countries.
- **IUU fishing and destructive fishing practices**. It is recognized that better management of fisheries in the Mediterranean is greatly challenged by a wide array of illegal activities, spanning from the use of dynamite and poison fishing in some coastal communities to the widespread disregard of common rules in place, leading to a culture of non-compliance. Although approximate estimates of the impacts of IUU fishing at global level exist, including by FAO, they are under-represented vis-à-vis the status of fisheries. Also, analysis of trends is difficult due to existing uncertainties, and when it comes to a semi-enclosed sea like the Mediterranean, specific regional estimates should be made in the remit of robust scientific advice for management purposes. It is stressed that Mediterranean countries, in their capacity as flag States, coastal States, port States and market States, are expected to act in a coordinated fashion to deter illegal activities and fisheries crime. This will require a common approach to monitoring, control, and surveillance, including for SSF and recreational fisheries. The efforts to quantify the extent and magnitude of IUU fishing should be enhanced. A methodology will be tested at the country level to this end. At the same time, as a quantification of IUU fishing should lead to renewed national commitment to eradicate IUU operations, the proposed project will strive to harmonize monitoring, control, and surveillance of fishing vessels. In this regard, the proposed project will involve the private sector to increase investments in best practices such as catch documentation schemes, traceability systems, eco-labelling, gear sensors and ad hoc technologies, such as solar power-based transponders and drones. Also, mitigation strategies to reduce by-catch, discards and the impacts that abandoned fishing gears have on living marine resources are in high demand.
- **Climate change, biodiversity loss and marine pollution, including marine litter, and non-indigenous species**. It is recognized that anthropogenic phenomena, such as climate change and the introduction of non-indigenous species, can have serious negative effects on the marine ecosystems and their living resources. The creation of a

regional/Mediterranean Sea adaptation strategy to cope with potential effects of climate change and non-indigenous species on fisheries consistent with the SAP-BIO is needed. Such a strategy should be based on the results of a vulnerability evaluation of the potential ecological and socio-economic effects of climate change and of the introduction of non-indigenous species in Mediterranean fisheries. Other indirect stressors that are known to be currently aggravating the situation include ocean noise pollution, acidification, micro-plastic, and abandoned fishing gear. While the ongoing MedProgramme tackles heads-on issues relating to marine pollution, future projects should elaborate the aforesaid adaptation strategy for key Mediterranean fisheries whilst considering the consequences that other anthropogenic activities can have on fisheries conservation.

- **Limited coordinated and integrated programming**. There are many programmes, projects and initiatives implemented and planned in the Mediterranean region. Some are sector specific while others are geographically focused, but these are often limited in scope and informed by a siloed approach. This siloed approach to tackling issues relating to marine environment and living resources is known to lead to inefficient use of resources, lost opportunities, duplication and, in the worst-case scenario, conflicts. Where there is greater coordination of efforts at regional scale, as seen in the partnership between OSPAR and the NEAFC, implementation of proposed actions is more efficient and effective, including avoiding/minimizing conflicts. Over time, cooperation and collaboration has increased progressively among competent agencies with sectoral mandates over the Mediterranean Sea as well, especially between the GFCM and the MAP. Greater impact and stronger outcomes can be expected if both agencies jointly programme actions so that each other's comparative advantages and mandates are capitalized upon and so that together the impact of their action is greater than operating independently.

Another pronounced barrier is overregulation and dysregulation in the Greek coastal territory (Petza et al., 2017). The national legal framework concerning spatial and temporal restrictions on fishing activities in the Aegean Sea is remarkably complex, as it consists of numerous provisions, enabled by many legal acts (which in many cases have also been amended), issued by various management bodies, aiming to regulate different and usually conflicting activities in the marine environment. The national Fisheries Restricted Areas (FRAs) identified in Greece are enabled by legal acts issued mainly by the Ministry of Rural Development and Food within the context of national fisheries legislation, but also by the Ministry of Environment and Energy, the Ministry of Culture and Sports and the Ministry of Shipping and Island Policy within the context of national environmental, archaeological, and maritime legislation, respectively. On the contrary, the EU and international legal frameworks concerning spatiotemporal restrictions on fishing activities in the Aegean Sea are clear and definite. They both consist of a single legal act, i.e., a Regulation issued by the Council of the EU and a Recommendation issued by the General Fisheries Commission for the Mediterranean (GFCM), respectively. These frameworks have not been amended since they entered into force. Proper GIS mapping of FRAs should enhance the implementation of robust maritime spatial planning, under the provisions of Directive 2014/89/EU.

The European Parliament is concerned about the lack of information on the relevance of nine million Europeans engaged in Marine Recreational Fishing (MRF), committing Member States to encourage environmental and socioeconomic sustainability of the sector (Pita et al., 2020). In Mediterranean countries there is substantial research effort, yet with persisting gaps, while the local governance challenges have been identified mostly concerning the rather low public investment in relevant research to cover the knowledge gaps of socioeconomic relevance, impacts on vulnerable species, and implications of global warming. Moreover, the MRF license system should be standardized to allow estimation of effort, catch and expenditure. Social networks, mobile applications, fisher ecological knowledge, and citizen science programs could help to develop cost-effective research and management. Science-based, adaptive policies should improve the allocation of resources between MRF and other stakeholders, introducing co-management to reduce conflicts.

Another identified barrier could be the restricted application of the Multi-Use (MU) concept (assemblage of more or less compatible marine water resources or sea uses) in a context of growing claim for marine space and in the pursuit of maritime “spatial efficiency”. The potential of soft MU involving Small-Scale Fisheries (SSF), tourism, and nature conservation related to Marine Protected Areas (MPAs), widely encountered in the Mediterranean basin, is of crucial importance to Greece (Kyvelou and Ierapetritis, 2021). As of now, the MU concept is not yet included neither in Maritime Spatial Planning (MSP) laws nor in strategic policy documents due mainly to the dominance of terrestrial spatial plans that favour exclusive rights of highly competitive and expansive maritime activities (e.g., aquaculture). In practice, MU is increasingly being practiced by local communities as a socio-economic instrument (e.g., fishing tourism), able to be also occasionally oriented to nature conservation. More robust analyses following the Drivers, Added Values, Barriers and Negative Impacts (DABI) concept should be employed in Greek maritime areas, in order to identify the socio-economic, environmental, political–regulatory, and technological factors that can enable or undermine the MU approach in the Greek coastal zones. The MU may be highlighted as a tool for sustainable use of marine space supporting the Blue Growth Agenda and reconnecting natural and cultural capital at sea, thus redefining also the role of fishers that under equitable conditions may become defenders of marine biodiversity and key actors for the sustainable management of fish stocks and ecosystems in the Mediterranean protected areas.

The main relevant barriers in Greece concern external priorities such as non-inclusive regulatory measures, insufficient capacity building including information on business opportunities and on marketing actions, low networking and synergies yet to a lesser extent, sustained bureaucracy, and non-fostered funding opportunities. However, the most important is the internal environment, i.e., the willing involvement of main actors, e.g., fishers, in the conservation, planning, and development processes (incl. MSP). The low implementation of certified co-management schemes, i.e., Fisheries Local Action Groups (FLAGs) in the country should be addressed in the future.

Vlachopoulou (2017) showed via questionnaire analysis that in general for Greece the short- and long-term objectives are prevented from being fully achieved by: regulatory barriers in assisting the slow response of ecosystems in resilience terms; the lack of social cohesion in terms of limited conflict among uses and lengthy response of adaptive management approaches; the suspension of social networking I terms of limited cooperation and cohesion between stakeholder groups; governmental inadequacy in terms of lack of shared open data and highly centralised management that does not allow for local action; economic barriers in terms of too high costs of investment in new approaches and technologies (with no state financial support), thus causing financial problems that turn the actors’ attention away from the issues. The very slow judicial decisions in associated legal cases and conflicts might also raise obstacles in the implementation of novel technologies and modern efficient managerial approaches.

The above barriers also apply to innovative solutions in maritime forecasts, marine surveys, water quality monitoring, and assessment of fish stock and non-fish resources.

Financial aspects

According to the OECD's report on "Fisheries and Aquaculture in Greece" (January 2021), in 2018, Greece produced 0.2 million tonnes of fish (including molluscs and crustaceans), with a value of USD 794.4 million. 80% of this value came from aquaculture and 20% from fisheries (that is, the capture of wild resources). Between 2008 and 2018, the quantity produced increased by 5%, while its value decreased by 22%. Greece is a net exporter of fish and fish products. Between 2008 and 2018, exports increased by a total of 11%, while imports decreased by 14%. In 2018 Employment in the seafood sector, including processing, accounted for 24825 jobs. This represented 43% more jobs than in 2008. Over the same period, the average value of production per employee decreased by 80% in marine fisheries and increased by 36% in aquaculture. In 2018, the fleet consisted of 14934 powered vessels, down by 13% since 2008. Small-scale vessels, those below 12 meters in length, accounted for 94.2% of the total number of vessels. The total gross tonnage of the Greek fleet in 2018 was 71104 tonnes, down by 20% since 2008. Small-scale vessels accounted for 40.3% of the total gross tonnage.

In 2018, Greece spent EUR 5 million (USD 5.8 million) financing services to the fisheries sector while EUR 0 million (USD 0 million) was recouped via cost-recovery charges, that is, fees paid by service users, such as for port access or management, and taxes or fees on resource use and associated profits. Having the sector bear some of the cost of services, reduces the extent to which taxpayers finance it. Net of cost-recovery charges, the public cost of services to the fisheries sector amounted to 3.7% of the value of production, while the OECD average was 8.5% in 2018. The intensity of fisheries services' financing relative to fleet size was USD 82.2 per gross tonne (gt) of total fleet capacity in 2018. This compares with an OECD average of USD 601.8 per gt in 2018. Some services to the sector aim to ensure its sustainability or improve fishing communities' well-being, while only indirectly supporting the intensity of fishing activities. In the OECD, such services, including management, control, and surveillance, accounted for an average of 59.2% of spending on services to the sector in 2018. Other services target fishers' ability to operate their businesses more efficiently or more sustainably, such as investment in education and training, marketing and promotion or research and development. These services accounted for an average of 16% of spending on services to the sector in the OECD in 2018. Finally, some forms of support can have a more direct relationship with production capacity, such as investment in or subsidised access to infrastructure like ports. In the OECD, these services have accounted for an average of 24.5% of financing of services to the sector in 2018.

Greece has been Spain's main trade partner since the beginning of the century, but its leadership declined as new actors entered the market. Imports of whole fresh seabream from Greece in 2010 reached around 7.000 tonnes, while imports from Turkey did not exceed 500 tonnes. After 2012 Turkey has replaced Greece as the main trade partner for Spanish importers; thus, the historical/traditional EU producers (Italy, France, Spain, Greece) are competing with imported products from Turkey and other emerging non-EU competitors that do not face the same production standards.

Considering financial aspects in EU fisheries it seems that Greece is under economic pressure from competing financial forces with investment cutbacks through the last decade due to antagonistic imbalances in the east-central Mediterranean. Therefore, a more robust GDP share should be targeted to funding of (higher risk) innovative I/T technologies (more so than monitoring equipment) and related research via EU and National economic tools.

With the adoption of Sustainable Development Goal 14 (SDG 14) of the 2030 Agenda for Sustainable Development, member countries of the United Nations (UN) agreed to end overfishing by 2020 and effectively regulate fishing activities based on science. Ending overfishing relies on controlling the quantity of fish being caught and enforcing scientifically established total allowable catches (TACs) for at least the main species of commercial interest is recognised as an effective and transparent way of achieving this. The value of production of the top-5 Greek species was USD 71.9 million, accounting for 45.7% of total fisheries production value in 2018. 0 of these species were then entirely under TAC limits, while 0 were partly under TAC limits (i.e., TAC limits were set for some fisheries targeting these species but not all). Regularly assessing the status of individual fish stocks is an essential component of sustainable fisheries management. Determining where stocks sit with respect to key limit or target reference points allows management performance to be evaluated. For the Review of Fisheries 2020, a total of 1119 stocks across 16 countries and economies (including the European Union), were reported as having recently been assessed, of which, 734 (66%) were assessed to have a biologically favourable status. Determining stock status and enforcing TACs because of quantitative assessments can require extensive information and expertise. In some cases, such as when fishers harvest a wide variety of species, the value of a stock is low, or data is unavailable, the cost and practicality of quantitatively assessing and managing individual stocks with TACs can be prohibitive. In these instances, data on catch rates and other relevant sources of information might be utilised to infer stock status. In addition, alternative tools to control the impact of fishing include limits to fishing effort such as on days at sea or fishing licenses and restrictions on fishing practices such as on fishing areas, gear, and seasons. Such tools were used to manage 5 of the top-5 species.

1.2 Enablers for introducing technology innovations

1.2.1 Review for Bulgaria

Accompanying policy (local/national authorities) support

Among the Bulgarian government's key objectives for the period up to 2030 are the technological transformation of the economy, green growth, and resource efficiency, and aligning with European digitalisation policies. This will be done through targeted and focused government support, while increasing specialisation in products and industries characterised by a higher intensity in R&D and innovation (and therefore higher added value). This should allow Bulgaria to boost its competitiveness globally and involves:

- Improving state-level international collaboration (bilateral and multilateral)
- Encouraging research organisations (ROs) and HEIs to internationalise
- Implementing National Research Programmes to solve social and policy issues
- Encouraging better communication strategies by ROs, HEIs, research infrastructures (RIs), centres of excellence (CoEs), and competence centres (CCs) public funding bodies, research programmes, etc.
- Significant increase in support for R&I in the field of ICT (incl. RIs, CoEs, etc.)
- Improving the legal framework to promote R&I, public-private partnership, and intellectual property management (a new Research and Innovation Act)
- Developing and widening the capacity and increasing the expertise of administrative and expert staff working in the field of research, innovation, technological transformation, and coordination with Horizon Europe
- Promoting technology readiness level from applied research achievements to their transformation into innovative products, services or processes, and their market launch
- Fostering joint strategic innovation programmes between industry and the research capital in the country for accelerating the transfer of knowledge and research results, commercialisation and generating disruptive innovations

In parallels, in Bulgaria there are:

- High demand for new or improved products,
- Good Information flow,
- High R&D sphere potential,
- Available intermediary infrastructure

More explanatory text will follow by BDCA ...

Corresponding promotion activities at national and local level

In the period 2014-2020, there were two National Operation Programmes in Bulgaria (supported by EU funds) that provided support to innovation advancement:

- National Operational programme "Innovations and Competitiveness", with a total budget for 2014-2020 equal to EUR 1.27 billion. The funding from the European Regional Development Fund (ERDF) exceeds EUR 1,079 billion and the national co-financing amounts to over EUR 191 million. (15% of the budget). The OP 'Innovation and competitiveness' (2014-2020) outlines procedures for the creation and development of Regional Innovation

Centres and the development of Innovation Clusters (priority Axis 1 "Technological development and innovation").

- National priorities in research were incorporated through the operational programme 'Science and education for smart growth' (2014-2020), which support the development and modernisation of two types of research centres - Centers of Excellence and Centres of Competence.

In addition, the research and innovation were supported also by a special funding programme of the Bulgarian National Science Fund, that will continue to operate also in the next programming period

It can be expected that similar programs and other promotion activities the above processes will continue according to European Research and innovation strategy 2020-2024: https://ec.europa.eu/info/sites/default/files/rtd_sp_2020_2024_en.pdf

Raising capacity and public awareness, including role of TIMMOD

Rising capacity of experts and decision makers, together with rising public awareness, are considered of very high importance when it goes for factors enabling introduction of innovative technologies in marine survey, fish stock and non-fish resource assessment.

In this view, the role of TIMMOD in Bulgaria shall be underlined. So far done by Bulgarian partners IFR and BDCA:

- Raised awareness & improved regional cooperation of R&D organisations in technology innovation of marine monitoring for assessment of fish stock & non-fish resources, achieved by organization of the 3rd Thematic Trans-boundary Meeting, held in Varna 5 and 6 July 2021.
- Improved technological expertise and practical skills of research institutions in use of innovative tools for monitoring, modeling, and data acquisition, achieved by joint participation in the 1st Pilot Demonstration Project, organised by BDCA, and held under coordination of the Institute of Fish Resources, at the 1st demo site - Bulgarian Black Sea coast, area of Varna.

The role of Dissemination events and Social media campaigns organised in Bulgaria by the 2 Bulgarian partners (IFR and BDCA) should be also underlined, as an important tool for raising capacity of involved researchers and surveyours, and increasing public awareness among key stakeholders and target groups.

1.2.2 Review for Romania

Accompanying policy (local/national authorities) support

Romania's Recovery and Resilience Plan (PNRR) 2021-2026, include 6 pillars: i) transition to green economy; ii) digital transformation, iii) intelligent, sustainable and inclusive grows economy; iv) social and territorial cohesion; v) heals and institutional resilience and vi) children, young, education and competencies. Key measures are: 41% to support green transition and 21% to support digital transition. Implementation of this plan include an essential condition: none of the plan measures will do not significant harm to the environment".

The proposed measures address the challenges identified in the context of the European Semester, supporting the green transition and digital transformation, as well as economic growth, social and economic resilience and job creation.

PNRR must intervene with reforms and investments in the following areas:

- Transport
- Environment, climate change, energy, energy efficiency and the green transition
- Development of urban localities, capitalization of cultural and natural heritage and tourism
- Agriculture and rural development
- Health
- Education
- Business environment
- *Research, innovation, digitization*
- Improving the built fund
- Resilience in crisis situations

Corresponding promotion activities at national and local level

In the period 2014-2020, has been implemented several National Operation Programmes in Romania (supported by EU funds) that provided support to innovation advancement:

Competitiveness Operational Program (POC)

POC 2014 - 2020 contributes to increasing competitiveness and economic development by improving access, security and use of ICT and by strengthening RDI:

- Priority Axis 1: Research, technological development and innovation (RDI) in support of economic competitiveness and business development
- Priority Axis 2: Information and Communication Technology (ICT) for a competitive digital economy
- Priority Axis 3: Supporting SMEs in response to the COVID -19 pandemic

Large Infrastructure Operational Program (POIM)

POIM 2014-2020 has as global objective the development of transport infrastructure, environment, energy and risk prevention at European standards, in order to create the premises for a sustainable economic growth, in conditions of safety and efficient use of natural resources:

- Priority Axis 1: Improving mobility through the development of the TEN-T network and the metro
- Priority Axis 2: Development of a quality, sustainable and efficient multimodal transport system
- Priority Axis 3: Development of environmental infrastructure in conditions of efficient resource management
- Priority Axis 4: Environmental protection through biodiversity conservation measures, air quality monitoring and decontamination of historically polluted sites
- Priority Axis 5: Promoting adaptation to climate change, prevention and risk management
- Priority Axis 6: Promoting clean energy and energy efficiency in order to sustain a low carbon economy
- Priority Axis 7: Increasing energy efficiency at the level of the central heating system in the selected cities
- Priority Axis 8: Intelligent and sustainable electricity and natural gas transmission systems
- Priority Axis 9: Protecting the health of the population in the context of the pandemic caused by COVID-19

Operational Program for Fisheries and Maritime Affairs (POPAM)

POPAM 2014 - 2020 mainly aims to increase production in aquaculture and processing. It also aims to increase the profitability of operators, conserve biodiversity and protect the environment, maintain and create jobs, especially in fisheries areas:

- Union Priority (UP) 1 Promoting environmentally sustainable, resource efficient, innovative, competitive and knowledge-based fishing
- UP 2 Stimulating environmentally sustainable, resource-efficient, innovative, competitive and knowledge-based aquaculture
- UP 3 Encourage the implementation of the CFP
- UP 4 Increasing employment and increasing territorial cohesion
- UP 5 Stimulation of marketing and processing
- UP 6 Encouraging the implementation of the IMP

Integrated Territorial Investments – Danube Delta (ITI Danube Delta)

ITI- Danube Delta is a new financial instrument for the 2014-2020 programming period, introduced by the European Commission (EC) to stimulate integrated territorial development.

The ITI Financial Instrument provides funding for projects from all operational programs, including investments from the CF, ERDF, ESF, EAFRD and EMFF.

In the 2014-2020 programming period, indicative allocations in the total amount of € 1,111,746,383 (approximately € 1.11 billion ESI funds) are established for the ITI instrument, distributed within the operational programs: POIM, POR, PNDR, POCA, POC, POCU.

Same time, innovation in Romanian will be funded by National Plan for Research, Technological Development and Innovation 2014-2020 (PNCDI III).

Future, it is expected that EU's key funding programme for research and innovation

"Horizon Europe 2021-2027", with a budget of €95.5 billion and Romania's National Plan for Research, Technological Development and Innovation 2021-2027 - PNCDI IV will continue supporting and implementing EU policies for research and innovation.

Raising capacity and public awareness, including role of TIMMOD

"Public's education and awareness on environmental protection" are one of the programs of Romanian Environmental Fund Administration, main institution that provides financial support for the implementation of projects and programs for environmental protection.

Romanian TIMMOD partner DDNI, are the main R&D actor for awareness and dissemination of innovative instruments in in technology innovation of marine monitoring for assessment of fish stock & non-fish resources beside others national stakeholders from education, environment and fishery domains

1.2.3 Review for Georgia

Accompanying policy (local/national authorities) support

In Georgia, - several major laws and numerous sub-legal acts are regulating the protection and management of water resources. However, current water-related legislation is inconsistent and does not provide for a clear regulation of such important topics for example, pollution prevention tools, ownership, and the possession and use rights related to water bodies, as well as water cadaster. The Water Law (1997) regulating water resources defines the main issues related to the protection and use of water. It defines the main principles of water policy and guarantees the security of state interests in water protection. However, it does not fully cover all aspects of water management, including the management of groundwater, which is regulated by the 1996 Law on Mineral Resources. The existing Water Law has an unworkable character because of the questionable legal validity of most of its provisions.

International environmental treaties and obligations play a significant role in framing water policy in Georgia. The EU-Georgia AA includes provisions of five EU directives on water and marine-related aspects (except for the flood directive) and the AA implementation Roadmap sets more than 25 actions for the approximation of Georgian legislation in the water sector with EU requirements. Other obligations are taken on by the country via international treaties. Specifically, Georgia is a party to the Bucharest Convention on the Protection of the Black Sea against Pollution and the MARPOL Convention on Prevention of Pollution from Ships (as well as the International Convention on Oil Pollution Preparedness, Response and Co-operation). In addition, Georgia is a party to the Ballast Water Management Convention and other international treaties concerning Black Sea protection against anthropogenic impacts (for example, the International Convention on Oil Pollution Preparedness, Response and Cooperation).

In order to improve marine governance, the Ministry of Environmental Protection and Agriculture of Georgia with the support of the EU-funded projects developed a proposal for a National Marine Environment Strategy and Action Programme. Development and adoption of the Strategy and Action Programme are envisaged by the EU-Georgia AA and the Law of Georgia on the Maritime Space. In particular, in 2018, the Georgian Parliament adopted an amendment to the Law of Georgia on the Maritime Space, obliging the Ministry of Environmental Protection and Agriculture of Georgia, together with other State agencies, to develop a National Marine Strategy for the Black Sea Protection and Action Programme for Achievement of a Good Environmental Status of the Marine Waters. The strategic document shall be approved by the government of Georgia no later than 1 September 2022. Support to develop the draft Strategy and Action Programme was rendered as part of the EU-funded project 'Support to the implementation of the environmental provisions of the EU – Georgia Association Agreement' that started in March 2019. This support included a participative process with Georgian stakeholders and a proposal for the text of the Marine Environment Strategy and its Action Programme. In the draft document, various actions are included in response to the challenges related to the monitoring of the Black Sea water quality, and Black Sea ecosystem protection. The document is currently under review and stakeholder discussions are planned,

Considering the above mentioned Georgia has the long-term goal (2030 NEAP) and identified three five-year targets in water resources management:

GOAL: To ensure the good qualitative and quantitative status of surface and groundwater bodies as well as coastal waters for human health and aquatic ecosystems

TARGETS: Target 1. Development of an effective system of water resources management Target 2. Reduction of water pollution from the point and diffuse sources and ensuring sustainable use of water resources Target 3. Improvement of the water quality and quantity monitoring and assessment systems

Corresponding promotion activities at the national and local level

2016-2020 The project EMBLAS (EMBLAS I; EMBLAS II, EMBLAS Plus), supported by the United Nations Development Program and the European Union, aimed to improve and strengthen the monitoring of the Black Sea environment. It assists the partner countries of the Black Sea region in solving common environmental problems and monitoring the marine environment. The project assessed the relevance of marine research methods, studied new ones, and introduced them to many training seminars or workshops organized by the project. The project also exchanged data between Ukrainian and Georgian scientists to introduce a common European methodology. It is noteworthy that for the first time in many years, large-scale studies were conducted on the Black Sea, covering various areas, including the study of all components of marine biodiversity, starting with microalgae and ending with marine mammals, including new organic pollutants. Marine litter monitoring using new software methodology, Deepwater anoxic layer study, etc. It is important that the studies showed positive results regarding the ecological status of the coastal waters of Georgia, especially in terms of biodiversity.

EU Project Water Initiative Plus for the Eastern Partnership countries (EUWI plus), The project helps Armenia, Azerbaijan, Belarus, Georgia, Moldova, and Ukraine bring their legislation closer to EU policy in the field of water management, with the main focus on the management of trans-boundary river basins. It supports the development and implementation of pilot river basin management plans, building on the improved policy framework and ensuring a strong participation of local stakeholders. The main objective of the project is to improve the management of water resources, in particular transboundary rivers, developing tools to improve the quality of water in the long term, and its availability for all.

Promoting Technology Innovation Environmental Monitoring And Modeling For Assessment Of Fish Stock And Non-Fish Resources – TIMMOD unites the efforts of 6 Project Partners from 5 Black Sea countries (Bulgaria, Romania, Georgia, Moldova and Greece) in a multisectoral & multidisciplinary project consortium: TIMMOD Innovation Network - sharing the common understanding that the Technological Upgrade is the key to “improve joint environmental monitoring”.

TIMMOD group includes research organisations, state environmental agency, research & innovation association, regional environmental agency – a group that can exploit their complementarities to boost technology innovation in the Black Sea water monitoring sector.

The overall project objective 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.

Promoting Innovation aims to utilize new tools, approaches and technology to assist the implementation of EU policies and programmes. BSB CBC programme is the appropriate platform to accelerate the technological upgrade that is not otherwise possible by a single effort of a single country or a single sector

Raising capacity and public awareness, including the role of TIMMOD

The EU/UNDP Project ‘Improving Environmental Monitoring in the Black Sea – Selected measures” (EMBLAS-PLUS) was dedicated to the protection of the Black Sea environment. The project was building upon the results and conclusions from the previous project phases EMBLAS-I and EMBLAS-II, which were implemented in Georgia, Russian Federation and Ukraine. The project was addressing the overall need for support in protecting and restoring the environmental quality and sustainability of the Black Sea, with the following specific objectives:

- Improve availability and sharing of marine environmental data from the national and joint regional monitoring programmes aligned with the European Union's Marine Strategy Framework Directive and Water Framework Directive principles and the Black Sea Integrated Monitoring and Assessment Programme (BSIMAP);
- Support joint actions to reduce riverine and marine litter in the Black Sea basin;
- Raise awareness on the key environmental issues and increase public involvement in the protection of the Black Sea.

The National Environmental Agency of Georgia, as the national authority responsible for the environmental monitoring, was one of the partners of this project

NEA experts participated in Joint Black Sea Surveys, which was organized in 2016, 2017 and 2019 by EMBLAS II and EMBLAS Plus. As part of the project, our specialists also participated in numerous seminars, workshops and training, as a result of which they received good practical skills and experience in the field of marine research.

It should be noted that within the framework of the project, the delineation of the Black Sea coast of Georgia was carried out for the first time.

NEA experts were involved in the further improvement of classification schemes in the Georgian coast through providing chemical and biological data from the surveys and providing relevant input to the documents developed by the responsible experts. The set of historical data available at NEA from the national monitoring and other international projects has been entered into DCT files. Contributions were provided to the preparation of the List of the Black Sea Specific Pollutants, According to MSFD/WFD and BSIMAP principles proposals for the creation of a national monitoring network for the Black Sea coast of Georgia have been prepared. The specialists from NEA in cooperation with TSU were participating in monitoring marine/river/coastal marine litter on the Black Sea coast of Georgia.

Also, NEA took part in environmental public awareness and education campaigns, conducted in the dissemination of the project results and visibility:

- The book about our Sea - “Secrets of the Black Sea”, the idea of which belonged to Dr Boris Aleksandrov, director of the Institute of Marine Biology in Odesa, was translated into Georgian by the staff of Fisheries, Aquaculture and Water Biodiversity Department of NEA and published with the support of the project EMBLAS Plus.
- Infographic "Destroying myths about the dolphins’ rescue” was translated into Georgian by the staff NEA and published in Georgian and English with the support of the project EMBLAS Plus;
- information was provided on the main objectives of the EMBLAS Plus project at a conference, organized by Tbilisi State University, which was held under the auspices of EU, UNDP and EU’s Joint Operational Cross-Border Cooperation Programme BSB 2014 – 2020.
- information was provided on the main objectives of the EMBLAS Plus project at a Conference dedicated to Black Sea Day, organized by Batumi State University.

- With the support of the EMBLAS Plus project, a multi-stakeholder workshop on the development of mariculture on the Georgian coast was organized. The information on the main goals and objectives of the project was provided at the seminar.

1.2.4 Reference to Moldova, and other Black Sea countries (Turkey, Ukraine, Russia)

As there are no representatives of Turkey, Ukraine and Russia, no any special considerations regarding Barriers and Enablers are analysed in this report. However, it is planned to fill-in this gap and provide some basic information through the mechanism of capitalisation of CBC Black Sea Program, exchanging information, experience and findings with other BSB projects

As long as Moldova has no real access and operation in marine waters, the applicability (and modifications) of the recommended technological solutions presented in this report will be discused in details during the national validation workshop in Moldova, planned February 2022, and will be included in the final updated version of this deliverable.

1.2.5 Review for Greece (Aegean / Mediterranean)

Accompanying policy (local/national authorities) support

Among the Hellenic Government's key objectives for the period up to 2030 are the technological transformation of the economy, green growth, and resource efficiency, and aligning with European digitalisation policies. The Operational Programme for support from EU Maritime and Fisheries Funds in Greece aimed at achieving key national development priorities along with the EU-2020 objectives. The OP addressed the general reform of the CFP and fully supported the priorities defined in the European Maritime and Fisheries Fund (EMFF) Regulation. The main objectives of the OP aimed at enhancing the competitiveness of aquaculture and processing sectors, the viability of sea fisheries sector and the sustainable development of traditionally fisheries dependent areas. The Programme also addressed the need for protection and rehabilitation of the marine environment and its living resources, the control of fisheries activities, the collection of fisheries data and the improvement of knowledge on the state of the marine environment.

The funding priorities of the EMFF's OP in Greece still focuses on the following priorities:

- Viability and sustainable development of the Greek fisheries sector as well as at the protection of the fishing/marine resources. This includes investments for the modernization of fishing shelters and landing sites, for better health and safety, for the promotion of innovation and partnerships between fishermen and scientists, for the development of complementary activities, new forms of income for fishermen and investments allowing fishermen to use and add value in unwanted catches. Permanent cessation of fishing activities and on board-investments to increase gear selectivity have also been provided.
- Fostering environmentally sustainable, resource efficient, innovative, and competitive and knowledge-based aquaculture. Under this priority, the EMFF supports productive investments in aquaculture as well as investments aiming at enhancing competitiveness and viability of the aquaculture sector.
- Promoting the implementation of the Common Fisheries Policy, for the collection and management of data as well as for supporting monitoring, control, and enforcement.
- Promoting the maintenance of the economic and social sustainability of the Greek fisheries and aquaculture areas, focusing on the creation of jobs and the diversification within and/or outside fisheries and aquaculture sectors and the sustainable exploitation of related products through the implementation of comprehensive local development strategies.

- Fostering marketing and processing.
- Integrated maritime policy aiming at improving knowledge on the marine environment, with particular focus on the development of part of CISE (Common Information Sharing Environment).
- Technical assistance to ensure efficient administration of the EU funding, including support to publicity and information measures as well as evaluations.
- Encouraging research organisations (ROs) and HEIs to internationalise
- Encouraging better communication strategies by ROs, HEIs, research infrastructures (RIs), centres of excellence (CoEs), and competence centres (CCs) public funding bodies, research programmes, etc.
- Significant increase in support for R&I in the field of ICT (incl. RIs, CoEs, etc.).
- Promoting technology readiness level from applied research achievements to their transformation into innovative products, services or processes, and their market launch.

IUU fishing harms law-abiding fishers by creating unfair competition and cutting profitability and employment opportunities, while weakening food security in countries that depend on local seafood. IUU fishing also undermines governments' capacity to manage fish stocks sustainably by adding pressure that is difficult to quantify when setting catch limits. It further threatens ecosystems when it makes use of damaging harvest methods and targets species that are already endangered. Adopting and implementing internationally recognised best policies and practices against IUU fishing is thus key to accelerate the elimination of this serious threat as agreed under SDG 14, which sets the objectives to end IUU fishing and eliminate subsidies contributing to it by 2020. The OECD IUU policy indicators investigate the extent to which countries meet their responsibilities in the most important dimensions of government intervention in relation to IUU fishing:

• Vessel registration, by which countries collect and publicize information on vessels operating in their exclusive economic zone (EEZ) or flying their flag;

• Authorisation to operate in the EEZ, by which countries regulate fishing and fishing-related operations in their EEZ;

• Authorisation to operate outside the EEZ, by which countries regulate the operations of vessels flying their flag in areas beyond national jurisdictions and in foreign EEZs;

• Port measures, by which countries monitor and control access to and activities at port;

• Market measures, by which countries regulate how products enter the market and flow through the supply chain and economically discourage IUU fishing;

• International co-operation, by which countries engage in regional and global information sharing and joint activities against IUU fishing.

Greece performs most strongly in Authorisation to operate in the EEZ; greatest scope for progress is in the area of Port state measures.

<u>Corresponding promotion activities at national and local level</u>

In the period 2014-2020, there were several National Operation Programmes in Greece (supported by National and EU funds) that provided support to innovation advancement:

- The OP Fisheries and Maritime with a total budget of 523,406,309€.
- The OP Human Resources Development, Education and Lifelong Learning with a total budget of 2,667,494,916€.

It can be expected that similar programs and other promotion activities the above processes will continue according to European Research and innovation strategy 2020-2024: https://ec.europa.eu/info/sites/default/files/rtd_sp_2020_2024_en.pdf

Raising capacity and public awareness, including role of TIMMOD

Rising capacity of experts and decision makers, together with rising public awareness, are considered of very high importance when it goes for factors enabling introduction of innovative technologies in marine survey, fish stock and non-fish resource assessment.

In this view, the role of TIMMOD in Greece is considered significant. Thus far AUTh Greek partner achieved the following:

- Raised awareness & improved regional cooperation of regional authorities, EU policy makers, and research organisations in technology innovation of marine monitoring and modelling for the assessment of fish stock & non-fish resources, achieved by the organization of the 2nd Thematic Transboundary Meeting, held in Thessaloniki on 19-20 April 2021.
- Improved information exchange on modern technological expertise and practical skills of research institutions' representatives in the use of innovative tools for monitoring, modelling, and data acquisition and sharing, achieved by the organization of the 3rd Dissemination Event, held in Thessaloniki on 28 May 2021.

Specialized digital promotional campaign in English and Greek languages has been organized in Greece by AUTh during April and May of 2021, one before TTM#2 and one before the 3rd Dissemination event. The following promotional activities were organized:

- Press release dissemination: The press release (D.C.4.1) especially created for the 3rd Dissemination Event in Thessaloniki, Greece, was distributed to the following media by e-mail:
    - News portal – GreenAGENDA.gr http://greenagenda.gr/ info@greenagenda.gr
    - Polymorphic website – thes.gr https://www.thes.gr/ info@thes.gr
    - Local e-Newspaper – Thestival https://www.thestival.gr/ thestival@gmail.com
    - Weekly magazine – Parallaxi https://parallaximag.gr/ parallaximagazine@gmail.com
    - Municipal Radio – FM100 https://fm100.gr/ newsradiofm100@gmail.com
- Invitations to relevant national stakeholders: The 3rd Dissemination Event in Thessaloniki, Greece, was organized as an online event in response to the COVID-19 pandemic situation in Greece, imposing several restrictions, such as lockdowns, travel restrictions, self-quarantine imposed for arrivals of persons from partners' countries, limitations in participants on meeting events, keeping safety distances among attendees, recommendations for disinfection and use of protection, etc. The participation of members by Project Partners was hindered due to relevant restrictions. Accordingly, 8 Greek organizations were invited, selected as the most important relevant stakeholders to participate in the event as guests. An option for online introduction to the event by joining the page of the social networks and project webpage was also offered. The same applies to the invitational promotion of the TTM#2 event that was virtually hosted by AUTh in Thessaloniki, Greece, and was organized as an online event too in response to the COVID-19 pandemic situation. Especially for the Seminar session many organizations from 5 partner countries were invited, selected as important stakeholders to participate either as presenters or as guests in the event. These included: RAPIV, NIMRD Grigore Antipa, DDBRA, Institute of Aquacultures, LIF Group (Shabla-Kavarna-Balchik), School of Biology AUTh, IHU, EU DG Mare, Municipality of Thessaloniki, SDSN Black Sea, Regional Authority of Central Macedonia, UAeg, CIMA Universidade do Algarve, Institute for Ecological Modernisation,

University of Architecture and Civil Engineering Sofia, Bulgarian Ship Hydrodynamics Centre (BSHC), Marine Cluster Bulgaria, International Black Sea Club Ltd, Federation of Fishing Areas – Braila, FLAG Delta Tulcea, FLAG Braila, ANPA Tulcea, Federation for Development of Romanian Marine Fisheries "RO-FISHING-BLACK SEA", University of Architecture, Civil Engineering and Geodesy (UACEG), Executive Agency for Fisheries and Aquacultures (EAFA), Environmental Agency, Institute of Zoology, and NGO "Eco Logistica". An option for online introduction to the event by joining the page of the social networks and project webpage was also offered. Several e-mails have been sent to the academic community of the Faculty of Engineering and the School of Civil Engineering in AUTh, as well as many other interested parties and stakeholders.

- Social Media: TIMMOD has consolidated its presence online via several social media channels, such as its Facebook page (https://www.facebook.com/TIMMOD-Project-114059673702692) and group (https://www.facebook.com/groups/725509191541670), the Linkedin group (https://www.linkedin.com/groups/12472311/), and the ResearchGate project (https://www.researchgate.net/project/TIMMOD). In order to inform the public about the concluded TTM#2 event, two posts with a concise description and a couple of screenshots from the sessions have been created by the administrators:
  https://www.facebook.com/groups/725509191541670/permalink/923989151693672/
  https://www.facebook.com/permalink.php?story_fbid=280362677072390&id=114059673702692
  Before the TTM#2 event the TIMMOD Innovation Network via Linkedin was updated by the following public post, where the itinerary of the event was attached containing details about the meeting and seminar, the roster of keynote speakers, and all relevant information:
  https://www.linkedin.com/feed/update/urn:li:activity:6788442441390297088

  Individual posts by Linkedin members of the TIMMOD team were also created to promote the TTM#2 event, e.g.:
  https://www.linkedin.com/posts/christos-makris-04596120_2nd-ttm-timmod-seminar-agenda-activity-6788441183686291456-eF5A

  For the upcoming 3rd Dissemination Event similar posts have been created:
  https://www.linkedin.com/posts/christos-makris-04596120_%CE%B4%CE%B5%CE%BB%CF%84%CE%AF%CE%BF-%CF%84%CF%8D%CF%80%CE%BF%CF%85-%CE%AD%CF%81%CE%B3%CE%BF%CF%85-timmod-activity-6791015236515180544-ANBL
  https://www.civil.auth.gr/news/events/1121-3%CE%B7-%CE%B5%CE%BD%CE%B7%CE%BC%CE%B5%CF%81%CF%89%CF%84%CE%B9%CE%BA%CE%AE-%CE%B5%CE%BA%CE%B4%CE%AE%CE%BB%CF%89%CF%83%CE%B7-%CF%84%CE%BF%CF%85-%CE%B5%CF%81%CE%B5%CF%85%CE%BD%CE%B7%CF%84%CE%B9%CE%BA%CE%BF%CF%8D-%CE%AD%CF%81%CE%B3%CE%BF%CF%85-timmod.html

After the events, the social media pages were updated with photos and information about the presentations delivered, etc.

2. ASSESSMENT OF ENVIRONMENTAL IMPACT OF INNOVATIVE TECHNOLOGIES AND GOOD PRACTICES CONSIDERED IN DT1.1.1 AND DT1.2.1 (*PRESERVING MARINE ENVIRONMENT*, *AVOIDING TECHNOLOGY SOLUTIONS GENERATING WATER*, *AIR OR NOISE POLLUTION*)

When selecting appropriate cost-effective technological innovations, special attention must be put to include as a major criterion the possible associated environmental impact during operation (e.g., producing underwater noise while using a towed side-scan sonar). Any suggested technological upgrade must be thoroughly checked versus environmental sustainability criteria.

This principle has been, and will be, a basic requirement when carrying out field surveys during the Pilot Demonstration Projects in Varna, Bulgaria (June 2021) and in Batumi, Georgia (October 2021).

It will also be a basic guide when drafting the Innovation Strategy within activity GA T.4.

Here below, some adverse impacts are described, relevant to the 4 categories of innovative marine survey technologies (as categorized in deliverable report DT1.2.1.)

Scientists and planners are increasingly turning to digital technology to save the ocean. Data is needed to map and monitor ocean conditions, assess the impacts of climate change, warn about ocean-related natural disasters, and manage the ocean's valuable economic and ecological resources.

Yet the same data technology that could help transform how we study and manage the ocean may also be unsustainable and environmentally damaging. As a result, at least some of the benefits of a more digitized planet and ocean may be offset by the environmental impacts of these efforts.

Fortunately, there are readily available solutions that could allow enjoying the benefits of a more digital ocean while limiting the negative environmental consequences of doing so.

The direction of development must be to liberate ocean data and countries to share more of the ocean data they already have.

The transition to sustainable ocean tech takes into account the environmental impacts of a more digital ocean pale in comparison to potential benefits, including environmental benefits, of having more and faster ocean data. There are concrete and readily available steps that can be taken to reduce the environmental impacts of ocean data and technology. Adoption of some or all of the options will only serve to increase these net benefits and reflect our shared commitment for a sustainable ocean data enterprise.

2.1 Innovative In-Situ Technologies. Advanced Instruments and Sensors

As a consequence of collection of data at increased temporal and spatial resolution, the data volume increases. Bun in fact the capacity for data analysis has not progressed comparatively. The growing discrepancy between the development of data collection and data analysis becoming a major bottleneck for effective use of the available data.

Government agencies are putting enormous amounts of environmental data into the cloud, and ocean scientists are in the process of creating arrays that will generate terabytes of new data. The hope is to unleash the power of big data to drive scientific discovery, ecological restoration and sustainable development. Yet processing this data requires large amounts of energy, potentially increasing carbon emissions.

To reduce carbon emissions, it is important to increase the efficiency of cloud computing for ocean data by employing simple software improvements and hyperscaling and to store ocean data on data centres that use green energy and batteries for back-up instead of fossil-fuel generators.

In addition, priority should be given to cloud providers and data solutions that take a “blue economy” approach to achieve net positive impacts on the ocean by creating, for example, underwater data centres that use natural ocean cooling to cool data centres, use these centres to collect ocean data and video, and have exteriors that are designed to promote eco-friendly reef-building.

Other energy-saving techniques include capturing heat energy from data centres and using it, and replacing old, carbon-emitting research vessels with autonomous sensor-carrying platforms while also pursuing a greener research fleet.

2.2 Sensor Carrying Platforms

Ocean sensors and the platforms that host them are full of materials that need to be mined from the Earth. The demand for these metals has led to global-scale efforts to explore and potentially mine minerals from the seafloor.

A solution to reduce the impact due to newly mined materials, and to thus reduce the environmental damage and biodiversity loss associated with mining (especially the sea floor), could be using recycled metals in ocean data sensors and platforms.

Many ocean sensor-carrying platforms are launched without any plans for recovery. Compounding the rise in the number of ocean sensors is the fact that many of these ocean sensors simply don’t last very long. While planned obsolescence is a frequently acknowledged downside of the digital economy, the problem in the ocean world is uncontrollable senescence - the ocean is a harsh and unforgiving environment for technical hardware.

As a result, non-recoverable ocean sensors contribute to the growing morass of ocean litter and plastic. When their batteries and metal parts corrode and fall apart, these sensors also release toxins and pollutants.

2.3 Remote-Sensing Technologies

Remote sensing/satellite observation of land and oceans is a field of research that was developed during the second half of the 20th century, and its importance is widely recognised because of the amount of information it can provide to the scientific community and the general public. The outcomes of remote sensing/satellite observation can be used to address and study significant aspects of environmental concern, such as habitat destruction, environmental degradation, forest fires, oil spills, and climate change. There is continuous improvement of the methods and means of remote sensing observations in order to achieve more accurate and useful information.

More than 10 remote sensing technologies have been studied within activity Act 1.2.1, and reflected in technical report D1.2.1. The main conclusions based on this study are:

An important advantage of Remote-Sensing Technologies is the possibility of observing large areas, and the main disadvantage is that they can observe only the water and land surface.

In general, the major advantage of Remote-Sensing Technologies is that they do not bring any adverse environmental impact on marine environment, sea water and living organisms.

The senescence of satellites is a mainstay in ocean data collection. As more satellites begin to clog space, the debris created by these satellites multiplies and much of that space junk falls back to Earth where it becomes ocean litter.

To reduce the marine litter created by ocean data collection, the durability of ocean sensors and platforms must be improved and regulate satellites with the ocean in mind. By focusing on more recoverable ocean sensors like small autonomous underwater vehicles and saildrones and putting more ocean sensors on mounted on maritime platforms that are either fixed (e.g. cables) or ships of opportunity that return to port (ferryboxes and ship-based sensors) marine litter can be reduced.

2.4 ICT Tools (numerical simulation systems, data handling and GIS tools)

The unavoidable digitalization of socio-political and scientific processes is based on ICT-driven changes. This fact has created increasing interest in the indirect environmental effects of these technologies. Assessments of indirect effects face various methodological challenges, such as the definition of the system boundary, the definition of a baseline as a reference or the occurrence of rebound effects.

Arushanyan (2013) has highlighted the fact that ICT tools' environmental impacts other than "Climate Change potential" and energy use are usually not as well studied and often omitted due to less interest and/or lack of reliable data. This poses the risk of sub-optimisation and problem shifting, as the environmental impacts of ICT solutions represent a large range of impact categories and the causes of these are not the same as the causes of, e.g., Climate Change potential. Manufacturing and the use phase were identified as the most important life cycle stages for the environmental impacts of ICT products. The use phase often dominates for many ICT products when assessing climate change potential and energy consumption, but for energy-efficient products, manufacturing is most likely to dominate the environmental impact. Important components contributing significantly to the impact from manufacturing were identified as being IC circuits, metals, plastic, LCD module and another depends on the product assessed and the quality of the data available. Up-to-date generic and specific data of better quality are needed to allow better assessment of a wider range of environmental impacts on different levels.

Methodological choices are challenging for any type of Life-Cycle-Analysis (LCA), but the questions of functional unit, time scope and allocation seem to be especially important for ICT solutions (Aranda et al., 2019). The choice of functional unit proved very important for the overall results in the case study performed. When there are difficulties in comparing two products due to their functional difference or different ways of providing the function, presenting the results through two or more functional units helps to demonstrate the complexity. Time scope definition, i.e., including or excluding long-term emissions, proved to have a significant impact on the overall impact of the online newspaper. The consideration of long-term emissions could significantly affect the environmental impacts in some impact categories (e.g., toxicity) due to the residues from mining precious metals necessary for production of the internal circuits included in every electronic device. Allocation appeared to be challenging and important to consider when assessing ICT solutions due to rather common multi-functionality of electronic devices.

User behaviour has also been identified as important. User practices can affect the overall impact of many ICT solutions and comparisons with non-ICT alternatives (Arushanyan, 2013). Parameters such as geographical location of the reader, type of device used, total use of device, life span of the device, etc. should be taken into consideration. Assumptions on substitution effects should be considered carefully when comparing ICT solutions with more traditional products (e.g., online or printed newspapers, e-books or hard-copy books, etc.). Better data on user behaviour are necessary for improved assessments.

For example, in the case of online newspapers, manufacturing of laptops, desktops and screens appears to be the key contributor to the environmental impacts. The use phase, i.e., electricity consumption when using the devices, had a lower impact in the present case study. However, this outcome might be different in assessments of the environmental impacts of reading an online newspaper in another country or region with another electricity mix. Content production and electronic distribution were identified as important life cycle stages of the online newspaper, but their contribution to the overall environmental impact is dependent on the number of readers, newspaper characteristics and reader practices.

Bieser and Hilty (2018) have presented a systematic literature review for the assessment of indirect environmental effects of ICT solutions, identified as those effects that change patterns of production or consumption in domains other than ICT, or more precisely, the environmental consequences of these changes. Out of the wide variety of EIA approaches about ICT, the most common application domains are virtual mobility (e.g., telecommuting), virtual goods (e.g., digital media), and smart transport (e.g., route optimization). LCA, partial footprint, and the "ICT enablement method" are the most common approaches. A major part of the assessments focuses on patterns of production (e.g., production of paper-based books vs. e-books), a smaller part on patterns of consumption (e.g., changes in media consumption). Yet, there is still a research gap in the investigation of ICT impacts on consumer behaviour, which could, for example, focus on social practices, and account for the dynamic implications of change. Thus, the ICT's impact on society and resulting environmental consequences are still largely unidentified but estimated to be inferior to the direct impacts of other tangible technologies.

The above considerations concerning specific types of monitoring technologies, are included in Table 4.1, when comparing different technologies from the above listed 4 categories. The two aforementioned life-cycle phases of ICT products are still associated with large uncertainty and further need better data on the actual flows. This especially concerns end-of-life treatment, since the well-functioning waste treatment process normally assumed in assessments differs significantly from possible informal recycling processes in reality. More information on actual electronic waste flows and treatment is required.

A first good assessment framework for environmental impact of ICTs in the EU can be found in its Rolling Plan of Standardisation activities:

https://joinup.ec.europa.eu/collection/rolling-plan-ict-standardisation/ict-environmental-impact

The ITU Telecommunication Standardization Sector (ITU-T) has also provided its own assessment framework for environmental impacts of the ICT sector (2012) and concludes that there is no single assessment framework that meets the needs of ICT organizations around the world. Instead, each organization needs to map the standards and guidelines to their own requirements, in terms of business strategy and environmental performance, in order to create an assessment framework that meets their own business challenges, and is right for them (Coroamă et al., 2020).

3. ECONOMICAL ASSESSMENT OF INNOVATIVE TECHNOLOGIES AND GOOD PRACTICES UNDER CONSIDERATION

3.1 Market research (estimated price review based on internet investigation)

Market research has been carried out, based primarily on prices published in Internet (where available) as well as on some quotation received by partners upon their requests.

Information on results from this market research can be found in section 4.1., table 4.1.1, where some estimated prices, or general observations upon the cost of equipment, are presented.

3.2 Preliminary analysis on economic efficiency (estimated costs versus expected benefits)

In most of the cases equipment for monitoring of water quality or/and assessment of fish stock and non-fish resources is quite expensive. Therefore, some attempt to analyse the economic efficiency of purchase and use of such equipment have been done with activity 1.3 - despite the very limited information on the prices of the equipment or/and software.

For the most appropriated innovative technology solutions, for which some information on the market price have been found, the Project Partners have been asked to provide their view concerning economic suitability - costs versus expected benefits.

A summary of this information is hinted herebelow in table 4.1, where a quick review is presented on the innovative technological solutions described in detail in deliverable report D.T1.2.1.

4. SELECTED INNOVATIVE SOLUTIONS AND RELEVANT BEST PRACTICES FOR WATER QUALITY MONITORING, FISH STOCK AND NON-FISH RESOURCE ASSESSMENT

4.1 Selected innovative solutions for water quality monitoring, fish stock and non-fish resource assessment

A review on world-wide existing innovative technologies, already proven in operational conditions, has been presented in Deliverable report DT1.2.1. This review is based on collecting comprehensive information on existing technological breakthrough solutions and relevant technical and operational approaches. The mapping of existing technology innovations covers all geographical areas (all European seas, and the world ocean), as well as any innovative solutions relevant to monitoring of parameters concerning fish and shellfish abundance.

This analysis distinguishes between technological readiness levels (TRL 4 to 9) of innovations, separating technologies in research/testing/verification phase, and other used in operating practices with already proven efficiency. The latest are analysed in order to suggest appropriate modern technologies applicable in Black Sea...

Here below, in table 4.1, a quick review is presented on 40 innovative technological solutions (described in detail in DT1.2.1), separated in 4 categories:

- Innovative In-Situ Technologies. Advanced Instruments and Sensors
- Sensor Carrying Platforms
- Remote-Sensing Technologies
- ICT Tools (numerical simulation systems, data handling and GIS tools)

Based on the collective assessment done by all 6 TIMMOD project partners, 12 of the above technological solutions (3 from each of the 4 categories) are nominated as "RECOMMENDED" for application for different tasks related to water quality monitoring, fish stock and non-fish resource assessment in Black Sea. The list of recommended technologies is presented here below

Project funded by EUROPEAN UNION

Table 4-1 Selected innovative solutions for water quality monitoring, fish stock and non-fish resource assessment

I. INNOVATIVE IN-SITU TECHNOLOGIES. ADVANCED INSTRUMENTS, SENSORS AND PLATFORMS.

Technology type / Technical solution	Existing product /service. Manufacturing Company	Environmental suitability of the product/service	Market research / Estimated Costs	Other considerations
1. Acoustic Doppler current profiler	Model "Sentinel V", Teledyne RD Instruments ltd, USA HydroSurveyor ADP system / SonTek (a Xylem brand), USA	Contributes to noise pollution in the ocean which may interfere with cetacean navigation and echolocation. The last models operate in a frequency range where noise pollution has not been identified to be a serious problem.	50-70,000 EUR. Cost is a concern (but is normally dwarfed by the cost of the ship required to ensure a safe and professional deployment)	
2. Multiparameter water-quality sonde	EXO 2, latest generation of marketed by YSI Inc, Xylem, USA In-Situ - Aqua TROLL 600 MPx Autonomous multi-parameter probe, NKE Instruments, UK	No adverse environmental impacts reported	8,000 -40,000 EUR, depending on number of sensors and accessories	
3. Multi-beam sonar for fisheries assessment applications	SeapiX-R, SeapiX-f (iXblue, Defense & Space, France) BioSonics Multibeam M3 sonar (Kongsberg Mesotech Ltd., Norway) DIDSON, Sound Metrics Corp., Bellevue, WA, USA	Possible acoustic contamination. Operating schedule could be subject of seasonal, breeding periods defining low/high impact. Contributes to noise pollution in the ocean which may interfere with cetacean navigation and echolocation. Hi frequency	Price may vary usually between 50 000 - 75 000 EUR. Cost may be a real concern for purchase by research institutions. However, it is normally dwarfed by the cost of the ship required to ensure a safe and	Highly recommended in combination with EchoView (average price 10 000 EUR) imagery processing software

		range models do not produce noise pollution that has been identified to be a serious problem.	professional deployment.	
4. Turbidity Meter (suspended sediment concentration), Optical Back-Scatter technology	OBS501- Turbidity Meter with Antifouling Features, manufactured by Campbell Scientific, UK	No environmental constrains	12,000.00 EUR	
5. Matrix Flu-UV optical fluorescence sensor	TriOS, NEXOS Project, NKE Instruments, UK LISST-200, by Sequoia, USA	No environmental constrains	Depending on product parameters.	
6. Flow cytometers / Imaging flow cytobot	IFCB, developed by WHOI, McLane Research Laboratories, Inc., USA	No environmental constrains	Depending on product parameters.	
7. Environmental Sampling Processor (ESP)	Monterey Bay Aquarium Research Institute (MBARI), Sensors: Underwater Research of the Future (SURF Center)	No environmental constrains	Depending on product parameters.	

II. SENSOR-CARRYING PLATFORMS

Technology type / Technical solution	**Existing product /service. Manufacturing Company**	**Environmental suitability of the product/service**	**Market research / Estimated Costs**	**Other considerations**
1. Towed optical or/and hydro-acoustic assessment device (TOAD/THAD), applicable to carry fish assessment devices	TRIAXUS ROTV for fishery research, MacArtney, Denmark TOV-2, JW Fishers, USA Underwater Camera System, NOAA's Alaska Fisheries Science Center, USA	Possible seabed contacts and disturbance in benthic habitat, esp. in sensitive areas, such as marine protected areas.(depending on product weight). No serious environmental constrains	5 000 EUR - 25 000 EUR depending on product parameters.	
2. Airborne LiDAR for	Harris Geospatial Solutions, Inc.	No environmental constrains.	Varies widely depending on	

marine water quality application		Collecting data with Airborne LiDAR is providing several benefits compared to other measurements.	the equipment and product software.	
3. Autonomous survey systems: Unmanned Surface Vehicles (USV) able to carry fish assessment devices Remote Operated Vehicles (ROV) for underwater applications for fish and shellfish studies	SeaRobotics UK's National Oceanography Centre (NOC) BUSCAMOS-RobObs MacArtney, Denmark ROTV platform with ScanFish devices, Eiva, USA UUV survey system "Iver4 580", Harris Geospatial Solutions RangerBot	No serious environmental constrains.	Starting from 50 000 EUR depending on the type, size, equipment, power source. Fully equiped could reach 1 200 000 EUR.	Autonomous systems, powered partially or completely by solar, wind and wave power bring several positive impacts replacing traditional manned and fuel systems having low footprint.

III. REMOTE SENSING TECHNOLOGIES

Technology type / Technical solution	Existing product /service. Manufacturing Company	Environmental suitability of the product/service	Market research / Estimated Costs	Other considerations
Satellite Imagery				

1. Satellite Imagery	NASA's Landsat 8 ESA's Sentinel-2 missions Ocean Service NOAA, USA	No environmental constrains during operation.	Upon inquiry.	Environmental Monitoring conducted is by satellite applications are becoming more accurate in areas such as geolocation of marine species, monitoring of overfishing and of algae growth, as well as wider monitoring of global water resources.
Aircraft-based sensor technologies				
2. Autonomous opto - acoustic surface robot platform. Ship-deployed high-endurance VTOL UAVs.	Manta UAV with the LDEO RAD Payload, WB Electronics Korea Electronics Technology Institute, IoT Convergence Research Center	No environmental constrains during operation.	Upon inquiry.	
Radar technologies				
3. Imaging techniques for coastal and ocean observations.	Chinese Gaofen-3 SAR imaging techniques, China Academy of Space Technology (CAST) Coastal Ocean Dynamics Applications Radar (CODAR), NOAA Environmental Technology Laboratory	No environmental constrains during operation.	Upon inquiry.	
4. Automated, non-invasive, opto-acoustic systems for stock assessment	SYMBIOSIS MkIII AOS	No serious environmental constrains.	Upon inquiry.	

ICT TOOLS. NUMERICAL SIMULATION SYSTEMS. DATA HANDLING & GIS TOOLS

Technological solution	**Legal appropriateness and compatibility**	**Environmental suitability**	**Market research/Prices**	**Other considerations**
1. Shallow water equations model	ADCIRC (ADvanced CIRCulation model), University of North Carolina at Chapel Hill, USA	Undefined adverse environmental Impacts. Estimation for very low consequences.	ADCIRC model free, with source code available by request via the website, allowing users to run the model on any system with a Fortran compiler. Pre-compiled Windows version of the model purchased alongside the software SMS 13.1 or else editions for *River & Coast* by AQUAVEO™: Local license starting at: $17,260 Flex license starting at: $21,790	Rather arduous setup and manipulation.
2. Ocean Component Model: Japanese ocean general circulation model	COCO 4.0, CCSR (Center for Climate System Research) , Atmosphere and Ocean Research Institute, University of Tokyo and JAMSTECRIGC Advanced Ocean Modelling Research Team	Undefined adverse environmental Impacts. Estimation for very low consequences.	Free of charge. Access to COCO 4.0 model is not available on-line. Only after registration and contact with Hiroyasu Hasumi (https://ccsr.aori.u-tokyo.ac.jp/~hasumi/COCO/).	Not a big community of researchers for updates and support.
3. COupled Hydrodynamical Ecological model for REgioNal Shelf seas	COHERENS Flemmish open-source ocean circulation model developed by several European institutions and the Management Unit of the North Sea Mathematical Models and the Scheldt estuary (MUMM, now OD Nature)	Undefined adverse environmental Impacts. Estimation for very low consequences.	Freely available – Open source. Information about COHERENS users is mandatory via an official registration form. Freely available and released under the "European Union Public Licence" (EUPL).	Easy to setup maintain and manage. Simplistic graphic output.

4. Finite Volume Community Ocean Model:	FVCOM a prognostic, unstructured-grid, finite-volume, free-surface, 3-D primitive equation coastal ocean circulation model developed by UMASSD-WHOI National research university, UMass Dartmouth	Undefined adverse environmental Impacts. Estimation for very low consequences.	Freely available – Open source. Information about FVCOM users is mandatory via an official registration form in GitLab.	No prior experience. Not clear online freely available instructions. Good visualization toolkit open source and free.
5. Primitive-equation model of the global ocean circulation used also for regional studies	HOPE (The Hamburg Ocean Primitive Equation General Circulation Model)	Undefined adverse environmental Impacts. Estimation for very low consequences.	Free of charge. Research-oriented and protected. Unavailable online.	-
6. General circulation model: based on the observation for a large-scale ocean circulation model designed for climate studies	LSG-OGCM- Large Scale Geostrophic Ocean, The Hamburg Large Scale), Max-Planck-Institut fuer Meteorologie, Hamburg (Germany)	Undefined adverse environmental Impacts. Estimation for very low consequences.	Free of charge. Academic-oriented. Unavailable online.	Not full support as other alternatives.
7. Sub-Grid Scale (SGS) form for mesoscale eddy mixing on isopycnal surfaces for use in non-eddy-resolving ocean circulation models	OPYC (The Ocean IsoPYCnal General Circulation Model), World Data Center for Climate (WDCC) is hosted by the German Climate Computing Center (DKRZ)	Undefined adverse environmental Impacts. Estimation for very low consequences.	Free of charge. Academic-oriented. Unavailable online.	-
8. Data-assimilative hybrid isopycnal-sigma-pressure (generalized) coordinate ocean model	HYCOM (HYbrid Coordinate Ocean Model), National Ocean Partnership Program (NOPP), as part of the U. S. Global Ocean Data Assimilation Experiment (GODAE)	Undefined adverse environmental Impacts. Estimation for very low consequences.	Free of charge. Academic-oriented. – Open source code – Registration – Uploaded in GitHub.	Full online forum support. Complex system, not easy to setup. Constant updates and release notes. Video support and good documentation.
9. Isopycnic coordinate ocean circulation model mainly used in global and/or watershed scales	MICOM (Miami Isopycnic Coordinate Ocean Model)	Undefined adverse environmental Impacts. Estimation for very low consequences.	Free of charge. Academic-oriented. – Untraceable online services.	-
10. 3-D General Circulation Model for atmosphere, ocean, and climate interaction	MITgcm (M.I.T. General Circulation Model): designed for study of the atmosphere, ocean, and climate, non-hydrostatic, finite volume method formulation, fluid phenomena simulation over a wide range of scales	Undefined adverse environmental Impacts. Estimation for very low consequences.	Free of charge. Research-oriented. – Open source code – Uploaded in GitHub.	Online forum support. Complex system, not very easy to setup. Constant updates and release notes. Good documentation.
11. 3-D ocean circulation model	MOM (GFDL Modular Ocean Model),	Undefined adverse environmental	Free of charge. Research-	No online forum support.

designed for studying the ocean climate system, developed and supported by researchers	NOAA's Geophysical Fluid Dynamics Laboratory (GFDL) in Princeton, NJ, USA	Impacts. Estimation for very low consequences.	oriented. – Uploaded in GitHub. Open-development software framework.	Complex system, but easy to setup. Good release notes and documentation.
12. Ocean modelling framework which is composed of "engines" nested in an "environment", numerical solutions of ocean, sea-ice, tracers and biochemistry equations and their related physics	Ocean dynamics "NEMO ocean engine", Gurvan Madec and NEMO System Team, Scientific Notes of Climate Modelling Center (27) – ISSN 1288-1619, Institut Pierre-Simon Laplace (IPSL)	Undefined adverse environmental Impacts. Estimation for very low consequences.	Free of charge. Research-oriented. – Uploaded in its own webpage. Open-source software framework.	Good online forum. Complex system. Rare updates. Good manual documentation
13. Ocean modeling code to simulate a wide range of problems, from small-scale coastal processes to global ocean climate change 14. Navy coastal ocean model (NCOM) Finite-volume coastal ocean model (FVCOM)	POM (Princeton Ocean Model), Princeton University	Undefined adverse environmental Impacts. Estimation for very low consequences.	Freely distributed to the academic community and commercial users by Copyright agreement – Registration - Open source code. Uploaded in its own webpage.	Full online forum support. Complex system, but easy to setup. Constant updates and release notes. Good documentation.
15. Three-dimensional hydrodynamic and sediment transport Estuarine and Coastal Ocean Model	ECOMSED, the Estuarine and Coastal Ocean Model, HydroQual, STEVENS INSTITUTE OF TECHNOLOGY	Undefined adverse environmental Impacts. Estimation for very low consequences.	Free of charge. Research-oriented. Unavailable online.	-
16. Ocean general circulation model for ocean and climate research	CCSM2.0 Parallel Ocean Program (POP), LANL (Los Alamos National Laboratory, USA)	Undefined adverse environmental Impacts. Estimation for very low consequences.	Free of charge. Research-oriented - Open source code. Uploaded in its own webpage and GitHub.	Limited forum support. Complex system. No pre- and post-processing setup. Good release notes and documentation.
17. Free-surface, terrain-following, primitive equations ocean model widely used for a diverse range of applications	ROMS (Regional Ocean Modelling System), Rutgers University, University of California Los Angeles, and contributors worldwide	Undefined adverse environmental Impacts. Estimation for very low consequences.	Free of charge. Research-oriented - Open source code. Registered users only. Uploaded in its own website.	Full online forum support. Complex system. Constant updates and release notes. Good documentation.

18. 3D hydrodynamic simulation tools for 3-D free surface flows modelling and associated sediment or water quality processes, standard for environmental and ecological studies	MIKE 3, ECO Lab module, DHI Group, Water Environment Health	Undefined adverse environmental Impacts. Estimation for very low consequences.	Proprietary software. Subscription Packages Perpetual Licenses Academic Licenses MS Azure Marketplace with own Internet License MIKE Software as a Service for one simple hourly fee **>1125€ per user per month for an annual subscription**	Easy-to-use and setup. Good prior experience. Very good graphical output.
19. Hydrodynamic and ecological modelling: Free and open-source suite of models	Delft3D, Deltares, the Netherlands	Undefined adverse environmental Impacts. Estimation for very low consequences.	Free of costs - Open source code and software – Registered users. Available via its own website.	Full online forum support. Complex system, but easy pre- and post-processing setup in two versions (a very good GUI and a Dashboard). Versatility in Windows and Linux O/S. Constant updates and release notes. Good documentation.
20. Planktonic ecosystem model coupled to several different hydrodynamic models, describes the biogeochemical cycling of carbon and the nutrients nitrogen, phosphorous, silicon, oxygen, and iron	ERSEM (European Regional Seas Ecosystem Model), Plymouth Marine Laboratory	Undefined adverse environmental Impacts. Estimation for very low consequences.	Free of costs - Open source code – Registered users. Available via its own website.	Easy coding and setup. Not full maintenance support. No forum. Only mailing contact with developers.
21. NPZD (Nutrient-Phytoplankton-Zooplankton-Detritus)	Met Office Hadley Centre Coupled Model, version 3 (HadCM3-C), Hadley Centre for Climate Prediction and Research; NCAS British Atmospheric Data Centre	Undefined adverse environmental Impacts. Estimation for very low consequences.	Academic source code – Unavailable online.	-
22. Plankton ecosystem model for anthropogenically-driven changes (climate,	MEDUSA-2 (Model of Ecosystem Dynamics, nutrient Utilization,	Undefined adverse environmental Impacts. Estimation for very low	Academic source code – Unavailable online.	-

acidification) and oceanic biogeochemistry, resolves a size-structured ecosystem	Sequestration and Acidification)	consequences.		
23. Global 3D model with local and regional applications representing lower-trophic marine ecosystems based on plankton functional types (PFTs)	PlankTOM6 & PlankTOM10: The PlankTOM series of models developed from the PISCES-T ocean BGC model (based on PISCES model of (Aumont et al., 2003),	Undefined adverse environmental Impacts. Estimation for very low consequences.	Academic source code – Unavailable online.	-
24. 3D ecosystem and carbon-cycle model intended to be used in global, regional, and local applications	PISCES (Pelagic Interaction Scheme for Carbon and EcoSystem)	Undefined adverse environmental Impacts. Estimation for very low consequences.	Academic source code – Unavailable online.	-
25. Bio-geochemical model, free software	ERGOM, used in several institutes and universities around the Baltic Sea, Leibniz Institute for Baltic Sea Research, Warnemuende, Germany by Thomas Neumann and Wolfgang Fennel	Undefined adverse environmental Impacts. Estimation for very low consequences.	Free of charge. Open source code – Research-oriented. Available online by its own website - Code Generation Tool (CGT) with editor (CGT-EDIT) - Programs are licesed under GNU Public License.	Good documentation. Need for Matlab support. Support only via mailing list. Rather slow process.
26. Quantum GIS	Open-Source Geographical Information system (for marine applications)	Undefined adverse environmental Impacts. Estimation for very low consequences.	Free of charge. Free software. Available online by its own website.	The most common solution for free GIS software. Constant evolution. Good support. Very active Community Forum.

Based on the findings in this report, and on the independent assessments of all TIMMOD project partners, the following technologies are nominated as RECCOMENDED for application in Black Sea:

Table 4-2 Technology innovations recommended for application in Black Sea

Category I: Innovative In-Situ Technologies. Advanced Sensors and Instruments	
1.	Multibeam Sonar for fishery applications (e.g.: SeapiX-R/F Volume 3D sonar, iXblue by Defense & Space, France; BioSonics Multibeam M3 sonar by Kongsberg Mesotech Ltd., Norway; DIDSON, by Sound Metrics Corp., Bellevue, WA, USA)
2.	Acoustic Doppler Current Profiler (e.g., ADP by SonTek, or ADCP by Teledyne RD Instruments)
3.	Multiparameter water-quality sonde (e.g., EXO-2 by YSI Instruments)
Category II: Sensor Carrying Platforms	
1.	Airborne LiDAR for marine water quality application (e.g., Harris Geospatial Solutions)
2.	Towed optical assessment device - TOW/TOAD (e.g., TOV-2, JW Fisher)
3.	New-generation survey ships (modern navigation systems, carryiong IT monitoring tools for fisheries, environmentally friendly and carbon emissions efficient and safe)
Category III: Remote Sensing Technologies	
1.	Autonomous opto-acoustic system (e.g., SYMBIOSIS project, Horizon 2020, University of Haifa)
2.	High-Frequency (HF) radar technologies in ocean monitoring (e.g., NOAA, or Massachusetts University)
3.	Underwater Time-Of-Flight Imaging Acquisition System (e.g., UTOFIA/ SINTEF)
Category IV: ICT tools	
1.	Delft3D Numerical Modelling System, Deltares, the Netherlands
2.	MIKE 3 Modelling of Coasts and Sea - ECO Lab module, DHI Group, Water Environment Health
3.	Open-source Geographical Information System, for marine applications (e.g., Quantum GIS, R-Studio with GIS libraries, and Python scripting with GIS libraries)

4.2 Recommended Best Practices with potential for replication in Black Sea

The mapping of good practices done within technical report DT1.2.2 was primarily focused (but not limited to) the Black Sea region. The focus was put on such practices that are suitable and can be replicated for the typical conditions of Black Sea. These good practices have been first presented by the GA T1 Leader BDCA at the Thematic Transboundary Meeting 2 (organized by AUTh, Greece, in April 2021).

In this report, further analysis (including check on environmental aspects and legal appropriateness is carried out, in order to select for further promotion of the most appropriate best practices.

Furthermore, the recommended best practices will be discussed by the project consortium and stakeholders at 5 national workshops, best selected of them will be published in the internet site of the project, will be showcased, and therefore promoted for further replication in the Black Sea basin.

Here below, in table 4.2, a comparison is presented between the 18 good practices with potential for replication in Black Sea, as studied in deliverable DT1.2.1.

As a result of comparison of different technologies, and findings in this report, 8 best practices are nominated for further consideration at the national validation workshops and final promotion through the TIMMOD communication and dissemination tools.

Table 4-3 Identified good practices with potential for replication in Black Sea

Good Practice / Technological solution	Owner / Operator	Legal appropriateness and compatibility	Environmental suitability	Other considerations
WATER QUALITY MONITORING, ECOSYSTEM FORECASTS				
Ecosystem Monitoring for Mediterranean Sea (Poseidon system),	Hellenic Centre of Marine Research, Greece	Yes	Yes	Potential for Up-scaling / replication in Black Sea. Will need (intergovernmental) investment.
Buoy Observation System	Marine Ecosystem and Climate Research Center (DEKOSIM, METU), Turkey	Yes	Yes	Potential for Up-scaling/replication in all Black Sea. Will need (inter-governmental) investment.
Space Monitoring of coastal Pollution, Russian Sector of Black and Azov Seas	Russia	To be confirmed	Yes	Restricted access, for Russian bodies primarily
Innovative monitoring of marine environment and waste on beaches	Institute of Oceanology IO-BAS Bulgaria	Yes	Yes	Part of international project
Photogrammetric & instrumental measurement of physicochemical and biological parameters	DiNiMar, Bulgaria	Yes	Yes	Applicable at small-scale (local projects) only
FISH STOCK ASSESSMENT. NON-FISH (SHELLFISH) RESOURCE ASSESSMENT				
Innovative methodology for the stock assessment and forecast of shellfish species	Institute of Fish Resources, Varna, Bulgaria	Yes	Yes	Recommended for use in other research Institutes in Black Sea region
Assessment of commercial fish stocks	National Environmental Agency, Georgia	Yes	Yes	Recommended for use by other Environmental Agencies in Black Sea

by hydro-acoustic system,				region
SKYFISH - Service for Water Quality Monitoring for Sustainable Fishing and Aquaculture in the Romanian Coastal Area	Project, Copernicus CMEMS, National Institute Grigore Antipa, Romania, TERRASIGNA, Romania	**Yes**	**Yes**	Already operating in Black Sea. Need extension to all Black Sea States
ESPOSS: Big Data Infrastructure for the Black Sea region	**Advanced Studies and Research Center (ASRC)**	**Yes**	**Yes**	Already operating in Black Sea. Need extension to all Black Sea States
Collecting water quality data by EMSO - EUXINUS	GeoEcoMar, Romania	**Yes**	**Yes**	
Offshore hydro-meteo buoy at Danube delta, Sulina branch	AFDJ Galati RA, Romania	**Yes**	**Yes**	Experience can be used / merged with other similar systems (e.g., DEKOSIM buoy network).
SENSOR-CARRYING PLATFORMS				
Underwater ROV “Max Rover”	NCMR, Greece	**Yes**	**Yes**	
Application of a flying drone to marine research	Institute of Oceanology IO-BAS Bulgaria	**Yes**	**Yes**	
Unmanned surface vehicle (USV) drone	CORES ltd, Varna, Bulgaria	**Yes**	**Yes**	
ICT TOOLS				
ICT tool for Smart Water monitoring	WIDEST project,	**Yes**	**Yes**	
MARIA-Box ICT tool	CyRIC - Cyprus Research and Innovation Center Ltd	**Yes**	**Yes**	

Best practices with potential for up-scaling/replication in Black Sea, recommended for further promotion by TIMMOD network:

Table 4-4 Recommended best practices for Replication in Black Sea

1) **POSEIDON system - Ecosystem Monitoring for Mediterranean Sea** (operated by Hellenic Centre of Marine Research, Greece)
2) **SKYFISH Service for Water Quality Monitoring for Sustainable Fishing and Aquaculture** in the Romanian Coastal Area, Copernicus CMEMS (operated by National Institute Grigore Antipa, Romania and TERRASIGNA, Romania)
3) **Hydro-acoustic system / application of multibeam sonar** (BioSonics scientific echo-sounders) for stock assessment (operated by LEPL National Environmental Agency of Georgia
4) Innovative methodology for assessment and forecast of shellfish abundance Institute of Fish Resources, Varna, Bulgaria
5) **Buoy observation systems for water quality monitoring** (operated by HCMR Greece, DEKOSIM Turkey, AFDJ Galati RA, Romania)
6) **Application of a flying drone to marine research** (operated by Institute of Oceanology IO-BAS Bulgaria)
7) **Application of Unmanned Surface Vehicle (USV)** drone for use with fish stock assessment tools, e.g., multibeam sonar (operated by CORES ltd, Varna, Bulgaria)

4.3 Recommendations on the Indicative roadmap for replication and up-scaling.

Some recommendations are given here toward the elaboration of the Innovation Strategy (planned in group activity GA4) as a flexible planning technique to support strategic and long-range planning for introduction of technology innovations in marine environment monitoring and fisheries research. The basic principle is to match short-term and long-term goals with specific technology solutions. The Strategy shall present a plan that applies to a new product or process and may include using technology forecasting or technology scouting to identify suitable emerging technologies.

It is also expected that roadmapping techniques may help R&D organisations to plan and implement in a more holistic way to include non-financial goals and drive towards a more sustainable development.

The indicative roadmap shown here below has three major targets:

to helps reach a consensus about a set of needs and the technologies required to satisfy those needs,

it provides a mechanism to help forecast technology developments, and it provides a framework to help plan and coordinate technology developments.

The indicative roadmap will be used in GA T4 to prepare the Innovation Strategy.

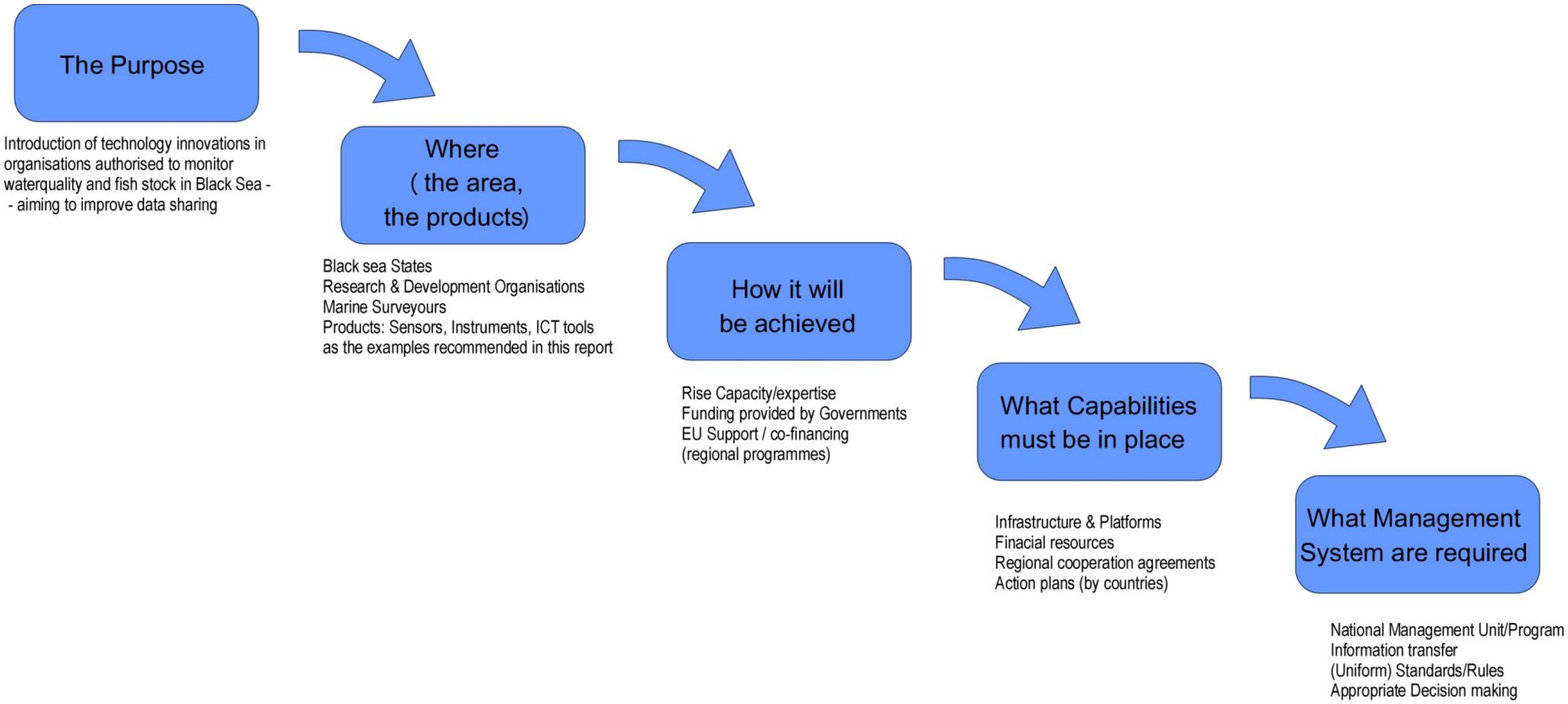

Figure 4-1Indicative road-map for the Innovation Strategy

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5. CONCLUSIONS AND RECOMMENDATIONS TO THE INNOVATION STRATEGY

This report provides analysis and recommendations on adoption of appropriate technology innovations and promotion of best practices for marine environmental monitoring and assessment of fish and shellfish resources at Black Sea. It builds upon findings of previously developed technical reports DT.1.1. and DT1.2. and recommendations provided during the project thematic transboundary meetings (TTM-1, TTM-2, TTM-3). The report covers various technology solutions, focusing on:

- general equipment / platforms, i.e., vessels, boats, buoys, satellites, autonomous surface vehicles, remote operated vehicles;
- new-generation sensors, presented by technology (e.g., acoustics, infrared); and by type (e.g., turbidity sensor, nitrate sensor, fish-count sensor, etc.);
- various methodologies of data collection/sampling/measurements, including methods/ tools of real-time measurements, advanced tools for water sampling for lab analysis, etc.;
- ICT tools / software for data handling/transmission technologies, e.g., radio telemetry, satellite transfer, etc.; software tools for data handling and visualization, including recent cloud technologies and web base solutions.

A review on major barriers and enablers for introducing technology innovations in fishery research in Black Sea is presented in Section 1. National aspects from the 5 countries represented in TIMMOD are discussed, while short reference to other Black Sea countries is also presented. Various regulatory and financial barriers are identified in the different countries. On the other hand, raising capacity and public awareness, including role of TIMMOD project is highlighted as an important enabler for technology advancement.

Key factors (other, than technological ones) influencing the replication of technology innovations are analysed: the environmental impact of the technical solutions (preserving marine environment, avoiding technologies generating water, air or noise pollution, are considered), together with the quick assessment on economical efficiency (estimated costs versus expected benefits) economical is presented. This analysis is used for further selection of most appropriate technological solutions.

Based on the analysis presented in this report, including assessment of environmental impacts and economical efficiency of various technology innovations, a selection of innovative solutions and relevant best practices for water quality monitoring, fish stock and non-fish resource assessment for the conditions of Black Sea is presented The list includes:

- 12 advanced technological solutions applied in EU or world-wide (in-situ and remote operated sensors and instruments, sensor carrying platforms, numerical simulation and data handling software, GIS and other ICT tools (Table 4.2)
- 6 Best practices, operated by research organizations or private industries within the Black Sea and Mediterranean area, with potential for further replication and up-scaling in the Black Sea region (Table 4.4)

Recommendations on the Indicative roadmap for replication and up-scaling of suggested innovative technologies is also presented.

The reccommendations provided in this report, and suggested technological solutions and best prctices will be finally discussed (together with the Draft Innovation Strategy) during the planned National Validation Workshops in first quorter of 2022.

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