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# The BLUEMED Italian White Paper: an overview of relevance, obstacles and proposals of the key sectors for a Blue Growth

BLUEMED Italian White Paper Working Group

Consiglio Nazionale delle Ricerche

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# 01

# EXECUTIVE SUMMARY

## 1.1. INTRODUCTORY REMARKS

The Mediterranean Sea is a crucial crossroad for the history, economy and culture of Europe, Middle East and North African countries. Many different interests depend on its resources. However, until very recently, past and current impacts of human activities on the basin have been largely neglected, nor has a coordinated plan for a coherent and sustainable use of its resources been developed.
The concept of Blue Growth and sustainable marine and maritime economic development adopted by the European Union (EU) since 2012 foresees a knowledge driven exploitation of marine resources, different from current practices and aimed towards the improvement of social wellbeing (EU, 2012). Blue Growth implies a drastic change from how operators from marine and maritime sectors have traditionally addressed management of marine resources, towards a synergistic, non-conflicting and sustainable use of the sea, still allowing for a significant growth and prosperity. This is now recognized as a global challenge and believed to be particularly relevant for the Mediterranean region, given its long history of marine resources exploitation and increasing human pressure. According to present development models, the economic growth potential of the Mediterranean Sea is not being fully harnessed. Further exploitation however needs to occur without compromising natural resources and their sustainability in the long term. The Mediterranean region is thus an ideal natural laboratory to test the implementation and feasibility of Blue Growth. To verify how realistic this approach is, a collective effort of joint analysis and strategy design is needed.
When considering the current economic crisis and the evolving political, social and environmental conditions in the Mediterranean Region, it becomes apparent that all the multidisciplinary actors from different countries need to build an ideal environment for constructive dialogue and lay the groundwork for conditions that allow societies, economic operators and policies to attract investments, while reconciling tensions and balancing economic growth, social implications and environmental conservation. Tackling climate change, the Mediterranean is indeed one of the hotspots for global warming, understanding ecosystem function, managing sustainability, all require the most effective initiatives and strategies. Hence, the EU Blue Growth initiative represents a long-term strategy to support growth in the maritime sector as a whole by harnessing the untapped potential of Europe's oceans, seas and coasts for the creation of "blue" jobs and economic growth.
To this aim, nine European Countries (Croatia, Cyprus, France, Greece, Italy, Malta, Portugal, Slovenia, Spain) and the European Commission (EC) have been promoting and supporting the BLUEMED Research and Innovation Initiative for blue jobs and growth in the Mediterranean area since 2014 (www.bluemed-initiative.eu). Since 2017, BLUEMED has been formally endorsed by all member countries of the European Union and of the Union for the Mediterranean (UfM), including non-EU countries, through the undersigning of the Valletta Declaration.
The EC also funded the BLUEMED project (2016-2020), a Coordination and Support Action (CSA) to promote the implementation of the BLUEMED Strategic Research and Innovation Agenda (SRIA). The BLUEMED SRIA is a shared reference for the Mediterranean countries that addresses key challenges and identifies the main common priorities to foster Blue Growth. The BLUEMED project involves all the EU Member States supporting the BLUEMED Initiative and is coordinated by the Italian National Research Council (CNR). Its success will mostly depend on the ability to involve the relevant actors and stakeholders in the definition of knowledge driven shared strategies, to be implemented at national and international level.
To support the participative process while connecting the top-down and bottom-up approach and stimulating a dialogue among stakeholders, the BLUEMED project established four thematic working groups, the so called BLUEMED platforms at Mediterranean level. Three of them reflect the three pillars on knowledge, economy, and technology clustering the SRIA key challenges; an additional cross-cutting platform is dedicated to policy (Tab. 1). The BLUEMED platforms are conceived as fora where national representatives interact to convey the messages from their communities to consolidate the BLUEMED SRIA. The platforms also act as dynamic observatories for monitoring the system. In the long term, the platforms are expected to become a transnational network that will continuously and operationally put into effect, monitor, prioritize and update the SRIA's actions in the Mediterranean.

| KNOWLEDGE PLATFORM | ECONOMY PLATFORM | TECHNOLOGY PLATFORM |
|---|---|---|
| POLICY PLATFORM | | |

**Tab. 1**
The three pillars of the BLUEMED SRIA reflected in the BLUEMED Platform and a cross-cutting Policy platform

Based on this framework and on research and innovation (R&I) priorities established in the Mediterranean by national and EU dedicated programmes, Strategic and Innovation Agendas, and building on the main outcomes of relevant projects and initiatives, **this White Paper reviews the present status of the main economic sectors involved in Blue Growth**. It also discerns the main obstacles to the achievement of the identified priorities and proposes possible strategies to overcome them, starting from an Italian perspective.
This contribution is the result of the active engagement of the Italian scientific community and relevant marine and maritime stakeholders. Several approaches and tools were adopted to manage these interactions, as reported below.

- *First national BLUEMED event*
  Preliminary ideas and suggestions were collected at the national workshop "BLUEMED meets Italian Stakeholders" held in Rome, at CNR Headquarters, on the 5th of June 2017. This participatory event gathered more than 100 people and offered the opportunity to launch the national BLUEMED platforms as mirror mechanisms of the Mediterranean ones, and initiate the process of identifying areas of intervention.
- *The survey "Share your view on the Research and Innovation agenda for the Med!"*
  A dedicated online survey was launched to collect suggestions to update the BLUEMED SRIA by examining each goal and action in detail, and proposing additional inputs and/or revisions, identifying barriers and bottlenecks, while stressing the specificity of the Mediterranean basin in relation to a proposal of actions.
- *Consultation with experts*
  Leading experts were invited to contribute to this paper by reviewing the state of the art of the blue economy sectors, the related cross-cutting issues and constraints, and to define trajectories towards Blue Growth objectives.
- *An inter-ministerial group on Blue Growth*
  To coordinate and strengthen the national position, open and public discussions through regular meetings were organized with decision makers for the first time in Italy, including representatives from relevant ministries, in order to better align and strengthen national programmes and strategies.

Further improvements will be integrated by creating the necessary links with the National Smart Specialization Strategy (S3) and the Italian Bioeconomy Strategy (BIT). The implementation methods of the S3 – definition and execution of strategic plans where national and regional interests and resources can converge – also ensure the involvement of Regions and the variety of productive knowledge expressed by the territories through multi-regional plans approved by the Conference of Regions and by the Autonomous Provinces.
In addition, a collaboration with the National Technology Cluster on Blue Italian Growth (CTN-BIG) established by the Ministry of Education, University and Research under the National Research Program 2015-2020 and strongly correlated with the National and Regional S3 and with Italian Law (L. 123/17), was activated and will be pursued. This effort will also serve as a guideline to consolidate the BLUEMED SRIA actions and to design an initial roadmap for their implementation.
The keystone of the work presented here is the recognition that effective steps towards a "blue" economy can only be achieved by transcending the mere identification of challenges and priorities for specific sectors, which inevitably reflect a partial, sectorial view. This means that the main effort must be directed towards an integrated view of how different activities, often conflicting, might coexist and even develop synergies. An in-depth analysis on how new technologies and new knowledge can overcome conflicts and improve our use of the sea, and/or on the extent to which existing technologies

and knowledge might be better exploited for the same scope is therefore considered essential. As a consequence, this document is not intended as a conventional list of pure priorities, but rather focuses on the identification of how the most relevant R&I challenges for Blue Growth can be more efficiently tackled.
The adopted methodology follows a scientific approach, starting from a detailed analysis of relevant activities and objectives for each of the main marine and maritime socio-economic drivers: food, transport, tourism, chemicals and materials, energy, security, ecosystem health. Gaps and barriers to Blue Growth are identified and different approaches to overcome them, with particular focus on cross-cutting high-level priorities as well as pragmatic actions for research and innovation to be shared at national and Mediterranean levels, are proposed.

## 1.2. DRIVING BLUE GROWTH

Economic growth in modern societies relies on innovation and exploitation of new resources that may expand the market. Human well-being depends on the fulfilment of basic needs such as food, health, equal opportunities to play an active role in society, e.g., jobs. There is a general consensus that the marine environment has a great potential to improve all the above. In many nations, this realization has triggered a growing interest to explore the potential of marine areas and design strategies that draw on marine resources and services in ways that go beyond their traditional and consolidated uses. On the other hand, it is acknowledged that the exploitation of marine systems needs to be increasingly sustainable to allow for long-term use. Initiatives reconciling both requirements fall under the umbrellas of Blue Growth and Blue Economy, as defined by EU (EC, 2017). Both concepts originate from the need for a holistic approach to a sustainable management of marine systems. These are indeed characterized by the complex interaction of the socio-economical and the ecological components.
This White Paper illustrates the Italian position on Blue Growth. It builds on an overview of the status of different sectors and activities as pillars of marine and maritime economy with the scope to sketch possible roadmaps and scenarios to foster Blue Growth in the Mediterranean area. The focus is primarily on Italian circumstances and predicaments, enlarging the perspective, for some sectors in particular, to the pan-Mediterranean level.
This document condenses the results of targeted interactions within the Italian scientific community and several players and stakeholders, including the Italian Ministries involved in marine and maritime affairs: Ministry of Education, University and Research - MIUR; Ministry of Economic Development - MISE; Ministry of Infrastructures and Transport - MIT; Ministry of Agricultural, Food and Forest policies and of Tourism - MIPAAFT, Ministry of Foreign Affairs and International Cooperation - MAECI; Ministry of Cultural Heritage and Activities - MIBAC; Ministry of Defence - DIFESA; Ministry of Economics and Finance - MEF; and the Agency for the Cohesion of Territories. These Ministries have been regularly consulted through a dedicated inter-ministerial group on Blue Growth specifically assembled for the first time in Italy. The ultimate goal of this analysis is to provide shared visions and to design future trajectories for joint research and innovation priorities in the Mediterranean, as seen from the Italian perspective. As such, it contributes to challenges and actions of the BLUEMED Strategic Research and Innovation Agenda and to the design of a roadmap for their implementation.
Since the market does not act as a regulator when it comes to common and shared resources, knowledge of the interactions and potential conflicts that can arise among the different sectors and the development of shared metrics to rank priorities are needed to prevent criticalities and to design sustainable solutions through strong governance practices. Consequently, Blue Growth and Blue Economy involve not only technological innovation and in-depth knowledge of the dynamics of marine ecosystems but an equally comprehensive knowledge of the economic, political and social drivers behind them. Only by integrating both kinds of knowledge, a realistic and thus successful strategy can be designed and proper governance tools can be developed. This paper thus also provides a synthetic survey of some juridical and political constraints, the main conclusions of which are as follows:

- A tailored set of rules fine-tuned for the specific morphology and size of the basin has not yet been produced. The main reference document is still the United Nations Convention on the Law of the Sea (UNCLOS, 1982), which was designed for the high seas and is, in several cases, inadequate;

- As a consequence, the need to delimit respective Exclusive Economic Zones (EEZs) has already produced a number of questions and disputes that have contributed to the abstention of the coastal states from the proclamation of their EEZs;
- Some states have established *minoris generis* maritime zones (i.e. fishing protection and/or exclusive fishing zones and ecological protection zones or both as hybrid zones) based on the principle of *in maior stat minus*, i.e. being the jurisdiction of a State on the waters of its own territory complete, the State itself can decide to limit the application of this jurisdiction to a specific function or over a defined area;
- Although the coastal states of the Mediterranean Sea seem to interpret the cooperation obligation stated by UNCLOS as a commitment to negotiate rather than as an obligation to reach an agreement, several multilateral agreements have been reached for the protection of the environment and fishery resources;
- Naval and other military forces and Coast Guard - Port Authorities may play a role to support the enforcement of international directives for the protection of the environment (e.g. the EU Marine Strategy Framework Directive, MSFD 'EU, 2008').

Our main analysis is then structured around five economical drivers, which shape the different sectors, namely food, transport, tourism, energy, chemicals and materials. It focuses on the present status and potential, as well as on the related gaps and barriers, sketching possible solutions to overcome them. Specifically, Tab. 2 provides for each driver a synthesis of the main strengths vs. problems at Mediterranean level, of the role that Research and Innovation (R&I) can play to foster Blue Growth, and a practical roadmap to be implemented.

Our analysis demonstrates that the majority of the objectives related to each of the economic drivers listed above is affected by criticalities and bottlenecks caused by three major factors:

- knowledge and technological gaps;
- missing/inefficient transfer from knowledge into practice;
- competition and conflicts among stakeholders' interests.

Though specific knowledge gaps are identified for each driver, common obstacles arise due to incomplete knowledge of the main physical and biogeochemical processes and cycles of the Earth system on one hand, and, from a completely different perspective, by the complexity of the processes that govern the creation and exchange of knowledge, the transfer of knowledge to innovation and the implementation of knowledge-based policies.

The analysis of the mutual interactions between the human activities and the Earth system functioning unveiled the uncertainties related to the evaluation of the effects of anthropogenic pressures on the marine environment and its vulnerable ecosystem. This is due to the systematic discharge of traditional and emerging classes of pollutants at sea, as well as the unreliable evaluation of the impact of marine environmental changes on human economic and social structure, through the modification of the ecosystem services. The long-term assessment of the value of natural resources remains uncertain due to the gaps in our basic knowledge of the dynamics of natural systems, which require continuous efforts and innovative approaches.

As such, the foundations of sustainable exploitation plans and successful management strategies must rely on an increased knowledge and effective protection of ecosystem health. The tools proposed here to develop this new knowledge and to mitigate human pressure on the marine environment include:

- the set-up of innovative networks of marine protected areas, better identified as "cells of ecosystem functioning", taking into account the connectivity among sites and the overall functioning of the system;
- the optimization and sustainment of existing observing systems and the design of future augmented observing systems, measuring new variables (e.g. referred to the genomic structure of an organism, the gene expression patterns, the proteins' abundance/structure/function) and developing new sensors and platforms;
- a better and long-term comprehension of the impacts, single and cumulative, of historical, ongoing and future sea uses and their pressures on marine ecosystems and biotic/abiotic resources, supporting an ecosystem-based management approach;
- the development of short and medium-term actions for environmental/ecosystem recovery and consequent re-launching of economic/industrial activity in polluted marine and coastal areas, as well as the definition of safe and sustainable decommissioning of previous installations no longer in use such as offshore platforms.

The different perception of economic priorities and environmental issues among the various stakeholders (scientists, industries, public authorities, civil society), as well as the distinct innovation priorities among nations and sectors, call for new conceptual and methodological approaches and frameworks that allow to foster the harmonization among policies and reduce potential conflicts, thus improving maritime spatial planning implementation processes and promoting maritime domain awareness, i.e. the effective understanding of anything associated with the global maritime domain that could impact the security, safety, economy or environment. This should include the exploitation of innovative tools to promote appropriate investments (e.g. based on smart technologies, Big Data analytics, artificial intelligence etc.), homogeneous legislation and capacity building throughout the Mediterranean and tools to enhance awareness at civil and political levels of the degradation of the marine environment and the critical impacts in terms of potential disruption of local economies, loss of resources and jobs, which can lead to an overall reduction of social well-being and safety of the entire Mediterranean area.

The definition of efficient trajectories, then, extends to the high-level policies governing knowledge creation and exchange, including pan-Mediterranean training networks of student exchange, and favouring the immediate transfer of knowledge to innovation. These are the processes ultimately responsible for sustainable growth.

Recognizing that the slow emergence of the knowledge economy in the European area played a major role in lowering productivity levels with respect to the United States, the analysis shows that successful high-level research and innovation strategies should primarily aim at fostering new knowledge generation and efficient and fair transfer of information among all stakeholders. The following main Knowledge-to-Blue Growth strategic objectives are identified:

- address the complexity of the interactions between research, stakeholders and policy makers and develop a scientific approach towards effective negotiation and knowledge-based decision processes;
- overcome knowledge fragmentation and promote cooperation and quality research enhancing competitiveness;
- extend knowledge frontiers including basic science and support innovative solutions.

To address these objectives, the following practical actions are proposed:

- develop innovative training and exchange frameworks to increase the efficiency in the interaction between scientists, stakeholders and policy makers, one example being represented by the BLUEMED Mediterranean working platforms on knowledge, technology, economy, policy and by their national counterparts, which in Italy led to the establishment of a permanent inter-ministerial group focused on Blue Growth, co-chaired by MIUR and CNR;
- define/strengthen dedicated technological clusters/districts that play a key role in transforming scientific results into socio-economic benefits. The National Technology Cluster Blue Italian Growth has been set up to generate the critical mass for innovative economic activities and initiatives also as test beds for the implementation of innovative science-to-policy approaches;
- consolidate open data policies by fostering data rescue/re-use, strengthening and enforcing policies for the harmonization and open access to data, supporting the evolution of ocean observing systems;
- promote open science policies by consolidating knowledge sharing initiatives and tools, such as scientific networks, open workshops, open access literature, ocean literacy, citizen science, educational and social outreach;
- exploit new multi-disciplinary data-driven opportunities by applying Big Data analytics tools in support of basic science applications and decision support systems, by also taking advantage of the opportunities provided by the explosive growth in the number of devices connected to the Internet of Things (IoT);
- revise public funding schemes and opportunities to enhance the adoption of open science practices, proposing also a partial shift of funds towards small-scale/Principal-Investigator-driven funding schemes, alongside on going large-scale collaborative projects.

| | FOOD |
|---|---|
| | **FISHERIES** |
| Relevance | Italy is the second largest producer of Mediterranean fisheries with average fish landings of about 15% (249,500 tons) and a value of about 29% (about 754 million €) of the total Mediterranean and Black Sea catches |
| Perspective | Fish yield used directly for human consumption<br>Strongly rooted in local culture, diet and cuisine |
| Problems | 85% of stocks are overfished<br>Fleet overcapacity<br>High level of undersized fish in catches<br>Fish demand exceeding national supply |
| Role of R&I | Ecology of fisheries resources<br>Ecosystem based fisheries management<br>Predictive models on the impact of global changes on ecosystems and fish assemblages<br>Innovative models and methods for stock assessment<br>Socio-economic analysis for more sustainable fisheries |
| Roadmap | Identifying stock units<br>Improving modelling for Ecosystem Based Approach to Fisheries<br>Reducing discards and improving small scale fisheries<br>Developing participatory management mechanisms and communication/cooperation among stakeholders<br>Implementing spatial based approach to fishery management<br>Advancing in data collection framework<br>Assessing impact of global change on fishery resources and ecosystems |
| | **FARMING** |
| Relevance | 25% of consumed fish is farmed<br>The average weight of farmed fish is expected to double in a few years |
| Perspective | It is the only alternative to replace fish from fisheries besides synthetic food |
| Problems | The sector is stagnating<br>Waste production and consequent impact on natural systems<br>At present feed is not sustainable |
| Role of R&I | Integrated multi-trophic aquaculture<br>New feed<br>Widening of aquaculture of low trophic levels<br>Circular economy to recycle wastes<br>New materials and logistics for offshore aquaculture<br>New strategies against pathogens |
| Roadmap | Set natural highly productive areas as a reference and design artificial systems mimicking natural systems.<br>Combine aquaculture in offshore multi-purpose platforms.<br>Develop new smart technologies.<br>Introduce new sources of raw material.<br>Explore alternative preventive and therapeutic measures.<br>Select different species to harvest |

| | TRANSPORT |
|---|---|
| | **SHIPBUILDING AND MARINE ROBOTICS** |
| Relevance | Europe shares 6% of the world shipbuilding activity and controls about 40% of the world fleet<br>The European maritime industry counts 300 shipyards and more than 22,000 maritime equipment manufacturers<br>In Italy 40,000 companies, distributed over 15 Regions, reach a turnover of 15 billion € and employ over 230,000 people<br>AUVs (Autonomous Underwater Vehicles) are a consolidated operational solution for defence, research and hydrocarbon extraction industry |
| Perspective | In the last five years the turnover of the shipbuilding industry has recorded higher growth than the rest of the economy (+2.1% against +1.9%) due to the positive trend in orders for cruise ships, a sector in which Italy holds a world leadership position<br>The turnover of the yachting industry reached 3.44 billion €, with a growth rate of 18.6% compared to 2015<br>Two active National Technology Clusters, Trasporti Italia 2020 and Blue Italian Growth |
| Problems | Lack of mandatory and strict regulations for vessels navigating in the Mediterranean<br>Some Mediterranean fleets are outdated and contribute to high environmental impacts and low safety levels<br>Only few of the maritime sector players are adequately familiar with new technologies<br>Lack of infrastructures to support low carbon technology strategies for ships |
| Role of R&I | *Shipbuilding*<br>Automation and connectivity (Information and Communication Technologies – ICT)<br>Innovative ship design and new manufacturing processes<br>Innovative materials<br>Low carbon technology<br>Solutions for safety<br>Low environmental impact solutions<br>*Marine robotics*<br>Sensing and perception<br>Navigation, guidance and control<br>Energy generation, storage and management<br>Propulsion systems, hydrodynamics, mechatronics and materials (also bio-inspired)<br>Marine Internet of Things (IoT) |
| Roadmap | Create the legislative, technological and infrastructural conditions to promote a highly connected and automated sea transportation system to improve safety and efficiency of shipping<br>Promote high quality training courses for the workers of the maritime industry to meet the demand for high-tech products using innovative and eco-sustainable production cycles<br>Provide dedicated funds to improve production technologies<br>Bridge the knowledge, technological and regulation gaps for the use of innovative materials<br>Support the design of LNG (Liquefied Natural Gas)-fuelled ships and related on-shore facilities as well as the research on battery, fuel cells and biofuels, push for new safety regulations and appropriate inland, coastal and offshore infrastructures<br>Promote specific actions, procedures and training for safe operations<br>Promote a joint effort at regional level to create acoustic maps of the polluted areas<br>Promote dual use research programs<br>Define mandatory regulations for ships passing through the Mediterranean with respect to chemical and physical emissions<br>Develop air, sea surface and underwater Unmanned Autonomous Vehicles and associated infrastructures for different types of operation, reducing the number of support vessels<br>Encourage the definition of inspection procedures supported by air, climbing and underwater robots |
| | **PORTS** |
| Relevance | Mediterranean port system features over one hundred ports of medium size (approx. one fourth of which are located in Italy) and a huge number of small and fishing ports (more than one hundred of which are located in Italy) |
| Perspective | 20% of the total world's maritime transport and 30% of the oil trades move through the Mediterranean<br>A constant increase of the volume of goods transported by sea passing through the Mediterranean is expected<br>The Italian port cluster generates directly and indirectly about 2.6% of Italian GDP, registering over 11,000 companies in the sector and 93,000 employees. |
| Problems | The Mediterranean port system is characterized by many ports of medium size while north Europe has fewer but much larger ports, better connected with on-land transport infrastructures<br>Due to infrastructure and management limitations, in the last 10 years the Italian port system has fallen from first to third place in Europe for imports and exports of goods by sea |
| Role of R&I | Development and application of ICT technologies<br>Digitalization of the logistic chain<br>Innovative solutions for energy generation and storage |
| Roadmap | Reduce the impact of ports on the surrounding environment (carbon dioxide, $CO_2$, nitrogen oxides, $NO_x$ and noise emissions) through the electrification of docks and the use of alternative energy sources<br>Improve or build new port infrastructures to provide services to different types of vessels (yachts, ferries, merchant and cruise ships, traditional and LNG fuelled ships)<br>Support the central role of the port system for transport intermodality<br>Promote high level training programmes on central topics for ports and logistics<br>Promote new partnerships among different stakeholders of the logistic chain |

| | TOURISM |
|---|---|
| Relevance | In Italy, the tourism sector added value amounts to about 10% of national GDP, while contributing with employment by 13%<br>Bathing tourism (domestic and international) is the main type of tourism in Italy |
| Perspective | Continuously growing sector, registering a 42% increase of tourist arrivals between 2000 and 2016, with foreign arrivals up by 58% |
| Problems | Critical flows require to urgently de-seasonalise and differentiate tourism offers, recognising that de-seasonalised tourism may create additional pressures on coastal systems |
| Role of R&I | Targeted knowledge based strategy<br>New ICT and services for sustainable tourism<br>Solutions to integrate coast and inland waterways<br>Manage challenges of the coming years, including climate change impacts |
| Roadmap | Assess impact of tourist flows on marine environment<br>Control and manage tourist flows to mitigate potential impacts on the environment<br>Promote collaboration between supply operators through business networks and product clubs<br>Insert products into the local tourist offers and improve promotion/distribution/communication channels<br>Promote product specific valorisation and tourist appreciation through live-learning approach, innovative tools and new technologies<br>Integrate the coast and the hinterland with slow inter-mobility<br>Encourage networks of tourism with other economic sectors (agriculture, crafts, culture, fishing) to extend the offers<br>Use tourism as a vehicle to educate people, and promote awareness of Italian cultural heritage and of and eno-gastronomic resources<br>Expand the opportunities offered by cruise tourism as a vehicle for ocean literacy dissemination and awareness rising on the status of marine ecosystems in the cruised areas |

| | ENERGY |
|---|---|
| Relevance | The growth of the marine energy sector has been relatively slow if compared to the onshore industry<br>MRE (Marine Renewable Energy) is a promising resource capable of responding to the energy demand of coastal and insular areas, preserving the marine environment |
| Perspective | The EU actively promotes the development and exploitation of MRE technologies in the context of the transition to low carbon energy<br>The milder climatic conditions of the Mediterranean allow the affordable testing of devices and stimulate the design of particularly efficient technologies for ocean energy harvesting<br>Italian technologies covering the whole value chain of offshore wind energy are ready for applications. The Italian government supports wave and tidal technology, where Italy is at the forefront of research in developing and testing prototypal and pre-commercial devices for ocean energy conversion. |
| Problems | Environmental and technical issues limit the implementation of offshore wind farms in the Mediterranean and scenarios of climate change make it difficult to decide on the best locations for wind farms<br>Lengthy authorization process<br>Traditional maritime sectors (e.g. shipping, fishing activities, tourism) are not always spatially compatible with the development of new maritime industries |
| Role of R&I | Concentrate efforts on a limited number of promising technologies for energy conversion from tidal streams and waves, targeting a reduction in the LCoE (Levelized Cost of Energy)<br>Develop sustainability assessment studies based on a life cycle thinking approach, embracing the environmental, economic and social dimensions<br>Investigate the possibility of integration of different types of energy production at sea (wind-tidal-wave) |
| Roadmap | Create and continuously support Blue Economy businesses and high-tech clusters while enhancing connections with the traditional know-how-based industries<br>Strengthen potential synergies between coastal and offshore energy infrastructures and other activities/threats such as aquaculture, protected areas and coastal erosion prevention<br>Share background data and information in the development and consent phase for different types of energy production at sea and jointly plan necessary infrastructures and grid connections<br>Develop larger demonstration projects to sustain MRE development from basic and applied research to final commercial deployment<br>Promote new business models and market opportunities arising from the cooperation between the national government and the private sector towards a cost-effective transition of the global energy systems |

| | CHEMICALS AND MATERIALS |
|---|---|
| | **THE DEEP SEA** |
| Relevance | Not relevant so far |
| Perspective | Second largest unexplored volume on the Earth<br>Mineral reserves of rare materials and biology |
| Problems | No easy access or exploitation<br>Scarce knowledge of the impact of goods exploitation on the deep sea environment<br>Jurisdictional access issues |
| Role of R&I | New materials and new technology<br>Better knowledge of the biota and their contribution to Earth system functioning<br>Evaluate impact and exploitation of gas hydrates |
| Roadmap | Stronger oil and gas supply chain<br>Implement the Directive 2013/30/EU on safety of offshore oil and gas operations improving environmental monitoring, hazard assessment, and conducting risk analysis<br>Promote scientific research and exploitation on gas hydrates<br>Better understand the deep sea ecosystem functioning<br>Store $CO_2$ (carbon dioxide) by seafloor microbial communities interacting with specialized fauna<br>Develop bioremediation approaches in the deep sea against pollutants |
| | **BLUE BIOTECHNOLOGIES** |
| Relevance | Not relevant so far (2% of EU bioeconomy) |
| Perspective | Presumed great potential of new materials and chemicals<br>High (5%) global annual average growth rate<br>Growing impact on pharmacology, cosmetics, bioremediation |
| Problems | Fragmentation of the sector in Italy |
| Role of R&I | New knowledge in fundamental biology<br>Focused -omics based marine technology |
| Roadmap | Fund new focused research collaborations<br>Implement specific political actions to support biotech industry<br>Test and promote safe natural products of marine origin<br>Create synergies with other activities, e.g. food, bioremediation<br>Explore preventive healthcare<br>Increase the prominence of Mediterranean companies at a global scale |

**Tab. 2**
The Blue Economy sectors in Italy

# 02

# THE GENERAL FRAMEWORK

## 2.1. WHAT IS BLUE GROWTH?

The concept of Blue Growth (Fig. 1) originates from the need, perceived at the scientific, policy and management level, for a holistic approach to the management of systems where socio-economic and the ecological components significantly interact through complex patterns (Eikeset et al., 2018).

The concept stems (together with the brother concept of "green growth") from the quest for "sustainable development", an idea endorsed by the United Nations since the seventies and recently reaffirmed at the Rio+20 Conference (UN, 2012). Goal n. 14 of the UN 2030 Agenda for Sustainable Development (UN, 2015), aims to 'Conserve and sustainably use the oceans, seas and marine resources for sustainable development'. Recognizing the importance of the role of the scientific community in supporting countries to create improved conditions for sustainable development of the Oceans, the United Nations proclaimed a Decade (2021-2023) of Ocean Science for Sustainable development (en.unesco.org/ocean-decade).

The Sustainable Development concept can be essentially described as the exploitation of natural resources that "meets the needs of the present without compromising the ability of future generations to meet their own needs" (Brundtland et al., 1987). It is therefore evident that the problem of achieving environmental sustainability is characterised by three fundamental dimensions interacting at a wide range of spatial and temporal scales: environmental, economic and social (Giovannoni and Fabietti, 2014).

The blue/green growth concept is articulated along the same three dimensions, but takes a step further by implying that in addition to the "conservation for future generations", sustainable use of natural resources can foster economic growth and development (www.oecd.org/greengrowth/).

Eikeset et al. (2018) state that the definition of Blue Growth has not yet achieved a general consensus, and that its meaning largely depends on "the social context in which it is used". As such, the "potential for miscommunication is large".

Marine ecosystems already provide humankind with several services (see below), that contribute to human health and prosperity. In order to successfully accomplish Blue Growth, any additional activities carried out by humans should not, in any way, hamper those services. Furthermore, not only do the characteristics (sec.2.2) and constraints (sec. 4.1) of the environment need to be taken into account but so should the socio-economic context (sec. 2.3-2.4) and the specific and general constraints (sec. 4.2-4.3) that could retard or inhibit Blue Growth. Indeed, for some, Blue Growth is about maximizing economic growth, whilst for others the focus is on sustainability.

The following is a brief description of the environmental and socio-economic context of the Mediterranean while section 4 discusses present natural and governance constraints in regards to the realization of Blue Growth.

## 2.2. THE ENVIRONMENTAL BACKGROUND

The Mediterranean Sea is a semi-enclosed basin with a relatively poor exchange with the open ocean waters, considering its volume. Mediterranean Sea water turnover time can range from a few years to a century. This means, in turn, that the basin retains tracers and pollutants for a significant amount of time. It also has high border to surface or volume ratios, which implies that the inputs for highly inhabited coasts have a significant impact.

As other seas, it provides key ecosystem services, "free of charge", that support human socio-economic systems. The "Millennium Ecosystem Assessment" (MEA, 2005) defines the following ecosystem services (Fig. 2):

- Provisioning, e.g. energy, water, food;
- Supporting, e.g. primary production and the main biogeochemical cycles);
- Regulating, e.g. basic habitat characteristics;
- Cultural, e.g. recreational and learning.

Such service provision is closely related to the economic dimension of Blue Growth, as summarized in the following section. In particular, some researchers (e.g. Lillebø et al., 2017) point out the need to study the capacity of marine ecosystems to "supply the required services" for Blue Growth given the indicators of Good Environmental Status and explore the required trade-offs between economic, social and environmental aspects.

### 2.2.1. SUPPORTING SERVICES

The two main ecosystem services related to Blue Growth are nutrient cycling and primary production.

**Nutrient Cycle**

The sustainment of ocean nutrient cycling is a fundamental service provided by marine ecosystems (MEA, 2005) which in coastal oceans is mostly impacted by the anthropogenic input of dissolved and particulate matter. In the past, nutrient increase in the coastal zones generated acute eutrophication processes (Cloern, 2001; Vollenweider et al., 2016). Eutrophication and anoxia in the coastal marine environment are closely associated and both depend on the primary production supporting service (see below). In short, the capacity and efficiency of a coastal marine system in regards to nutrient recycling depend on land-based input and on the structure and physical-chemical dynamics of the coastal ocean.
Rabalais et al. (2009) point out that land-based nutrient input built up in coastal Oceans (in absence of adequate management strategies) will increase proportionally to the growth of coastal population and industrial and agricultural activities. Proper management is thus crucial, since the implementation of adequate policies aiming to reduce the nutrient load to the ocean might be fundamental in reducing, or at least mitigating, the problem. For instance, the phosphate concentration in the northern Adriatic Sea seems to have progressively decreased since the implementation of European Environmental policies (Giani et al., 2012).

**Primary production**

The coastal oceans cover only 7% of the global ocean area, but provide 14-30% of global ocean primary production (Gattuso et al., 1998), thus being a very productive ecosystem. Moreover, jointly with transitional areas (e.g. lagoons) they are typical sites for fish spawning, deposition and recruitment. The Mediterranean basin is not characterized by large shelves, and displays strong North-South, East-West gradients in trophic regimes (e.g., D'Ortenzio and Ribera d'Alcalà, 2009). However, it has a global primary productivity comparable to other regions of similar latitudes (Lazzari et al., 2012). More importantly, such processes show a marked seasonal and interannual variability and are very sensible to anthropic pressures. The importance of such ecosystem services can hardly be overstated at both the local (coastal) and global levels. Every form of life on Earth directly depends on primary production. Any (qualitative or quantitative) alteration of the service would trigger substantial variations in all the other ecosystem services, including food provision.

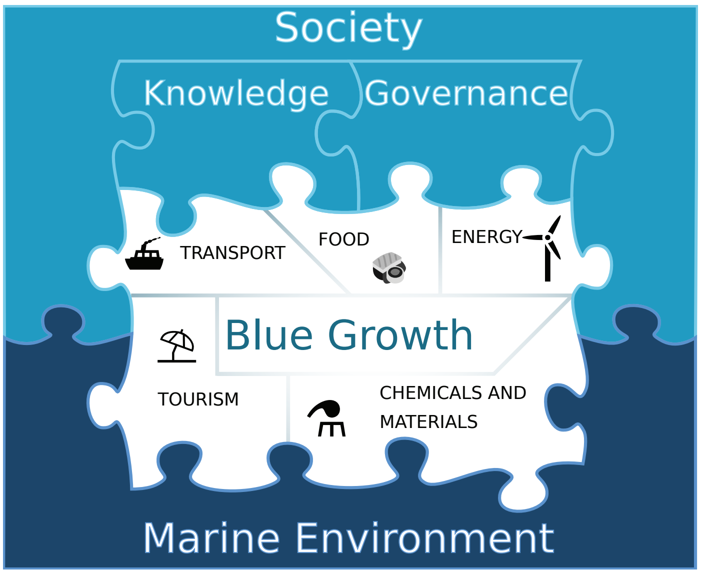



**Fig. 1**
Tangram of contents

### 2.2.2. PROVISIONING SERVICES

**Food provisioning**

Sustainable food provisioning through fisheries and aquaculture is an extremely important ecosystem service for the development of Blue Growth (see section 4.1). This service is strongly dependent on the "primary production" provision service (Pauly and Christensen, 1995) and the interaction between the two services is also an aspect to consider since diverting most of primary production to food production might damage other components of the ecosystem.

The so-called acidification process, due to increased carbon dioxide concentration in seawater (Orr et al., 2005) with the main consequences of an "acid" ocean, is another aspect of the present scenario which mostly affects commercially relevant organisms defined as "calcifying" (Cooley and Doney, 2009), among which Mollusca such as mussels and clams. Acidification in Mediterranean Sea is following a trend similar to that of open ocean sites, despite the large alkalinity inputs from rivers (e.g., Flecha et al., 2015).

"Non-blue" practices, i.e., overexploitation of some fish and macro-invertebrates as well as habitat loss, have been the main human drivers of historical changes in biodiversity (Coll et al., 2010; Lotze et al., 2011; Coll et al., 2012) and are also part of the current environmental context.

### 2.2.3. REGULATING SERVICES

**Climate regulation**

The ocean is a fundamental component of the global climatic system. Its regulating function is mainly exerted through the absorption/release of heat and atmospheric gases that also modulate the anthropogenic component of climate change in time and space.

Due to its limited surface the Mediterranean Sea is not a key player of climate regulation at global scale but rather a potential victim of climate change. A specific feature of the basin is the presence of strong North-South, West-East gradient in terms of key drivers as heat fluxes and fresh water budgets (de Madron et al., 2011) that should stimulate a clever spatial planning for the exploitation of natural resources (see also sec. 5.2.1).

**Waste treatment**

The coastal marine ecosystem performs a "waste treatment" service, sequestering and cycling pollutants. The ecosystem's ability to perform such a service is tightly linked to its structure and state (MEA, 2005) and on the pollutant characteristics (as explained in the above paragraph on the nutrient cycle service). When pollutants are released in the marine environment, their concentration is affected by dilution, advection and diffusion processes. Further concentration modifications are driven by detoxification processes (microbial decomposition) and sequestration (sediment burial), a process particularly important for synthetic pollutants barely decomposed by chemical or biochemical processes (see section 5.1 on ecosystem health and sustainability). As mentioned earlier, the boundary to surface ratio of the basin is relatively high with respect to the open ocean. This has a contrasting effect in that though there is more pressure, there is also more potential to handle the pressure. The point is to prevent a pollutant load from exceeding the natural depuration capacity of the ecosystem through waste disposal treatment plants. Regretfully, some basin areas are impacted beyond their handling capacity (Ait-Mouheb et al., 2016) and should be tackled with a Blue Growth perspective.

**Risk regulation**

This service depends on the "skill" of natural structures to mitigate environmental alterations such as the loss of coastal areas due to erosion processes or sea level rise (MEA, 2005; Beaumont et al., 2007). Coastal areas are threatened by increasing risk of flooding (Neumann et al., 2015). In this case as well, the "substitution" of natural solutions with artificial structures would entail economic costs and could potentially generate conflicting conditions with respect to other ecosystem services (provisioning and/or cultural).

### 2.2.4. CULTURAL SERVICES

Ecosystem cultural services provide immaterial benefits to human beings through spiritual, esthetical and recreational activities. They encompass a wide and diverse range of activities not easily quantifiable but still very relevant for a Blue Growth approach (e.g. Ghermandi et al., 2009) given that such services are strictly linked to tourism (section 3.3).

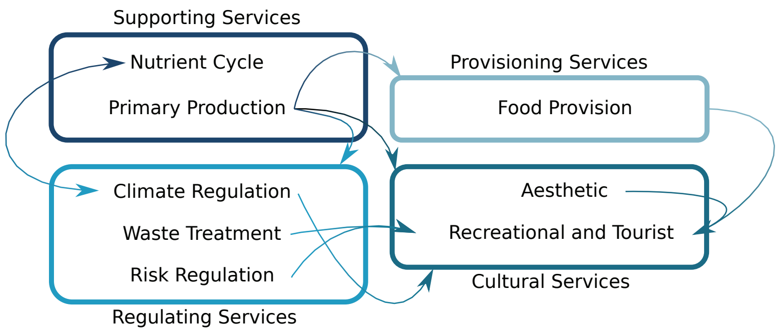



**Fig. 2**
Interdependencies among marine ecosystem services

## 2.3. THE SOCIO-ECONOMIC CONTEXT

The declared scope of Blue Growth is to enlarge and intensify sustainable exploitation of marine resources to favour economic growth and social wellbeing. Accordingly, the key message of Blue Growth is that: so far, the marine realm has been underexploited, therefore its unused or partially used resources may become a means to solve problems of low growth rates and long-term underemployment in several countries, including EU member states. This clarifies that the primary scope of Blue Growth is economic growth and job creation but it also happens to be its more problematic aspect. In other words, is sustained growth really sustainable and free of unintended consequences?

Hadjimichael (2018) used the long history of EU fishery policy to explore the dangers and the potential of Blue Growth. In fact, the fisheries sector is one of the most regulated sectors in the EU, and despite the increase in the number of regulations over time this has not led to the anticipated reduction in landings nor has it helped tackle over-fishing. Rickels et al. (2018) examined the progress of EU coastal states in the Baltic and North Sea, and the Atlantic Ocean against SDG14 and showed that the majority of countries fail to achieve comprehensive blue growth. Sweden, Spain, Ireland, and in particular Portugal experienced a considerable decline in scores since 2012. The only exemption is Estonia which managed to improve its scores over time under both concepts of sustainability. The unsustainable development at the EU level is mainly driven by deteriorations in indicators related to fisheries. In a 2017 WWF Report entitled "Reviving the economy of the Mediterranean Sea" (Randone et al., 2017) an alarming growth trend of almost all maritime industries is expected to develop, thus causing potential conflicts over space and other resources. "Limits to Blue Growth" (ESEC, 2012), is a Joint NGO Position Paper that highlights environmental risks included in the Blue Growth study for the five Focus areas, i.e. (i) *Aquaculture* (discharges of nutrients in coastal areas; farmed fish of non-native origin; algae production); (ii) *Cruise shipping* (traffic, traffic flows, and $CO_2$ emissions; waste emissions in Arctic regions); (iii) *Ocean renewable energy* (the impact of tidal barrages and construction of energy farms,); (iv) *Marine minerals mining* (disturbance of deep sea ecosystems, operations on the sea-floor); (v) *Blue biotechnology* (unintended extraction of species). Finally, some more radical authors (Martínez-Alier et al., 2010; Hueting, 2010) concluded that *"... there is a need to de-link sustainability and growth since environmental sustainability is not compatible with economic growth"*.

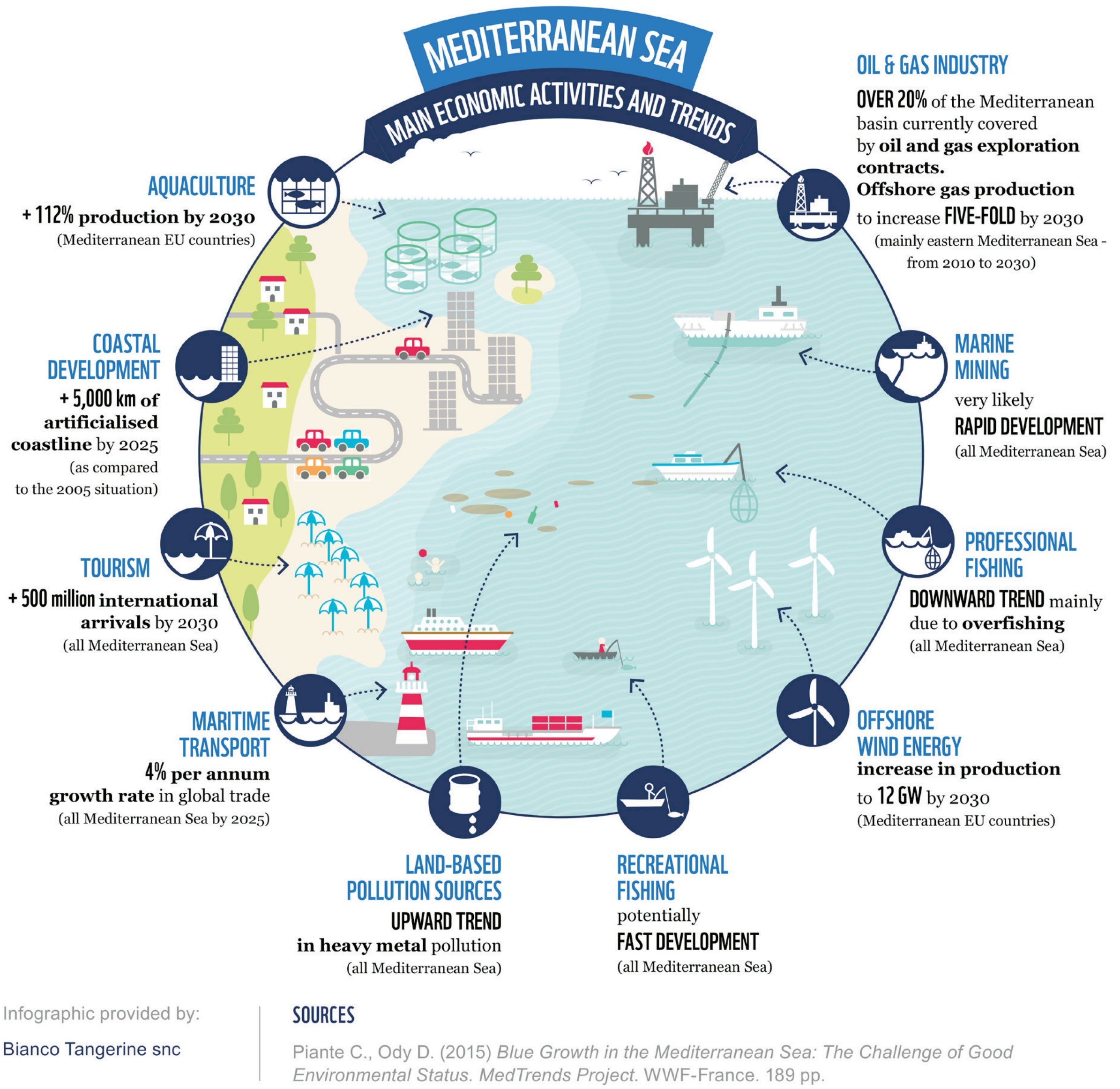



**Fig. 3**
Main economic activities/trends in the Mediterranean Sea (Source: Randone et al., 2017)

Nevertheless, the accompanying recommendation is that the design and implementation of actions/activities in different marine and maritime sectors should be framed in a context of greater efficiency and sustainability, to create new "blue" jobs and foster the transit from "old" unsustainable economies to "blue" economies.
Many of the economic activities (Fig. 3) that represent the base for Blue Growth are interdependent or potentially competing for the same resource. Such interdependence implies that such activities cannot be dealt with separately and should be treated as acting in a general economic equilibrium (e.g. Walras, 2013), where gains and losses of each sector depend on those of the others. Unlike the internal costs (capital and labour), the gains and losses of each activity, whatever the sector may be, depend on the "ecosystem services" mentioned above (see also, Costanza et al., 1997), for which none of the operators pays a cost, but the utilization of which, by each operator has an impact on the utilization of the same service by the others and on the environment itself.
From a strictly economical point of view, this is

an example of what economists define a market failure (Bator, 1958), which occurs when the resource (service) is not, or cannot become, a property of a single operator, as is the case for many natural resources. This can lead to a misuse of the resource by one or more operators causing irreversible changes in the system, thus mining further exploitation of the resource by the other operators and, ultimately, by all.

A resource not taken into account in the costs of an activity is often defined as an externality, e.g. (Buchanan and Stubblebine, 1962). The problem of conflicting use of a shared resource and the negative consequences is often referred to as "The tragedy of commons", e.g. (Lloyd, 1833; Hardin, 1968). Different solutions have been explored to deal with such issues, including punitive measures. A general discussion can be found in the book by the Nobel laureate Elinor Ostrom (Ostrom, 1990).

The above issues have stirred up much controversy among politicians, economists and ecologists, and would require a deeper analysis. However, on one point there is a widespread consensus: the market does not act as a regulator when the resource is in common, as in the case of the sea. A strong governing capacity is therefore needed to prevent the "tragedy".

Two more aspects should be considered in the general economic framework in which Blue Growth is promoted: the important role of technology, and the uncertain measurability and long-term assessment of the value of natural resources. The latter has been the object of very active research in the past two decades, (e.g. Costanza et al., 1997; MEA, 2005). Still, we are far from being able to determine what the gains and losses of a specific action in the environment will be, even from the perspective of the human species, due also to the gaps in basic knowledge of the dynamics of natural systems. As far as the former is concerned, being the marine environment much less accessible to extant human 'tools', mostly developed for the exploitation of terrestrial environments, an increase in the use of the 'sea' resource requires relevant investments in technological research and the parallel development of advanced technologies. This, in turn, can favour big enterprises, with the risk of creating oligopolies or monopolies. Both aspects require a strong governance.

## 2.4. THE MARINE AND MARITIME ECONOMY SECTOR IN ITALY

The marine and maritime economy is one of the most dynamic sectors in Italy, mainly due to the continuity of capital investments, even during the recent financial crisis. The contribution of the Blue Economy sector to the national GDP amounts to 3% (43 billion €) and represents a percentage of about 3.5% of the employment sector in Italy (for a total of 800,000 units) with a positive trend of ~3% in the 2011-2016 period. These data are covered in the 2017 report on the marine and maritime economy in Italy (CCIAA, 2017), and show that this economic sector thrived despite the recent economic collapse. The marine and maritime economy is a very important asset for the Italian economic development, also considering the strategic location of this country in the Mediterranean region, with approximately 7,456 km of coastlines encompassing 15 regions and 645 municipalities, with 57 coastal Chambers of Commerce and ~190,000 companies. Italy ranks at third place in the G20 for maritime transport, exceeding 17 million tonnes of tonnage, with high ranking roll-on/roll-off (ro-ro), cruise ships and chemicals tankers. Furthermore, Italy holds a leading position in Europe in cruise traffic (with 6.2 million passengers and 4,600 vessels), and in the construction of passenger ships and luxury motor yachts (CCIAA, 2017). The data on the impact of maritime activities on the Italian economy are equally important, going beyond the aspects closely related to their transport dimension, and directly involving the productive, manufacturing and tertiary sectors of the economy.

A specific aspect of the marine and maritime economy is related to the so-called multiplier of income. This is defined as the multiplier power of investments, which, in the case in point, is, on average, 1.8, with a high 2.6 value in the sector of maritime transports alone. Directly and indirectly, this sector consistently impacts employment, with 102,200 units in the maritime transport sector and 325,000 in the logistics and auxiliary activities linked to ports. Fishing (104,900 direct units), naval mechanics (133,799), naval shipbuilding (133,200) and leisure activities (70,400) represent other important sectors of employment.

Data confirm the prominent role of the marine and maritime economy in the context of the European Community for which it currently generates direct employment for nearly 5 million people and a product value of 500 billion €. The available projections for 2020 estimate 7 million work units involved in the sector associated with a production of 600 billion € (CCIAA, 2017). In the following sections, prominent marine and maritime economy sectors and their potential for Blue Growth will be analysed in more detail.

## 2.5. LINKING THE SRIA TO BLUE GROWTH ECONOMIC DRIVERS

The BLUEMED-CSA scope is to pave the way to European Blue Growth through various tools and strategies. A fundamental step in this direction is the refinement and formulation of an implementation plan of the BLUEMED Strategic Research and Innovation Agenda (SRIA). The BLUEMED SRIA has already been updated twice, in April 2017 and in October 2018 (EC ad hoc advisory group, 2015 and 2017; Barbanti et al., 2018). The Agenda reflects a breakdown of the research and innovations priorities highlighted by BLUEMED promoters. To better align the analysis carried out in this White Paper with the BLUEMED-CSA objectives Table 3 lists the SRIA priorities and the driving economic sectors to which they are predominantly associated, based on general objectives and possible benefits.

| ECONOMY DRIVER | OBJECTIVES | SOCIETAL BENEFIT | ENVIRONMENTAL BENEFIT |
|---|---|---|---|
| **Food** | • Progress towards a "marine Neolithic revolution":<br>achieve sustainable fisheries while promoting/developing large scale blue aquaculture | • Creation of new jobs<br>• Conversion of unsustainable to sustainable jobs<br>• Healthy food provision<br>• Food as cultural asset | • Contribution to achieving the Good Ecosystem Status |
| **Transport** | • Progress towards smart, clean, safe and connected maritime transport, marine vehicles and structures | • Maintenance /promotion of blue shipbuilding, competitive industries<br>• Creation of new jobs for "smart" services<br>• Contribution to the creation of an integrated mobility system<br>• Improvement of maritime safety and passengers security | • Reduced $CO_2$ emissions<br>• Prevent environmental accidents<br>• Reduced impact on marine ecosy-stems (noise, pollution) |
| **Tourism** | • Develop smart technologies and services for sustainably managing tourism | • Creation of new jobs<br>• Well-being of coastal communities<br>• Preservation of the Mediterranean cultural heritage<br>• Fostering of sustainable tourism as an asset | • Reduced impact of human activities on marine and coastal ecosystem |
| **Chemicals and materials** | • Progress towards a sustainable exploitation of marine biotic and abio-tic resources, including raw materials and molecules of industrial interest | • Creation of hi-tech companies and qualified jobs<br>• Potential benefits for healthcare<br>• Better share of basic materials | • Possible replacement of impacting with non-impacting materials and substances |
| **Energy** | • Increase the fraction of installed ma-rine renewable energy power plants | • Increase in energy supply<br>• Decrease in costs | • Reduced greenhouse gas emissions from energy production<br>• Reduced oil & gas transportation |

**Tab. 3**
Objectives and benefits for each economy driving sectors

With the aim of explicating the link with the BLUEMED SRIA, Table 4 illustrates the connections between the challenges and goals set in the SRIA with the economic drivers of societal and environmental benefits mentioned above.

| ECONOMY DRIVER | BLUEMED SRIA CHALLENGES AND GOALS | CROSS-CUTTING ENABLERS FOR BLUE JOBS AND BLUE GROWTH |
|---|---|---|
| **Food** | **MEDITERRANEAN SEA ECOSYSTEMS: CHARACTERIZE PRESENT DYNAMICS, SERVICES, RESOURCES, VULNERABILITY AND RESILIENCE TO NATURAL AND ANTHROPOGENIC PRESSURES (K)**<br>Understanding the functioning of the Mediterranean ecosystem<br>**MEDITERRANEAN SEA: FORECAST CHANGES OF THE BASIN UNDER CLIMATE AND ANTHROPOGENIC PRESSURES AND DEVELOP SERVICES IN THE FIELD OF SUSTAINABLE ADAPTATION TO CLIMATE CHANGE AND PLANS FOR MITIGATION (K)**<br>Forecasting the Mediterranean Sea dynamics and climate<br>Preparing to climate change and define adaptation/mitigation measures<br>**INNOVATIVE BUSINESSES BASED ON MARINE BIO-RESOURCES IN THE MEDITERRANEAN (E)**<br>Developing new methodologies and tools<br>Generating new products and services<br>**ECOSYSTEM-BASED MANAGEMENT OF MEDITERRANEAN AQUACULTURE AND FISHERIES (E)**<br>Develop optimal fishing strategies, technologies and practices<br>Develop optimal aquaculture strategies, technologies and practices<br>**MARITIME CLUSTERS IN THE MEDITERRANEAN (E)**<br>From traditional maritime economic to Blue Growth activities<br>Mediterranean Blue start-ups<br>**GOVERNANCE OF MARITIME SPACE AND MARINE RESOURCES IN THE MEDITERRANEAN (E)**<br>Strengthen synergies among science, industry, policy-makers and society<br>Effective maritime spatial planning in the Mediterranean<br>**INNOVATIVE OFFSHORE INDUSTRIAL PLATFORMS INCLUDING MARINE RENEWABLE ENERGY AND CO-USE (T)**<br>Changing the rationale: one platform, multiple uses and activities | Open data, open science, open innovation<br><br>International Cooperation and Coordinated Transboundary Networks |
| **Transport** | **MARITIME CLUSTERS IN THE MEDITERRANEAN (E)**<br>From traditional maritime economic to Blue Growth activities<br>**GOVERNANCE OF MARITIME SPACE AND MARINE RESOURCES IN THE MEDITERRANEAN (E)**<br>Strengthen synergies among science, industry, policy-makers and society<br>Effective maritime spatial planning in the Mediterranean<br>**SMART, GREENER AND SAFER MARITIME TRANSPORT AND FACILITIES IN THE MEDITERRANEAN (T)**<br>Greening vessels, facilities and services<br>Safer maritime transport<br>Connected and automated transport<br>**OBSERVING SYSTEMS AND OPERATIONAL OCEANOGRAPHY CAPACITIES IN THE MEDITERRANEAN (T)**<br>Towards an observing system of systems<br>Tailor-made sensors and platforms<br>Security and safety services and technologies in the Mediterranean supporting the Blue Growth | Interaction between scientists, stakeholders, policy and decision makers, civil society<br><br>Building capacity, blue skills and blue professionals |
| **Tourism** | **MEDITERRANEAN SEA ECOSYSTEMS: CHARACTERIZE PRESENT DYNAMICS, SERVICES, RESOURCES, VULNERABILITY AND RESILIENCE TO NATURAL AND ANTHROPOGENIC PRESSURES (K)**<br>Understanding pollution impacts, mitigation, and remediation in the Mediterranean Sea<br>**HAZARDS AND THE PROTECTION OF COASTAL AREAS AND OPENS SEA IN THE MEDITERRANEAN (K)**<br>Reducing the risk of disasters and their effects<br>Protecting maritime cultural heritage<br>**SUSTAINABLE TOURISM AND CULTURAL HERITAGE IN THE MEDITERRANEAN (E)**<br>Linking tourism, tourists and environment<br>Increase the economic impact of the Mediterranean natural and cultural heritage<br>**MARITIME CLUSTERS IN THE MEDITERRANEAN (E)**<br>From traditional maritime economic to Blue Growth activities<br>Mediterranean Blue start-ups<br>**GOVERNANCE OF MARITIME SPACE AND MARINE RESOURCES IN THE MEDITERRANEAN (E)**<br>Strengthen synergies among science, industry, policy-makers and society<br>Effective maritime spatial planning in the Mediterranean<br>**MARINE AND COASTAL CULTURAL HERITAGE IN THE MEDITERRANEAN: DISCOVERING, PROTECTING AND VALUING (T)**<br>Technology solutions for the Mediterranean natural and cultural heritage | Promoting and implementing strategies and action plans |

<table>
<tr><th>ECONOMY DRIVER</th><th>BLUEMED SRIA CHALLENGES AND GOALS</th><th>CROSS-CUTTING ENABLERS FOR BLUE JOBS AND BLUE GROWTH</th></tr>
<tr><td>Chemicals and materials</td><td>MEDITERRANEAN SEA ECOSYSTEMS: CHARACTERIZE PRESENT DYNAMICS, SERVICES, RESOURCES, VULNERABILITY AND RESILIENCE TO NATURAL AND ANTHROPOGENIC PRESSURES (K)<br>Understanding pollution impacts, mitigation, and remediation in the Mediterranean Sea<br>HAZARDS AND THE PROTECTION OF COASTAL AREAS IN THE MEDITERRANEAN (K)<br>Reducing the risk of disasters and their effects<br>INNOVATIVE BLUE GROWTH TRAJECTORIES: BIOTECHNOLOGIES, FOOD, AND THE DEEP SEA RESOURCES (K)<br>Exploring the potential of blue-biotech<br>Exploiting the Deep Sea<br>INNOVATIVE BUSINESSES BASED ON MARINE BIO-RESOURCES IN THE MEDITERRANEAN (E)<br>Developing new methodologies and tools<br>Generating new products and services<br>MARITIME CLUSTERS IN THE MEDITERRANEAN (E)<br>From traditional maritime economic to Blue Growth activities<br>Mediterranean Blue start-ups<br>GOVERNANCE OF MARITIME SPACE AND MARINE RESOURCES IN THE MEDITERRANEAN (E)<br>Strengthen synergies among science, industry, policy-makers and society<br>Effective maritime spatial planning in the Mediterranean<br>SMART, GREENER AND SAFER MARITIME TRANSPORT AND FACILITIES IN THE MEDITERRANEAN (T)<br>Greening vessels, facilities and services<br>OBSERVING SYSTEMS AND OPERATIONAL OCEANOGRAPHY CAPACITIES IN THE MEDITERRANEAN (T)<br>Towards an observing system of systems<br>Tailor-made sensors and platforms<br>Security and safety services and technologies in the Mediterranean supporting the Blue Growth</td><td rowspan="2">Open data, open science, open innovation<br><br>International Cooperation and Coordinated Transboundary Networks<br><br>Interaction between scientists, stakeholders, policy and decision makers, civil society<br><br>Building capacity, blue skills and blue professionals<br><br>Promoting and implementing strategies and action plans</td></tr>
<tr><td>Energy</td><td>MEDITERRANEAN SEA: FORECAST CHANGES OF THE BASIN UNDER CLIMATE AND ANTHROPOGENIC PRESSURES AND DEVELOP SERVICES IN THE FIELD OF SUSTAINABLE ADAPTATION TO CLIMATE CHANGE AND PLANS FOR MITIGATION (K)<br>Forecasting the Mediterranean Sea dynamics and climate<br>Preparing to climate change and define adaptation/mitigation measures<br>Reducing the coastal risk of disasters and their effects<br>MARITIME CLUSTERS IN THE MEDITERRANEAN (E)<br>From traditional maritime economic to Blue Growth activities<br>GOVERNANCE OF MARITIME SPACE AND MARINE RESOURCES IN THE MEDITERRANEAN (E)<br>Strengthen synergies among science, industry, policy-makers and society<br>Effective maritime spatial planning in the Mediterranean<br>Promote the role of Marine Renewable Energies (MRE) in the energy transition phase<br>OBSERVING SYSTEMS AND OPERATIONAL OCEANOGRAPHY CAPACITIES IN THE MEDITERRANEAN (T)<br>Towards an observing system of systems<br>Tailor-made sensors and platforms<br>Security and safety services and technologies in the Mediterranean supporting the Blue Growth<br>INNOVATIVE OFFSHORE INDUSTRIAL PLATFORMS INCLUDING MARINE RENEWABLE ENERGY AND CO-USE (T)<br>Changing the rationale: one platform, multiple uses and activities<br>Increase the fraction of installed marine renewable energy power plants</td></tr>
</table>

**Tab. 4**
Match between economic drivers and BLUEMED SRIA priorities, including pillars (K=knowledge, E=economy, T=technology), key challenges, and relevant actions

# 03

# FROM SOCIETAL/ECONOMIC DRIVERS TO THEMATIC BLUE OBJECTIVES

This White Paper revolves around five Blue Growth driving sectors with relevant and potential impact on the economy (Fig. 4): food, transport, tourism, energy, chemicals and materials. For each sector we present a concrete roadmap of actions, in addition to the state of the art, envisaged development and related research and innovation needs.

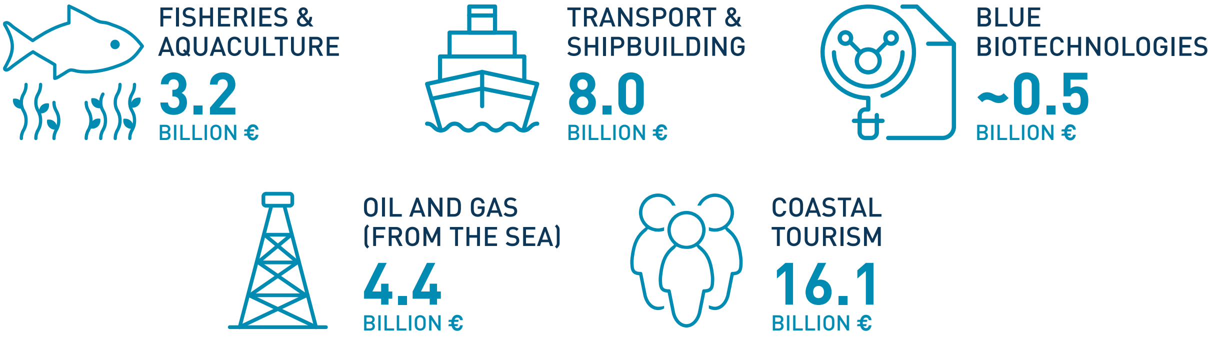



**Fig. 4**
Economic drivers key revenues in Italy (in billion €)

## 3.1. FOOD

Fisheries and aquaculture are primary sectors of the Italian economy. The current state of marine living resources strongly suggests the need to implement initiatives to reverse the current trend of overexploitation and conserve biodiversity in marine ecosystems to secure a sustainable future for the fisheries sector. Conversely, though aquaculture is one of the world's fastest-growing food production industries, it is stagnant in Italy and throughout the European Union.

### 3.1.1. FISHERIES

For centuries fishing has been a source of wealth for coastal populations. In addition to its role for food provision, fishing has been the main source of economic prosperity for many coastal communities as evidenced by the exploitation of large single species stocks, such as cod *Gadus morhua* (Linnaeus, 1758) in the Atlantic (Hayden et al., 2015) and the bluefin tuna *Thunnus thynnus* (Linnaeus, 1758) in the Mediterranean (Longo and Clark, 2012). As traditional and mature maritime activities, fisheries are not explicitly integrated in the Blue Growth (BG) strategy, presumably because they are perceived as having limited potential for growth. However, links between fishing activity and the core BG innovation strategy are evident and the opportunities for fisheries and coastal communities in the context of economic growth, employment and innovation, offered by a Blue Growth, should be adequately investigated (Stobberup et al., 2017).

**Status of the Italian fisheries and their relevance in the Mediterranean**
In the Mediterranean and the Black Sea regions, seven States (Turkey, Italy, Algeria, Spain, Tunisia, Greece, and Ukraine) accounted for more than 80% of total landings in the 2000-2013 period, being Italy the second largest producer with average landings of about 250,000 tons per year (FAO, 2016). The total value of the Mediterranean and Black Sea fish and shellfish landings is estimated to reach at least 2.65 billion €, with Italy leading in the region with about 754 million €, accounting for about 29% of the total landing value (FAO, 2016). Fisheries and aquaculture contribute to the economy of countries bordering the Mediterranean Sea and provide employment for about 600,000 people (Sacchi, 2011). In 2013, about 27,000 people were employed in the Italian fisheries (STECF, 2015) and about 6200 in the processing sectors (STECF, 2014).
In the last two decades, a clear negative trend in

total fish landings was observed throughout the Mediterranean, although average yield of non-EU countries is still growing (FAO, 2016). Recent single species assessments showed a general overfishing of commercial fish and shellfish stocks along with a rapid decline of large predators, variation in primary production and invasion of non-indigenous species related to global change (Colloca et al., 2017 and references therein).

### The Common Fisheries Policy of the European Union and the General Fisheries Commission for the Mediterranean Mid-Term Strategy

Mediterranean fisheries policies are applied at different levels (local, national, European and regional). Although fishing fleets generally operate in territorial waters close to ports, there are many areas where fishing resources are shared among different countries with different styles of life and socio-economic structures, such as the Strait of Sicily (Italy, Malta, Tunisia, Libya and Egypt) and the Adriatic Sea (Italy, Slovenia, Croatia, Albania and Montenegro). Management of shared stocks implies a complex system of relationship where the European Union (EU) interacts with the member states and the General Fisheries Commission for the Mediterranean (GFCM-FAO). This Regional Fishery Management Organization includes all the coastal countries in the region and other Contracting Parties, such as the EU itself. At EU level, the Common Fisheries Policy (CFP) of the European Union aims at exploiting fish stocks at a level of Maximum Sustainable Yield (MSY) by 2020 at the latest. Other objectives worthy of mention are to minimize the discarded fraction of catch, adopt the regionalized approach in implementing the long-term management plans, and reverse the decline in employment in the fisheries sector.

The Resolution for a mid-term strategy (2017–2020) towards the sustainability of Mediterranean and Black Sea fisheries (GFCM, 2016) aims at:

i. reversing the declining trend of fish stocks through strengthened scientific advice in support of management;
ii. supporting livelihoods for coastal communities through sustainable small-scale fisheries;
iii. curbing illegal unreported and unregulated (IUU) fishing, through a regional plan of action;
iv. minimizing and mitigating unwanted interactions between fisheries and marine ecosystems and environment; and
v. enhancing capacity-building and cooperation.

Due to the main CFP objective to balance the fishing fleet to productivity of stocks, the EU fishing fleet capacity has declined in terms of both tonnage and engine power in the last 20 years (EU, 2016). Conversely, the fleets of non-EU countries are still growing in terms of fishing power, thus undermining the target of sustainable fish stock exploitation at basin level.

In relation to the implementation of the Common Fisheries Policy (CFP), Italy has put into place a series of measures for the management of fishery resources based mainly on the implementation of Multi Annual Plans for fishery management (MAPs). The plans regulate fisheries at different spatial scales, from local (e.g. the Marine Protected Areas - MPAs promoted by the Sicilian Government) to basin scale (e.g. the MAP for small pelagic stocks in the Adriatic Sea and that for deep water rose shrimps and hake in the Strait of Sicily), as well as the intermediate scale (e.g. the MAPs of trawling fisheries in the 7 Geographic Sub Areas surrounding Italy).

Although some improvements towards more sustainable Italian fisheries have been accomplished (Sabatella et al., 2017), Mediterranean fisheries there still have a long way to go before reaching the Maximum Sustainable Yield (MSY) target in 2020, as reported by the CFP.

Within this framework, it is worth noting that differences in level of socio-economic development of Mediterranean countries make it difficult to reach a common vision on stock status, fishery objectives and management measures in the near future in areas such as the Strait of Sicily and the Adriatic Sea which are strategic to Italian fisheries and where resources are shared with non-EU Countries.

### Some research needs for improving fisheries in the Mediterranean

Moving fisheries from the current overfishing status towards a sustainable exploitation requires new and improved knowledge on the behaviour of stocks and fishermen in a changing Mediterranean ecosystem under the pressure of global change. This essentially means balancing catch with stock productivity. Some relevant topics for research in Fisheries were identified by European bodies such as EFARO (the European Fisheries and Aquaculture Research Organisations), SAPEA (Science Advice for Policy by European Academies) and COFASP (an ERA-NET project dedicated to the cooperation on fisheries, aquaculture and seafood processing). Taking into account the suggestions of these bodies, the Italian National Program for Fisheries and Aquaculture 2017-2019, the BG strategy, and the main features of fisheries in Italy, the following research priorities are proposed:

1. **Identifying population units (stock boundaries) and stock-recruitment relationships**
   Stock identification is an interdisciplinary issue that involves the identification of self-sustaining components in natural populations. It is a central theme in fisheries science, being a prerequisite for stock assessment and management. It is well known that the most part of population models assumes that individuals belonging to the same stock have homogeneous demographic parameters (e.g., growth, maturity, and mortality rates) and a life cycle in which ideally, new individuals are produced by older cohorts of the same stock each year. Despite their relevance to fisheries assessment and management, stock structure and delineation of stock boundaries are still uncertain in many areas, including the Mediterranean. Consequently, the reliability of stock assessments and the effectiveness of fishery management are severely limited for many fishery resources. A substantial research endeavour in stock identification was recently concluded in the Mediterranean within the EU project STOCKMED (Fiorentino et al., 2015). This project represented the first attempt to tackle the issue of stock units' identification at a Mediterranean scale using a formal multidisciplinary approach. The preliminary results obtained by the STOCKMED framework need to be validated with specific multidisciplinary studies to verify the geographical boundaries of the distribution of the main commercial stocks. This aspect is crucial in order to identify the proper spatial scale for investigating the spawning stock–recruitment relationships that are the cornerstone of sustainability of fishery resources.
2. **Modelling approaches for Ecosystem Based Marine Resource Management**
   In the last decades, there has been a progressive transition in fishery sciences from a "reductionist" perspective based on a single species approach to a "holistic" approach considering the trophic interactions of species within an ecosystem. The single species stock models (i.e. prey or predator) have been progressively extended to more species linked by trophic relationships (multispecific models) up to numeric simulation of the ecosystem as a whole (ecosystem models) (Plagányi, 2007). This conceptual evolution, known as Ecosystem Approach to Fishery Management (EAFM), considers fisheries management within a wide framework of relationships that include the biological, environmental, economic, social and administrative components of the system (Garcia and Cochrane, 2005). The EAFM perspective supersedes classic management styles and targets, aimed at maximizing production surplus (Maximum Sustainable Yield) or economic performance (Maximum Economic Yield). In the EAFM, the benefits for society provided by natural capital made up of fishing resources must also include those generated by the ecosystem functions and essential habitats (Essential Fish Habitats - EFH) which allow the completion of the life cycles of the resources. However, despite the availability of several different ecosystem models in an EAFM perspective (Stecken and Failler, 2016) they continue to be used mostly as "strategic" tools to provide insights on the effects of fishing on the ecosystem. Short term recommendations on the status of the stocks is still largely based on single species models (Hilborn, 2011; Fogarty, 2014). A main future challenge for EAFM in the Mediterranean is therefore the combination of both modelling approaches for a more comprehensive assessment framework.
3. **Discard and small-scale fisheries**
   As it is known, some fisheries, such as trawling, are not particularly selective systems, with a high number of species caught in the same fishing operation and with the production of high quantities of discard, that include species of null or poor commercial value or undersized commercial species (Tsagarakis et al., 2014). The reduction of discard is one of the pillars of the reformed Common Fisheries Policy (EU Reg 1380/13). Many studies have been dedicated to improve the selection process of towed gears by changing mesh size/shape and/or using a selection grid in the net (Lucchetti, 2018). These technical solutions, together with the protection of nurseries, should be adopted within MAPs to reduce unwanted catch in areas where they are more abundant (Milisenda et al., 2017). Considering the poor selectivity of towed gears, those fisheries with less impact and greater efficiency in use of catches (i.e. less discard), such as small-scale fisheries (SSF),

must be properly re-considered (Farruggio, 2016). The reformed CFP assigns a relevant role to SSFs, emphasizing the use of small boats rather than towed gears. The strategy enhances the relationship between artisanal fishing and other specific socio-economic activities of the different coastal territories, primarily tourism. The integration of SSF in the BG strategy implies that all stakeholders, from fishermen to consumers, embrace the responsible use of marine biodiversity for food within a sustainable development from an ecological, economic and social point of view.

4. **Participatory management, communication, and collaboration among scientists, policy makers and stakeholders**

   According to literature, the classic "command and control" approach is often at the basis of failure of fishery management. On the contrary, management based on co-management shared between fishermen, researchers and administrators, appears to be a management approach generally associated with greater sustainability of fishing activities, especially in SSF, also in relation to the highest levels of compliance (Leite and Pita, 2016). In this context sharing of knowledge among the various stakeholders in the fishing supply chain is a necessary condition, albeit not sufficient on its own, for an effective and transparent management of capture processes.

   Extensive experience gathered in many fisheries all over the world has shown that exchange of information on status of stock, performances of fisheries, management objectives, adopted measures, monitoring of management effects, and surveillance/control procedures are pre-requisites for an effective sustainable use of fisheries resources. The maintenance and enhancement of the natural capital constituted by fish stocks and related ecosystem services is related to a set of social rules and behaviours of fishermen, known as social capital. Social capital plays a crucial role in the promotion of trust, cooperation and communication among fishermen and other actors in the sector and can reduce the competitiveness in "the race to fish" and rate of depletion of fishing resources (Wilson et al., 2013; Schultz et al., 2015).

5. **Spatial based approach to fishery management**

   Although the spatial dimension of ecological and capture processes are not traditionally considered in assessment or in management, during the last decades spatial analyses have progressively infused fishery sciences. Protecting the Essential Fish Habitats (EFHs), i.e. habitats where commercial species perform their life cycles, mainly spawning and nursery, has become a relevant aspect of stock conservation (Garofalo et al., 2011; Colloca et al., 2015). In terms of the significance of the spatial scale, in a recent review on the effects of MPAs on fisheries, Hilborn (2014) recalled the importance of assessing how much the benefits of closing a fishery area are reflected outside the protected area and how source-sink dynamics is of crucial importance for the correct understanding of the potential of MPAs. The positive effects of the spill-over from MPAs to adjacent areas, which is one of the cornerstones of spatial management of fishing resources, has recently been confirmed in different areas of the central-western Mediterranean (Pipitone et al., 2014).

   A new modelling approach (SMART - Spatial MAnagement of demersal Resources for Trawl fisheries) for the assessment of the effects of nurseries protection on fishing mortality and economic performance of demersal fisheries was developed by Russo et al. (2014). The authors showed that, in the case of deep water rose shrimp, which is the main target species in the Strait of Sicily, the protection of three main nurseries in the area while maintaining the current fishing effort could reduce fishing mortality rates by a value corresponding to a 10% reduction of fishing effort.

   Another interesting research topic is the relationship between productivity of fishery target species and biodiversity, and their interactions in space. From a general point of view, the loss of biodiversity is related to a diminished capacity of the oceans to provide food, maintain high environmental quality and to recover from perturbations (Worm et al., 2006). However, it is reasonable to expect that a simplification of the community on fishing grounds that reduces the abundance of competitors and predators can direct productivity of fished grounds towards species of greater commercial value (Brander, 2012).

   The experience of shrimp fishermen in different areas of the Mediterranean suggests that the reduction of predatory species and biodiversity in fishing grounds generally increases shrimp catch. These considerations allow to imagine a spatial management of fishing activities with a strong impact on habitats, such as trawling, where grounds allocated to fisheries alternate grounds assigned to conservation. This approach, in line with the ideas at the basis of the European Marine Spatial Planning Directive, may allow the optimization, on adequate spatial scales, of the ratio between productivity of fisheries resources in the fishing grounds and the overall ecological good status of the communities and the environment within a larger area containing the fishing grounds (Fiorentino, 2017).

6. **Data collection framework for a more effective fishery management**
   Enhancing regional coordination and coherence in data collection is a pre-requisite for the implementation of a regionalised, ecosystem based, fisheries management in the Mediterranean. Currently, data collection in European countries in support of the CFP, is co-financed by EU and member states. Data collection is governed by the EU data collection framework (DCF) and related regulations. Two main aspects should be considered: i) there is an increasing demand on fishery related data collection (to include MFSD aquaculture economics components) and ii) the need for European data collection programmes to be integrated with Third Countries to build an effective advisory system on fisheries status in the Mediterranean.
   The Data Collection Reference Framework (DCRF) is the first comprehensive GFCM framework for the collection and submission of fisheries-related data in the GFCM area (Mediterranean and Black Sea). It is the result of a series of coordinated actions focused on fisheries data collection, which were launched in 2013 under the umbrella of GFCM Scientific Advisory Committee (SAC) and take into account the inputs of the GFCM Working Group on the Black Sea. These data are of paramount importance for the work of the GFCM in order to support the decision-making process, based on sound scientific advice from its subsidiary bodies. Until countries of the southern coasts of the Mediterranean are able to collected proper data, no realistic assessment and management of national and shared stocks can be achieved.
   Another type of research that is needed to improve data collection on fisheries concerns the increase of automatic collection of data to allow a wider space and time coverage. Vessel Monitoring Systems (VMS) and Automatic Identification Systems (AIS) make it possible to determine the spatial distribution of fishing effort with good accuracy (Russo et al., 2016a) thus allowing implementation of spatial based management. Although the accuracy of electronic logbooks, catch and effort data reported by fishermen, is still inadequate in terms of catch quantities, the general pattern of fishing activity in terms of exploited assemblages can be reliably derived (Russo et al., 2016b). Another promising source of information involving fishermen is provided by the Fishery and Oceanography Observing Systems (FOOS). These are automated systems for the collection of georeferenced data in support of oceanography and fisheries science, and provide services for fishing operators (Patti et al., 2016).

7. **Global change and fisheries**
   Climate change, through long-term temperature increase and a higher frequency of short-term extreme events, is undoubtedly affecting the biology and ecology of sea-dwelling organisms (see also sec. 4.1.2). The most evident changes affect life cycle, reproductive effort and demography, but generally result from subtle adaptive responses, such as physiological adjustments and micro-evolutionary processes (Lejeusne et al., 2010). A main consequence of warming is a simultaneous increase in the abundance of thermo-philic and thermo-tolerant species and the disappearance or rarefaction of 'cold' steno-thermal species. Whilst the Eastern Mediterranean was colonized by Lessepsian migrants, non-indigenous species (NIS) entering through the Suez Canal, in the Western Mediterranean, migration from the Gibraltar Strait is reinforced by mariculture and shipping (Katsanevakis et al., 2013). Along the coast of the Middle East and North Africa up to the Strait of Sicily, the NIS represent a main component of commercial landings and their role is expected to become more prominent following the expansion of the Suez Channel in 2015. Although the Strait of Sicily still seems to be a biogeographic barrier to the sudden increase of NIS in the western Mediterranean (Geraci et al., 2018), it is important to prioritize monitoring and modelling of changes in biodiversity in the next future.
   Another main aspect of global change is ocean acidification (see also sec. 2.2.2) which

can lead to changes in the relative species composition at a given trophic level affecting overall productivity (Le Quesne and Pinnegar, 2011). Possible effects at the organism level include reduced growth and reproductive output, increased predation and mortality, alteration in feeding rates and behaviour and reduced thermal tolerance. Whilst general theories for understanding the sensitivity of species to acidification are developing (Melzner et al., 2009), closely related taxa have shown different responses to acidification (Miller et al., 2009). Understanding the direct effects of acidification on fish species requires laboratory experiments on different life stages of commercial species to be scaled up to population-level to predict potential impacts on fisheries production and yields. Observations from experimental studies can be used to modify parameters in single- or multi-species models to assess responses of populations to direct physiological impacts. However, habitat availability and prey or predator abundance can also be correlated with acidification effects. Indeed, accurately predicting responses in population dynamics requires explicit inclusion and understanding of community-level processes.

## A ROADMAP TOWARDS SUSTAINABLE FISHERIES

- Identifying stock units
- Improving modelling for Ecosystem Based Approach to Fisheries
- Reducing discards and improving small scale fisheries
- Developing participatory management mechanisms and communication/cooperation among stakeholders
- Implementing spatial based approach to fishery management
- Advancing in data collection frameworks
- Assessing impact of global change on fishery resources and ecosystems

### 3.1.2. AQUACULTURE FOR SEAFOOD

The EU Blue Growth Strategy identifies aquaculture as a sector, which could boost economic growth across Europe and bring social benefits through new jobs. The reformed CFP also aims to promote the sector and EU Member States are currently developing national aquaculture strategies. Italy, for example, launched the "Strategic Plan for Aquaculture in Italy 2014-2020" and promoted the establishment of the National Aquaculture Platform (ITAQUA) to as tool for planning the sustainable development of aquaculture activities.
Presently, a quarter of seafood products consumed in the EU (including imports) are produced on farms; in 2011, 1.24 million tons of aquaculture goods were produced in the EU, worth 3.51 billion € (Science for Environment Policy, 2015). In contrast with other regions of the world, aquaculture production is stagnating in the EU, while imports are rising. At the same time, there is a growing gap between the amount of seafood consumed in the EU, and the amount caught from wild fisheries. The European Commission calls for this gap to be partly reduced with environmentally responsible aquaculture (EC, 2013).
According to the Federation of European Aquaculture Producers (FEAP, 2015), European Mediterranean countries including Turkey, produced 148,367 tons of sea bass and 146,467 tons of sea bream in 2014, the most consumed fish species in the Mediterranean area.
Projections indicate that European aquaculture in the Mediterranean Sea might grow by more than 100% by 2030 up to a total production exceeding 600,000 tons. This is equivalent to a rise in the sector's total (direct and indirect) value of 5 billion €, and the provision of 10,000 additional jobs in Mediterranean European countries (Piante and Ody, 2015).
This level of development inevitably results in conflicts over space and other resources. Acquaculture is becoming the prime competitor of mass tourism in the pursuit of available coastal surfaces and is associated with environmental concern regarding the discharge of substances such as antibiotics and nutrients (from the fatty acid and protein-rich feed) into coastal areas, leading to deterioration of local marine environments (Buschmann et al., 2006).
Even though the intake of feed by farmed fish is no more than 30%, while the rest goes to waste, aquaculture generally also performs a more efficient conversion in terms of feed protein to food protein compared with other protein costs of animal foods (Smil, 2002). Duarte et al. (2009) argued that environmental costs of mariculture are far lower when compared with those of terrestrial agriculture, not to mention, the global impacts caused by the production and application of fertilizers, antibiotics and growth hormones, pesticides and animal-released methane. In addition, when considering global nitrogen-use efficiency in animal production, marine animals possess a much higher nitrogen-use efficiency, ranging, respectively, from 20% to 30% in shrimp and fish, compared with livestock production, which for example, is 5% for beef and 15% for pork (Smil, 2002 cited in Duarte et al., 2009; Duarte et al. 2009).
Estimates of nutrient retention and potential release by fish into the water are not readily available and are changing rapidly as feeds, feeding practices and culture methods evolve. Nitrogen and phosphorus retention (in sea bream and sea bass) is about 46% and 38%, respectively (Lupatsch et al., 2003). The current trend is to increase nutrient retention and reduce losses as feed quality is improved, so that most N is excreted in the dissolved form (mainly as ammonia) and most P as particulate (Brigolin et al., 2014).
A concerted approach in research and development policies **to make Mediterranean aquaculture sustainable**, and, possibly, change the perception of aquaculture could resolve many of the abovementioned issues and allow us to continue to enjoy seafood that is fresh, relatively cheap, wholesome, from a nearby environment, with minimal impact on our ecosystem and ethical responsibility.
Integrated Multi-Trophic Aquaculture (IMTA), is a farming system where aquaculture species from different trophic levels, and with complementary ecosystem functions, are farmed in close proximity, in such a way that one species' uneaten feed and wastes, nutrients and by-products are recaptured and converted into fertilizer, feed and energy for another by exploiting synergistic interactions between species (Troell et al., 2009; Barrington et al., 2009). Farmers combine fed aquaculture (e.g. finfish) with extractive aquaculture, incorporating species from different trophic levels in the same system (Granada et al., 2016), which utilizes the inorganic (e.g. seaweeds or other aquatic vegetation) and organic (e.g. suspension-and deposit-feeders) excess nutrients generated from fed aquaculture. (Granada et al., 2016).

Ferreira et al. (2012) showed that, when gilthead bream is reared in IMTA with oyster (*Crassostrea gigas*), the environmental impact of cultures was substantially reduced. Benefits for the ecosystem include the removal of a substantial pollution load representing a population equivalent (PEQ) of 5500. Futhermore, with IMTA, organic deposition is reduced by about 7%, which is significant considering that shellfish themselves add particulate waste to the culture area due to faeces and pseudofaeces. Also, the combination of these cultures enhanced oyster production by 20% once the gilthead bream culture provided additional organic detritus as a food supplement. Even profits were higher by over 230% for finfish monoculture and 68% higher for shellfish monoculture. (Granada et al., 2016).

Furthermore, IMTA is the only practical remediation approach with a prospect for additional farm revenues by adding commercial crops, while all other biomitigation approaches have generally caused additional costs to the producer (Troell et al., 2009).

**The Need for Diversifying Responsible Aquaculture Systems and for an Ecosystem Approach**

By learning from mistakes in capture fisheries, it is possible to ensure that aquaculture management does not fall into the same cracks, and consider the cultivation of multiple species in proximity and their interactions with each other and with wild species: diversification of the aquaculture industry is advisable for reducing economic risk and maintaining sustainability and competitiveness.

From an ecological point of view, diversification also means cultivating more than one trophic level, i.e., not just raising several species of finfish (that would be "polyculture"), but adding organisms of different and lower trophic levels into the mix (e.g., non-carnivorous fish, seaweeds, shellfish, crustaceans, echinoderms, worms, etc.) to mimic the functioning of natural ecosystems. Staying at the same ecological trophic level would not address some of the environmental issues because the system would remain unbalanced due to non-diversified input and output needs (Chopin et al., 2012).

In Europe, the model for fed fin-fish aquaculture has been very linear, in line with a fast replacement economy where the inputs to the industry lead to consumption of natural resources with high energy and water consumption, with externalized wastes. This is in contrast to the principles of IMTA, which aims to create an industry-based spiral or loop system (now termed the circular economy) that minimises energy flows, losses, and environmental deterioration, without restricting economic growth or social progress (Hughes and Black, 2016).

Evolving aquaculture practices will require a *conceptual shift toward understanding the workings of food production systems* rather than focusing on technological solutions. The IMTA is not the solution (the silver bullet) to and for everything, but can be very useful in developing the best aquaculture practices of tomorrow. IMTA is based on several common-sense principles:

1. the solution to nutrification is not dilution, but extraction and conversion through diversification, rewording of the first law of thermodynamics "Nothing is lost, nothing is created, everything is transformed". What is waste for some (fish) is gold for others (i.e. seaweeds, mussels);
2. presently, the most advanced IMTA systems in open marine waters have three components (fish, suspension feeders or grazers such as shellfish, and seaweeds, in cages, rafts, or floating lines), but they are admittedly simplified systems. More advanced systems will have several other components (e.g., crustaceans in mid-water reefs; deposit feeders such as sea cucumbers, sea urchins and polychaetes in bottom cages or suspended trays; and bottom-dwelling fish in bottom cages) to perform complementary functions either because various size ranges of particles are involved, or because of their presence at different times of the year (e.g., different species of seaweeds;
3. most fin-fish aquaculture in Europe is intensive (FAO, 2012), while the extractive species usually used in IMTA are extensive cultures, with much lower levels of production per unit area.

Considering productivity per unit input and measuring other outputs as well as fish, there are significant opportunities to increase productivity. This increase in productivity happens firstly because there is an increase in production from the lower trophic level species that are grown alongside the fin-fish and secondly because there is good evidence to suggest that these species are able to utilize the nutrients from the fin-fish and are more productive when grown alongside fed aquaculture. As such, there is a clear increase in productivity of the whole system per unit feed (if the farmer could convert 100% of waste emissions to product). However, to make this meaningful to the farmer, there needs to be a proven case that IMTA not only results in significant cost saving in solids treatment, but an additional by-product, can be sold at above the production costs plus an acceptable margin.

Recent studies demonstrated that, theoretically, a fish farm culturing a thousand tonnes of seabream will gain an additional yield of 58 t of omnivorous fish (i.e. grey mullet) without having to feed them. The FCR (Food Conversion Ratio) is thus reduced by 12%, and consequently there is a decrease in overall feed costs (Shpigel et al., 2016), which constitute the main cost (around 50%) in fish production (Pelletier et al., 2007). It is the eco-efficiency win/win situation, with the second win being reduced environmental impact. This is achieved through the ability of the extractive organisms to make use of waste products of the fin-fish production as nutrients and energy. As such, these waste streams are assimilated into the tissues of the extractive organisms and removed from the environment (Granada et al., 2016).

In this scenario, there are two waste product streams of interest: 1) dissolved nutrients and 2) particulate organic matter (POM: fish faeces and uneaten pellets). Therefore, IMTA is likely to increase the total benthic impact of any one farm, if that farm now incorporates mussel and seaweed production (Troell and Norberg 1998), but the benthic impact per unit of production (finfish plus mussels and/or seaweed) would be significantly reduced (Hughes and Black, 2016). On the other hand, the balance of trade-offs is currently not sufficiently positive to motivate the large-scale uptake of IMTA in Europe. If we contrast these facts against the situation in Asia where the balance of trade-offs is in favour of the adoption and practice of IMTA, it becomes apparent why this farming system has yet to become a standard practice in Europe.

In fact, IMTA has been practiced for centuries in Asia, while in Europe it is still in its early stages where nonetheless, there have been solid indications of potential financial benefits by boosting algae and shellfish growth (i.e. Turkey) (Troell et al., 2009). The integration of mussels and oysters as biofilters in fish farming has also been studied in a number of countries, including Australia, USA, Canada, France, Chile and Spain. Recently, a number of case studies have explored IMTA ability to reduce nutrient pollution increasing the production, with the aim of achieving a "zero impact farm." Simulations on sustainable marine aquaculture in Europe, predict that harvesting 7000-9000 tonnes of mussels farmed using a space-efficient 'smart farm' system, could recover 100% of nutrients (88 tonnes of nitrogen and 9.6 tonnes of phosphorus) released by 2105 tonnes of finfish each year (Science for Environment Policy, 2015).

IMTA used in conjunction with the seaweed *Gracilaria vermiculophylla* (used to produce agar) is able to remove 0.5% of nitrogen from the effluent of a land-based farm (Abreu et al., 2011), but blue mussels are more effective than algae in removing nutrients, and need much less space (Holdt and Edwards, 2014). In the last fifteen years, the integration of seaweed with marine fish culturing has been examined and studied in Canada, Japan, Chile, New Zealand, Scotland and the USA. Seaweeds in such integrated cultivation systems, reduce the environmental impact of intensive fish aquaculture and increase the yield of total biomass produced on a single site thus adding value to the investment in finfish aquaculture (Troell et al., 2009; Chopin et al., 2012).

As long as European producers continue to use current farming methods, they will not be able to compete with seaweed producers in Southeast Asia, South America and Africa. The future production of macroalgae on a large-scale and at relatively low cost could unlock new propects for the use of biomass for Human consumption and animal feed (SAPEA, 2017). Although the current demand for seaweed raw material can be met by cultivating biomass within the coastal zone, large-scale production is foreseen to occur in offshore sites, due to more stable growth conditions and avoidance of conflicts arising with other users of the coastal zone (Stévant et al., 2017). However, upscaling seaweed cultivation requires technological breakthroughs in farming and harvest methods in addition to developing value-added products based on seaweed, e.g. targeting health and disease issues in humans and farmed animals.

The following points also need to be addressed in the vision of Blue aquaculture.

*Offshore aquaculture.* Technology from other offshore activities can contribute to the development new aquaculture methods, that allow to avoid competition with zones of high ecological value (e.g. MPAs) near the coast.

Strategy involves moving aquaculture out into the open ocean where the water is pristine and currents are strong and steady enough to continually flush the farms of fish waste. The open ocean also provides farmed fish with more consistent

salinity and temperature. This means they are less stressed and less vulnerable to disease, which promotes better growth and minimizes the need for antibiotics or vaccines.
There is growing interest in moving coastal farming to offshore sites because it would reduce constraints related to competition for space with other activities and reduce environmental and aesthetical impacts. The structures and moorings envisaged must be capable of withstanding all types of involved loads. Therefore, stronger versions of conventional inshore technologies or alternative concepts will be necessary. Highly specialized, remote control and monitoring capabilities via leading-edge telemetry systems must therefore be a major component of the operating methodology. In particular, it must be feasible to feed and observe the fish regardless of whether staff is present on site. Large feed storage capacity will also be an essential feature. Higher capital and other fixed costs that need to be offset by economies of scale. For this reason, cage structures with operating volumes and output far higher than those currently found inshore will be required. This entails a change in mind set on the part of industry regulators. More rigorous management and forward planning regimes will be required than are currently the norm at inshore locations.

*Combining aquaculture and offshore multipurpose platforms.* Develop concepts for the next generation of offshore platforms which can be used for multiple purposes, including energy extraction, aquaculture and platform related transport. Offshore platforms structures combined with fish, seaweed and mussel aquaculture were identified as the most promising conceptual multi-use design: they provide opportunities for more effective use of marine space in the future (such energy and aquaculture combinations), and provide more environmentally friendly solutions (such as IMTA, that extend aquaculture production while reducing nitrogen release). They are regarded as a possibility for future sustainability of economic developments at sea, and thus also for Blue Growth.

*New species*. Investigating new fish species in the Mediterranean, where aquaculture is already widespread in inshore areas and opportunities lie further from the coast. Demand has dropped for sea bass and sea bream, which are the most popular species currently farmed in the Mediterranean, and consumers are increasingly moving away from small plate-sized fish towards convenient, clean fish meal preparation instead. One solution is to farm larger, fast-growing species such as meagre, greater amberjack, providing the adoption of sustainable practices.

*Need for substantial improvement of the performance of fish species*, developing sustainable, cost-effective feeds that improve KPIs by maximizing growth potential and survival and improving feed efficiency.

*Need to develop sustainable, cost-effective feeds using alternative ingredients* of low ecological footprint that support enhanced growth and welfare of selected fish promoting fillet quality to satisfy consumer demands. Diets may be formulated with levels of fish meal substitution by alternative protein sources of vegetal origin as (soybean, barley, canola, corn, cottonseed and pea/lupin (Jana et al., 2012). However, complete substitution for plant ingredients has not yet been possible, due to the presence of certain compounds in plants that are not favourable to fish (antinutritional factors) and the lack of certain essential (omega-3) fatty acids (Tacon et al., 2006). Monitoring the release of nitrogen and phosphorous in the coastal zones must be considered mandatory in order to avoid potential negative impacts of intensive aqua-farming. Oily fish is considered to be an important source of omega-3 fatty acids in human nutrition, but feeding fish with plant oil-based diets alone reduces the amount in their flesh. Recent research, however, has found that the fish oil input can be reduced by switching to fish oils in the period just prior to slaughter, although further study is needed.

*Need for new fish species with low FFDR (Fish Feed Dependency Rate)*, which are surely more sustainable. The use of plant products is more economical and environmentally sustainable, suggesting a focus on omnivorous and detritivorous fish species. Such species, as the grey mullet (Mugil caepahalus), can be farmed with diets formulated with high levels of fish meal replacement (up to 75%) by alternative plant protein sources (Gisbert et al., 2016).

*New sources of raw material*. Algal biomass and insect flours have come to stay and replace fishmeal from extractive activity.

*Need for New smart technologies*. Robotization, automation, control, use of drones to see the behaviour of populations in cages at sea and management on land. Farmed fish welfare could be measured with sensors that would determine the control of exercise, the effect of diet and general health. They would help optimize resources and reduce losses.

*Biotechnology to increase sustainability of aquaculture production*, including alternative preventive and therapeutic measures to enhance environmental welfare, sustainable production technologies for feed supply. The impact on chemical reduction would be evident and we are increasingly approaching production models based on knowledge rather than foresight.

### A ROADMAP TOWARDS A MARINE "NEOLITHIC" REVOLUTION

- Set natural highly productive areas as a reference and design artificial systems that mimic those natural systems
- Integrate offshore multi-purpose platforms with aquaculture facilities
- Develop new smart technologies
- Introduce new sources of raw material
- Explore alternative preventive and therapeutic measures
- Select different species to harvest

## 3.2. TRANSPORT

The transport sector, which includes shipping, marine equipment, ports and logistics, is experiencing a significant revolution generated by the impressive increase of the capacity of the world fleet, the change in the direction of traditional Mediterranean trades from west to east, the rapid growth of some new technologies, and a new integrated vision of transport systems and related infrastructures. On the other hand, in the last few years marine robotics has become an operational solution in many engineering fields. In particular, it can extend the operational areas in air, as well as, sea surface and underwater environments, for different types of operation.

### 3.2.1. TRANSPORT, SHIPBUILDING AND MARINE ROBOTICS: TOWARDS SMART, CLEAN, SAFE AND CONNECTED MARITIME TRANSPORT, MARINE VEHICLES AND STRUCTURES

The transport and shipbuilding sectors, together with marine equipment, represent traditional economical drivers for a blue economy. The European maritime industry currently counts 300 shipyards and over 22,000 maritime equipment manufacturers. The Italian maritime industry is globally constituted by 40,000 companies with a territorial distribution that involves 15 Regions. It reaches a turnover of 15 billion € and employs over 230,000 people (CCIAA, 2017).
As a result of the economic crisis, the number of shipbuilding companies has decreased over the last years by up to -5.8% with a consequent reduction in employment. Nevertheless, in the last five years the turnover has recorded higher growth than the rest of the economy (+ 2.1% against + 1.9%) due to the positive trend in orders for cruise ships, a sector in which Italy holds global leadership (CCIAA, 2017). Another strategic and world leader sector for the Italian blue economy is the yachting industry. The latest report by UCINA (2017) indicates that in 2016 the total turnover of the yachting industry reached 3.44 billion euros, significantly higher with respect to the minimum of 2.43 billion reached in 2013 and with a growth rate of 18.6% compared to 2015. The 66.5% of turnover comes from sales on foreign markets and 33.5% in Italy. The total number of employees is equal to 18,480.

In addition, as stated in Douglas-Westwood (2016), Autonomous Underwater Vehicles (AUVs), an emerging technology from niche market sectors, have recently become a consolidated operational solution in various marine fields such as defence (over 70% of demand with about 700 units), research (22%) and the commercial sector of hydrocarbon extraction industry (4%), with a CAGR (Compounded Average Growth Rate) of 10%. At the same time, the Unmanned Surface Vehicle market is expected to reach a CAGR of about 14% in the period 2017-2021 mostly thanks to increasing exploitation in hydrographic and oceanographic sectors. A similar trend is expected for the market of equipment and sensors installed on autonomous marine vehicles.

At the same time, the shipping industry is facing the need to improve its efficiency and safety standards and to bridge the gap with relevant hydrographic information: poorly charted areas cause voyages to be longer than necessary and potentially more hazardous for the environment; optimum loading of ships may be more difficult, thus increasing overall costs. The saving of time and money resulting from the use of shorter and deeper routes and the possibility to use larger ships or load ships more effectively generates important economies for national industry and commerce. Modern charts also provide the information required to create technological and infrastructural conditions to support automated sea transportation systems through the establishment of suitable traffic routing systems for unmanned vehicles as well.

Specific actions have been promoted by the Italian government to support this strategic sector for the national economy. Among others is the creation of National Technological Clusters: "Trasporti Italia 2020" and "Italian Blue Growth".

Safety, efficiency, and greening have been in the last decades, and continue to be, the central scientific and technological themes of the maritime transport sector. Climate changes and the subsequent need to find new green energy sources together with the rapid progress of new technologies (Information and Communication Technologies (ICT), Internet of Things (IoT), machine learning, additive manufacturing etc.), have fostered substantial changes in this sector (EU, 2017). The new vision is to no longer consider the single marine vehicle or infrastructure as "stand-alone" but as part of an integrated mobility strategy. The keywords of this revolution are connected, automated and efficient mobility. These are the characteristics that can jointly provide the answers to societal needs, environmental challenges and economic expectations for the EU maritime industry. In this frame, the European Commission adopted a "mobility package", in May 2017, which also covers a new strategy on EU investments in research and innovation for a greener and more efficient transport. The process was initiated a few years ago and promoted through specific actions in the frame of H2020.

The global (DNV-GL, 2014), EU (2017) and national (CTNT, 2015; Trasporti Italia 2020, 2015) strategies for the future of shipping thus focus on: automation and connectivity, innovative ship design, new manufacturing processes, innovative materials, low carbon technology, solutions for safety and low environmental impact. These areas might bring significant innovation and opportunities for the maritime industry and its competitiveness.

Finally, marine robotics has been identified at EU and at national level as a strategic sector, in a vision of integrated systems constituted by manned and unmanned vehicles, vessels, harbour and offshore infrastructures as well as monitoring and security, dual-use systems for defence, surface and underwater platforms.

Connected and automated transport technologies can contribute to increase the efficiency and safety of the transport system. It is clear that a fully connected and integrated mobility system can globally and drastically reduce fuel consumption and emission. Nonetheless, safety is the main area where connectivity and automation are expected to provide improvements to waterborne transport since the human factor remains the most important cause of marine accidents. The safety of shipping is also of primary importance to avoid rare but dramatic ecological disasters. On the other hand, a high automation level is fundamental to optimize the on-board ship management systems, with significant impact on fuel savings. Modern ships have a high degree of automation and all ship systems can, in principle, be remotely controlled. However, this will require that a number of not trivial technological gaps and legislative issues be resolved in the next future.

The connected and automated ship concept also involves the ubiquitous presence of sensors for monitoring engines, structures, operational response, etc. Collecting such a large amount of data during the ship's life, will strongly encourage the introduction of machine learning methodologies, capable of identifying coherent behaviours in the bulk of the "Big Data" and generate information and models that can be useful to both the design and operative phases.

Thus, major technological improvements relate to ICT applications and in particular, the optimized use of IoT in remote areas, new Big Data management, data exchange standards between ships, ports and coast guard, and acceptable levels of cybersecurity. Moreover, a regulatory framework that supports an efficient introduction of these technologies is needed as well as the creation of a service centre for maritime transport. It is expected that all these gaps will be filled between 2025 and 2030.

An ambitious prospect for high connectivity and automation is represented by the Autonomous ship. Although some basic technological demonstrations have been carried out, it is still quite a new challenge with little technology available today. According to the call "Mobility for Growth 2018-19", the expectation for 2020 is to "develop and demonstrate to TRL7 a fully autonomous vessel within a realistic environment". The Autonomous Ship is currently being considered for inland waterways, short sea shipping, ferries coastal operations and urban water transport, and is expected to be in service for the above operations by 2030. The unavailability of sites to test autonomous vehicles and the lack of standards and regulations are, at the moment, the main bottlenecks for operability.

Ship design, development and manufacturing make up a collaborative, integrated and highly complex set of processes and tools that consider the whole vehicle life cycle. The process comprises many disciplines: vehicle performance (hydrodynamics, manoeuvring, propellers, etc.), energy storage, propulsion systems, connectivity, automation, safety, security, passenger comfort and regulatory issues. There is a global trend towards the integration of digital design with digital manufacturing with the aim of improving quality, reducing costs, delays and reworks. The preliminary design phase is crucial for the ship design cycle. The iterative procedure traditionally used, sometimes based on a number of semi-empirical rules, is only partially able to consider in a holistic way all of the mentioned disciplines. Moreover, climate change has imposed new constraints on the design of marine vehicles and structures that need to withstand increasingly severe sea conditions; a climate driven variable should be introduced in the process. Thus, there is a need to adopt knowledge based strategies of analysis able to develop innovative concept designs that adapt to different scenarios and apply new technologies, on the basis of numerical simulations integrated in a multidisciplinary optimization procedure. These new methodologies can also be applied to the design of innovative vessels for inland transport, for intervention in case of oil-spill and environmental emergencies, for autonomous vehicles for rescue at sea, etc.

New manufacturing sustainable processes are also needed to reduce the impact on the environment. While medium and large maritime industries already adopt up to date production cycles, some small and medium enterprises (SMEs) use outdated technological processes that are not able to guarantee low environmental impact. The problem is twofold: on one side investments are needed to renew the manufacturing process, on the other, operators are sometimes not adequately prepared to handle new technologies and need professional training courses. Finally, Additive Manufacturing (AM) can give a valuable support to realize innovative design solutions that would be impractical with conventional processes. Additive Manufacturing can also represent a revolutionary innovation for in-site production and repair of ship/machinery components during navigation: new designs for more efficient machinery/control components and spare parts to be produced locally in various ports around the world. This would improve responsiveness to market demands, shorten the time for repairs and contribute to more efficient ship operations.

New materials and developments in material technology are fundamental to meet new environmental regulations, improve ship safety and comfort, reduce fuel and maintenance costs and operate in adverse environmental conditions (e.g. deep sea operations) (DNV-GL, 2014). Shipbuilding industry manufacturing processes are structured to use steel, a cost-effective, flexible and easy to weld repair and recycle material that guarantees high structural strength but is no longer able to cope with all the new requirements. The use of high strength and lightweight materials such as composite (mostly fiber reinforced plastic) and aluminium is, to date, limited to specific civil ship production segments, to components of ship superstructures and to military ships. Other realistic, current and future, innovative solutions for lightweight ship structures and components are provided, for instance, by the recent development in graphene production, the application of new processes for composite material manufacturing and the use of aluminium

foam. Moreover, intelligent materials i.e. materials with self-healing or self-cleaning properties, with sensing capabilities or with properties that change with locations, will be potentially used in the future both to build ship sections and components and as protective coatings.
Bridging the technological gaps in material manufacturing is essential in order to overcome the limitations on the production of large structures and reduce high production costs. Moreover, new junction processes and technologies (welding, gluing etc.) for different materials must be implemented. Verification of the global structural strength, of the fatigue life and of the vibro-acoustical behaviour of new construction materials is needed to ensure adequate safety and comfort levels. New standards and regulations will most likely be necessary.

*Low carbon technology.* Although electrification is a fundamental issue for the new mobility system, due to the high costs and technological effort needed to support the large use of electric systems on board ships, the waterborne sector has focused most of the research aimed at reducing nitrogen oxides and sulfur oxides emission, on alternative fuels (EU, 2017). Currently, the main alternative to Heavy Fuel Oil is Liquefied Natural Gas (LNG) that can lead to reductions of 85-90% for NOx and near 100% for SOx. In Europe about 50 LNG-fuelled ships are in operation and others are on order. The main problems related to the construction of LNG-fuelled ships are: practical design issues concerning safety of passengers and crew, the need to update standards and regulations, the higher costs of a LNG-fuelled ship with respect to those powered with oil and the lack and cost of bunkering and refuelling infrastructures.
In this framework, it is worth mentioning the project GAIN4Med, aimed to launch and test the LNG networks for storage and supply facilities. Additionally, the recent Boating Code (D.Lgs. 229/17) foresees an upcoming regulation of LNG and electrical engines utilized on recreational boats. Methanol is another option to reduce SOx emissions for inland as well as for short-sea shipping but it poses a number of new challenges to operators in terms of handling and safety.
Moreover, large-scale biofuel production can substantially reduce emissions from the transport sector, and make a significant contribution as of 2030: indeed, production of high quality biogas is one of the most stimulating challenges of the near future. Today, the largest biofuel producers in the world are USA and Brazil.
The request of renewable biofuel production that does not compete with food resources, is stimulating new technologies and directing research towards new types of biofuels (e.g. algae, biomass, agro-wastes, wastes from industry, end-of-life consumer goods). A key topic is the production of gaseous and liquid fuels by thermochemical processes. Other current research topics include biogas cleaning by functionalized carbon sorbents, studies on combustion properties and kinetics, and development of small-scale demonstrative units integrated with fuel cells for reforming biogas into a hydrogen-rich mixture (DIITET, 2018).
In regards to ship electrification, the expectation of EU for 2020 is to: i) have ports that offer electric plug in for ships allowing the ships engines to be switched off ii) use hybrid electric systems for inland waterways and have significantly larger battery capacity in comparison to 2016, iii) have fully electric vessels for urban waterborne transport and iv) use LNG in combination with fuel cell technology to provide continuous 10 MW electric power. Perspectives for 2030 are the expansion of Electric Storage System (ESS) technologies for vessels routes within 20-30 miles from ports and the use of fuel cell technology to provide 100% propulsion power on a short sea vessel. In 2050 ESS ships using either batteries or fuel cells will make up the majority of those operating in EU territorial waters.

*Solutions for safety and safe operations*. Most of the technologies listed above are linked to ship safety but, due to the predominant role of this topic, some other important issues are here discussed. Active and passive safety solutions are the technological and industrial response to the increased attention of the public opinion toward maritime accidents, with reference to both human casualties and environmental disasters. Although shipping has steadily improved safety performances over the past few decades, there are still significant challenges ahead. Active safety involves the development of automated systems and of advanced decision support tools that contribute significantly to on-board safety. Passive safety involves the design for safety, treating safety as one of the most important disciplines in the design process, e.g. optimizing the design for reduced platform motions irrespective of the existence of active fins controlled by a gyroscopic

control system, subject to possible electrical fails.
But safety entails much more: the training of the crew to respond to emergency situations, the introduction of Dynamic Risk Management systems focused on prevention and the challenge of safe evacuation of large passenger ships. Ideally, ships should be designed with safety levels beyond today's state of art with respect to resistance to capsizing, sinking and fire safety so as to never encounter the need to be evacuated at sea, thus rendering the Safe Return to Port (SFtP) requirement unnecessary.

*Reducing shipping environmental impact.* Marine mammals and many species of fish are particularly vulnerable to adverse impacts from incidental shipping noise because they primarily use the same low frequency sounds as those generated by commercial ships for communication, and/or to perceive their environments (IMO, 2008).

The problem of anthropogenic noise emissions at sea has been assessed only in recent years. The first international legal instrument to explicitly include anthropogenic underwater noise within the definition of pollution is the EU Marine Strategy Framework Directive that identified underwater noise as the 11th indicator for the Good Environmental Status of the seas. In the same document, member States are invited to monitor the state of national marine waters.

To date, the problem has been analysed mainly at regional level, in particular for restricted areas where there is a higher concentration of species of marine mammals or fish. A preliminary report for the Mediterranean has been recently issued (Maglio et al., 2015). National and international regulations usually do not address underwater noise quantitatively in the sense of specifying acceptable underwater source levels but rather restrict harmful activities that are detrimental to marine animals. The International Maritime Organization (IMO) issued a number of non-mandatory guidelines (IMO, 2008) intended to provide general advice on the reduction of underwater noise. Various ISO standards related to underwater radiated noise have been developed and three Classification Societies (DNV, BV and RINA) in (DNV, 2010; BV, 2017; RINA, 2017) have attempted to adjust limits for radiated underwater noise from commercial ships.

The collaborative projects, SILENV - Ships oriented innovative solutions to reduce noise and vibrations, SONIC - Suppression Of underwater Noise Induced by Cavitation and AQUO - Achieve QUieter Oceans by shipping noise footprint reduction, were funded by EU in the frame of the 7th EC R&I Framework Programme FP7. The goal of the projects, was to develop tools to investigate and mitigate the effects of underwater noise generated by shipping. The results of the last two projects are summarized in a joint guidelines report for regulation on underwater noise from commercial shipping (Baudin and Mumm, 2015). Within these projects, there was also an attempt to promote a joint effort between the marine and maritime research community to define noise limits and dangerous frequency range, according to the characteristics of the sound source and its surrounding environment. This cooperation needs to be strengthened further. Adversely, there are several limitations for accurately simulating sound sources and sound propagation and there is a lack of experimental data at full-scale size that can provide numerical models and model scale experimental data validation (ITTC, 2014; ITTC, 2017).

Open sea noise measurements and data post-processing carried out according to common standards, possibly shared among the scientific community and acoustic mapping of the most sensitive areas are other fundamental prerequisites to exploit available technologies to fill knowledge gaps.

All activities related to the transport of goods and people in the Mediterranean carried out by a huge number of small and large vessels clearly have a great impact on the marine and coastal environment that cannot always be contained through the construction of greener ships. In fact, the Mediterranean Sea, bound by the Straits of Gibraltar on the west side and the Suez Canal and the Bosporus Straits on the east side, is amongst the world's busiest areas for maritime activity: vessel activity in this basin has been rising steadily over the past 20 years.

The Mediterranean Sea is therefore host to a large diversity of shipping fleets and traffic routes, ranging from important fishing fleet, cruise ships traffic, ro-ro ferries, passenger, cargo plus passenger and pure cargo, large container carriers and tankers.

All these ships navigate through the Mediterranean as a shortcut between the Eastern and West African waters, and between the Black Sea, Europe, Asia and the Americas, causing environmental impacts in terms of alien species, accidental oil spills, underwater noise level, etc. It is worthwhile to also understand that the great majority of these ships were not built in Europe and therefore a pure

European technological effort for a new generation of greener ships would therefore be ineffective in attacking these problems. Instead, European as well as International regulatory actions, based on the scientific evidences of the environmental impacts on the Mediterranean need to be implemented.

*Marine robots design and development*. Marine Robots have been identified as a good example of cross domain robotics and can be applied to many different market domains such as Agriculture, Civil, Commercial and Consumer. Marine robots are allowing to cover the aerial (Unmanned Autonomous Vehicles - UAVs), surface (Unmanned Surface Vehicles - USVs) and underwater (AUVs, remotely operated underwater vehicles - ROV, and gliders) segments. Paradigms and methodologies for the Autonomous cooperation of heterogeneous robots, even in the presence of manned platforms (aircraft, helicopters, vessels, etc.) operating in the same area, calls for the development of new and advanced tools. Moreover, the complexity and cost of at sea operations and the extension of areas to be explored and surveyed, as well as the needs of persistent monitoring and rapid environmental assessment, require the development and implementation of new operational concepts able to minimize the presence of support vessels in operational areas and improve autonomous underwater intervention capabilities. In this context, a fleet of air, surface and underwater marine robots can act as a tool for manned/unmanned ships, thus extending the operational field in space and time. In order to do this, further research and innovation on the topics of: cooperative robotics, sensing and perception, navigation, guidance and control, energy generation, storage and management, propulsion systems, hydrodynamics, mechatronics and materials (also bio-inspired), and marine IoT is required.

In the meantime, robots can contribute not only to ship construction, by introducing more automation in shipbuilding, but also to transport safety through the development of unmanned systems for the management (e.g. deployment and recovery) of emergency towing devices, and of robots for the inspection of ship structures. This RD&I activity, strictly involving classification societies and regulatory bodies, aims to define inspection procedures supported by air, climbing and underwater robots.

A final note concerns the dual use character of most of the cited technologies. Joint civil/military actions, for instance in the frame of coordinated research programs, and technology transfer from naval defence to civil applications can provide valuable inputs in the realization of the above-mentioned objectives. Worthy of mention in this regard, is the project EUCISE2020 - EUropean test bed for the maritime Common Information Sharing Environment in the 2020 perspective, aimed at increasing maritime situational awareness.

## A ROADMAP TOWARDS SMART, CLEAN, SAFE AND CONNECTED MARITIME TRANSPORT, MARINE VEHICLES AND STRUCTURES

The starting point for achieving the goals outlined above is the growth of knowledge through consistent collaboration of researchers of different expertise. Other elements emphasized are summarized in the following. In particular, it is proposed to:

- Create the legislative, technological and infrastructural conditions to promote a highly connected and automated sea transportation system to improve safety and efficiency of shipping
- Promote high quality training courses for the workers of the maritime industry to meet the demand for high-tech products using innovative and eco-sustainable production cycles
- Provide specific funds to improve production technologies
- Bridge the knowledge, technological and regulation gaps for the use of innovative materials
- Support the design of LNG-fuelled ships and related on-shore facilities as well as the research on battery, fuel cells and biofuels, push for new safety regulations and appropriate inland, coastal and offshore infrastructures
- Promote specific actions, procedures and training for safe operations
- Promote a joint effort at regional level to create acoustic maps of the polluted area on the basis of data measured and processed according to common standards
- Strengthen the cooperation between the marine and maritime research communities
- Promote dual use research programs
- Issue mandatory regulations for ships passing the Mediterranean with respect to chemical and physical emissions, considering their expected costs and benefits
- Develop Unmanned Autonomous Vehicles and related infrastructure that can extend the area - on the air, on the sea surface and underwater- for different types of operation, e.g. monitoring illegal activities, supporting search and rescue activities, helping the Civil Protection service respond to disasters, supporting offshore economic activities, minimising the presence of support vessels
- Encourage the definition by Classification Societies and Regulatory Bodies (e.g. the International Maritime Organization – IMO) of inspection procedures supported by air, climbing and underwater robots

### 3.2.2. PORTS: THE FUTURE OF MEDITERRANEAN TRAFFIC AND THE ROLE OF ITALIAN PORTS

The Mediterranean port system comprises over 100 major ports of medium size, while north Europe has fewer, albeit much larger ports (Rotterdam is the only European port within the top 10 ports in the world). In 2015, over 80% of the volume of international trade was transported by sea and, in particular, 20% of the world total maritime transport and 30% of oil transactions across the Mediterranean basin (MAECI, 2017).

The Italian port system is represented by 144 ports including small and medium commercial ports and fishing ports and by 15 Port Authorities.

Conveniently located right in the middle of the Mediterranean, 1,100 miles from Gibraltar and 1,050 miles from the Suez Canal, Italy already catches over 50% of the goods through Mediterranean Sea.

The Italian port cluster, including both freight and passengers, directly and indirectly generates about 2.6% of Italian GDP, registering over 11,000 companies in the sector and 93,000 employees (CENSIS, 2015). The multiplier effect is at 2.9 for turnover (Italian average) and 2.4 for employees.

Despite Italy's strategic position in the Mediterranean, the constant increase of the volume of transported goods (UfM, 2017) and the relatively high number of European corridors, the Italian port system fell from first to third place in Europe for imports and exports of goods by sea. This decline was not only a consequence of the world financial crisis of 2008, but also due to changes in global maritime traffic flow and to

structural problems of the Italian port system. In fact, global maritime traffic and the global fleet capacity increased. In 1994, large container vessels typically had a capacity of 3,000 TEUS (Twenty-Foot Equivalent Units); by 2018, vessels of 20,000 TEUS were pulling into Italian ports. Moreover, until the nineties, traditional Mediterranean trade routes travelled west for the most part and successively shifted eastwards. The Italian port system did not properly keep up with such changes and fell behind North European (Hamburg, Rotterdam, Antwerp range) and South Mediterranean (TangerMed, Malta, Port Said, Piraeus) ports.
A deep analysis of the economic and political scenario in relation to maritime traffic, the effects on Italian ports and the critical aspects of the Italian port system can be found in the National Port and Logistic Plan issued in 2015 (D.L. 133/14, 2014).
The analysis contained in the plan, not only emphasized the strengths of the different transport sectors and their potential opportunities, but also revealed several inherent points of weakness.
The Italian port system is not competitive in terms of costs and efficiency due to a lack of physical infrastructures, which are lagging behind European standards, with a considerable impact on transit times. In general, port services in their various forms show inefficiencies, directly linked to the so-called last mile (mainly rail), to the number and variability of the necessary interlocutors for import/export processes, as well as to the high costs of ship support services (in particular technical and nautical services).
The size of Italian ports is not comparable to those of the Northern Europe because of the morphology of Italy and because ports are often located close to the centre of historical cities. As a consequence, the container gateway sector has a lack of space for further expansion of the surface area of port terminals which is not compensated by an efficient use of rail intermodality.
Passenger traffic has a high demand on some specific routes (Messina Strait, connections with Sardinia etc.) but the increase in demand in the tourism sector and the general positive trend of the cruise sector represent a big opportunity for the growth of passenger traffic. However, to proceed towards this goal there is a need to improve ground services, connections with other modes of transport as well as a careful planning and management of tourist flows (see section 3.3). Some Italian ports for transhipment traffic have the capacity to receive and manage very large ships (more than 300 m in length); however, the significant increase of ship size and capacity affects not only gateway and/or transhipment ports, but also regional ports with feeder traffic, which be upgraded. Finally, the governance of port authorities, until 2016, was not efficient and or particularly in tune with the single port, resulting in a lack of a global vision and strategy.
The plan defines a strategy to overcome the limitations discussed above and to revitalize the port and logistics sector through 10 strategic objectives. One of the main aspects concerns the improvement of port efficiency, the reduction of transit times and costs for goods through the simplification of procedures with particular regard to some sensitive areas such as dredging, the approval of infrastructure projects and criteria for selecting infrastructure investments. In parallel with infrastructure measures, a strategy to improve the accessibility of ports on land and beaches by enhancing rail services (fast railway corridors) and promoting new services and maritime links to support markets and logistical supply chains is addressed among the objectives of the plan. Moreover, it is understood that to improve the quality and competitiveness of logistic services provided within and outside of ports, technological innovation of the national logistic platform needs to be implemented. This is a crucial condition to ensure functional integration and management of port systems with interports and logistic platforms also taking into account non- adjacent territories that have already demonstrated the ability to work together in a positive and effective way.
Furthermore, the growth of the port and logistic system must take place in accordance with the principle of sustainability, with minimal impact on the environment. Particular attention is thus devoted to promote a wide range of different measures for port sustainability ranging from electrification to the creation of infrastructures for the storage and distribution of LNG.
The plan also advocates for the development of research and technological innovation in Italian ports encouraging the adoption of the Intelligent Transport Systems for the management of port operations and promoting structured research collaboration with universities and research centers and high-level training course programs in synergy with the industries connected to ports and logistics.
Following and in application of the strategic logistic and port plan of 2015, a new port law was approved in September 2016 (D.L. 169/16, 2016). According

to the new law, Port Authorities have been merged, their number has been reduced to 15, covering 54 commercial ports, overcoming the mono-port governance system in favour of unified governance structures for a multi-port system.
The new strategic plan of the Italian ports is expected to boost the development of Blue Growth and promote the role of Italian ports as strategic and efficient hubs for maritime traffic in the Mediterranean. The southern regions of Italy will especially benefit from port reform because while in northern Italy around 35% of maritime import/export accounts for total trade, in Southern Italy it accounts for over 60% (SRM, 2015).

## A ROADMAP FOR PORTS

To improve the competitiveness of Italian port systems, it is proposed to:

- Reduce the impact of ports on the surrounding environment (carbon dioxide, $CO_2$, nitrogen oxides, NOx and noise emissions) through the electrification of docks and the use of alternative energy sources
- Improve or build new port infrastructures to provide services to different types of vessels (yachts, ferries, merchant and cruise ships, traditional and LNG fuelled ships)
- Support the central role of the port system for transport intermodality
- Promote high level training programmes on central topics for ports and logistics
- Promote new partnerships among different stakeholders in the logistic chain

## 3.3. TOURISM

The impact of tourism on the Italian economy, whether nationwide or coastal, is proven by its contribution to the national GDP (about 10%), and to employment numbers, amounting to 13% (CNR-IRiSS, 2016). For years, tourism has been a growing sector. According to data retrievable at www.istat.it/it/archivio/turismo or ec.europa.eu/eurostat/web/tourism/data between 2000 and 2016, incoming tourists increased by 42%, while overnight stays increased by 17%. This trend is even more relevant if one considers that foreign arrivals have risen by >58%, bringing the share of foreign tourists from 44% in the year 2000 to 49% today. The composition of foreign tourism flows is also an important indication of diversified patterns and behaviours: the German speaking component (26% of total international arrivals) mainly focuses on seaside resorts, lakes and spas in northern Italy; Anglo-Saxon and non-European mature tourism prefers cities of art. In the coming years foreign tourism flows will also be affected by international initiatives such as the Silk Road Initiative, that targets an increase in connectivity and cooperation between Eurasian countries.

The domestic market has been characterized over the years by a clear preference for predominantly traditional seaside summer tourism and by interregional movements by private transportation for short-range mobility (often towards a second home).

Although domestic and international sea bathing and seaside tourism generates only 21% of arrivals, it amounts to 30% of attendance, making it the main type of tourism in Italy. This is also reflected in the seasonality of tourism, characterized by a strong summer peak. However, coastal tourism shows significant differences at the local scale. Some areas are characterized by a high number of tourists while other places, especially in the coastal hinterland, are struggling to become popular tourist destinations and to intercept and integrate with nearby seaside tourism. However, coastal destinations have considerable seasonal problems and strongly depend on the "traditional" and typical bathing beaches and establishments, essentially linked to relaxation and recreation, that show lower consumer spending compared to other types of tourism.

It is then clear that, in order for an already important sector with strong potential to gain momentum, a clear and targeted strategy is needed. A fundamental step is a proper assessment of the impact of tourism on the marine environment, its space-time variability and affected ecosystem services through dedicated monitoring plans. In this framework, new ICT technologies and services will play a crucial role to foster sustainable tourism and overcome challenges of the coming years, including those linked to climate change (EEA, 2017; Bosello et al. 2016; EC, 2017).

It is necessary to differentiate touristic offers and to sustainably distribute tourism flows, by developing products that attract not only summer travel but also customers to experience coastal destinations throughout the year. Differentiation in space and time of tourism flows could be accomplished by promoting the historical-cultural, natural and eno-gastronomic resources of the hinterland. This would allow to achieve the twofold objective of promoting new products along the coast, aimed towards more "evolved" and "spending" tourists, and favour the development of "minor" and distributed resorts. This strategy should also to predict the dynamics of tourism in Italy from now to 2020. It is estimated that flows will continue to grow by about 3% per year, mainly thanks to the extra-European inbound tourism flows (> 6.4%); cultural tourism is expected to be the most dynamic, while seaside tourism will slow down and green tourism will expand (CISET, 2018). An effective strategy, based on the development of smart technologies and services for sustainable tourism, should act on three related themes:

- integration between coast and hinterland with slow inter-mobility;
- integration of tourism with other activities;
- development of new coastal tourism benefits among which "live-learning" experiences with new ICT technology opportunities coming from broader initiatives at European and international level.

Slow mobility can be promoted by enhancing the existing network of cycling routes to include paths between coastal and inland territories as well as mobility structures such as inland waterways and railways.

The development of alternative tourism products that respond to the growing demands would offer a more experiential, engaging and active holiday. Examples include products based on the integration of tourism with other types of local production, such as agriculture, fishing, and crafts. Another example of alternative tourism is fishing and ichthyic tourism ("*pescatourism*" - Piasecki et al., 2016; Manente, 2016), which involves local fishermen from the Small-Scale Fishery sector or local workshops, so that vital productive activities and professions can be valued and preserved while supporting a positive and less impacting evolution of the fisheries sector. The development of such products can be supported by interactive tools able to enrich the visiting experience and offer a better use of tourist resources (for example, virtual reality technologies that allow to learn a certain artisanal technique or recreate ancient territories or particular historical events. Some examples of interventions aimed at the innovation of coastal tourism through an experiential and "live-learning" approach with the use of new technologies, include responsible underwater tourism, volunteering camps for responsible tourists, experiential-educational proposals through boat trips with biologists, marine archaeologists and other experts, etc. The valorisation of underwater itineraries and their attractions can be achieved through the implementation and use of ICT technologies as a tool in support of tourism and the use of marine resources. All these relatively new and partially unexploited tourism typologies can promote tourism sustainability and increase citizen awareness of marine ecosystems and their goods and services (i.e. promote Ocean Literacy). In addition, they can often be carried out within Marine Protected Areas, also contributing to conservation objectives, as several experiences and good practices are showing (e.g. MedPAN, 2016).

It is also important to monitor and make the best possible use of the opportunity offered by the continuous increase of cruise tourism by developing a plan for the sustainable management of these specific tourist flows, as well as for the regulation of cruising traffic, in strong synergy with the port and the logistic sectors (see section 3.2.2). However, a better planning of touristic routes is only one of the conditions for the development of innovative forms of sustainable coastal tourism. Another is the involvement of all the potential stakeholders, which would allow for differentiating the product portfolio and the type of product to be offered (underwater tourism, cycle-tourism, etc.). This is a prerequisite to create synergies that would ensure appropriate investments in tourism, in terms of re-training and specialization of the actors involved, as well as for seizing Community and national funding opportunities.

At the governance level, sensible 'foresight' can help achieve these objectives (Cariola and Rolfo, 2004). Foresight offers advantages in regional tourism development by helping tourism stakeholders to proactively anticipate future changes and prepare for possible events (Awedyk, 2016). This is a relatively new topic in tourism research (Güell, 2012). Foresight helps to anticipate customer needs, develop new services and maintain the attractiveness of tourism businesses, in reference to all destinations rather than a limited scope such as that characterized by the traditional planning process. Through active participation, an integrated vision of a possible plausible future that takes into account a wide range of factors, can gradually take form and be developed. It also helps to formulate realistic and innovative tourism strategies that embody the views of many stakeholders. The future of each sector of the economy depends mainly on the customers, and the best way to predict the future is to create it. Foresight is a kind of approach that enables stakeholders to decide what actions are needed to ensure optimal conditions, taking into account relevant global trends in research, technology, and relating them to the socio-economic contexts.

The starting point for achieving the goals outlined above is a clear and targeted strategy, focusing mainly on new ICT technologies and services for sustainable tourism and integrating coast and inland waterways. This strategy is in line with the directions of the relevant European Strategies (for example EUSAIR for the Adriatic and Ionian macro-Regions) as well as of the Italian Tourism Strategic Plan elaborated by the Committee of Tourism Promotion, coordinated by the former Ministry of Cultural Heritage and Tourism. New opportunities and challenges from broader initiatives at European and international level can also certainly favour the innovation of coastal tourism.

## A ROADMAP FOR SUSTAINABLE TOURISM

- Assess impact of tourist flows on the marine environment
- Control and manage tourist flows to mitigate potential impacts on the environment
- Promote collaboration among supply operators through business networks and product lines
- Insert products into the local tourist offers and improve promotion/distribution/communication channels, also helping to reduce unnecessary long distance transport
- Promote product specific valorisation and tourist appreciation through live-learning approach, innovative tools and new technologies
- Facilitate slow inter-mobility along the coast and throughout the hinterland
- Encourage networks of tourism with other economic sectors (agriculture, crafts, culture, fishing) to broaden the scope of services.
- Use tourism as a vehicle to educate people, and promote awareness of Italian cultural heritage and of and eno-gastronomic resources
- Expand the opportunities offered by cruise tourism as a vehicle for ocean literacy dissemination and awareness rising on the status of marine ecosystems in the cruised areas

## 3.4. ENERGY

### 3.4.1. ENERGY TRANSITION AND ITS IMPACT ON THE MARINE SECTORS

Maritime energy transition aims at reducing emissions and establishing natural gas as the fuel of choice in global shipping. It calls for a global 'turn to gas', as promoted by the UN institution International Maritime Organization (IMO), and a common approach by the shipping industry and government to invest in infrastructure development and retrofits. The initiative was launched in 2016 after the COP 21, XXI Conference of Parties, i.e. countries that ratified the UN Framework Convention on Climate Change (UNFCCC) and has since found broad support within the private sector. Between now and 2030, the energy transition for the maritime industry will increase steadfastly, and slightly less rapidly from 2030 to 2050, with growth primarily in non-energy commodities, such as the container trade and non-coal bulk. As energy production and export patterns change, the fuel mix will be much more diverse. In 2050 oil will remain the main option for trading vessels, but natural gas will step up to become the second-most widely used fuel, and new low carbon alternatives will proliferate.

With large uncertainties related to the price of different type of fuels, the geopolitical scenario is, at the moment, unclear. As a recent study by Yliskylä-Peuralahti (2016) pointed out, "at a landscape level, low fossil fuel prices reduce the economic profitability of using non-fossil energy sources in maritime transport, and inhibit the development of related infrastructure. At a regime-level, the limited demand for low-emission, non-fossil fuel-based maritime transport from the side of the cargo-owners, lack of interest, and maritime regulations that do not currently support greenhouse gas reduction or energy efficiency strongly enough, hinder the transition".

In a wider perspective and in the long-term, the transition to a new integrated overall energy system with a drastic reduction to $CO_2$ emissions is considered to be of paramount importance for reaching the targets set up in the Paris Agreement. There is an emerging consensus that energy efficiency and transition from fossil fuels to renewables in energy production will not be able to reduce $CO_2$ emissions on its own, to the extent needed to maintain the increment of temperature within 2°C by the end of the century. Moreover, to stay "well beyond 2°C" would require that from 2060 onwards, the energy system produce "negative emissions" by promoting bio-energies with CCS ($CO_2$ Capture and Storage). CCS is a technique which can be applied for securely underground storing of carbon dioxide emissions from power plants (including those using natural gas) and high energy industries (producing steel and cement, needed for renewable energy infrastructures).

The geological offshore environment is the most promising for the implementation of CCS in Europe, demonstrated by the running CCS projects off-shore Northern countries. In this respect, the Mediterranean offshore may become fundamental. The first step in the long-term process enabling the exploitation of offshore geological storage sites is a comprehensive analysis of suitable geological formations. This first phase has been performed, thanks to the EC projects GeoCapacity (Assessing European Capacity for Geological Storage of Carbon Dioxide) and $CO_2$ Stop on the assessment of the $CO_2$ storage potential in Europe, both carried out by Croatia, France, Greece, Italy, Portugal and Slovenia (e.g. Volpi et al., 2015a, b; Civile et al., 2013; Donda et al., 2011).

The next crucial step will be to extend the survey to other nations capitalizing on available public geological and geophysical offshore data and finally to compile a "$CO_2$ Storage Atlas of the Mediterranean Sea", as was realized for the Norwegian Sea and the North Sea.

**Hydrocarbons exploitation**

Since the 1960s, Italy has been at the forefront of offshore exploration and production of hydrocarbons (see section 3.5.1), as well as related technologies and services. Extraction of oil started in the Sicily Channel while the Adriatic Sea is characterized by abundant Natural Gas Reservoirs. Over 150 offshore infrastructures, either in shallow water or mid-deep water, have been active in Italy of which more than 40 have been decommissioned and the rest are still active in natural gas and/or oil extraction.

This represents a significant part of the maritime economy whose main industrial district is located in Ravenna in Emilia-Romagna, followed by the regions of Sicily, Marche and Abruzzo where the most important operators and service companies, both large and SMEs involved all along the supply chain, are located.

Over the years the quantities of natural gas produced have reached maximum values of approximately 16 billion cubic meters/year obtained in the three-year period 1994-1996. After the initial phase during the 1970s when offshore production generated small quantities of oil, the first large oil fields were established at sea in the Adriatic Sea and offshore Sicily during the 1980s and 1990s. Since the year 2000, there has been a clear decline in production, both in terms of natural gas and oil. This is mainly due to low investments on offshore exploration and workovers led by geopolitical effects on oil prices and company strategies as well as Italian policies. As of 2010 the hype and public concern about environmental sustainability of hydrocarbon activities have led to a significant decrease in permits granted and in explorations, leading to an acceleration of the end-of-life of offshore activities. Geophysical knowledge on a significant number of hydrocarbon reserves in the Adriatic-Ionian Seas is relatively well established and relevant data is available.

In recent decades the hub of offshore oil & gas exploration and production has been the Eastern Adriatic-Ionian Sea as well as the Eastern Mediterranean area. For instance, the Zohr Field, offshore Egypt, plays an important role for the economy of the whole country and potentially for the Mediterranean area thanks to LNG potential (see section 3.2.1). Therefore, Italian technology and knowhow in geophysical exploration (drilling, equipment maintenance in harsh environments, logistics (by air and by sea) and decommissioning) are becoming increasingly consistent with Blue Growth strategies.

## A ROADMAP FOR THE ENERGY TRANSITION PHASE

- Re-evaluation of natural deposits based on existing data (Big Data analytics applications)
- Nationwide cost/benefit analysis of further exploration and production in Italy based on national needs and supply risk
- Definition of a regulatory framework that takes into account both environmental impact and sustainability

### 3.4.2. MARINE RENEWABLE ENERGY (MRE)

The global energy system is changing, due to both an ever-increasing demand driven by rising living standards, and to the enhanced environmental awareness and concern of public opinion. In the power sector, renewables and nuclear capacity additions supply most of the surge in demand, as the energy mix is being redefined. Affordable, secure and sustainable energy systems will progressively integrate more diverse energy sources and will rely substantially on distributed generation, thus opening up the market to innovative technologies and smarter renewable power.

In this context, marine renewable energy (MRE) is recognized to hold a great potential. MRE is energy which can be harnessed from the ocean or the wind blowing over open sea areas. Power can be extracted and converted into usable energy from five main sources, namely offshore wind, surface waves, tides/currents, and thermal and salinity gradient sources. Although the growth of the marine energy sector has been relatively slow if compared to the onshore renewable energy technologies, MRE is regarded as a promising resource capable of responding to the energy demand of coastal and insular areas, while preserving the marine environment.

The EU has been actively promoting the development and exploitation of marine energy technologies in the context of the planned transition to a low carbon energy system. The European Strategic Energy Technology Plan (SET-Plan) recently prioritized the Key Actions for the marine energy sector (Set-Plan, 2018), aiming at confirming the EU global leadership in the field, and at filling the residual gap between research or prototype demonstration projects and their commercial deployment.

Substantial reduction of costs is essential, as well as further demonstration of technology reliability and survivability in aggressive sea conditions. The Plan recommends to concentrate efforts on a limited number of promising technologies for energy conversion from tidal streams and waves, targeting a reduction in the levelized cost of energy (LCoE) for the deployment of tidal stream energy converters, off-shore wind energy and integrated wind energy systems in deep waters (>50 m) at a maximum distance of 50 km. Considering the typical Mediterranean coastal bathymetry and landscape preservation constrains, deep water installations appear to be the most suitable. At a European level, the total installed offshore wind capacity for Europe is equal to 11027.1 MW. The total power generated by those off-shore farms covers the 1.5% of total European electricity consumption as reported by Wind Europe (windeurope.org/#).
Indeed, the offshore wind industry in Northern Europe is rapidly improving its competitive position, while the implementation of offshore wind farms in the Mediterranean is lagging behind. This is imputable to additional constraining environmental and technical issues that limit the adoption of near-shore bottom-fixed technologies and encourage resorting to floating platforms, moving the farms farther offshore and possibly operating in synergy with ocean renewables. Since the main negative impact of wind farms is visual intrusion, this technological advancement would favour social acceptance, and at the same time enable placing farms where the resource is higher and more stable.
Italian technologies covering the whole value chain of offshore wind energy are ready for the purpose, but their deployment is still on standby. One limiting factor is the complexity and length of the authorization process.
The ocean energy sector in Italy may be at an earlier stage of development, but increasing interest in the exploitation of wave and tidal technology to produce clean and renewable energy is apparent from Government intervention. Examples include high incentives for ocean renewables in the Italian Renewable Energy Action Plan (MISE, 2010) and various research and development activities carried out by public and private players. Italy is indeed at the forefront of research in developing and testing prototypal and pre-commercial devices for ocean energy conversion. This is confirmed by the number of international partnerships in which Italian actors are actively involved.

The Mediterranean Sea and the Italian coasts in particular, offer substantial opportunities for both significant energy production and technological development. The latter is mainly favoured by the specific characteristics of the Mediterranean basin, where milder climatic conditions allow affordable testing of devices and stimulate the design of particularly efficient technologies for ocean energy harvesting. The most promising Italian ocean energy technologies focus on wave and tidal energy converters. A range of innovative technical solutions has been developed with the aim to enhance efficiency of energy conversion and/or storage and distribution.
Italian SMEs engaged across the supply chain for wave and tidal energy converters have a long and rich history of innovation capacity, able to support all the specific, high-tech steps of the design and production process. The opportunities for Italy to compete in the international arena, would greatly improve with the creation and continuous support of blue energy business and high-tech clusters, and with enhanced connections to the historic know-how-based industries that provide specific manufacturing expertise. Furthermore, the Italian ocean energy sector can benefit from the experience of Italian offshore oil & gas exploration and the resulting specialized knowledge that can be transferred to the blue energy sector, and from the long-term experience of the shipbuilding and maritime industries.
Traditional maritime sectors (e.g. shipping, fishing activities, tourism) are not always spatially compatible with the development of new maritime industries. Competition between different sectors for alternative uses of sea space (see section 5.2) can lead to suboptimal economic development, while their uncontrolled coexistence can induce negative cumulative impacts on the environment.
Potential conflicts can arise between MRE installations and maritime transport (e.g. increased potential risks to the safety of navigation due to higher traffic density in transit areas and shipping lanes and visual limitations), fisheries (e.g. fishing restrictions in the security zone around energy farms and gear type restrictions for the protection of submarine cables connecting energy farms to the onshore distribution grid), tourism (e.g. limited access to sea space for leisure purposes and low social acceptance) and environmental protection (e.g. the destruction of marine habitats due to the installation or removal of infrastructures, increased turbidity, noise and vibrations that can

affect the distribution of fish populations and marine mammals).

Nevertheless, potential synergies have been brought to light, particularly in regards to the capacity of offshore energy infrastructures to create artificial reefs that are beneficial to marine ecosystems, by providing additional hard bottom habitats and increasing biomass in specific areas. Safety zones may also serve as protected areas for the preservation of marine resources and marine communities, especially sedentary and short-lived species. Moreover, energy farms located close to the coast can host aquaculture activities, while also providing clean energy for their management. Wave energy farms can also serve as wave breakers, limiting damage to offshore or coastal installations. Synergies can also be established among the different types of energy production at sea (wind-tidal-wave), by jointly collecting background data and information in the development and consent phase and jointly planning the necessary infrastructures and the grid connections, thus sharing related cost burden.

MRE is definitely recognized to hold a great potential, but as of now, significant cost and time reductions are still necessary. Larger demonstration projects should be facilitated in order to progress its development from basic and applied research to final commercial deployment. To this end, cooperation between national government and the private sector is recommended to envisage new business models and create market opportunities for the benefit of both manufacturers and users while contributing to a cost-effective transition of global energy systems.

Despite the progress recognized by the international clean energy arena, Italy is still underrepresented at European level in regards to MRE. A targeted national policy of interventions and investment is now crucial for economic growth, high-skilled job creation and strategic positioning of the Italian industry in the competitive global market. The vitality and commitment of a well-established community of actors from research institutions, SMEs and industry can provide a solid foundation for effective public policy intervention, in support of both research and connected and downstream enterprises, enabling the upscaling of and access to the international market.

### Life Cycle Assessment

The extent to which a certain type of renewable energy or innovative technology can contribute to an affordable, secure and sustainable energy system should always be evaluated in the particular geographical and socio-political reference scenario in order to ensure its best potential development.

MRE development is no exception and should be matched with sustainability assessment studies based on a life cycle thinking approach that embraces the environmental, economic and social dimensions. Due to its quantitative nature, life cycle sustainability assessment can be useful to evaluate implications arising from the implementation of different MRE systems and the potential impacts associated to a chosen mode of energy generation throughout its lifetime: in fact, manufacture, operation, maintenance and decommissioning phases will all have various effects on the environment.

A holistic life cycle sustainability assessment would allow the evaluation of the eco-compatibility of existing technological solutions (including offshore wind, wave and tidal energy converters) and the eco-design of new implementation proposals in a comprehensive way that takes into account the efficiency of resource consumption as well as the opportunities connected with recycling scenarios, in accordance with the European Commission Report on critical raw materials and the circular economy action plan.

A study by the Institute for Energy and Transport, Joint Research Centre, European Commission (Uihlein, 2016) focusing on the life cycle impacts associated with MRE has highlighted the benefits that can be obtained from the implementation of wave and tidal energy systems in terms of greenhouse gas emissions, with an average global warming potential for all device types equal to 53±29 g $CO_2$-eq kWh–1 (comparable with those of other renewable technologies). On the other hand, drawbacks have been pointed out, particularly in regards to materials used and resource consumption (and consequent toxicological effects on humans and the ecosystem) during the manufacturing and installation phases of technological devices and infrastructures. In this respect, the improvement of efficiency and lifespan of ocean renewable energy generating systems would be essential to further reduce their life-cycle environmental impacts. Nevertheless, to date, only a few life cycle assessments have been carried out for ocean energy systems, as most systems are nearing the pre-commercial array demonstration stage, while only a few are being deployed as full-scale prototypes in real-sea environments.

For most of the available ocean technologies, the main environmental impact is represented by the mooring and foundations of the systems (over 40% for 12 out of 15 cases analysed; Uihlein, 2016). Nonetheless, there are few exceptions where the structural or power take-off components are the most impactful. Conversely, the effects of installation procedures, transports and end of life treatments are small or negligible (less than 10%). The burden of mooring and foundations is the most relevant also in terms of other impact categories, followed by electrical connections and power take-off components, depending on the category. These results reflect the mass of the components, mainly made of steel (over 45% of the total weight, except in the overtopping devices) and of concrete. That is the main reason why the environmental impact could be sensibly lowered using a different type of steel and varying other parameters such as efficiency, lifetime, the mass of the mooring and the distance from the shore, thus turning a constraint into an opportunity.

Other studies (Huang et al., 2017; Elginoz and Bas, 2017) concerning the life cycle assessment of offshore wind power systems show that ferrous metals for wind turbines have the highest impact on the environment (estimated to be about 73%) because they represent ~ 90% of their weight (Huang et al., 2017). In addition, electricity consumption at the production stage, fuel consumption and air emissions during maritime transportation and construction, and concrete materials for offshore substations, are among the most significant sources of environmental impact. For instance, electricity cables which are mainly made of copper (Elginoz and Bas, 2017) greatly impact the abiotic depletion potential.

The environmental burden of each stage during the life cycle of an off-shore turbine is mainly allocated to the foundations, and the contribution of each phase to relevant emissions is roughly estimated to be 36-41% for production, 31-34% for installation, 13-17% for end-of-life and 14-15% for operation and maintenance (Huang et al, 2017). Calculations have shown that in this context, the implementation of adequate scenarios for waste materials recycling, could reduce the environmental impact by about 25% and the EROI (Energy Returned On energy Invested) can be further increased for offshore wind power systems from 17 to 23% (Huang et al., 2017).

Given the increasing interest in the exploitation of MRE and the vibrant research and development activities that can rely on high added value manufacturing skills, Italy can play a leading role in sustainability analysis. Studies concerning life cycle assessment with a cradle-to-grave approach including end-of-life stages and possible strategies for material recovering, reuse and recycling should be strongly encouraged for the best development of ocean energy systems in accordance with the EU recommendations.

## A ROADMAP FOR THE MARINE RENEWABLE ENERGY

- Creation and continuous support of BE business and high-tech clusters, in parallel with enhanced connections with the historic know-how-based industries
- Identification and strengthening of potential synergies between coastal and offshore energy infrastructures and other activities/threats (e.g. aquaculture, protected areas, coastal erosion prevention, etc.)
- Sharing background data and information in the development and consent phase for different types of energy production at sea, and joint planning of the necessary infrastructures and grid connections
- Larger demonstration projects to sustain MRE development from basic and applied research to final commercial deployment
- New business models and market opportunities arising from the cooperation between the national government and the private sector towards a cost-effective transition of global energy systems

## TOWARDS A SAFE AND SUSTAINABLE DECOMMISSIONING OF OFFSHORE O&G PLATFORMS

The gradual change in public awareness about the importance of marine environment preservation and sustainable use of its resources has led in recent years to a growing recognition of the relevance and complexity of decommissioning industrial offshore platforms and facilities. Decommissioning is indeed recognized as a crucial phase of the life cycle of offshore platforms (especially those related to Oil&Gas industries) and must be planned in accordance with sustainability and safety principles that encompass risk assessment focused on ecological integrity protection, safe and economically efficient operations, and that also guarantee inter- and intra-generational equity.

The exploitation of mineral hydrocarbon resources in Italian marine waters, has been carried out through offshore platforms and infrastructures, some of which have now reached the end of their production life cycle and must now be dismantled and removed as required by the concessions granted to guarantee the safety of mining operations.

Since the 90's, worldwide attention has turned to engineered solutions and dedicated research for the definition of specific procedures, based on advance planning, to follow starting at least two years before the scheduled disposal date of the platform and that also consider alternative uses as well as sustainable disposal options (Twachtman, 1997). More recently, however, significant changes have been proposed in the international and national regulatory, technological and ideological frameworks, calling for a revision of possible decommissioning approaches. In particular, while current international and regional regulatory frameworks (i.e. the Geneva Convention 1958, the Barcelona Convention 1976, the UNCLOS Convention 1982, the IMO Guidelines 1989, the OSPAR Convention 1992) recommend the complete removal of offshore platforms, pipelines and other related infrastructures at the end of their life cycle, from a social, environmental or economic point of view, other options could be more effective and environmentally sustainable.

In fact, no systematic and homogeneous regulatory framework for Decommissioning of oil and gas extraction plants exists in Italian law. The most recent indications pertain to two Legislative Decrees (D.Lgs. 145/15 and D.Lgs. 104/17), stating that the Ministry of Economic Development, in agreement with the Ministry for the Environment, Territory and Sea and with the Ministry of Cultural Heritage, will be adopting national guidelines for the Decommissioning of offshore platforms in order to ensure high standard environmental quality assessment.

As such, all kinds of decommissioning projects based on the current Italian legislation should be carried out. Safety issues need to be addressed exhaustively, reducing to a minimum the impact on the marine environment and maritime navigation, and taking into account social aspects (i.e. employment) and financial responsibilities of businesses. Re-use and/or dismantling operations undeniably represent a significant cost for concessionary companies (mainly ENI and Edison, for Italy). These businesses, which are regularly engaged in other types of activities and have already performed two decommissioning campaigns in the recent past (the first in the 90s and the other in 2005), will have to dismiss about 20-40 platforms of various nature (mono-tubular, underwater wellheads, 4 legs, etc.) in the near future. For full platform dismantling, the total investment needed in the next 5-10 years is estimated to be around 470 million €. These investments will be niched in a high-technological sector, and represent an opportunity to strengthen the technological and operational capabilities of the industrial supply chain of services to the oil industry in Italy. Italy represents an excellence at the global level, and is a key interlocutor with territories and organizations that are sensitive to security issues, environmental protection and sustainable exploitation of marine resources. Indeed, in the near future, a large number of oil infrastructures at sea is expected to be decommissioned, starting with those present in the waters of the United Kingdom, Denmark, Holland and Norway. These are all markets where the Italian chain of services to the oil industry has been present since the beginning and which could thus offer further opportunities.

Decommissioning involves a series of activities and options such as partial or complete removal, reuse for other purposes, leave in place, or relocation. Each option is characterized by its own impact on the environment, costs, and socio-economic and security aspects. In order to be able to choose the best decommissioning option, proper decision-making tools need to be developed.

These should provide a case by case analysis of sustainability and safety issues, resulting in an objective, traceable and transparent assessment of the different possibilities. A preliminary overview of available decision support system methodologies has been initiated within the "Safe and Sustainable Decommissioning (SSD)" project. The project focusses on Multi-Criteria Analysis (MCA) to support decision making throughout the Decommissioning phase. MCA represents a value-added policy instrument in line with the most recent literature (e.g. Bernstein et al., 2010; Henrion et al., 2015), especially when multiple interest groups with conflicting objectives are involved. The MCA model was integrated with an array of possible scenarios, public opinion perception data, test and validation indicators and criteria collected through a consultative approach via the "Forum of the Future of Offshore Platforms" launched at the Offshore Mediterranean Conference & Exhibition (OMC 2017). The development of advanced MCA tools is thus believed to be an effective approach to assist regulators, operators and stakeholders in increasing awareness, identifying best available technologies, defining objective indicators and criteria, and finally implementing shared decommissioning programs for the Italian offshore platforms and related infrastructures.

In fact, the present situation of offshore installations for oil and gas in Italy is similar to that found in many other places worldwide (e.g. USA, North Sea, etc.), with most of the installations constituted by jacket steel platforms deployed between the 60s and 80s. More specifically, 49 shallow water platforms have already been decommissioned, having reached the end of their economic life (Assomineraria, 2016), but approximately 145 offshore platforms are still operating both within and beyond twelve miles from the Italian coasts.

The first decommissioning campaigns were carried out by dismantling all the topsides, treatment facilities and deck infrastructures. The final recovery/treatment and disposal was organized in dedicated onshore areas. Conversely, up to 23 jacket steel infrastructures were used to form the "Paguro" artificial reef (now a Site of Community Importance, SCI, in the Adriatic Sea).

According to recent studies by the Directorate-General for Environmental Safety and Security of Mining and Energy Activities National Mining Office for Hydrocarbons and Georesources (DGS-UNMIG) of the Ministry of the Economic Development (Grandi, 2017; Caliri et al., 2017; Antoncecchi et al., 2017) no less than 20 offshore platforms, mostly used for natural gas extraction in shallow water areas, will get to the end of their production lifetime before 2021, and even more will get into their decommissioning phase by 2030 and beyond. It must be noted, then, that a significant number of these platforms will not undergo an Environmental Impact Assessment (EIA) procedure, because at the time this was not applicable.

## 3.5. CHEMICALS AND MATERIALS

Blue Growth is the long-term strategy to support sustainable growth in the marine and maritime sectors as a whole. Seas and oceans have great potential for exploitation of mineral resources and oil and gas. Moreover, the deep sea represents the world's largest environment and offers one of the highest levels of biodiversity on our planet and a wide variety of mostly unexploited ecosystem services. This chapter explores the most relevant aspects related to a sustainable exploitation and use of new chemical materials and resources (specifically biochemical) from the marine system, with particular regard to the deep sea environment.

### 3.5.1. THE DEEP SEA: A NEW FRONTIER

According to a recent OECD report (OECD, 2016) the global trend of demand and supply of mineral resources indicates a steady increase (by about 2% annually in the last decade) driven primarily by increasing population and increasing demand for ICT hardware, electric vehicles and renewable energy facilities. The trend is expected to accelerate in the future even though the global market (demand vs supply) is subject to high levels of uncertainties. These originate from the concentration of some rare earth elements (REE) mostly located in China and from the fact that these RRE might not be available to external markets due to the strong Chinese economic growth.

Despite the increase of the use of renewable energy resources, the increasing global energy demand will require that the oil and gas industry remains a major player throughout the transition to a greener energy system in the next two decades. Offshore production will provide 30% of the hydrocarbons supply, with a nearly 60% increase in gas production compared to a 12% increase in oil production offshore in the year 2040.

The blue economy of the Mediterranean region must face this scenario considering the availability of resources and the pressing need to preserve the marine environment.

#### Mineral resources

The term Deep Sea Mining (DSM) refers to the whole process of exploration, exploitation and related environmental assessments of non-biotic natural resources (raw material resources) located on and below the seabed in deep waters (EPRS, 2015). The term deep water refers generally to seafloor located beyond the continental shelf break, therefore implying the continental slopes, rises and abyssal plains of oceanic basins. Deep sea mineral resources can be located within the Exclusive Economic Zone (EEZ) that are governed by sovereign states, or in areas beyond National Jurisdiction under the supervision of the International Seabed Authority (ISA), a United Nations agency. It follows that in the Mediterranean Sea only the former case applies.

Among mineral resources, the following three types can be distinguished in terms of genesis, distribution and economic potential (ECORYS, 2012; EPRS, 2015)

Poly-metallic (manganese) nodules are made of ferromanganese oxides, containing other valuable metals like nickel, copper, manganese, molybdenum, lithium, rare-earth elements and possibly cobalt. They are found on relatively flat, abyssal seafloor (4,000 to 6,000 m water depth) in sedimentary environments characterized by extremely low sedimentation rate, which means that they accumulate very slowly.

Poly-metallic sulphides (or seafloor massive sulphides - SMS) are deposits of heavy metal sulphides derived from mineral precipitation from hot hydrothermal vents at depths between 1,500 and 3,000 m. They are made of sulphide minerals containing various metals, such as copper, lead, zinc, gold and silver. Their origin is linked to the mid-ocean ridge hydrothermal systems and to volcanic hot spots, but can also be found in convergent tectonic settings such as back-ark basins. The deposits can reach several metres of thickness.

Cobalt-rich ferromanganese crusts are layers a few millimetres to centimetres in thickness, and occur on the slopes or tops of submerged volcanoes and seamounts at depths of about 800 to 2,400 m. They are composed of ferromanganese oxides and contain cobalt, nickel, manganese, tellurium, rare-earth elements, niobium and possibly platinum.

The global distribution map (e.g., WOR, 2014) indicates unequivocally that the Mediterranean Sea is not a hot spot for deep sea mineral resources, with some evidence of limited occurrence of poly-metallic sulphides in the Aegean and Tyrrhenian seas, associated to the local active volcanic systems.

**Hydrocarbons**

Hydrocarbons are the so called 'fossil fuels' generated either by thermal maturation of organic matter buried in marine sedimentary basins transformed in oil and /or thermogenic gas (methane and higher hydrocarbon gases) or by biogenic production of methane by micro-organisms that feed on residual organic matter in shallow, low temperature marine sediments in the absence of oxygen. The carbon sequestered in the subsurface from the natural carbon cycles is returned to the atmosphere when fossil fuels are burned, thus determining the observed anthropogenic increase of global $CO_2$ levels in the atmosphere.

In the last two decades, marine geophysical and geological research demonstrated the occurrence of huge quantities of hydrocarbon gases (mostly methane) in the solid state hydrate form in the upper few hundred meters of continental margin sediments. Unlike conventional hydrocarbon reservoirs, gas hydrates are present in low concentration over huge areas. Their economic potential is under evaluation and the first production tests are underway (Pacific Ocean). However, the relevance of gas hydrates in the marine environment is based on their role as buffer of the carbon exchange between the geosphere and the hydrosphere (affecting the global carbon cycle) and by their role as geological hazard affecting submarine slope stability and controlling gas seepage through the seafloor. The benthic and microbial ecosystems based on the occurrence of methane hydrates at the seabed and in the shallow subsurface are also a matter of frontier research in oceanography. Given the unfavourable geological, geophysical and oceanographic conditions, the gas hydrate prospect of the Mediterranean Sea (www.migrate-cost.eu/wg-1-resource-assessment) is rather poor. The Mediterranean Sea continental margins (Gulf of Valencia, Gulf of Lion, Adriatic Sea, Sicily Channel, Northern Ionian Sea, Sirte Gulf, Nile fan) have been sites of oil and gas exploration and production since the early phases of development of the oil industry. The general hydrocarbon declining trend in the Mediterranean has been recently dramatically reverted by the discovery of huge gas reservoirs in the Levantine Basin. This discovery will affect future exploration strategies, with unpredictable outcomes.

**Opportunities and risks**

Though DSM is considered a sector with significant long-term potential not operating at a commercial scale, in the short term, it certainly will not be directly affecting the Mediterranean blue economy. Resources are too scarce and environmental vulnerability is too high to justify the risks of the development of DSM industry in the Mediterranean. However, Mediterranean-based industry and research may benefit from the global development of DSM. The value chains of DSM and hydrocarbon industry reveal a substantial overlap in the exploration and production phases (Keber et al., 2017). This suggests that there are important opportunities for Italian companies working in the oil & gas supply chain to provide their products and services to this new industry. Furthermore, in the past years, the Italian maritime research community has gained valuable experience and could therefore actively contribute to further development of very important aspects of the nascent industry, such as resource assessment, environmental monitoring and mining risk assessment. A combination of advanced research capabilities in the maritime field and a strong, well established oil and gas supply chain could form a basis for providing technological solutions in deep sea mining as well.

Furthermore, the occurrence in the Tyrrhenian Sea of small-scale poly-metallic sulphides deposits introduces an opportunity to establish leading research projects focusing on the ecosystem impact of DSM using natural laboratories and in situ biological and oceanographic observatories that can be specifically located to provide scientifically-based information to policy makers to aid them in establishing the appropriate guidelines and procedures for environmental assessments.

The discovery of gas reservoirs in the Levant Basin is likely to trigger new pressure for exploration and production. The regulatory framework for environmental assessments of hydrocarbon exploration and production is rapidly evolving in the Mediterranean region, with large differences still existing among different states. The trend towards increasing environmental protection, promoted, among other things, by the implementation of EU Directives on safety of offshore oil and gas operations, is going to introduce opportunities for scientific research and creation of new jobs in the field of environmental monitoring, hazard assessment, and risk analysis.

Finally, gas hydrate research in the Mediterranean Sea offers opportunities for in situ testing and observation of gas hydrate system sensitivity to environmental change and the influence on geological hazards. No gas hydrate exploitation can be foreseen in the Mediterranean Sea based on present-day knowledge.

**Deep sea ecosystem goods and services**

Ecosystem goods and services are defined as "benefits human population derive, directly or indirectly, from ecosystem functions" (Costanza et al., 1997). We know that they play a crucial role in sustaining people's well-being (MEA, 2005). However, ecosystems, increasingly exploited and damaged by humans, are at risk for the sustainable provision of ecosystem goods and services in the future (Worm et al., 2006). Especially for services, often not traded on markets, (i.e. public goods), the absence of a price is improperly assumed as an absence of value (Newcome et al., 2005). Valuing both the benefits and the costs of ecosystem degradation can represent a way to contribute to decision making processes (UNEP-WCMC, 2011) and a tool to move towards a more sustainable development (MEA, 2005). This is the idea behind the ecosystem service approach in which social, economic and ecological perspectives are integrated (Barkmann et al., 2008). A large number of investigations on the valuation of ecosystem goods and services have been published in the last two decades, contributing to significantly improve our knowledge on the value of natural capital (Liquete et al., 2013). Valuation methods have also been greatly refined (Atkinson et al., 2012), but numerous gaps still remain in understanding the real value of a wide range of benefits from the ecosystem functions (Naber et al., 2008).

The deep sea represents the world's largest environment; nevertheless, it is largely unexplored (Ramirez-Llodra et al., 2011) though it provides one of the highest levels of biodiversity on our planet (Danovaro et al., 2010, Danovaro et al., 2014) and a wide variety of ecosystem services. Some of these ecosystem services are unique, irreplaceable, and play a key role in sustaining human well-being (Armstrong et al., 2012, Thurber et al., 2013). Unfortunately, due to the technological development and the depletion of shallow-water resources, deep sea ecosystems are increasingly exploited (MEA, 2005, Norse et al., 2012) and, unexpectedly, greatly affected by anthropogenic stressors and climate changes (Danovaro et al., 2001; Danovaro et al., 2004; Danovaro et al., 2008; Ramirez-Llodra et al., 2011). In addition, once impacted, the costs for the restoration of deep sea ecosystems are much higher than those estimated for shallow-water ones (Van Dover et al., 2014). Since there is not a shared view of the deep sea marine ecosystems or a common knowledge of the benefits we can obtain from them, estimating the values of deep sea ecosystem services is problematic (Mendelsohn and Olmstead, 2009). The Mediterranean deep sea ecosystems are not an exception.

There is an urgent need to understand the ecosystem functioning of deep sea ecosystems, in order to be able to establish a management plan to exploit and preserve deep sea resources; these ecosystems are already under great pressure from fishing, hydrocarbon extraction, and mining, all of which are expanding. The classification of services provided by deep sea ecosystems performed by Armstrong et al. (2012) and Van den Hove and Moreau (2007) used the Millennium Ecosystem Assessment. The classification includes supporting, provisioning, regulating, and cultural services. Supporting services are those that are necessary to produce other ecosystem services; provisioning services are products used by humans that are obtained from ecosystems; regulating services are the benefits obtained from the regulation of ecosystem processes, and cultural services are the non-material benefits people obtain from habitats and ecosystems. Although this approach has been criticized as reducing the focus on mechanisms underpinning the system, the ecosystem functions and services assessment framework gives decision makers a basis for the identification of management options. Among the supporting and regulating services, it is important to mention the role of deep sea ecosystems in the storage of carbon. The deep sea has already absorbed a quarter of the carbon released from human activities. The storage of $CO_2$ also influences climate and many other deep sea functions and services. Along the same line, sequestration of methane, another powerful greenhouse gas into carbonates is largely driven by seafloor microbial communities interacting with specialized fauna.

The deep sea also represents an area where waste products are stored and detoxified through biotic and abiotic processes. For example, persistent organic pollutants, macro- and micro-plastics, sewage, and oil can be removed through bioremediation, facilitated by bioturbation, i.e. the process that regulates the decomposition and/or sequestration of waste by biogenic mixing of sediments performed by organisms.

Among the provisioning services, fish stock is one of the most tangible ecosystem services provided by the deep sea. Currently, at least 27 deep sea stocks are under the total allowable catch (TAC) regulation in the European waters (Norse et al., 2012). However, the mean depth of fishing is increasing at a rate of ca 62.5 m per decade, from below 200m to 1000m.

Other crucial provisioning services for human activities are represented by oil and gas reserves stored in the deep seabed. During recent years, we have witnessed the development of new technology for offshore drilling and large reserves of hydrocarbons are being found. Hence, the industry of oil and gas moved from land to the deep waters. Behind oil and gas, deep sea beds are also characterized by reserves of metals, which are also rare Earth elements. Mining is not limited to resources such as metals, but also supplies "ornamental" services, as in the exploitation of some species for jewellery (e.g., red coral and other precious corals).

Finally, deep sea ecosystems offer a variety of aesthetic and inspirational services, including literature, entertainment, ethical considerations, tourism, and spiritual wealth and well-being. Some of the main cultural services provided by the deep sea are important for education and science. Deep sea ecosystems thus play an important role, since they provide a number of services required to support the current way of life for humans and human wellbeing. At the same time, the importance of intangible values of deep sea ecosystems makes it difficult to fully assess their global value (Van den Hove and Moreau, 2007). Valuation results are often unstable since preferences for unfamiliar, often highly abstract and complex environmental goods depend on the level of previous knowledge of the participating stakeholders and the information provided to them. A recent study by Zanoli et al. (2015), applied the Q methodology to explore subjective perspectives on Mediterranean deep sea. The participant sample was partly composed of experts in Marine Sciences (marine biology degree), and partly of non-experts. They were asked to perform a Q-sorting experiment, and rank a Q sample of 36 underwater photographs of the marine wildlife, seascapes, and ecosystems in the Mediterranean deep sea. Photographs were sorted by a subjective priority relative to (a) a personal overall view; (b) personal perception of the potential interest for fishermen; and (c) perception as if they were fishermen. Three distinct groups were formed on the basis of their subjective view on the importance of deep sea ecosystems in the Mediterranean Sea: "Noah's Ark Fans", "Ecosystem Functions Supporters" and "Deep Coral Lovers", which depended on their experience and cultural background. These results confirm that education is a key step in the appreciation and consciousness of the importance of the deep sea in our societies.

## A ROADMAP FOR A SUSTAINABLE EXPLOITATION OF DEEP SEA RESOURCES:

- Develop a stronger and well-established oil and gas supply chain for providing technological solutions also in deep sea mining
- Develop specific research actions to investigate ecosystem impact of DSM and related mitigation programs
- Develop specific actions to improve implementation of the Directive 2013/30/EU in terms of scientific activities and capacity building in the field of environmental monitoring, hazard assessment, and risk analysis research
- Improve knowledge and scientific research on gas hydrates in the Mediterranean Sea and connected potential exploitation
- Develop a better understanding of the deep sea ecosystem functioning, in order to provide a robust and sustainable management plan to exploit and preserve deep sea resources
- Develop specific research activities in the field of $CO_2$ storage by seafloor microbial communities interacting with specialized fauna
- Improve knowledge on bioremediation approaches in the deep sea, facilitated by bioturbation, of persistent organic pollutants, macro- and micro-plastics, sewage, and oil

### 3.5.2. BLUE BIOTECH: POTENTIALS AND LIMITS

The biological, genetic and chemical variety of marine organisms and compounds represents a sort of Pandora's box for blue biotechnology (Martins et al., 2014). In the past 10 years, blue biotechnology emerged as one of the most interesting and promising R&D fields. Thanks to the recent technological and scientific advancements, the study of marine ecosystems revealed the existence of an uncountable number of new and mostly unstudied organisms and bioactive compounds. Some of these natural substances demonstrated a huge potential, while others are already being used in the production of goods and services. Main fields of development are in fact pharmaceuticals, nutraceuticals, cosmetics, energy, life science products and new materials.

The definition of the term "marine biotechnology" was initially established in 2015, as a result of an OECD workshop. Marine biotechnology is thus "the application of science and technology to living organisms from marine resources, as well as parts, products and models thereof, to alter living or non-living materials for the production of knowledge, goods and services". OECD (2016) underlines the elements that the definitions of blue biotechnology share: the involvement of science for knowledge building; the process of utilization of that knowledge to realize products and services; the societal aims that the development of blue biotechnology brings with it.

Fraunhofer Group for Life Sciences (2016) defines "blue" as the new emerging color in biotechnology. According to the research organization the term "blue biotechnology" includes "all biotechnological procedures that exploit aquatic (marine and limnic) organisms or are aimed at doing so; (...) a comprehensive definition that spans beyond the area of marine biotechnology". The European Commission is in line with the above definition, describing blue biotechnology as the utilization of marine or fresh-water bio-resources as a target or source of biotechnological applications.

Although blue biotechnologies have raised increasing interest both at the academic, industrial and institutional levels, the information on the companies that belong to marine sectors is not well organised (Leary et al., 2009).

The European Commission (ECORYS, 2014), acknowledges the blue biotechnology potential and investigated the sector by constructing a database of stakeholders and patent profiling. Blue biotechnology represents between 2-5% of the European Bioeconomy, with an annual turnover of 302-754 M€. The investigation identified 107 firms (84 SMEs and 23 multinational corporations - MNCs). It underlined the role of small and medium enterprises in bridging the gap between academic partners and the commercialization on the global market; a weak link, due to the financial risks, that must be strengthened.

A strong path of development is predicted by Global Industry Analysts, as the marine market is expected to reach 4.8 billion in 2020, with an annual average growth rate of 5%. Key drivers of the market include increasing attention of consumers on environmentally friendly products and the growth of research and development investments, expected to reach $6.4 billion (corresponding to 5.5 billion €) by 2025 (Global Industry Analysists, 2015; Smithers Rapra, 2015).

Growing Sectors in the near future would be the cosmetic industry and the fuel industry based on utilization of macro and micro algae for biofuel production. The fastest growing market will be the Asian-Pacific via the aquaculture and hydrocolloid segments, while North America would be the largest market for algae derived bio-energy. Europe would, emerge instead as a leader in research and development activities due to its unexplored and underexploited marine resources (e.g., Docosahexaenoic acid from algal oil, Enzing et al., 2014).

In any case, further in-depth studies are necessary to investigate the main characteristics of the companies that belong to the sector, to understand the links among the marine industries and define relationships among firms and the academic partners.

Greco and Cinquegrani (2016) studied a sample of 467 companies that use fresh water and marine organisms for research and production activities. The sample showed a large variety of organizations worldwide with the coexistence of large both Multi-National Corporations with start-ups, operating in and for several industries (pharmaceuticals, cosmetics, food and nutraceutical, chemistry and new materials, energy). The United States is home to the largest number of firms, representing almost 35% of the total, followed by France (12%), UK (8%), Norway, Spain and Germany (4% each). Almost 70% of the companies of the sample serves more than one market, operating in several subsectors.

In the pharmaceutical industry, the first product of marine origin approved by the FDA (Food and Drug Administration) in 1969 was cytarabine (Ara-C) and after more than 40 years, it is still the most effective drug in oncological treatment (Martins et al., 2014). By August 2017, there were seven approved molecules of marine origin, and over 20 candidates in the pharmaceutical clinical pipeline. Mayer et al. (2010) found almost 600 compounds of marine origin with antitumor and cytotoxic effects, while more than 650 are the marine natural products with a variety of pharmacological potential activities. Glaser and Mayer (2009) define this increasing trend as the "marine pharmacology renaissance". The identification of new antibiotics is an issue of worldwide interest in applied marine pharmacology. A recent large metagenomics analysis of the ocean water, marine sediments and biofilms (e.g., on macroalgae), revealed that most of the genes detected (90%) are not included in public databases (Sunagawa et al., 2015); they are likely to produce specialized metabolites of interest required for short-range molecular interactions, thus representing one of the most promising natural sources for future antibiotics. Seaweed bioactives possess a wide spectrum of biological actions.

The so called "supply problem" is generally considered a limit for biomass and specific product access. Emerging potential strategies are needed to overcome the problem. Molecular genetics and microbial fermentation approaches are viable avenues for sustainable production of marine leads. The longstanding use of marine compounds as food ingredients and nutritional supplement especially in Asian countries (Japan, China, Korea) is well known. Despite the difficulties linked to the approval of "novel food", macro and micro-organisms are increasingly being approved for their nutritional value and as supplements with general benefits to health, as in the case of Polyunsaturated Fatty Acids (PUFAs) developed by Martek and used for the infant segment (Griffiths, 2016). Enzing et al. (2014), based on an analysis of the nutraceutical sector, found algae-derived DHA in 99% of food products made for children.

In the cosmetic sector, the number of companies that use marine compounds in their cosmetic lines is constantly growing as a consequence of the recognition of the excellent properties of ocean ingredients (Kim, 2013).

Significant developments can also be expected from marine microbes and enzyme industrial applications and the adoption of microbes and enzymes in the fish and seafood industries in the near future. The potential of this field is well illustrated by a sentence found in an editorial note "At least a third of this planet's biomass resides in the oceans, and the rules of the marine biochemical game seem to be fundamentally different than those described in our biochemistry textbooks." (Tawfik et al., 2016).

Enzymes can play key roles in some marine related bioprocesses and value chains such as (Trincone, 2017): (i) the integrated valorisation of fish processing by-products and waste (i.e. marine bio-refinery value-chain); (ii) raw material pre-treatment and food manipulation; (iii) the selective and efficient modification of structurally complex marine molecules; and (iv) marine biomarkers and monitoring and bioremediation of contaminated sediments and marine water.

The potential of the marine biorefinery value-chain was tested with interesting results on seaweed biomass (a cellulosic biomass without lignin). It is a non-food biomass (no competition with food production) that grows without any need of fertilisers or pesticides by removing the excess of nutrients from the seawater. Marine microalgae are becoming a valid alternative source of molecules and materials and an interesting biomass for the production of feed through tailored biorefinery schemes. The energy sector is positively marked by marine microalgae, macroalgae and bacteria, the latter showing their utility in microbial fuel cells, i.e. systems that harvest electricity generated by microbial metabolisms. In this area, we still need to develop technologies and facilities for large-scale cultivation and fractionation and to identify microbial strains and enzymes to break down macroalgal polysaccharides. A common opinion is that marine biorefining is in its infancy compared to biorefineries for terrestrial biomass.

The recovery and the exploitation of the by-products and waste of the seafood value chains with the production of bioactive agents, chemicals, materials and fuels with the minimization of the inherent problems of pollution are key priorities of the marine biotic sector and biotechnology is the enabling technology mainly exploited for addressing them.

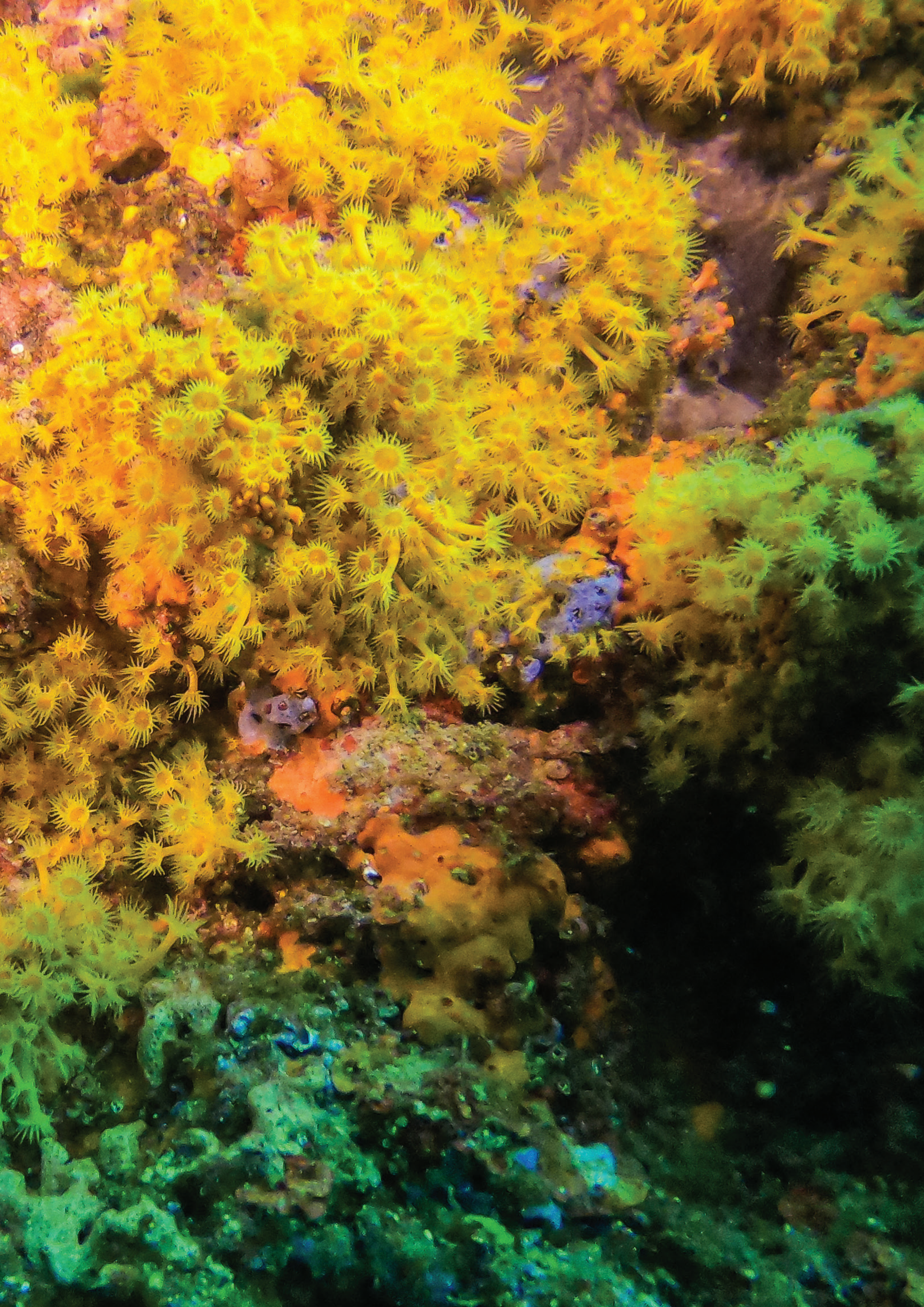
Fungal organisms, both marine and terrestrial (whose occurrence at sea has been considered incidental) are increasingly regarded as evidence of marine ecological flexibility. Thus, these organisms are increasingly investigated in view of their possible biotechnological exploitation. Research that aims to unravel, categorize, catalogue, exploit and manage the diversity and ecology of microorganisms thriving in marine polluted sites is a key priority and opportunity for improving our knowledge on native bioremediation capacities mediated by indigenous microbes and for designing novel site-tailored in situ bioremediation approaches (Daffonchio et al., 2013). However, a gap between the general knowledge from the lab and the few field studies performed so far and the specificity/suitability required by the actual site treatment still exist; bridging this gap could shed more light on the useful features of the marine biotechnology in the marine habitat decontamination and restoration.

Market value of marine biotechnology products and services is difficult to estimate because it requires tracking the range of products and services across different sectors and precise identification of the roles and contributions of marine biotechnology, separating them out from other factors.

The scientific evolution of natural products of marine origin has been driven and enhanced, in the opinion of Glaser and Mayer (2009), by the academic community together with the involvement of private organizations. The joint work of public research centres and industrial partners, characterized by a more collaborative approach, allowed the process of re-birth of blue biotechnology. Molinski et al. (2009) also underline the role of collaboration between entrepreneurial scientists and small and medium companies in the exploitation of blue biotechnologies, especially in the pharmaceutical industry where big companies during the 1990s declined their participation, not believing in the industrial potentialities of marine compounds.

## A ROADMAP FOR BLUE BIOTECH

- Fund new focused research departments
- Implement specific political actions to support biotech industry
- Test and promote safe natural products of marine origin
- Create synergies with other activities, e.g., food, bioremediation
- Explore prevention beside health care
- Increase the weight of Mediterranean companies at a global scale



# 04

## PRESENT NATURAL AND GOVERNANCE CONSTRAINTS

Actions aimed to promote Blue Growth must carefully consider the current natural, economic and social contexts (see sect. 2), the general constraints and possible obstacles beyond those analysed for the specific sectors (sect. 3). In this section, we briefly summarize some of these which for the most part, pertain to environmental dynamics, especially climate change, and to legal issues.

## 4.1. NATURAL CONSTRAINTS

The enduring and ever-growing anthropogenic pressure on ecosystems has led the International Commission on Stratigraphy of the International Union of Geological Sciences to define a new (and current) geological "epoch" as the Anthropocene, i.e. the Human age (Monastersky, 2015). The term implies acknowledgement that human activities significantly affect and modify the main physical and biogeochemical processes and cycles of the Earth System. The most evident side effect is the ongoing global warming induced by the anthropogenic mediated increase of atmospheric concentration of greenhouse gases (Stocker et al., 2013).
The modification of the Earth temperature and energy budget feedbacks (*inter alia*) determines changes in the general circulation of atmosphere and ocean, in the water and in the major biogeochemical cycles. The relevant scales of climatic impact range from years to decades in time and from local to global scale in space. Within these ranges lie many anthropogenic processes (see as an example Fig. 5 from Clark, 1985).

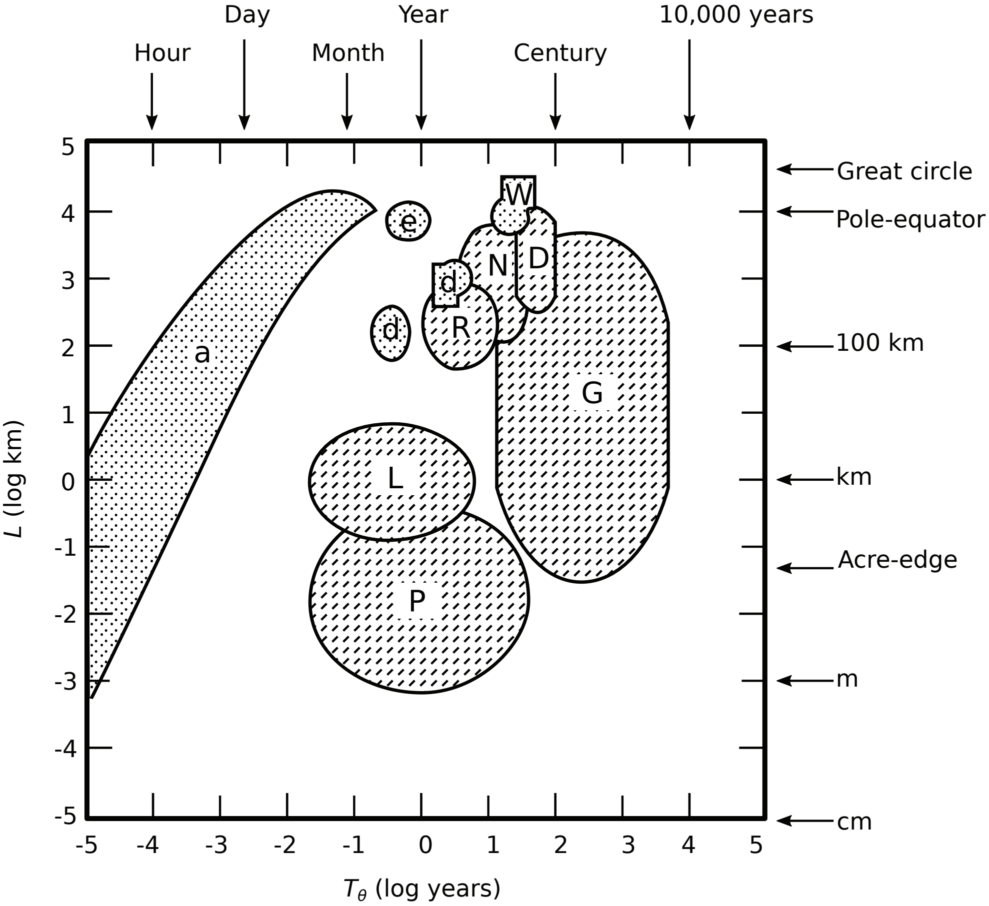



**Fig. 5**
Scales of interactions among climates, ecosystems, and societies. Stippled areas and lowercase letters represent climatic phenomena: (a) atmospheric phenomena, (e) El Niño, (d) drought, (w) warming. Diagonally shaded areas and upper case letters represent social and ecological phenomena: (P) population ecology, (G) geographical ecology, (L) local farm activities, (R) regional agricultural development, (N) national industrial modernization, (D) global political/demographic patterns (from Clark, 1985).

The Mediterranean region is exposed to climatic impact induced by the anthropogenic alteration of the Earth-System energy budget (Lejeusne et al., 2010). This occurs on scales varying from local extreme events, determining abrupt alterations of coastal and open sea ecosystems, to basin scale phenomena, implying changes in the temperature distribution and/or in the thermohaline and wind-driven circulation. As a consequence, modifications of biological processes and biogeochemical cycles arise, e.g. changes in the biogeographical characteristics, ingression of alien species, changes in water mass production sites, rates, magnitude, thus affecting the services provided by the basin.

Indeed, actions for Blue Growth should not alter or hamper the ecosystem services that naturally contribute to human health and wealth.

In the following subsections, the impact of climatic change on the main services is briefly discussed. Even being aware that the time scale of climatic change is likely longer than the time scale considered for a Blue Growth initiative, in a long-term perspective of sustainable use of marine resources we cannot ignore the possible changes in the system which may be amplified by the effect of plans designed for the system in its present status.

### 4.1.1. SUPPORTING SERVICES

**Nutrient Cycle**

In the mid-latitude open ocean, nutrient cycling is directly linked to vertical dynamics (stratification/mixing) of the water column. As such, this ecosystem service is modulated in the long term by climatic variability. It is thus likely to be mostly impacted by the ongoing "global warming", that could determine an overall decline of marine biological productivity, due to an enhanced vertical stratification of the water column and to a general re-arrangement of the ocean atmosphere interactions (Moore et al., 2018).

**Primary production**

The global warming process would induce significant changes on the spatio-temporal primary production dynamics, for instance through a change in the characteristics of the vertical ocean structure or through a re-arrangement of the atmospheric circulation patterns, leading to a modification of the upwelling phenomena and mixing that contribute to upper ocean fertilization. Both processes may impact the Mediterranean, even though a limited number of upwelling sites is present in the Mediterranean (Bakun and Agostini, 2001). Temperature increase has been recorded in the Mediterranean (von Schuckmann et al., 2016; von Schuckmann et al., 2018), albeit without homogeneous pattern over a one-year period (Maffucci et al., 2016) which makes the ecosystem response more complex to predict. The term 'Tropicalization' of the basin has often been used to highlight this trend (Bianchi and Morri, 2003) with isotherms moving poleward and a consequent alteration of the typical temperate seasons. "Tropicalization" is also causing a northward shift in the distribution of tropical species. This change is related to global warming and is impacting the biodiversity of the Mediterranean (Zenetos et al., 2010). The eastern basin is presently the most impacted, as invading species are spreading rapidly northwards and westwards from Suez (Lejeusne et al., 2010). Moreover, the observed decrease in the spatial gradient of species richness has also been attributed to a combination of other factors, such as global warming related changes in food availability and salinity (Surugiu et al., 2010). Also, low productivity rates (oligotrophism) and the connected smaller size of exploitable species in the eastern Mediterranean basin (Levantine nanism, Por, 1989) could be enhanced by a reduced nutrient provision service determined by a change in the vertical ocean structure (see above). The analysis by MacNeil et al. (2010) on the possible consequences of global warming on exploitable marine biological resources indicated as "likely cases": the disappearance of commercially important species or the significant variation in population structure of fishery relevant species, due to the "invasion" of species more adapted to higher temperatures. This also demands for a continuous monitoring of the primary production of the basin, which ultimately determines its carrying capacity in terms of food provision (see below).

### 4.1.2. PROVISIONING SERVICES

**Food provisioning**

As stated above, the food provisioning service through fisheries and aquaculture heavily depends on the "primary production" provision service (Pauly and Christensen, 1995), with strong two-way interactions and potentially significant responses to natural and human-induced changes. Indeed, changes in the distribution of fishery resources could be determined even by relatively small changes in temperature and/or dissolved oxygen together with changes in ocean circulation patterns (e.g. Roessig et al., 2004).

An important issue for the Mediterranean regions is the so-called "Tropicalization" process, i.e. the northward shift in the distribution of tropical species. This change is related to global warming and is impacting the biodiversity of the Mediterranean (Zenetos et al., 2010). The eastern basin is presently the most impacted, as invading species are spreading rapidly northwards and westwards from Suez (Lejeusne et al., 2010). The observed change in species richness is due to a combination of factors related to global warming, including food availability and salinity changes (Surugiu et al., 2010). Low productivity rates (oligotrophism) the reduced size of exploitable species in the eastern Mediterranean basin (Levantine nanism, Por, 1989) could be further worsened by a lower nutrient provision related to changes in the vertical ocean structure. Indeed, analysing the possible consequences of global warming on the exploitable marine biological resources, MacNeil et al. (2010) indicate as "likely cases": the disappearance of commercially important species or the significant variation in population structure of fishery relevant species, due to the "invasion" of species better adapted to higher temperatures.

The potential variations depicted above depend mostly on physical changes. In addition to these, it is necessary to consider the changes due to chemical processes, especially the so-called acidification process due to increased Carbon Dioxide concentration in seawater (Orr et al., 2005). The main consequences of an "acid" ocean on the food provisioning services would mostly affect all the commercially relevant organisms defined as "calcifying" (Cooley and Doney, 2009), among which Mollusca such as mussels and clams.

Furthermore, the direct impact of human action must also be considered. For a time span not easy to predict, a 'blue' exploitation of the marine resources will certainly face 'non-blue' practices. Indeed, over-exploitation of some fish and macro-invertebrates and habitat loss have been the main human drivers of historical changes in biodiversity (Coll et al., 2010; Lotze et al., 2011; Coll et al., 2012). At present, habitat loss and degradation, followed by fishing, climate change, pollution, eutrophication, and the establishment of invasive species, are the most important factors affecting taxonomic groups and habitats (Claudet and Fraschetti, 2010; Coll et al., 2010; Abdul Malak et al., 2011; Lotze et al., 2011; Bianchi et al., 2012; Coll et al., 2012; Micheli et al., 2013). The prevention of these impacts, even if intrinsic in the Blue Growth, requires initiatives and enforcement of policies that go beyond the planning stages.

An important component of the food provisioning marine ecosystem service is connected to aquaculture. In this case, in addition to warming and acidification processes, Brander (2007) points out that additional stress factors to this service include changes that occur due to extreme meteorological conditions, an increased incidence of pathologies and space conflicts related to the construction of coastal defence structures to prevent flooding from sea level rise.

A quantitative assessment of such potential changes is obviously prone to large uncertainties. It is however clear that changes in distribution and availability of fishery and aquaculture resources will generate a (positive or negative) impact on socio economic systems that rely on food provision services. Blue Growth must then take the uncertainties into account and plan possible mitigation adaptation strategies accordingly.

### 4.1.3. REGULATING SERVICES

**Climate regulation**

The Mediterranean Sea is experiencing a significant warming trend (e.g. von Schuckmann et al., 2016; von Schuckmann et al., 2018; Schroeder et al., 2016). The peculiarity of this basin puts the entire biogeochemical properties of the Mediterranean at risk, such that this ocean basin is considered a hot spot for future climate change (Giorgi, 2006; Bindoff et al., 2007). The coastal ocean is an important part of this regulating system (Heckbert et al., 2011), being characterized (as stated above) by consistent primary production levels and contributing (locally and globally) to climate regulation by sequestering and releasing atmospheric $CO_2$.

**Waste treatment**
Marine pollutant concentration is affected by dilution, advection and diffusion processes, by detoxification processes (microbial decomposition) and sequestration (sediment burial). All these processes are mostly physical and/or (bio)chemical. Consequently, variations in the physical, chemical and ecological features of the coastal ocean linked to climatic or anthropic pressure can modify the waste disposal ecosystem function. Socio-economic systems are supported by the ecosystem services. Any substitution of an ecosystem service would inevitably carry additional costs.
Waste treatment substitution represents the best example of this concept. Today, the pollutant load exceeding the natural depuration capacity of an ecosystem is handled by waste disposal treatment plants. A reduced waste treatment service would automatically determine an increased substitution service with a higher economic cost.
Further details on relevant issues related to the management of waste and marine ecosystem recovery are reported in section 5.1.3.

**Risk regulation**
The risks of coastal area loss have been evaluated by considering future climate scenario simulations. These analyses show that sea level modification related to changes in the volume of marine water, averaged over the entire Mediterranean basin, rises by about 4 to 40 cm in 100 years. These results were obtained by analysing a subset of 12 global models considered in the 4th Intergovernmental Panel on Climate Change (IPCC) Report for different emission scenarios. Using a similar approach, Tsimplis et al. (2009) estimated a mean steric sea level rise of about 13 cm by the end of the twenty first century for the Mediterranean Sea. More recent projections by IPCC estimate an additional 25 cm in 2081-2100 due, directly or indirectly, to terrestrial ice melt.
The socio-economic and political implications of a growing risk of inundation thus demands serious consideration and continuous scientific assessment of long-term sea-level variability, which should translate into coastal planning by Mediterranean Countries (Nicholls and Hoozemans, 1996). Not only would generalised coastal erosion on all coastal plain areas result in property loss but salt wedge penetration would also replace the fresh water table and impact agriculture significantly limiting its output. Moreover, coastal erosion may fatally result in exhumation of poisonous materials buried in coastal landfills in the past decades thus increasing damage and economic loss.

## 4.2. LEGAL FRAMEWORK

From a legal and political standpoint, the Mediterranean basin is characterised by a high degree of uncertainty and fragmentation. Indeed, it is the meeting point of three continents and it is crossed by a fifth of the world's maritime traffic (UNEP/MAP, 2012). Mediterranean resources and its marine environment are, and have been, central to the debate of an articulated international cooperation, that has developed over the years with the aim of reconciling very different interests. As part of the basin is still subject to the legal regime of the high seas, despite being relatively close to the mainland, it is open to free use and exploitation by all states (UNCLOS, 1982, art. 87). Proclamation of national exclusive zones beyond the territorial sea in the basin has yet to be accomplished, due to a number of reasons including the strategic importance of commercial and military navigation in its waters, the political and economic relations between coastal States and, above all, the difficulties of delimiting maritime borders (see below).
The general regulatory framework of reference is the UNCLOS (1982). It has been ratified by almost all the coastal States of the basin and by the European Union (EU). The regulation of marine activities, including, in particular, navigation, exploitation of resources and protection of the environment contained in this convention, adopted by consensus, can be considered expression of customary law. However, partly because its provisions are beginning to show "signs of obsolescence", and partly because they were designed, in many cases, for the open ocean, UNCLOS is often inadequate when it comes to the specificities of the Mediterranean.

The dimensions and the morphology of the Mediterranean basin are such that the distance between opposite coasts belonging to two different states does not exceed 400 nautical miles at any point (Fig. 6). Consequently, the coastal states need to be in agreement with the opposite and/or adjacent coastal state on the maximum extent of their exclusive economic zones (EEZs) according to art. 74 of the UNCLOS (1982) and the consolidated jurisprudence of the International Court of Justice, starting from the Judgment of 20 February 1969 (ICJ, 1969) formulated in the case of the delimitation of the continental shelf of the North Sea. The proclamation by all the coastal states of each EEZ would lead to the disappearance of marine areas subject to the high seas regime.
The need to delimit respective EEZs has already produced a number of questions and disputes (MRAG et al., 2013) that have led Coastal States to refrain from proclaiming their EEZs.
Indeed, with considerable delay compared to other seas, the process of extending national jurisdiction beyond the territorial sea in the Mediterranean, which began in the '90s, is still in progress. Most of the Mediterranean coastal States have claimed EEZs. Some have established *minoris generis* maritime zones (fishing protection and/or exclusive fishing zones and ecological protection zones or both as mixed zones) on the principle of "*in maior stat minus*".

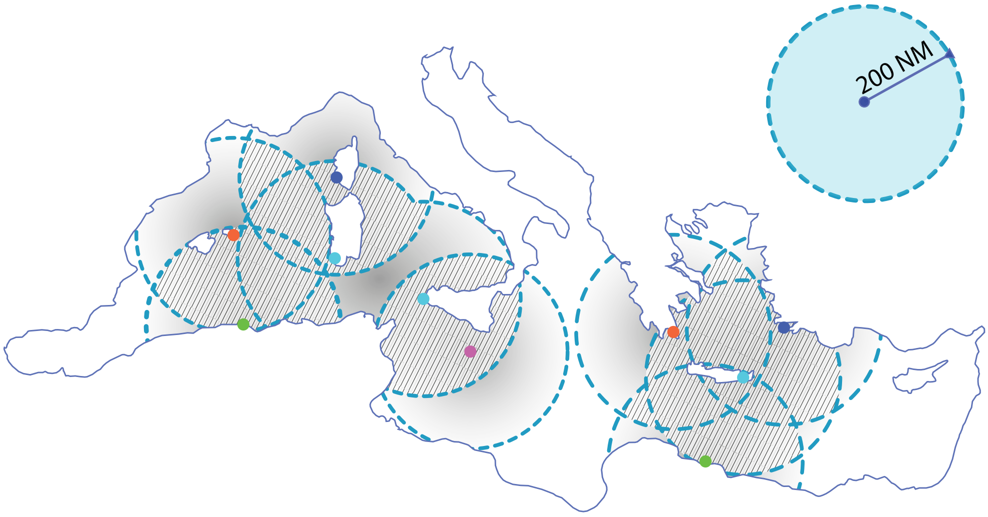



**Fig. 6**
EEZs and the Med scale: the hatched areas clearly show that, even by taking into account single points on the shoreline, the Mediterranean spatial scale does not easily allow the enforceability of EEZ 200 nautical Miles scale, according to UNCLOS 1982.

In reference to the previously mentioned complexity of the issues of delimitation of marine spaces in the Mediterranean, a key point is the limited spatial extension of the basin with respect to the surface cover of each state. The prospect of recurrent legal interstate disputes to resolve the issue has slowed down any decision on the definition of the areas of exclusive jurisdiction beyond territorial waters. Furthermore, the practice of bilateral agreements among Mediterranean states setting the boundaries among the EEZs cannot prevent complaints of third States in close proximity of the demarcated areas. The maritime borders are therefore particularly fragile. Finally, there are technical difficulties due to the presence of islands and islets and the conformation of very jagged coasts, throughout the basin.
A number of bilateral treaties on maritime borders are already in force (two of which apply judgements of the International Court of Justice), and in some cases it is uncertain whether or not the "provisional" solution agreed upon can be considered legally binding (e.g., the *modus vivendi* between Italy and Malta 1970 on the partial delimitation of the continental shelf).
In this context, international cooperation aimed at ensuring sustainable economic exploitation of marine resources has encountered considerable difficulties. Despite past and ongoing attempts, in various forums, multilateral and bilateral cooperation has not progressed enough to cope with the complexities of this sea.

## INTERNATIONAL COOPERATION FOR RESOURCES CONSERVATION AND ENVIRONMENTAL PROTECTION - THE COMPLEXITY OF LEGAL FEATURES

**Art.123 of the United Nations Convention on the Law of the Sea (UNCLOS, 1982)** calls for the cooperation of states bordering enclosed or semi-enclosed seas, in the specific domain of living resources conservation and management, environmental protection and scientific research.

The coastal States of the Mediterranean Sea seem to interpret the duty to cooperate, as being one that can be carried out "directly or through appropriate regional organization", that is as an obligation to negotiate rather than as an obligation to reach an agreement.

A concrete cooperation, even if just within the limited scope of Art. 123, would overcome some of the constraints imposed by the existing and future national borders, especially if one considers the obligations of EU member states under the Maritime Spatial Planning (MSP) Directive (EU, 2014) and the Integrated Maritime Policy (IMP, EC, 2009). The Maritime Spatial Planning, in accordance with the Directive 2014/89/EU (EU, 2014a), entails a process by which the relevant Member State authorities analyse and organize human activities in marine areas to achieve ecological, economic and social objectives. An example of cooperation among coastal states is the Pelagos Sanctuary for Mediterranean Marine Mammals (www.tethys.org/activities-overview/conservation/pelagos-sanctuary/) managed by France, Monaco and Italy in the Ligurian Sea, therefore including Corsica and Sardinia waters. The sanctuary covers the same area where France declared an EEZ in 2012 and Italy declared a Zone of Ecological Protection (ZPE) in 2011. The Italian ZPE was established in the Ligurian Sea and in the Tyrrhenian Sea in 2011 (D.P.R. 209/11, 2011) in compliance of Law 61-2006 which established Ecological Maritime Zones (EMZs). Moreover, Italy initiated a marine environmental protection policy that established protected marine areas (currently 27) making Italy a leading country in the implementation of the Marine Strategy Framework Directive 2008/56/EC (EU, 2008).

Many **multilateral agreements**, in addition to UNCLOS, have been ratified by the majority of Mediterranean states. They include treaties for the protection of the endangered species (CMS, 1979, COE, 1979), treaties related to navigation (IMO, 1974; IMO, 1978; IMO, 1989), treaties adopted by the International Maritime Organization and treaties on the prevention and punishment of criminal conducts (e.g., IMO, 1988; UN, 2000). Particularly important are the 1995 Fisheries Convention for the so-called Straddling Stocks (UN, 1995) and the UNESCO Convention on the Protection of the Underwater Cultural Heritage (UNESCO, 2001).

Many **regional or sub-regional treaties** concerning the protection of the marine environment are also in place. It is worth noting that the issue of biological diversity and the need to protect it, is absent in UNCLOS, which takes into consideration the "conservation of biological resources" for the sole purpose of ensuring its optimal use based on the criterion of maximum sustainable exploitation (maximum sustainable yield - UNCLOS, arts. 61 and 62).

The notion of biodiversity has been incorporated into the international legal system since the nineties when the **UN Convention on Biological Diversity** (UN, 1992) was adopted. The convention, makes explicit reference to the Law of the sea (UNCLOS, 1982) and affirms that the provisions stated therein will not affect the rights and obligations arising from other existing international agreements, unless the exercise of those rights or compliance with those obligations can cause serious damage or danger to biological diversity. However, the provision specifies that, in regards to the marine environment, the Contracting Parties are required to implement the Convention in accordance with the rights and obligations of States under the law of the sea (UN, 1992, art.22).

There are currently two regulatory systems for the protection of biodiversity in place at regional level. One is the EU legislation which, through Directive 92/43/EEC (the so-called **"Habitats" directive** (EU, 1992), established the Natura 2000 site network (ec.europa.eu/environment/nature/natura2000/index_en.htm). However, this system appears to be of little relevance for two main reasons. Firstly, its scope does not go beyond the limits of the national jurisdiction of the Member States (territorial seas and EEZs), which can be a significant limitation in a basin, such as the Mediterranean characterized by the presence of offshore areas. Secondly, in line with a global trend, the number of marine and coastal protected areas, established within territorial seas and beyond (EEZ), is, in percentage, very small compared to the number of land-protected areas. Indeed, until the 2015 report of the European Environmental Agency (EEA) on the state of biodiversity in Europe, marine and coastal protected areas were scarce (EEA, 2015). According to the 2011 data of the World Database on Protected Areas, 12.7% of land terrestrial surfaces and 7.2% of coastal marine areas (0-12 nautical miles) are protected (UNEP-WCMC, 2017). Therefore, the protected areas amount to only 4% of the total of marine areas subject to the jurisdiction of a State (up to the limit of 200 nautical miles). These data are even more remarkable when one considers that most of the Earth's surface is covered by the sea (IUCN, 2010; UNEP-WCMC, 2017). The proportions are similar on the European scale: in 2010, the number of protected marine areas amounted to 20% of designated areas and 75% of these are within 12 nautical miles of a territorial sea (EEA, 2015, p. 11).

The other system is the **"Barcelona Convention"** for the protection of the Mediterranean Sea environment" (MAP, 1995). This is the most advanced system among those developed under the auspices of the United Nations Environmental Protection Program (UNEP), for various regional seas. The 'Barcelona system' consists of a political component, the Action Plan (UNEP, 2015) and a legal component (MAP, 1995).

In particular, the "Protocol concerning Specially Protected Areas and Biodiversity" established a number of protected areas (MAP, 1995). Its purpose is to preserve the common natural heritage of the Mediterranean region (ecosystems, habitats and species), to preserve the diversity of genetic heritage and protect specific natural sites. The Specially Protected Areas were established within marine and coastal areas subject to state sovereignty or jurisdiction and are included in the list of "Specially Protected Areas of Mediterranean Importance" (SPAMI). To date, 32 sites are on the SPAMI list, including the Sanctuary for Marine Mammals – Pelagos, an area established in the waters of the north-western Tyrrhenian Sea, jointly coordinated by France, Italy and Monaco. Indeed, the Protocol has the objective of creating a system aimed not at the simple identification of important areas in terms of biodiversity, but to their shared management. The States signing the protocol undertake the obligation "to comply with the measures applicable to the SPAMIs and not to authorise nor undertake any activities that might be contrary to the objectives for which the SPAMIs were established".

Finally, it is necessary to mention two important regional fisheries organizations which have competence in the Mediterranean. The **General Fisheries Commission for the Mediterranean (GFCM)**, created in 1949 to promote the development, conservation, rational management and optimal utilization of living marine resources, as well as the sustainable development of aquaculture in the Mediterranean and Black Sea, and the **International Commission for the Conservation of Atlantic Tunas (ICCAT)** created in 1966, which is also competent in the Mediterranean for that which concerns the conservation and management of tuna (see sect. 3.1).

Within this complex framework, the EU clearly plays a crucial role for environmental governance in the Mediterranean region, due to both its geographical position and its global political influence. Indeed, a number of EU member States are key players through the development of strategic partnerships and specific relations on marine affairs with non-EU States such as Israel and Morocco and Turkey. Such partnerships include UNCLOS, the Barcelona Convention and the GFCM.

## 4.3. SECURITY AND MILITARY ISSUES

The Mediterranean Sea has seldom experienced an era of complete pacification and today is no exception, with various geopolitical hostilities, illicit traffics, inadequacy of Search and Rescue (SAR) services and illegal fishing being commonplace. These circumstances all hinder stable economic growth. There are many reasons for the current maritime conflicts in the basin among which the most crucial has been identified by the literature as being the perspective of coastal states which view their maritime borders as rigid and impenetrable "walls" (Conforti, 1987).

It is a matter of fact that the military uses of the Mediterranean Sea are an important issue for coastal states and for non-Mediterranean superpowers interested in the strategic position of the basin (mainly USA, China and Russia). The topic of security and military uses of the sea are, and have been in the recent past, a matter of concern for communities, civil society and the international community as a whole.

The fragmented legal framework currently in place does not allow for clear absolute certitude in regards to the rules applicable to each maritime zone or to the limits of foreign military activities in the maritime zones of the Mediterranean Sea. The main problem is related to the freedom of navigation in the EEZ in carrying out naval manoeuvres. Moreover, the use of the sea for illegal activities, such as illegal fisheries or smuggling and trafficking of people, has dramatically increased the need of international law enforcement at sea.

In view of the above, national naval and military forces, and coast guard authorities can play an important role in supporting the Blue Growth process, since they can ensure security at sea and contribute to promoting and maintaining conditions of peace (Tanaka, 2015).

A non-military role, based on the legal regime of the "right of visit" embodied in Art.110 of the UNCLOS, falls within the framework of "Coast Guard Function" (CGF) as recognized by the 2014 European Maritime Security Strategy (EUMSS, EU, 2014b). Neglecting this potentiality would be an expression of an outdated, prejudicial vision of military activities.

Indeed, an important role in maintaining peaceful conditions in the Mediterranean basin is assigned, in cooperation with bodies of the Italian Navy, to the Coast Guard Authorities (as Italian Coast Guard and Guardia di Finanza) whose tasks related to security at the sea, are summarized as follows:

- countering of trafficking and smuggling of foreign processed tobacco, drugs and human beings by transnational organized crime, which entails an operational action characterized by a close synergy between air, maritime, territorial and specialist components;
- operational functions for public order and law enforcement at sea, according to the international and domestic legal frameworks as applied by the directives issued by competent Italian authorities;
- surveillance of maritime borders, also with the aim of countering irregular immigration, including the activities related to the development of international cooperation operations under the aegis of the European Border and Coast Guard Agency (Frontex).

Italian Naval and Maritime Forces also contribute to:

- maritime police services, in order to ensure orderly and safe activities in harbours, the territorial sea and navigation safety sectors, and the to the Synthetic Aperture Radar (SAR) service;
- countering illegal fishing by cooperation with the authorities and protecting the market to maintain free and fair competition;
- preventive measures against the threat of intentional illegal acts on both shipping and port facilities, through a careful and punctilious monitoring activity and implementation of the international and national legislation.

Coast Guard Authorities by ships and aircraft, also contribute to:

- maritime police services, in order to ensure orderly and safe activities in harbours and in the territorial sea, in the safety of navigation, maritime search and rescue;
- monitoring fisheries activities and inspection by countering illegal fishing and, and ensure a free and competitive market.

# 05

# FROM EXPLOITATION PLANS TO MANAGEMENT STRATEGIES

The previous paragraphs have described and examined the rationale behind the vision of Blue Growth, the general context in which it can be framed, the possible strategies to follow in the key sectors, and some potential obstacles, which could relent or hamper a smooth transition. As already stated, a significant step towards Blue Growth is a change in how marine resources are currently being exploited, specifically, (sec. 4) the management and mitigation of existing impacts and the prevention of additional impacts. This section, discusses present day strategies that tackle both challenges.

## 5.1. ECOSYSTEM HEALTH AND SUSTAINABILITY

Ecosystem health is an elusive concept, as long as a metric is not selected. Costanza and Mageau (1999) proposed three criteria for assessing ecosystem health: vigour, organization, and resilience. Measuring these benchmarks is not straightforward but they can be used as conceptual references in pursuit of ecosystem health. They shall be duly integrated in the Blue Growth tailored metrics that are being developed.

### 5.1.1. MARINE PROTECTED AREAS AS A SOURCE OF BIODIVERSITY AND NEW KNOWLEDGE

Marine systems are three-dimensional and undergo rapid changes due to oceanographic processes and swift dynamics of plankton populations (the core of marine ecosystem functioning) whereas terrestrial systems are two-dimensional and their habitats, mostly defined with vegetation structure, are much more stable, though vulnerable to extreme meteorological events (floods, droughts, fires) and convulsive geological events such as landslides or volcanic eruptions and earthquakes. Nonetheless, the most widespread habitat of the planet (i.e. the water column) is not a simple medium (like the atmosphere) but is customarily considered as such. This outlook should change.
The most important prerequisite for Blue Growth in the Mediterranean region is a sound functioning and management of the whole system and its sustainable exploitation. As discussed above, the word "sound" is not always easy to qualify. It is beyond the scope of this contribution to analyse in detail how the 'soundness' of functioning and management can be assessed but some obvious criteria can be agreed upon among which the key role played by 'protection' policies. The establishment of Marine Protected Areas (MPAs) is a pillar in these policies.
Marine Protected Areas (MPAs), thus, should be Marine Protected Volumes. Furthermore, the very name of the science of biological conservation suggests stability as a target: habitats and the biodiversity therein must be "conserved". The transfer of a mainly terrestrial vision into a different domain is difficult. The Habitats Directive (EEC, 1992), for instance, lists just nine marine habitats, and they are all benthic (i.e. two-dimensional).
The aim of MPAs is to protect biodiversity, but establishing a number of MPAs is not enough. In fact, though they protect particular patterns of biodiversity expression, they are limited in space and cannot have a bearing on the processes that generate protected patterns. Appropriate tools to cope with this discrepancy are contained in the Marine Strategy Framework Directive (MSFD, EU, 2008) and in the definition of Good Environmental Status (GES) therein. The first descriptor of GES, in fact, requires that biodiversity is maintained, and this should happen in all EU waters, by 2020, and not only in MPAs. The other 10 descriptors of GES, furthermore, reflect the main stressors that can alter the conditions of marine systems, in which case functioning of the ecosystem can be compromised and GES is not achieved. Biodiversity and Ecosystem Functioning (BEF) are the pillars of GES and these comprise both patterns and processes.
The protection of unique features of biodiversity is usually the main objective of MPAs, and the beauty of seascapes has influenced the selection of most of the sites to protect (Boero, 2017). In other words, MPAs in many cases protect landscapes and not BEF. It is very important to adopt special measures to protect outstanding features of marine biodiversity with focused actions (i.e. MPAs) but it is also very important to protect the environmental functions that allow for the persistence of these features. Hence, it is important to insert MPAs into networks that are consistently managed. This

policy is in perfect agreement with the MSFD and GES. In short, MPA networks can be effective tools to achieve GES.

Boero et al. (2016) provide a set of guidelines on how to design networks of MPAs based on connectivity. It is tenuous, in fact, to design MPA networks based on political divisions of the marine space, or on convergence of managing policies in an artificial consortium of MPAs. In order to be effective, an MPA network must comprise an ecologically coherent space. Boero et al. (2016) introduced the concept of Cells of Ecosystem Functioning to define these ecologically coherent units of management and conservation, based on connectivity.

This approach is also compatible with other spatially explicit objectives of management such as Integrative Coastal Zone Management (ICZM), Maritime Spatial Planning (MSP) and the Ecosystem Approach (EcAp). These divisions of marine space, at present, are based on management objectives and do not care much for the ecological connections that determine the functioning of ecosystems. Coastal zones, for instance, are connected with the deep and the high seas through marine canyons that drive up- and down-welling that connect spaces that cannot be managed effectively in isolation from each other.

The identification of coherent units of management and conservation (i.e. the Cells of Ecosystem Functioning) is a stringent priority to achieve sustainability (Thiede et al. 2016). The measure of sustainability, and thus of the efficacy of Blue Growth initiatives, is the achievement of GES.

This requires a better understanding of the integrated dynamics of the system in which a specific site, elected for conservation, is embedded. Such an approach would not only translate into an effective protection but would also stimulate and foster a holistic understanding of how the Mediterranean marine ecosystem functions interact.

## ROADMAP FOR THE SET-UP OF A NETWORK OF MARINE PROTECTED AREAS

- Map seafloor habitats in relation to geological features and water column processes
- Detect and follow the spreading of non-indigenous species
- Merge observations of benthic and pelagic habitats to generate a unified view of the interconnection among the two realms and of their linked patterns and processes
- Revive taxonomy and promote projects on the fauna and flora of EU waters
- Foster long-term series of observations with readily available task forces to study episodic events of ecological relevance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### 5.1.2. OPTIMIZATION AND SUSTAINMENT OF EXISTING OBSERVING SYSTEMS AND DESIGN OF FUTURE AUGMENTED OBSERVING SYSTEMS

In this section, we will focus on the knowledge distilled from ocean and coastal observations, which is required by a variety of applications/drivers from scientific, technological and societal sectors (e.g. EOOS, 2016).

The increasing interest in collecting, accessing, (re)using interoperable marine data is indeed not surprising. What is remarkable is the lack of concerted actions at Mediterranean level (and not only) in factual support to marine observations. A large part of recent projects and initiatives are related to coordination and governance based on the (wrong) assumption that marine data are already collected and just need to be assembled, exposed and (re)used. A significant example is the lack of specific commitments in support to sustained observations by CMEMS.

Even the joint initiative of the European Marine Board (EMB) and the European Global Ocean Observing System (EuroGOOS) to launch the future European Ocean Observing System (EOOS), as clearly stated on the website (www.eoos-ocean.eu/about/what-is-eoos/), "will not take ownership or control of ocean observing in Europe. Rather, EOOS will provide a light and flexible coordinating framework to help manage and improve the existing observing effort". The Mediterranean Operational Network for the Global Ocean Observing System (MONGOOS), the Global Ocean Observing System Regional Alliance for the Mediterranean, acts more as a community (or at best a forum) in facilitating access to the in situ data and derived products. The European projects JERICO (Joint European Research Infrastructure for Coastal Observatories) and JERICO NEXT have played a key role in fostering this approach, as well as FIX O3 (Fixed-point Open Ocean Observatories) and ODYSSEA (Operating a network of integrated observatory systems in the Mediterranean Sea), to cite a few. Long-lasting pan-Mediterranean networks have been encouraged (by the Mediterranean Science Commission (CIESM) to sustain repeated cruises and long-term fixed point observations.

The existing observation coverage therefore is not exhaustive, not even for the physical Essential Ocean Variables (EOVs). Large part of the Mediterranean Sea for instance has no sustained tide gauge stations and the number of 'endangered' stations is increasing. Available data derives from national efforts by EU and non-EU countries focused mostly on their Exclusive Economic Zones. The national systems, to different extents, adopt a multiplatform approach often including remote sensing and modelling components to provide most of the physical and some biogeochemical EOVs needed by national and/or European operational oceanography services. ESFRI research infrastructures such as Euro-Argo (observations with profiling floats), the European Multidisciplinary Seafloor and water-column Observatory (EMSO), the Ocean Thematic Centre of Integrated Carbon Observation System, and the European Marine Biological Resource Centre (EMBRC) are the backbone of ocean observation at Mediterranean level and are including non-EU partners in their activities.

In summary, all of the above initiatives share the ultimate goal to help produce an updated representation of the state of the Mediterranean. They fall into very diverse categories, such as coordination, data reorganization, automated monitoring, essentially physics and chemistry parameters, regular cruises and methodological advancements. This fact reflects the different operational systems that are in place and the different Technological Readiness Levels (TRL) of the EOVs acquisition systems. Although traditional cruises, in particular in coastal areas, are still carried out regularly, they are very expensive, mostly take place in fair weather conditions and are unable to collect even basic data on biological processes. Conversely, rapid-response cruises are important because they allow to observe and quantify the impact of short-term events such as river floods reaching the sea, major storms, flooding, severe erosion of coastal systems or biological blooms having relevant consequences on the entire ecosystem stability. Also, biological and chemical EOVs are still marginal or at best, based on quantities that are easily observable (e.g. chlorophyll, Colored Dissolved Organic Matter (CDOM), nitrate), deliberately oversimplifying the complexity of the biomes and their highly sophisticated interactions with each other and with habitat changes, as induced by both human and natural stressors.

There is a growing awareness of the need of a holistic approach in understanding the role of marine organisms in shaping the environment and in characterizing composition and functioning of marine ecosystems. Recent advancements in marine biology (e.g. Danovaro et al., 2016; Pomponi et al., 2016), together with more pervasive automated networks of physical and chemical observations, will allow the identification of key variables and biodiversity indicators at the level of species and functional groups, habitats and ecosystems. The combination of existing and developing sensing technologies in biogeochemistry, oceanography, and imaging with the ongoing "-omics revolution" in biology, is expected to enable unprecedented, holistic insight into marine ecosystems.

The advancement of ecological research should thus rely upon a smart combination of Long Term Ecological Research (LTER)-like long time series, well established automated observations and innovative visual, acoustic and molecular techniques, i.e., the so called -omics which analyse the sequence of fundamental biological components, e.g., DNA, RNA, proteins, that enable to observe ecological phenomena with new understanding and much greater detail than would be possible through manual observation alone (Porter et al., 2009). Omics-driven techniques and eco-genomic samplers (Environmental Sample Processor (ESP) (Scholin, 2013) and the Autonomous Microbial Genosensor (AMG) (Fries et al., 2007) for instance target an important gap in existing sensing capacities: the ability to sense the composition, functions, and responses of ecological communities that both drive and respond to marine phenomena across all scales. Traditional taxonomy is generally time-consuming, and visual identification of organisms often turns out to be impossible, making large-scale and intense monitoring programs difficult to undertake. Molecular techniques are more generic, and can identify cryptic and microbial species (Ainsworth et al., 2010), target a broader range of taxa in a single analysis and are less dependent on subjective judgement, though limitations in these techniques are well recognized (e.g. Collins and Cruickshank, 2012). Last but not least, the -omics outcomes are auditable by third parties, which is essential for dispute resolution and reliability. To reach their full potential omics approaches must be combined and contextualized with reference libraries (which in turn may require traditional biological sampling) and complemented with additional traditional and advanced technologies. This implies creating a tight connection with advanced biological research in the laboratories.

Why do we need augmented observations (Crise et al., 2018; G7, 2017)? Multiple signals are detectable in new sensors and platforms (including -omics data), allowing multipurpose and cost-effective surveillance of numerous ecosystem properties including biodiversity, stress, pollution responses, and invasive species occurrence. Many of the techniques have a low/medium TRL and few of them are fully marketable or available from the shelf. This means that a considerable effort is required in order to unlock their full potential.

It is thus crucial to increase the sustainability of the use of resources. Recent European Directives - notably the Marine Strategy Framework Directive (EU, 2008), but also the Water Framework Directive (EU, 2000), the Habitat directive (EU, 1992) and the management of NATURA 2000 sites - require biodiversity data and information as well as environmental data that augmented observatories have, in principle, the capacity to provide. Molecular approaches have the potential to contribute to a large number of MSFD Descriptors and represent promising tools to analyse the biodiversity of different biotic components (e.g., from prokaryotes, micro-eukaryotes to metazoans) (Danovaro et al., ibidem).

The fulfilment of Agenda 2030 Sustainable Development Goal 14 (Ocean) and 13 (Climate) (UN, 2015) and the ecosystem approach in the sustainable use of living resources (Reg. EU 1380/13) as the forthcoming World Ocean Assessment are all calling for more biological data.

An unequivocal and universally accepted definition of marine observatory has yet to be established. The label first appeared in 1920 in relation to the opening of the Imperial Marine Observatory at Kobe, Japan (Okada, 1921). This is not the context to formalize such a definition, but operationally we can consider an observatory an infrastructure that is able to collect qualified and interoperable physical, chemical, biological and sedimentologic data in a delimited area by adopting multiple platforms and automated sensors that are able to observe and characterize the dominant modes of time variability of processes in as much detail as possible, so as to be able to predict their future trajectories. The complexity and the extent of the observatory will vary from case to case and will obviously be dictated by the user/scientific needs and the capacities allocated. The design of the (integrated) observatory (Fig. 7) is expected to be modular and parsimonious in order to respect these requirements.

A modern approach to the design of integrated marine observatories requires a full knowledge of the geomorphological context where the

observatory is located, as derived from state-of-the-art multibeam bathymetric surveys. Surveys should be repeated in time particularly in highly dynamic areas where oceanographic processes lead to erosion and/or deposition of sediment. In addition, for observatories potentially impacted by discharges of terrestrial origin, river gauges should be re-introduced and maintained to provide quantitative data on river liquid and solid discharges close to the observatory site.
Unlike monitoring, the observatory is able to promptly detect events that were either expected or unexpected while providing an additional pack of correlated observations to properly interpret them. Such data can also be used for monitoring purposes or integrated for long term (decadal-scale) studies.
Augmenting marine observatories by integrating some of the above-listed technologies with the more standard technologies is expected to greatly enhance the scope of the traditional observatory moving from the abiotic domain to the observation of lifeforms from microbes to whales, allowing unprecedented insight into the structure and functioning of marine ecosystems. Despite these encouraging perspectives the limited political support for a long-term financial commitment and the lack of human capacities are however curbing a further development and extension of such an endeavour. Encouraging messages however, have been delivered by high-level stakeholders' fora. In their joint Communiqués released in Tzukuba (G7, 2016) and later in Turin (G7, 2017) the G7 Science Ministries acknowledged the recommendations of the "Future of Seas and Oceans" Working Group that calls for more substantial commitments in sustained ocean observations and focuses on augmenting existing marine observatories with novel ecological sensing technologies and know-how. The Organisation for Economic Co-operation and Development (OECD) has noted that -omic technologies have already transformed how the ocean is viewed, and praised its socio-economic value. The report on Marine Biotechnology (OECD, 2013) states: "Advances in genomics and computer science have transformed earlier views of the ocean. It is no longer simply a source of food, but a vast reservoir of genetic potential and a means of achieving a wide range of socio-economic benefit. .... [However] new Infrastructures are needed, with new models, new culture systems and new bioinformatics-based approaches to visualize genomics and other types of data".
The metabarcode and standard data sets exhibit statistically correlated alpha- and beta-diversities, and the two data sets produce similar policy conclusions for two conservation applications: restoration ecology and systematic conservation planning.

## ROADMAP TO IMPLEMENT AUGMENTED OBSERVATORIES

- Design augmented observatories through a modular and multidisciplinary approach based on the knowledge of the ecological, geomorphological and physical context of the site
- Re-design the physical and chemical sampling strategies to match biology and seafloor dynamics
- Planning of rapid-response oceanographic surveys during major events such as river floods, storms, biological events or undesired human-induced polluting events (e.g.: oil spills)
- Bridging multiple scales and disciplines to discover new phenomena and principles
- Integrating DNA sequencing-based technology with lab studies (<50% is known) and creation of reference genomes
- Addressing legal and management issues with data sampling and exploitation
- Establishing operating principles and standards, up to redefining ecosystem-state indicators for policymakers
- Breaking down the boundaries between oceanographic and genomics communities: new integrative tools for the analysis
- Training a new generation of genomics-enabled oceanographers

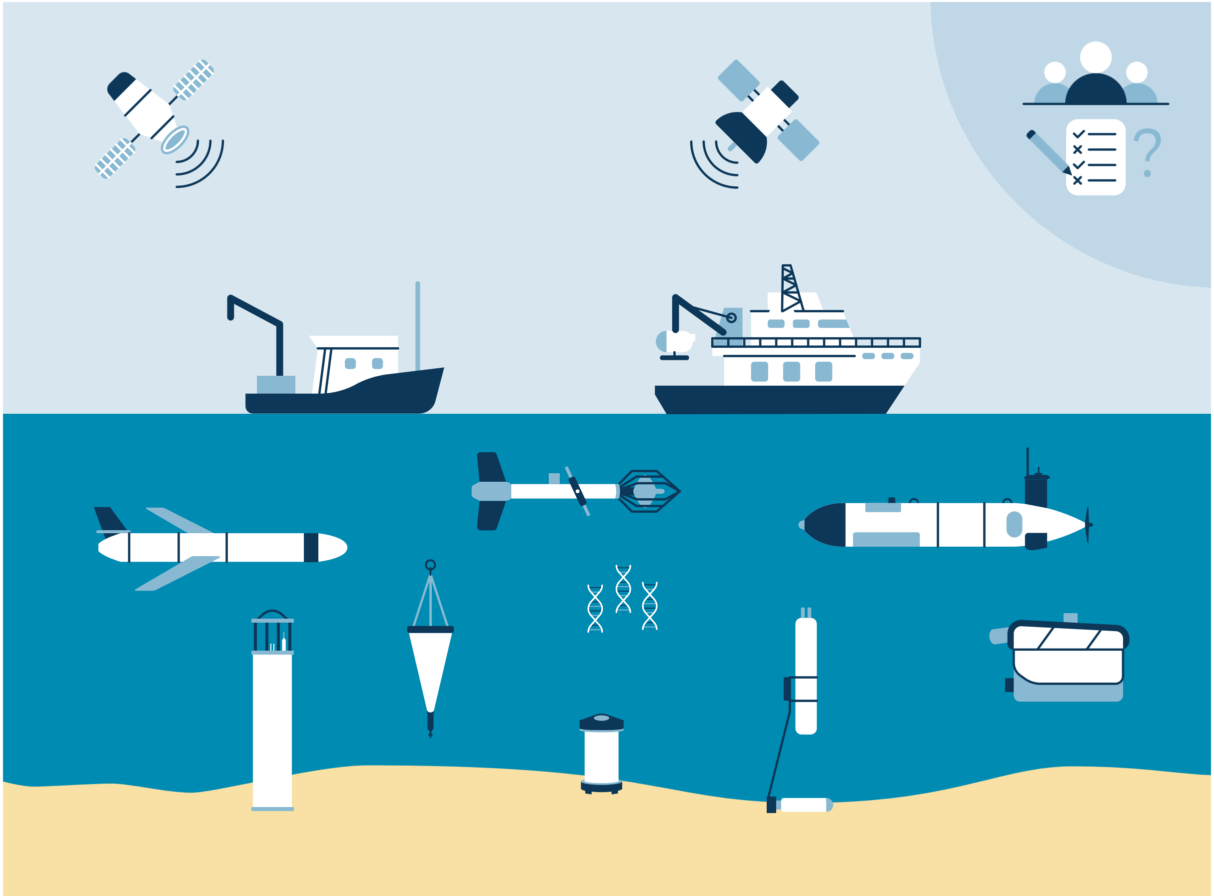

**Fig. 7**
Representation of integrated observatories

### 5.1.3. MARINE ENVIRONMENT AND ECOSYSTEM RECOVERY

In Europe, the long standing industrialization processes and poor environmental management practices left a legacy of many contaminated sites. Among them are sites hosting (or that have hosted) production and processing plants and facilities. In the Mediterranean region, most of these sites, and in many cases associated landfills that include chemical wastes, are located in coastal areas, and in particular in sheltered lagoons and embayment. Industrial human activities have rapidly degraded coastal ecosystems worldwide (Halpern et al., 2008; Mora et al., 2011; Perry et al., 2011). As a consequence, and along with climate change, anthropic pressure often engendered the collapse of many coastal ecosystems (Hughes et al., 2003; Pagán et al., 2016). Environmental policies and laws must protect the marine environment and regulate its exploitation.
The European experience in the implementation of legislation aimed at protecting the sea and (Boyes and Elliott, 2014) is long standing. At the time of writing, EU has issued over 200 directives, regulations and other forms of marine-related policies (Beunen et al., 2009). These include the Marine Strategy Framework Directive (MSFD) and the Maritime Spatial Planning Directive (MSP), whose goals should be to improve marine environmental sustainability by promoting sustainable growth in industry. These two directives, in particular, aim at creating an operational framework for achieving the Good Environmental Status (GES) (Boyes et al., 2016; Maccarrone et al., 2015; Schaefer and Barale, 2011), thus contributing to the promotion of a coordinated decision-making process, as envisaged by the Integrated Maritime Policy (Meiner, 2010).
In Italy, 13,000 potentially contaminating sites have been identified. Among the marine-coastal

areas characterized by the greatest anthropogenic impact, some particularly polluted sites (so-called national interest sites) have been identified and cover a total area of about 1,800 square kilometres where the pollution of soil, sub-soil, surface water, groundwater and marine waters is so extensive and extreme to represent a severe hazard for both public health and the environment.

The management of sediments in these sites is particularly complex, mainly due to the large volumes of polluted soils/sediments, the relative high level of contamination, and the lack of an appropriate legislation and specific guidelines, not to mention the considerable economic costs required to operate remediation procedures. A further, and generally underestimated specific aspect of risk associated to these highly contaminated territories is that of natural hazards (earthquakes, landslides, hydrological instability, etc.) which could provoke additional effects on mechanisms of widespread re-distribution of contaminant and impact on a wider range of environmental compartments with unforeseen effects on the ecosystem and human health safety.

The theme of remediation of marine-coastal environments characterized by the presence of pollutants of anthropogenic origin is therefore of strategic interest for the Italian Blue Growth system, not only in view of the enormous extent of marine-coastal spaces currently unsuited for the development of blue economies directly related to the marine system, but also in relation to significant threats to the health of populations living in neighbouring areas.

However, the interest in the sustainability issue for contaminated historical sites has not been limited to the sole initiative of each Member State. The European Community, has strongly contributed to the development and dissemination of the sustainability approach both by prescribing the adoption of shared and "sustainable" solutions in some of the most recent Environmental Directives (EU, 2000 and EU, 2004) and by promoting and financing many research projects dealing with contaminated sites and brownfields.

These projects contributed to create a network of knowledge and transnational research that helped focus on specific problems and influence European environmental policies. An updated estimate (Confindustria, 2016) indicates that the remediation phase of the most polluted sites requires an investment of about 10 billion €. In addition, re-industrialization processes, following the remediation phase, would lead to an increase in the production level of more than 20 billion € over a period of five years and in the total added value of about 10 billion € linked to a planned increase of about 200,000 standard work units, i.e. jobs, (Confindustria, 2016). Investments on direct and indirect (conversion of uses) environmental remediation would then provide a definite positive economic impact with an estimated doubling of incomes and significantly boost employment in the field of professional diving.

Specific and strategic interests are also related to the aspects of remediation and best technology related the recovery of coastal environments and ecosystems. The overall costs of remediation of contaminated sediments depend mainly on the amount of material to be treated, the characteristics of the area to be treated, the chemical and physical characteristics of the sediments, nature and concentration of the contaminants to be removed and the necessary technologies available today. Besides these purely technical factors, additional socio-economic factors must be evaluated site by site, for the choice of "best technology". The activities of sediment remediation, in fact, must be included in the spatial planning. This means that the remediation strategy must take into account the specific intended use of the site and reference the threshold concentration limits of contamination beyond which risk analysis is imperative. The lack of an appropriate legislation and specific national and international guidelines make the assessment of the sediment remediation activities more complex both technically and economically. In any case, defining the economic value of a remediation intervention is not an easy task as it involves a high number of factors and is essentially addressed without the benefit of any formal national/international reference for economic evaluation.

Information on remediation activities in European countries are scarce and difficult to find. This is due to two main factors. One is the early stage of the European experience on sediment remediation technologies (bench scale and pilot scale) unlike the US, duly considering the diversity of market conditions between the two economic systems. Also, transparent data collection system is lacking; for example, the US Environmental Protection Agency Superfund system systematically provides updated and specific information on environmental assessment and actions carried out to recover highly polluted areas of the US territory.

## A ROADMAP FOR A SUCCESSFUL ENVIRONMENTAL AND ECOSYSTEM RECOVERY

- strengthen the regulations governing the process of remediation of polluted sites
- review the rehabilitation policies with a sustainable approach and by properly targeting environmental recovery and socio-economic sustainability
- identify development models to streamline resources for the recovery of polluted areas
- set-up the remediation and marine-coastal monitoring chain, including an industrial chain dedicated to the recovery of contaminated materials by integrated techniques (physical, chemical and biological)
- develop knowledge and research in the field of environmental remediation also to enhance the public awareness
- provide socio-economic development plans for contaminated areas useful to relaunch the economic activity (commercial, industrial, touristic) in the medium-long-term period in the areas of interest
- define a strategic plan and an action priority for the environmental recovery of coastal marine areas

## 5.2. PLANNING AND MANAGING SEA USES

### 5.2.1. MARITIME SPATIAL PLANNING: LESS CONFLICTS AND MORE SYNERGIES AMONG SEA USES

Maritime Spatial Planning (MSP) is a practical way to establish a more rational organization of the use of marine space and the interactions between one use and another, to balance demands for development with the need to protect marine ecosystems, and to achieve social and economic objectives in an open and planned way (Ehler and Douvere, 2009). According to Ehler and Douvere (2009) and EC (2008), properties of an effective MSP should be: ecosystem-based; integrated across sectors and agencies; area-based; adaptive; strategic and anticipatory; participatory.

As such, MSP is a key enabling factor for a sustainable development of sea economy (OECD, 2016; UNESCO-IOC/EC-DG MARE, 2017). The sea economy is the sum of the economic activities of ocean based industries and the assets, goods and services of marine ecosystems (OECD, 2016). Analyses and evaluations have been and are being developed on the impact of MSP to increase the stability, transparency and predictability of the investments and in general promote sea economy. EC (2011) determined that, if the process is managed properly, the economic effects of MSP are fourfold:

i) enhanced coordination and simplified decision processes;
ii) enhanced legal certainty for all stakeholders in the maritime arena;
iii) enhanced cross border cooperation;
iv) enhanced coherence with other planning systems.

Furthermore, several additional economically-relevant effects are likely to result from MSP, such as reduction of impacts from anthropogenic pressures for an earlier achievement of good environmental status in the coasts and seas and safeguarding of ecosystem services provided by our seas.

EU Directive 2014/89/EU (EU, 2014) "establishes a framework for maritime spatial planning aimed at promoting the sustainable growth of maritime economies, the sustainable development of marine areas and the sustainable use of marine resources". The Directive clearly shows how MSP will contribute, inter alia, to achieving the aims of many other Directives, therefore emphasizing the need for coordination and harmonization among policies and legislation. Each Member State shall establish and implement maritime spatial planning in its marine waters (sensu MSFD) by 2021, taking into account land-sea interaction (i.e. coordination between MSP and ICZM), organizing and sharing the use of the best available data necessary for maritime spatial plans, cooperating trans-boundaries with EU Member States and with Third Countries, establishing public participation processes and ensuring the cooperation between national authorities and stakeholders.

According to art.8 of the Directive, possible activities, uses and interests may include: aquaculture areas, fishing areas, installations and infrastructures for the exploration, exploitation and extraction of oil, of gas and other energy resources, of minerals and aggregates, and for the production of energy from renewable sources, maritime transport routes and traffic flows, military training areas, nature and species conservation sites and protected areas, raw material extraction areas, scientific research, submarine cable and pipeline routes, tourism, underwater cultural heritage.

To promote the sustainable growth of maritime economies, the sustainable development of marine areas and the sustainable use of marine resources, maritime spatial planning should apply an ecosystem-based approach (Katsanevakis et al., 2011) as referred to in Article 1(3) of Directive 2008/56/EC (EU, 2008). A relevant, though often overlooked, aspect is understanding the cumulative pressures on coastal ecosystems that come from land-based stressors, particularly heavy in the presence of a non-circular economy leading to waste (e.g. plastic), biological and chemical pollution (driven by zootechnical, agricultural and industrial activities and impacting the marine ecosystems and potentially the blue economy.

Italy adopted the EU Directive on Maritime Spatial Planning through the Legislative Decree n. 201 of the 17 October 2016. This Decree provides for the adoption by December 2020, of maritime spatial plans within the marine waters and seabed on which Italy has jurisdiction. Guidelines on how to prepare the plans on predefined maritime areas (Adriatic Sea; Western Mediterranean; Ionian Sea and Central Mediterranean) have been developed by an Interministerial Committee coordinated by the Presidency of the Council of Ministers (DPCM 01/12/2017). Maritime plans will be prepared by a Technical Committee coordinated by the Ministry for Transports and Infrastructures with the

participation of other Ministries and the Regions belonging to the maritime area. The Committee may involve external experts that provide technical-scientific advice and support.
The preparation of maritime spatial plans is an opportunity for Italy, as well as for all other Mediterranean countries, to rethink and improve both their sectoral and integrated strategies on sea economy, while encouraging multi-purpose uses and developing a vision for the future.
In fact, MSP aims at improving coexistence among present uses and protection of ecosystems from unsustainable pressures, while securing some leeway for future needs and developments (e.g. offshore multi-trophic aquaculture, multi-use platforms, wave energy farms, blue biotech farms, deep sea mining, new ships and related infrastructures, artificial islands, etc.). Most of these development potentials and trajectories are described in Chapter 3 as "Blue Objectives" related to the main societal and economic drivers.
Moreover, MSP inevitably entails transnational cooperation among Mediterranean countries (Carneiro et al., 2017), on themes such as a wider definition of maritime zones (see also paragraph 4.2), the shared use of resources that do not by nature respond to strict administrative boundaries (e.g. fish stocks, maritime routes) or the development of technologies and services applicable to wide areas (e.g. CMEMS and other observing systems, decision support tools).
As the Directive recommends and as all experiences and best practices show, early stage and continuous involvement of a wide range of stakeholders is needed to produce a robust, transparent, forward looking and agreed plan. Starting from the experience gained at regional and local level, this holistic approach shall be adopted to provide the national MSP stakeholders with dedicated tools to exploit the defined maritime spatial plan. Relevant services and information are provided to monitor the implementation of the plan over wide sea areas, by using both in-situ and remote observing systems.

**Research needs for effective Maritime Spatial Planning implementation**

The MSP process must have a solid science and knowledge base and as such stimulate a number of new scientific demands. Indeed, MSP represents an excellent test bench for science-to-policy. A number of projects, initiatives and studies analysed and proposed the needs and role of multidisciplinary science for maritime spatial planning (e.g. Nittis, 2012; JPI-Oceans, 2015; Cormier et al., 2016). BLUEMED SRIA already recognizes MSP as one of the key sectoral enablers in the Mediterranean, identifying two goals ("Strengthen synergies among science, industry, policy makers and society" and "Effective maritime spatial planning in the Mediterranean") and thirteen actions.
Science and Knowledge requirements for MSP can be grouped as follows:

- Conceptual and methodological approaches and frameworks improving the planning process and harmonization among policies;
- Research on ecosystem functioning, human impacts and understanding of marine ecosystems goods and services;
- Development of tools for data management and for support in planning and decision making at different levels (Stelzenmuller et al., 2013; Depellegrin et al, 2017; Pinarbasi et al., 2017).

While there are a number of contributions of multidisciplinary science for maritime spatial planning, it is important that research and innovation in other sectors (i.e. the socio-economic drivers of Section 3) are developed taking into account their relationship and impact on the use of marine space, as well as potential conflicts and synergies with other uses.
For a better understanding of bidirectional land-sea interactions affecting coastal and marine uses and coastal marine ecosystems in the short and medium-long term, the spatial domain of interest needs to comprise areas on land.
Table 5 below lists a number of requirements in multidisciplinary science and knowledge in relationship with priority thematic areas and key steps of a typical MSP process (according to Ehler and Douvere, 2009 and UNESCO-IOC/EC DG MARE, 2017). They can eventually be further developed, to build a scientific roadmap for MSP, in line with the requirements of the authorities responsible for the implementation of the process and the development of maritime plans.

| PRIORITY THEMATIC AREAS AND KEY STEPS | REQUIREMENTS IN MULTIDISCIPLINARY SCIENCE AND KNOWLEDGE |
|---|---|
| Definition of planning boundaries and planning scales | Understanding of ecosystem dynamics and functioning, for ecological coherence of the planning process and planning measures |
| Transboundary maritime spatial planning | Understanding of the problems and the opportunities (social, economic, environmental) related to the establishment of new maritime zones (EEZ and/or other *minoris generis* zones) |
| | Strengthen knowledge on environmental pressures across borders |
| | Understanding and supporting MSP implementation and requirements in the deep sea: knowledge gaps on scientific, socio-economic, governance issues |
| Existing conditions / Initial assessment | Observing systems (for ecosystems, human pressures, natural pressures) informing the planning process and feeding the adaptive management of the plan |
| | Improved access to marine data, including economic, social as well as environmental information, for planners and improved synergies with existing information and data management processes and tools |
| Defining and analysing future conditions | Predicting trends in anthropogenic and natural pressures and impacts, including climate change, to be considered in the designing phase of the spatial plans |
| Preparing the spatial management plan using an ecosystem-based approach | Sustainability, definition and prioritization of measures: approaches and tools to identify the trade-offs between ecological dynamics and socio-economic needs in order to improve adaptive management scenarios of resource uses |
| | Research to understand marine ecosystems goods and services and their environmental, economic and social value |
| | Research on the land-sea interface: better understanding of cumulative pressures on coastal ecosystems from land-based stressors, supporting ecosystem-based management strategies and solutions |
| | Development of tools able to assess cumulative impacts of human activities for an eco-sustainable exploitation of marine resources |
| | Understanding options, advantages and disadvantages of governance systems for effective MSP |
| Monitoring and evaluating the performance of the marine spatial plan for adaptive planning and management | Observing systems (for ecosystems, human pressures, natural pressures) informing the planning process and the adaptive management of the plan |
| | Improved access to marine data, including economic, social as well as environmental information, for planners and improved synergies with existing information and data management processes and tools |
| | Sustainability, definition and prioritization of measures: approaches and tools to identify the trade-offs between ecological dynamics and socio-economic needs in order to improve adaptive management scenarios of resource uses |
| | Development of tools able to assess cumulative impacts of human activities for an eco-sustainable exploitation of marine resources |
| Stakeholders engagement | Research on multi-level governance and stakeholder engagement processes in support of MSP/ICZM |
| Capacity building | Training courses and knowledge exchange activities to improve the level of institutional, technical and human capacities at national level for the implementation of MSP |

**Tab. 5**
Requirements in multidisciplinary science and knowledge in relationship with priority thematic areas and key steps of a typical MSP process.

To support science-to-policy transfer in regards to the above priorities and steps, a close collaboration between scientists and policy makers (e.g. directly supporting the Technical Committee in charge of preparing the plans by the year 2020) and a comprehensive and two-way involvement of scientists in stakeholder engagement activities and processes on negotiations on planning measures are recommended.
This process could be facilitated by the promotion and joint participation in pilot projects to build capacity for MSP and facilitate the exchange of MSP expertise among EU countries and between EU and non-EU countries (e.g. Adriplan, Supreme, Simwestmed, Ritmare – ICM-MSP in the Adriatic Ionian Region, Portodimare).

### 5.2.2. SECURITY: COUNTERACTING ILLEGAL ACTIVITIES FOR A SUSTAINABLE GROWTH

A free and open maritime order based on the rule of law is a cornerstone for stability and prosperity of the international community. The Mediterranean Sea is one of the most congested maritime routes and it is therefore crucially important that freedom of navigation, connectivity among regions and cooperation on capacity building is ensured among all coastal States. The different nature of criminal activities at sea, indeed, calls for a diversified response and a comprehensive analysis of all its aspects.
The EU global Strategy states that "A solid European defence, technological and industrial base needs a fair, functioning and transparent internal market, security of supply, and a structured dialogue with defence related industries." At the last European Defence Agency's (EDA) Ministerial Steering Board meeting on 18 May 2017, Defence Ministers endorsed EDA's revised approach towards the establishment of a structured dialogue and enhanced engagement with industry based on a set of priority actions. Engagement in this context is intended to improve interaction and contribute to harmonisation of national and multi-national requirements. The topic to be examined is the Maritime Surveillance – one of the Capability Development Plan (CDP) areas identified as part of the 2014 Priority Action. Taking into account the vital Maritime interests for Europe landscaped in the EU Global Strategy and the EU Maritime Security Strategy, Maritime Awareness is the starting point for Maritime Security to allow a timely response (see section 4.3).
The continued instability in several areas in the Middle East, Africa and Asia has resulted in an unprecedented displacement of people at a global level and an increased influx of migrants and refugees in Europe, especially through its South-eastern and Mediterranean borders. The management of the migration crisis is a complex process that requires significant capacities and cooperation/coordination amongst several stakeholders (humanitarian aid and civil protection actors, EU and UN agencies, NGOs involved in day-to-day management of the migration crisis, national authorities).
In order to effectively address this unique emergency situation, several actions should be undertaken to support the mitigation of its effects, monitoring and preventing its root causes and responding to and recovering from its occurrence. Key aspects such as human rights protection, containment of illegal immigration and identification of illegal traffic are crucial for minimisation of impact. In Europe, the current issues regarding maritime and land security are primarily related to counter the irregular migration pressure, particularly relevant in the European South Borders, with main reference to the arc of instability spanning from Central Mediterranean to Ionian and Aegean waters up to the Black Sea. At the same time, the development of adequate capacities to effectively and timely provide humanitarian aid and to organise rescue missions along the different migration routes should remain a European priority.
In that context, monitoring migration phenomena, in the mitigation, preparedness and response phases, can support actions aimed at promoting stability and cooperation within fragile states for human and economic development and enforce national and international security. To that end, recent studies have recognized that the integration of different sensing techniques such Earth Observation (EO, in particular from Sentinel satellites), maritime information systems (i.e. Automatic Identification System (AIS), Long-Range Identification and Tracking (LRIT), Satellite AIS), social sensing (e.g. twitter data) and digital call records using "Big-Data" platforms, can be very effective in providing valuable insights and information on human migration and movements. The full exploitation of Big Data relies on identifying and understanding

the technical and legal constraints and developing appropriate methodological approaches to the management of such sets of data sources according to specific information needs.
Likewise, protection of marine resources is an emerging key priority at global level, with food security in much of the developing as well as developed world dependent on stopping the decline in fish stocks driven by overfishing and climate change. It is estimated that about one-fifth of all fish taken from our oceans is the result of a widespread illegal, unregulated and unreported (IUU) fishing. The economic development and welfare of island and coastal nations world-wide is threatened both by IUU fisheries and illegal trafficking of every sort.
Illegal fishing also exacerbates the problem of overfishing, because IUU vessels even operate in marine protected areas where fishing bans are in place. Indeed, within Marine Protected Areas (MPAs) fishing activities are banned all year-round as in marine nursery areas.
In the past decade Satellite-based maritime surveillance has proven its potential to contribute efficiently to maritime surveillance, but there is much scope for improvement in terms of its integration in Law Enforcement sectors, such as IUU Fishing and monitoring of illegal fishing vessel behaviours in general.
The degradation of the marine environment also presents crucial security challenges in terms of disruption of national economies, potential displacement of people and degeneration of national identities and loss of lives. Sea-level rise, sea water acidification and global warming require scientific research and capacity building, effective and robust regulations/legislation, tailored incentives, R&I actions, education and communication plans as well as the creation of robust partnerships between academia, industry, public institutions and regulatory bodies. Advanced monitoring systems are crucial to understand the dynamics of the planet and the changes in place. In order to contribute to this challenging task we need a plurality of sensors in space and on Earth, each of them delivering specific features and capabilities. To this purpose, Cosmo Skymed and Copernicus programs, as well as the partnership model between institutions and industry (i.e. the Italian Space Agency, Telespazio and E-Geos) are examples of effective interagency cooperation.
One single technology, even if sophisticated, can hardly satisfy the complexity of overall maritime awareness requirements. Permanent surveillance and awareness over any AoI (Area of Interest) in the world still requires the combination of Land, Sea, Air and Space sensors and systems. Sophisticated technologies include land and naval radars, RPAS (Radar Position Analysis System) with fast reaction activation that can support both patrolling and evidence gathering missions. Space borne AIS and Radar/EO sensors are fundamental to progress toward persistent wide area surveillance at affordable costs. The existing EO satellites and constellations already allow NRT (Near Real Time) operational services and can monitor open-sea areas. The automatic data fusion with other information sources provides a comprehensive maritime picture, while the new constellations of microsatellites will improve the persistency and revisit capabilities. A wider and faster data transfer capability is key. Real-Time representation of the maritime picture is always dependent on the technological chain that transfers the information from the sensor to the decisional entity; machine-learning techniques will then help operators to filter information and reduce the workload, improving efficiency and effectiveness.
The European Commission points out that maritime security is the basis for global trade and prosperity, and in October 2017 announced that 37.5 million € will be allocated to ensure maritime security and counter piracy along the south-eastern African coastline and in the Indian Ocean. 4 million € of investment will be also spent for its satellite monitoring programme (Copernicus) in 2017 to support EU agencies and EU Member States in monitoring oil pollution and large-scale commercial fisheries (including the fight against illegal, unreported and unregulated fishing) in the Northeast Atlantic, the Mediterranean, the Baltic, the North Sea, the Black Sea, the Pacific Ocean and around the Canary Islands.
Security monitoring systems will also fulfil the need of monitoring critical infrastructures, such as offshore platforms and wind farms. A short and medium-term set of indications is derived, to perceive a sustainable growth through the exploitation of Security services in the Mediterranean, as detailed in the roadmap hereafter.

## A ROADMAP FOR SECURING THE MED

- promote Maritime Domain Awareness through a strategic framework based on voluntary contributions provided within flexible and inclusive institutional structures
- enhance awareness at both civil and political levels of the fact that degradation of the marine environment presents crucial security challenges in terms of disruption of national economies, displacement of people, degeneration of national identities, loss of lives
- keep fostering the creation of a "system of systems", leveraging on all available assets to maximize efficiency and cooperation among the entities in charge of maritime surveillance
- implement and largely use platforms allowing Big Data analytics and social sensing data integration
- invest on innovative tools, approaches and ideas, to implement new paradigms along with incoming new technologies
- adopt interoperable and interagency solutions of marine surveillance carried out by naval and maritime institutional structures
- promote appropriate investments, homogeneous legislation and capacity building throughout the Mediterranean, together with a sound sense of ownership in order to ensure full participation from all stakeholders
- review and reinforce policies dedicated to the maritime security to achieve relevant sustainability goals and socio-economic advantages

# 06

# KNOWLEDGE TO BLUE GROWTH TRAJECTORIES

The previous sections provided a detailed view of the research and innovation objectives related to the principal economic drivers for Blue Growth in the Mediterranean area (Table 3), and identified the main obstacles posing a threat to their effective realisation. The analysis revealed some common and relevant criticalities which call for cross-cutting interventions both at national and trans-national levels.

Indeed, although specific knowledge gaps have been identified and detailed for each objective (encompassing the natural sciences, engineering/ technology, economy, etc.), common obstacles arise due to the complexity of the processes that govern the creation and exchange of knowledge, the transfer of knowledge to innovation and the implementation of shared and efficient knowledge-based policies. These processes are ultimately responsible for sustainable growth and generally require trade-offs between conflicting stakeholder interests.

Regrettably, the distinct innovation priorities among nations and sectors and the subtle to stark differences in the perception of the various stakeholders (scientists, industries, public authorities, civil society) of knowledge-based approaches and knowledge economy represent the most detrimental factors for Blue Growth. The subsequent slow emergence of the knowledge economy in the Euro area has indeed been recognized as the major cause of lower productivity with respect to the United States (EC, 2016). Research and innovation strategies must then be designed to effectively drive sustainable and socially inclusive economic growth. They require a pragmatic approach organized around clear and achievable objectives (Burgess et al., 2016). As such, successful high-level research and innovation strategies should primarily aim at fostering new knowledge generation, and efficient and fair transfer of information among all stakeholders, also by enhancing Responsible Research and Innovation approaches.

Responsible Research and Innovation (RRI) is defined as "a transparent, interactive process by which societal actors and innovators become mutually responsive to each other with a view to the (ethical) acceptability, sustainability and societal desirability of the innovation process and its marketable products" (Von Schomberg, 2013). RRI-oriented processes should be diverse and inclusive, anticipative and reflective, open and transparent, responsive and adaptive to change (Amorese, 2018; Stilgoe et al., 2013; Scholten et al., 2016; L'Astorina and Di Fiore, 2018).

European institutions have incorporated such reflections in policy discourses and funding programmes since the turn of the Millennium, with the launch of the Lisbon strategy (focused strategically on building a European Knowledge Society), and the development of the Science and Society line of reasoning (and funding) aimed at building a balanced interplay between the two realms. The topic experienced a significant evolution, in terms and understanding, during the last European Research Framework Programmes: Science and Society was renamed Science in Society, to emphasize the inseparability of the two dominions and requalify the nature of knowledge as being co-produced by both scientists and societal actors (Stirling, 2006). Today it appears in the current Framework Programme under the denomination Science with and for society, a further shift in prepositions aimed at reinforcing the commitment to orientate scientific research towards social aims (Owen et al., 2012).

Efficient and fair transfer of information among all stakeholders involves interactions and exchanges from one level to the other (e.g. between scientists and policy-makers, between nations, etc.) and within each level (e.g. promoting common policies, enhancing knowledge exchanges and minimizing duplications). Both processes require the development of multidisciplinary, cross-sectorial approaches, including advanced Information and Communication Technologies (ICT) tools for the management and synthesis of an ever-growing amount of data through Big Data analytics.

Most of these considerations apply to a wider economic and societal vision of the EU Research and Innovation policy than one strictly related to the Mediterranean marine and maritime sectors. On the other hand, the European Commission recognizes the definition of sea-basin strategies as the framework for cooperation between the European Union, the Member States and their regions and third countries that share the same basin in order to "address common marine and maritime challenges, find joint solutions and maximise common assets for the entire region" (EC, 2017). In fact, as in other Regional Seas, interdisciplinary knowledge gaps, fragmentation and conflictual interests among sectors and nations, lack of information on potential synergies and insufficient exchange among scientists, industries and policy makers are indicated as the major threats to the achievement of the EU blue

growth strategy (Andrusaitis et al., 2016).
The complexity of the Mediterranean area in terms of environment, human activities, regulation, governance and industrial sectors, then, makes the definition of efficient strategies for Blue Growth particularly challenging, but also of primary importance given its delicate geo-political context. These strategies should consequently aim at a fair distribution of the economic and environmental benefits of Blue Growth, preserving social sustainability and promoting human wellbeing across European and non-European Mediterranean countries, as recently restated by the Member States of the Union for the Mediterranean (UfM) and of the European Union (EU) through the Valletta Declaration on Strengthening Euro-Mediterranean Cooperation through Research and Innovation signed on the 4th of May 2017 (Malta Presidency of the Council of the European Union, 2017).
Based on these premises, the following key Knowledge-to-Blue Growth strategic objectives have been identified:

| | | |
|---|---|---|
| address the complexity of the interactions between research, stakeholders and policy makers and develop a scientific approach towards effective negotiation and knowledge-based decision processes; | overcome knowledge fragmentation and promote cooperation and quality research enhancing competitiveness; | extend knowledge frontiers (including basic science) and support innovative solutions. |

With respect to the first two strategic objectives, the following pragmatic actions have been outlined:

- the development of innovative training and exchange frameworks and tools to increase efficiency of interaction between scientists, stakeholders and policy makers, to enhance knowledge circulation practices and to implement Responsible Research and Innovation approaches to Blue Growth;
- the implementation of a knowledge-based planning and management of marine space considering all its possible uses while preserving marine ecosystems;
- the definition/strengthening of technological clusters/districts for Blue Growth (also as testbeds for the implementation of innovative science-to-policy approaches);

These actions are based on the recognition that only by following a knowledge-based approach, it will be possible to foster a coordinated and coherent decision-making process, maximizing sustainable development, economic growth and social cohesion of Mediterranean countries, and to efficiently and consistently implement the "Marine Spatial Planning" 2014/89/EU directive at EU level.
The Knowledge-to-Blue Growth strategic objectives require an improvement in the way knowledge (in its wider sense) is created and disseminated in the framework of national and international research and innovation programmes, and made available to the stakeholders.
The primary means to achieve these goals are well summarized by the paradigm of Open Science, defined as free, accessible, transparent, integral, reliable, collaborative, and definitely close to both civil society/policy makers and public/private economic actors. Open Science, intended as the combination of new knowledge and open sharing and dissemination of knowledge itself, represents the building block of technological creativity and high impact innovation, which are recognized as the primary drivers of sustained economic growth (Mokyr, 2017). One key way to address the challenges of a sustainable economy thus consists in removing existing barriers for Open Science, which are related to a number of different general factors, as thoroughly analysed in the Reflections of the Research, Innovation and Science Policy Experts High Level Group on "Open Innovation Open Science Open to the World" (RISE, 2017), and further analysed in the following sections.
Moreover, present cross-sectorial knowledge gaps

point to a specific need to, on the one hand, sustain and advance our observational knowledge of the marine ecosystem functioning and of the impact of human and natural pressures on the marine environment; on the other, develop innovative multi-disciplinary data analysis tools (e.g. Big Data analytics).
Here, the focus lies on three specific actions aimed at overcoming knowledge fragmentation, extending knowledge frontiers, and supporting Open Science. These are identified as particularly relevant for both Italian and Mediterranean marine and maritime sectors:

- the consolidation of Open Data policies and the exploration of new data-driven opportunities (fostering data rescue/re-use, sustaining existing observing systems and designing future augmented observing systems);
- the exploitation of new multi-disciplinary data through Big Data analytics;
- the revision of public funding schemes and opportunities to enhance the adoption of Open Science.

Each of these Knowledge-to-Blue Growth strategic objectives (synthetically presented in Table 6) is detailed in the following subsections.

| | OBJECTIVES | RETURN | HOW |
|---|---|---|---|
| KNOWLEDGE-TO-BLUE GROWTH | Overcome knowledge fragmentation and promote cooperation and quality research, enhancing competitiveness | Reduction in costs for implementing innovative and sustainable solutions<br><br>Increase in social sustainability of Blue Growth and human wellbeing with fair distribution of benefits within Mediterranean countries | Promote Open Data, Open Access<br><br>Stimulate data rescue<br><br>Optimize and extend observing systems and networks |
| | Extend knowledge frontiers (including basic science) and support innovative solutions | Stimulated multidisciplinary approaches<br><br>Development of innovative solutions<br><br>Supported ecosystem management based on advanced knowledge | Promote Open Science<br><br>Develop tools based on Big Data analytics<br><br>Revise funding schemes<br><br>Support young researchers |
| | Address the complexity of the interactions between research, stakeholders and policy makers and develop a scientific approach towards effective negotiation and knowledge-based decision processes | More efficient transfer of knowledge into fit-for-purpose socio-economic-environmental policies and strategies | Science diplomacy<br><br>Revise and strengthen technological clusters/districts<br><br>Monitor Blue Growth production chains |

**Tab. 6**
Schematic presentation of the main Knowledge-to-Blue Growth strategic objectives

## 6.1. IMPROVE THE INTERACTION BETWEEN SCIENTISTS, POLICY MAKERS, STAKEHOLDERS AND SOCIETY

The effective construction and establishment of "Knowledge-to Blue Growth trajectories" requires a constant dialogue and interaction among all actors involved, i.e. scientists, policy makers, stakeholders and civil society. In fact, the process is not a simple "one-way" flow from Knowledge to Blue Growth, i.e. to knowledge application and exploitation, but a much more complex and adaptive process, with multiple flows and two-way connections (Roux et al., 2006; Van Kerkhoff and Lebel, 2006; Cornell et al., 2013).

The discussion goes beyond the "knowledge exchange", i.e. the interchange of knowledge between research users and "scientific" producers (Mitton et al., 2007), which, when done successfully, is believed to increase the likelihood that knowledge and evidence will be used in policy and practice decisions, thus increasing the success of those decisions in meeting their objectives (Cvitanovic et al., 2015). Instead, we are referring to a wider, systemic and multidimensional process that spans from problem formulation to prioritization

of actions to allocation of resources and joint implementation.
A recent but lively tradition of academic and policy-related studies demonstrates the close connection between the efforts (as early as the initial stages) towards inclusion of all the stakeholders involved and the public, and the amelioration of the social acceptability of the undertakings (Jasanoff, 2004; Wynne et al. 2007). Efficient interactions should include all the relevant forms of specialized and non-specialized expertise, especially when the issues at stake are "trans-scientific" (Weinberg 1974) or positioned at the borders between the scientific, social, political and economic realms – i.e. when multiple, potentially conflicting, visions, compete to define problems and propose solutions (Gibbons et al. 1994; Funtowicz and Ravetz, 1993; Funtowicz, 2010; Jasanoff, 2004; Ziman, 2000; Hacking, 1999).
Indeed, while the present global socio-economic situation and its ongoing trends do not allow for inefficiencies and fragmented approaches, and despite significant development in recent years of the dialogue between scientists and non-scientists, there are still a number of barriers and bottlenecks within the "Blue Growth" world that need to be progressively removed.
Cvitanovic et al. (2015) identified the following main barriers to knowledge exchange between scientists and decision-makers that can be, in a broader sense, extended to other stakeholders and to civil society:

- cultural differences: in general scientists construct theories, test hypotheses and refine conceptual models over time based on rigorous methodological approaches to withstand the highest degrees of public scrutiny and criticism, while in the world of decision-making science is just one point of view, and frequently not the most influential (Cook et al., 2012);
- institutional barriers: while engaging with decision-makers is important to marine scientists on a personal level, a range of institutional barriers prevent this from happening, since marine research institutions are in general perpetuating a culture whereby action-orientated research that actively engages decision-makers is under-valued (Cvitanovic et al., 2015). Likewise, decision-makers can pay little or no attention to certain relevant scientific topics because their institutions do not consider them as current priorities;
- science in-accessibility (see also section 6.4): the duration of the standard publication process may produce out of date information that is less useful to decision-makers and stakeholders (Linklater, 2003), while most scientific literature is not freely available, with scientific journals requiring subscription to access the contents. Also, it does not always provide clear outcomes for further exploitation of results;
- conventional approaches to knowledge exchange: often scientists and decision-makers are viewed as two independent groups, whereby scientists are the producers of knowledge and thus responsible for making that knowledge available to end-users. The resulting linear and unidirectional knowledge transfer process, based on traditional modes of communication where scientific information is packaged for broad dissemination, fails to acknowledge and integrate the diversity of social contexts among end-users or the multiplicity of actors involved, preventing the uptake of scientific results in decision-making and in wider exploitation processes;
- personal perceptions and worldviews: personal perceptions and interpretation of scientific knowledge, based on one's own knowledge and past experiences, can affect the extent to which it is utilised in decision-making processes, especially when dealing with highly popularised and contentious environmental issues (Raymond et al., 2010).

An RRI-oriented approach to Blue Growth would thus necessarily imply the merging of multiple levels: a governmental and policy-making level, the academic community, the numerous market stakeholders, from the big multinational companies to the single fisherman, the civic, environmental or educational organisations and associations which deal with sea-related issues, and the citizenry at large. An endeavour with good prospects should focus on building a community that shares values and visions, respects the diversity of actors and roles, and on incorporating their interests and different perspectives.
Overcoming these barriers would bring about several and very relevant value added benefits: an expedited process, resource streamlining, promotion of socio-economic development, guaranteed use and valorisation of knowledge, more robust decisions based on a consistent supply of information to the decision making process and finally more resources for research and innovation. Better interaction between scientists, stakeholders, policy makers and civil society is one of the key

objectives of the BLUEMED Initiative, as well being acknowledged in the BLUEMED Initiative background documents. In fact, such interaction is one of the key ingredients of the work plan carried out by the BLUEMED Coordination and Support Action (CSA) to deploy the Initiative.
From a conceptual point of view, the process can be described through four main steps (Figure 8).

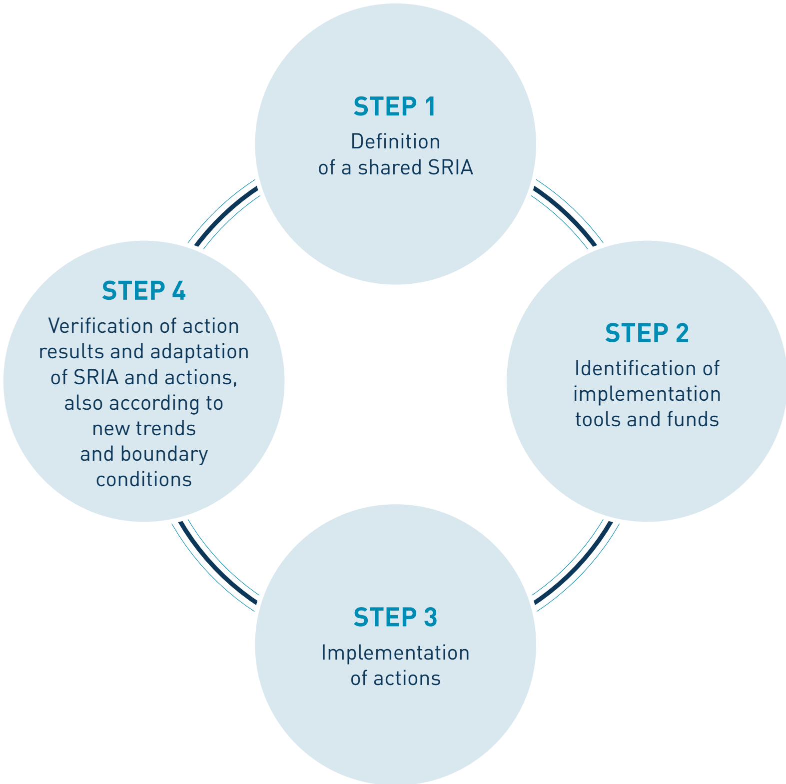


**Fig. 8**
The four main steps of the interaction process among scientists, stakeholders, policy makers and civil society.

The implementation of this general view at national level should be and is in fact being accomplished through specific actions.
The interaction and dialogue among the players involved should have a clear structured form and not be conducted through a limited number of more or less random, albeit intense, interactions. Single actions, proposals, lobbying should consistently feed the process until completed. To help pilot this process, BLUEMED CSA established four national Platforms (Knowledge, Economy, Technology, Policy) that will mirror the four Platforms established at Mediterranean level and that have longer time perspective than the four-year project. In this framework, the Italian partners are promoting a permanent inter-ministerial group, co-chaired by MIUR and CNR, as a sort of "core group" of the national Policy Platform, while reinforcing the involvement of the Regional Administrations. This process needs to be synchronised with the newly established National Technological Cluster (CTN) on Blue Italian Growth ("BIG"), according to the 2015-2020 National Research Program (MIUR, 2016) and to L. 123/2017.
The process should serve and support the implementation of national policies related to Blue Growth and, not secondarily, also inform and address their evolution, as several chapters of this White Paper highlight. There are several examples to show where and how knowledge can raise awareness, support and propose new policy measures. The ongoing revision process of the regional Smart Specialization Strategies, which in many aspects do not properly consider the potential of blue economy, now offers a great, yet challenging opportunity.

Once the overall process has been established and the overall strategy defined (STEP 1 and 2 of Figure 8), actions should be outlined in more detail and accomplished with the same interaction / engagement emphasis and using a case-by-case approach that best suites the specific action: co-design, co-production, embedding, knowledge broker, boundary organisation (Cvitanovic et al., 2015).
The empowerment of this process should be evident and effective. In other words:

i) some resources should be made promptly available for sustaining this knowledge exchange and valorisation activity, including monitoring and evaluation;
ii) strategic documents and identified actions should directly steer the decisions of policy-makers and funding agencies;
iii) criteria for awarding research and innovation funds should explicitly and effectively include measures of stakeholder engagement.

A second and complementary level of action concerns the dialogue with civil society, considering its importance (e.g. awareness, inputs, transparency, consensus and support) and its specific technicalities (e.g. engagement at local level, language, ambassadors). Responsible Research and Innovation approaches can be implemented by:

- conceiving virtual and real places of encounter, creatively making use of different engagement methods – i.e. going beyond the rigid format of meetings or workshops, and broadening possibilities to include a multiplicity of styles and processes, suitable to the diverse relevant actors (e.g. networking professional associations, motivating challenge-driven researches, collectively elaborating policy proposals, upstream engagement, including consensus conferences and communication and education activities) and applying specific facilitation methods, since experts and non-experts will not automatically understand each other, nor presumably share the same baseline vision;
- promoting citizen science initiatives and improved communication, which needs to abandon any temptation to consider this process as a one-way transfer of information, and rather value its role as a medium of knowledge circulation, a real boundary spanner (Guston, 2001), and an active shaper of balanced, inclusive, sensitive and responsive exchanges among the actors, never neglecting to begin each effort by analysing and respecting the existing perceptions and attitudes in reference to the issue at stake.

## 6.2. STRENGTHENING TECHNOLOGICAL CLUSTERS/DISTRICTS FOR BLUE GROWTH

The role of Maritime Clusters in the promotion of innovation, creation of jobs and economic growth is well acknowledged (ECORYS, 2014; EC, 2017). They play a key role in translating scientific results into socio-economic benefits, generating the critical mass for innovative economic activities and initiatives.
The 2014-2020 Italian National Research Program has identified 12 specific areas of competences - including Blue Growth – in order to better structure and implement at both national and local level, policies expected to significantly impact the social and economic development of the country. On each of the 12 areas of competence, National Technological Clusters (CTN) are being created, as permanent dialogue platforms between public research, private companies and the territories, without taking the role a new intermediate funding agency.
In accordance with this vision and mandate, the recently established CTN on Blue Growth aims at generating new opportunities for the technological development and innovation of the national marine and maritime industrial system, by integrating public and private research. In particular, it will focus on Blue Growth themes and will carry out consulting and coordination activities among the main players of the public/private research system. These actions will be carried out in collaboration with the appropriate Ministries, and are expected to provide the following outcomes:

- definition of technological roadmaps and shared innovation development roadmaps;
- definition of long-term scenarios for technology in Italian industry, and implementation of more general surveying instruments to support a more informed policy making and resource allocation for industrial research;
- alignment and integration of existing roadmaps and actions on Research and Innovation (at regional and national level) with the corresponding European and Mediterranean ones, in close cooperation with national representatives of European committees and of

boards/Secretariats of international initiatives;
- building of a common system of research infrastructures for sea economy.

Six development trajectories and three cross-cutting themes have been identified as being primary for the cluster actions together with the appropriate references to strategic international documents.
The development trajectories are defined as follows:
- *Marine environment and coastal zone*: maritime monitoring and surveillance, marine hazard, coastal protection, environmental intervention services, safety at sea and in the harbours, protection and greening of coastlands and harbours, protected marine areas, data integration, services for forecasting, pollution and discharges into the sea (including hazardous war debris), sensors for GES indicators.
- *Blue Biotechnology*: bio-remediation, biopharmaceuticals, biomolecules, biomaterials.
- *Renewable energies from the sea*: offshore wind energy, waves and tidal energy, marine geothermal energy, microbial fuel cell.
- *Abiotic marine resources*: oil and gas, mining, methane hydrates, offshore $CO_2$ storage.
- *Marine biotic resources*: fisheries and aquaculture, ecosystem services, reduction of the use of fishmeal, biodiversity and measures against alien species diffusion.
- *Shipbuilding and Marine Robotics*: vessels, systems and infrastructures for harbour- and offshore- applications (mining, energy, civil engineering, fishery), marine robotics for monitoring and safety, surface vessels and submarines (with the exception of waterways mobility systems, already included within the 2020 CTN Transport Italy), dual systems for defence.

The cross-cutting themes are listed below:
- *Skills and Jobs*: The Italian state system suffers from a reduced pace of change of learning pathways and of long-life learning, as compared with the requirements imposed by the rapid development of both technologies and of socio-economic models. The design, production and use of technologies developed within CTN BIG will require expertise to be transferred through appropriate training programmes and will promote the entry of young people into the employment market.
- *Research infrastructures*: national infra-structures (both public and private) need to be integrated through significant investments in order to comply with international standards. They also need to be optimized, both in terms of resource sharing and time availability.
- *Sustainability and economic uses of the sea*: in order to evaluate the prospects of sustainability for the definition of policies concerning marine strategy, an analysis of the "economic uses of the sea" is required.

The cluster is a structure open to all national players. The goal is to create a single aggregative organization at national level (Community), capable to effectively represent the sea sector in an international context, and acting as a meeting point between regional and national authorities. Public and private players for the most part include:
- companies, together with their associations;
- research performing organizations and universities;
- other public or private research organizations;
- other public entities (National System for Environmental Protection, Marine Protected Areas, State Corps);
- territorial aggregations (technological districts, innovation poles, public-private laboratories, etc.).

The links between the players of the cluster will be both cooperative and complementary. This is the peculiar point of this joint action, which aims at defining strategies, implementing shared activities, and improving the performances of the Italian system in the areas of research, innovation and growth of human capital of the sea economy.

## 6.3. OPEN DATA POLICIES AND THE EXPLORATION OF NEW DATA-DRIVEN OPPORTUNITIES

Open access to marine data is one of the pillars of Open Science and is thus recognized as a crucial engine for "smart and sustainable growth" by the European Union (EC, 2014). The mechanisms through which the release of marine data to the public can stimulate innovation include innovative science by both established and novice scientists and transfer of new findings to the market for value added activities, increased efficiency of existing services/operations, removal of difficulties and

reduction of costs related to the assembling and processing of different types of data from different sources. Indeed, a whole host of new products and services based on multiple sources of data and historical data rescue and re-use, could be created, with the proper support to innovative R&D through targeted policies (see section 6.5).
In light of this, in order to stimulate marine and maritime research and innovation, policies fostering harmonization and open access to data need to be strengthened and enforced (e.g. by introducing specific clauses to obtain access to public funds). Meanwhile, proper support for the evolution of ocean observing systems, both at national and international level must be guaranteed.
In this context, the European Commission has already taken significant steps forward by setting up the Copernicus Marine Environment Monitoring Service (CMEMS, marine.copernicus.eu/), the Copernicus Climate Change Service (C3S, climate.copernicus.eu) and by supporting the European Marine Observation and Data Network (EMODnet, www.emodnet.eu), as well as specific pan-European standardised infrastructures such as SeaDataNet/SeaDataCloud (www.seadatanet.org/). Combining information from both satellite and in situ observations with advanced numerical modelling, CMEMS freely provides state-of-the-art daily analyses and forecasts to both scientific and private users. This service offers the unprecedented ability to observe, understand and anticipate changes in the marine environment and provides regular and systematic reference information on the physical state of oceans and regional seas. CMEMS provides an integrated, open and free service to respond to emerging issues in the marine and maritime environmental, business and scientific sectors, but it does not directly sustain in situ observations and at the time of writing, does not cover the full range of biogeochemical data (see section 6.1.2).
SeaDataNet/SeaDataCloud assembles marine data, products and metadata collected by oceanographic fleets and automatic observation systems, relying on standardised and harmonised quality-control procedures, thus providing interoperable and restriction free marine data. SeaDataNet merges data from active national oceanographic data centres or data focal points of 34 countries, including Italy, into a unique virtual data management system.
The SeaDataCloud project, however, has already identified several major challenges, all related to the need to strengthen the Open Data policies by providing more data sets (e.g. some important data collections are missing), easier access and more comprehensive integration (particularly of data from several different research projects). Indeed, EMODnet counts on SeaDataCloud for improving and upgrading the underlying SeaDataNet standards, INSPIRE compliance, tools, services, and essential infrastructures, but actions should be taken at national level to feed existing infrastructures with all available data.

## 6.4. EXPLOITATION OF NEW MULTI-DISCIPLINARY DATA THROUGH BIG DATA ANALYTICS

The term "Big Data" refers to datasets that are so vast and complex that they cannot be adequately analysed through standard analysis techniques and limited computing resources. The definition of Big Data is, in fact, strictly related to the capabilities of the data users and available tools, which make "Big Data" an ever-moving target. Big Data are characterized by the so called three "Vs" (VVV), i.e. great Volumes, great Variety (heterogeneity in multiple dimensions) and great Velocity (data can be readily acquired and dispatched, and streamed in real-time). More traditional marine and maritime data are growing so fast that they can now be effectively classified as "Big Data" (e.g. increasing number of observations from autonomous instruments, remote sensing imagery, output of numerical forecast models, climatological simulation ensembles, etc.). More than ever before, the definition encompasses the explosive growth of information provided by social networks and connected devices of any kind. Indeed, the most striking new technological challenge is represented by the exploitation of the huge amount of data provided by networked physical devices, hosted in mobile or fixed appliances (vehicles, ships, houses, sensor stations, etc.). Electronics, software, sensors, actuators, and connectivity of device networks enable data collection and exchange, creating the so-called Internet of Things (IoT), leading to an exponential increase in data volume.
Two additional "Vs" have also been used to describe/

characterize Big Data: Veracity, i.e. quality and reliability, that have to be assessed before data analysis (80% of Big Data management!) and Value, i.e. Big Data hide great value that should be unlocked and released to businesses, society, research, etc. With respect to Veracity, if social media, micro-blogs and social networks are capable of providing real-time information for early warning and preparedness, special attention needs to be paid to ethical issues both in terms of the collection and misuse of such data. In regards to data privacy concerns, the European Commission approved the General Data Protection Regulation (EU, 2016) which addresses some of the internet based data collection issues.

Big Data analytics can thus offer unexplored opportunities in describing human behaviour, society and the natural environment of the Earth, as well as in driving the decision-making processes through advanced predictive tools. They cover a wide range of applications with potentially no domain limitation: safety and security, green energy, resources and environmental monitoring and protection, utilities, smart agriculture, smart cities, transportation, fuel management, intelligence, cargo and personnel tracking. Big Data seem to embody the Digital Earth concept which was conceived in 1999 by U.S. Vice-President Al Gore, articulating a vision of "Digital Earth" as a multi-resolution, three-dimensional representation of the planet that would make it possible to find, visualize, and make sense of vast amounts of geo-referenced information on the physical and social environment. It was deemed as almost impossible to achieve at that time, but, after a decade, rapid technological advancements have turned that vision into daily reality.

Traditional infrastructures and approaches for data management and analysis are far from being adequate to exploit Big Data potential. New technologies, architectures and methods able to integrate enormous amounts of highly heterogeneous data types in a relatively short period of time are still in initial stages of development. One of them is HPC (High Performance Computing); another is Data Science (ability to extract meaning and value from Big Data) and visualization. Different types of skilled support, including domain experts, need to be involved in Data Science, and collaborate in the interpretation phase.

The core step in Data Science is data analysis, known as analytics. The term refers to the extraction of synthetic representations of data and, sometimes, predictions, able to guide further decisions (i.e. prescriptive analysis, such as exploiting pattern recognition in autonomous vehicles). Big Data analytics can indeed support several disciplines and sectors (e.g. analysis/interpretation of genomic data, evaluation of environmental impacts, minimization of the time between detection and reaction to a specific condition, etc.). Data driven intelligence, coupled with self-learning abilities, can foster the creation of predictive analytics models identifying correlations in available data to create multiple scenarios and allowing entities in charge to opt for the best possible decisions, both within their standard operational procedures and in response to emergency situations.

Indeed, the maritime surveillance sector is in constant growth and public administrations as well as privately held companies are becoming increasingly interested in investing. In the Middle East and Africa, for example, IoT spending reached 6.8 billion € in 2017. In Italy, analytics-derived market has a volume of about 1.1 billion € with a 22% growth factor.

Big Data, IoT and Data Science are going to have a high impact on the markets and are already creating new jobs around the world (i.e. Data Scientists). This is a sector that requires teams of highly qualified professionals with various skills and backgrounds (data managers, analysers, visualizers, domain experts, business or social value experts).

Satellite imagery and connectivity are an absolute "must" for data technology, together with the need of new systems to achieve more efficient, responsive, and reliable systems that gather satellite data. Huge capability to store, process and compute data, analytic tools supporting Decision Support Systems will be necessary in the very near future, in particular for all the applications relevant to long term management of wide spatial areas. With a growing understanding of its wide-scale application and cost-cutting capabilities across vertical markets, the public sector has taken a keen interest in IoT and M2M (machine-to-machine) technologies.

All available data are/will be stored and managed by using distributed, spatio-temporal databases, able to leverage a highly parallelized indexing strategy for fast Big Data querying and manipulation. Specific tools will be needed to manage and provide value-adding information on complex application scenarios. In line with the concepts of management of large amounts of data, cloud computing, data cubes

processing and exploitation of open source data, service providers are developing new algorithms for the automated and in NRT (Near Real Time) processing of data acquired from different sensors. User communities in the scientific, civil and military fields will all be able to benefit from automatic processing and data fusion systems. With these functionalities, it will be possible to increase the exploitation of series of historical datasets and real-time automated monitoring and control across distances in remote regions. The need will be much more pressing with the coming mega-constellation of micro-satellites. This technology is benefiting particularly from the huge availability of Earth Observation data, which can be integrated with other geospatial data, already reaching a high level of automation in some fields.
The recent successful exploitation of the Copernicus Program of the European Commission is giving further breath to the so called downstream products (value-added information coming from the processing and fusion of satellite imagery), which are feeding user services to the marine research field as well.

## 6.5. REVISION OF PUBLIC FUNDING SCHEMES AND OPPORTUNITIES TO ENHANCE THE ADOPTION OF OPEN SCIENCE PRACTICES

Removing existing barriers to Open Science is considered one of the key factors to stimulate innovation and promote sustainable growth. Open science is strongly supported within the European scientific community (RISE, 2017), and Italian researchers are no exception, as clearly revealed by a recent survey carried out by the Italian Ministry for Education, University and Research (MIUR) in preparation for the future European ninth Framework Programme (MIUR, 2017). Answers to specific questions on the importance of Open Science revealed a strong consensus among the Italian scientific community (MIUR, 2017, questions n. 19D and 25A). On the other hand, while support to Open Science is widespread also among marine scientists (as confirmed during the first national BLUEMED meeting), various current practices at both European and National level have undeniably ended up unveiling critical obstacles to Open Science and innovation.
One of the major problems originates from the excessive competition created by a general lack of opportunities for funding small/medium projects (especially for young researchers) coupled with low success rates for applications, which largely discouraged participation in H2020 (see answers to question n.8 of the MIUR Survey).
In regards to H2020 applications, success rates have significantly dropped with respect to FP7 (from approximately 18% to 12% for Italian applicants, EC, 2015), reaching a level lower than what would be acceptable if quality of applications is taken into consideration (funding rates under 20-30% make it impossible to discriminate between meaningful differences in quality, e.g. François, 2015). In fact, recent analyses of peer review assessments demonstrated that peer review percentile scores fail to correctly predict grant productivity if funding levels are similarly low (Fang et al., 2016). Indeed, variability in reviewer evaluations can be greater than actual differences in quality, meaning that selection can become an almost random process. Moreover, while excellence is certainly an important parameter to consider, there is a general agreement among Italian researchers that quality is not effectively guaranteed by taking excellence as a unique criterion (see MIUR, 2017, question n.32), while scientific/social impact of projects should also be considered during evaluation (MIUR, 2017, question n. 33). As such, even if competition itself is not necessarily a negative factor for science, extreme competition caused by funding rates that fall under 20-30% is surely not beneficial to Open Science, as researchers will tend to keep their best results as secret weapons, and will be discouraged to share data openly.
In addition to low success rates, two main limiting factors have been identified by Italian researchers: the difficulty to obtain funds for basic science and low technology-readiness-level research and the lack of opportunities to get small projects funded.
In fact, a clear request to fund more projects focused on multidisciplinary, basic science and low technology-readiness-level research emerged from the MIUR survey results (MIUR, 2017, question 13, 26A and 26C), which were corroborated by consultations with the more restricted community of scientists working on Mediterranean marine and maritime research.
Concerning the second issue, small collaborative and principal investigator-driven projects are indeed considered as crucial means to encourage

the participation of newcomers and allow young researchers to emerge (MIUR, 2017, question 26F), while large projects are not considered particularly relevant to increase the quality and quantity of the scientific results (MIUR, 2017, question 26E). This problem is deemed as particularly severe by the Italian community, considering the low success rates for ERC applications and the extremely limited resources assigned by MIUR to the calls dedicated to young researchers (e.g. Programma "Futuro in Ricerca", futuroinricerca.miur.it). Indeed, there is a clear request by Italian researchers to homogenize R&D investments at national level across Europe (MIUR, 2017, questions 19C and 25B).

It is evident that small projects or even principal investigator-driven funding mechanisms would provide a higher flexibility to respond and adapt to ground-breaking ideas and cutting-edge technologies. Conversely, larger collaborative projects tend to reaffirm and freeze established communities. They also consume considerable amounts of energy and resources due to the excess burden required by proposal preparation and project management issues, increasing the risk of failure of high scientific quality proposals for reasons not related to scientific quality itself, or, even worse, potentially leading in some cases, to a decrease of the overall quality of the research funded.

A relative shift of funds from large-scale collaborative projects towards small-scale/P.I.-driven funding schemes is thus considered of primary importance to promote quality research and reduce the administrative burden related to application and project management.

# 07

## MONITORING OF BLUE GROWTH PATHS AND ACTUALIZATION

Countries embracing Blue Growth will be facing one of the biggest challenges in the next future. Indeed, achieving sustainable development will require:

1. concerted, transnational actions to deal with the commons;
2. a novel attitude towards an environment that is still poorly known and
3. a holistic, transdisciplinary vision.

This setting calls for regular, dedicated, monitoring actions, including the development of

4. proper indicators and metric, for tracking the success and evolution of planned Blue activities (EU, 2018).

The BLUEMED Initiative has been designed to implement the SRIA with a shared framework of reference among European and non-European Mediterranean countries in order to identify common and nation-specific priorities. In regards to the first requirement, the Group of Senior Officials BLUEMED Working Group (GSO-BLUEMED WG) which is steering the Initiative, can be a valuable monitoring tool for decisions and actions.

Transnational exchange of information is crucial for cross-fertilization and conflict prevention. The forum should regularly distribute a synthesis of key issues in a timely manner and serve as a support system for the elaboration of regulations and policies. The core of Blue Growth oriented activities is and will be confined to specific sites or spaces under the jurisdiction of a single state or of very few partner states.

In order to become socially accepted or attractive, the second requirement must be fulfilled. This calls for promoting ocean literacy, public outreach and citizen involvement to pave the way to a different perception and awareness of the marine ecosystem. To this aim, a network involving educators, stakeholders, governmental agencies that is monitored to also inform decision makers, can be envisioned. The third and fourth requirements strongly depend on the interaction among the scientific community, the economic operators and the decision makers. The monitoring of this activity is likely the most important because its realization is the main prerequisite for Blue Growth.

The Italian scientific community, in addition to its own national thematic associations or consortia, contributes to the activities of the BLUEMED Coordination and Support Action (CSA) promoting the Initiative, e.g., this White Paper (WP), and to the National Technological Cluster for Blue Italian Growth (CTN-BIG). The latter also gathers the main Italian stakeholders of Blue Economy making the CTN-BIG the primary representative for knowledge transfer and industrial, *sensu latu*, activities framed in the Blue Growth initiative. Finally, there are all the public administrations and governmental bodies whose decisions and directives regulate and support Blue Growth. The National Interministerial Group (NIG), promoted by the Italian BLUEMED community and complemented by the participation of the Regions can ensure exchange and coordination among the entities involved.

The following is a preliminary proposal of actions to create the conditions for effective short and medium-term monitoring.

- It is necessary to define and develop a set of metrics to verify the status, degree of advancement and success of the actions within the different Blue Growth sectors. The BLUEMED CSA may catalyse the discussion but a key role should be played by the CTN-BIG and the NIG & Regions.
- Based on these metrics or on available standard indicators, a yearly assessment of the state of Italian Blue Growth for each of the specific sectors should be prepared, collecting inputs from the industrial sectors of reference or their associations. An example is the Annual document of the Unioncamere on the state of Blue Growth in Italy.
- The NIG & Regions should organize periodic meetings with the aim of identifying evolving gaps and needs, prepare reports, and suggest actions in support of specific sectors.
- The final version of the SRIA will provide a wide scope and structured view of the priorities for fostering Blue Growth while in this WP some preliminary road maps are proposed for each sector. Monitoring the match between these and the realization of related specific actions could fall under the responsibility of the NIG & Regions and the CTN-BIG with the support of the BLUEMED CSA-Italy (until its end date).
- While the CTN-BIG focuses more on the Italian scenario and on the realization of Blue Growth, European support in terms of funding scientific research and innovation initiatives should be stimulated and oriented, based on a SWOT analysis of Blue Growth progress. This should be managed by NIG & Regions (operating dedicated funds), possibly in collaboration with a dedicated panel of volunteer technical experts from the scientific community. Coordination with other Mediterranean countries and with the European Commission should be promoted through the BLUEMED-CSA-Italy.

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### 2. THE GENERAL FRAMEWORK

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**3. FROM SOCIETAL/ECONOMIC DRIVERS TO THEMATIC BLUE OBJECTIVES**

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# LIST OF ACRONYMS

| | |
|---|---|
| AIS | Automatic Identification System |
| AM | Additive Manufacturing |
| AOI | Area of Interest |
| AQUO | Achieve QUieter Oceans by shipping noise footprint reduction |
| AUV | Autonomous Underwater Vehicle |
| BEF | Biodiversity and Ecosystem Functioning |
| BIT | Bioeconomy in Italy |
| BG | Blue Growth |
| C3S | Copernicus Climate Change Service |
| CAGR | Compounded Average Growth Rate |
| CCS | CO2 Capture and Storage |
| CDOM | Colored Dissolved Organic Matter |
| CDP | Capability Development Plan |
| CFP | Common Fisheries Policy |
| CIESM | Mediterranean Science Commission |
| CMEMS | Copernicus Marine Environment Monitoring Service |
| CGF | Coast Guard Function |
| COFASP | Cooperation on Fisheries, Aquaculture and Seafood Processing |
| CSA | Coordination and Support Action |
| CTN-BIG | National Technology Cluster Blue Italian Growth |
| DCF | Data Collection Framework |
| DCRF | Data Collection Reference Framework |
| DSM | Deep Sea Mining |
| DIFESA | Ministry of Defence |
| EAFM | Ecosystem Approach to Fishery Management |
| EC | European Commission |
| EcAp | Ecosystem Approach |
| EDA | European Defence Agency |
| EEZ | Exclusive Economic Zones |
| EFARO | European Fisheries and Aquaculture Research Organisations |
| EFH | Essential Fish Habitat |
| EEA | European Environmental Agency |
| EIA | Environmental Impact Assessment |
| EMBRC | European Marine Biological Resource Centre |
| EMSO | European Multidisciplinary Seafloor and water-column Observatory |

| | |
|---|---|
| EMZs | Ecological Maritime Zones |
| EO | Earth Observation |
| EOOS | European Ocean Observing System |
| EOV | Essential Ocean Variable |
| EROI | Energy Returned On energy Invested |
| ESS | Electric Storage System |
| EU | European Union |
| EUMSS | European Maritime Security Strategy |
| EuroGOOS | European Global Ocean Observing Sysytem |
| FDA | Food and Drug Administration (US) |
| FEAP | Federation of European Aquaculture Producers |
| FFDR | Fish Feed Dependency Rate |
| FIX-O3 | Fixed-point Open Ocean Observatories |
| FP7 | Seventh Framework Programme |
| GDP | Gross Domestic Product |
| GES | Good Environmental Status |
| GFCM | General Fisheries Commission for the Mediterranean |
| GSO-BLUEMED WG | Group of Senior Officials BLUEMED Working Group |
| HPC | High Performance Computing |
| ICT | Information and Communication Technologies |
| IoT | Internet of Things |
| ICZM | Integrated Coastal Zone Management |
| IMO | International Maritime Organization |
| IMP | Integrated Maritime Policy |
| IMTA | Integrated Multi-Trophic Aquaculture |
| IPCC | Intergovernmental Panel on Climate Change |
| ISA | International Seabed Authority |
| IUU | Illegal, unregulated and unreported |
| JERICO | Joint European Research Infrastructure for Coastal Observatories |
| LCoE | Levelized Cost of Energy |
| LNG | Liquefied Natural Gas |
| LRIT | Long-Range Identification and Tracking |
| LTER | Long Term Ecological Research Network |
| M2M | Machine to Machine |
| MAECI | Ministry of Foreign Affairs and International Cooperation |

| | |
|---|---|
| MAP | Multi Annual Plan (for fishery management) |
| MCA | Multi-Criteria Analysis |
| MEF | Ministry of Economics and Finance |
| MIBAC | Ministry of Cultural Heritage and Activities |
| MIPAAF | Ministry of Agricultural, Food and Forest policies and tourism |
| MISE | Ministry of Economic Development |
| MIT | Ministry of Infrastructures and Transport |
| MIUR | Ministry of Education, University and Research |
| MONGOOS | Mediterranean Operational Network for the Global Ocean Observing System |
| MNC | Multinational corporation |
| MPA | Marine Protected Area |
| MRE | Marine Renewable Energy |
| MSFD | Marine Strategy Framework Directive |
| MSP | Maritime Spatial Planning |
| MSY | Maximum Sustainable Yield |
| NGO | Non-Governmental Organization |
| NIG | National Interministerial Group |
| NIS | Non-indigenous species |
| NRT | Near Real Time |
| OECD | Organisation for Economic Co-operation and Development |
| ODYSSEA | Operating a network of integrated observatory systems in the Mediterranean Sea |
| OMC | Offshore Mediterranean Conference & Exhibition |
| PEQ | Population equivalent |
| POM | Particulate organic matter |
| PUFA | Polyunsaturated Fatty Acids |
| R&D | Research and Development |
| R&I | Research and Innovation |
| ROV | Remotely operated underwater vehicle |
| RPAS | Radar Position Analysis System |
| RRE | Rare earth elements |
| RRI | Responsible Research and Innovation |
| S3 | Smart Specialization Strategy |
| SAC | Scientific Advisory Comittee |
| SAPEA | Science Advice for Policy by European Academies |
| SET-Plan | European Strategic Energy Technology Plan |

| | |
|---|---|
| SFtP | Safe Return to Port |
| SILENV | Ships oriented innovative solutions to reduce noise and vibrations |
| SAR | Synthetic Aperture Radar |
| SMART | Spatial MAnagement of demersal Resources for Trawl fisheries |
| SME | Small and medium enterprise |
| SMS | Seafloor massive sulphides |
| SONIC | Suppression Of underwater Noise Induced by Cavitation |
| SPAMI | Specially Protected Areas of Mediterranean Importance |
| SRIA | Strategic Research and Innovation Agenda |
| SSD | Safe and Sustainable Decommissioning |
| SSF | Small-scale fisheries |
| TAC | Total allowable catch |
| TRL | Technological Readiness Level |
| UAV | Unmanned Autonomous Vehicle |
| UfM | Union for Mediterranean |
| UN | United Nations |
| UNCLOS | United Nations Convention on the Law of the Sea |
| UNEP | United Nations Environmental Protection Program |
| UNFCCC | UN Framework Convention on Climate Change |
| USV | Unmanned Surface Vehicle |
| VMS | Vessel Monitoring System |
| VVV | Volumes, Variety, Velocity |
| WP | White Paper |
| ZPE | Zone of Ecological Protection |

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