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An International Journal of Earth Sciences

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The Starfish Mission: an Italian perspective

Editors: Maria Cristina Pedicchio, Angelo Camerlenghi, Cosimo Solidoro

OGS National Institute of Oceanography and Applied Geophysics

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Table of contents

Chapter 4 Zero pollution

Chapter 5 Decarbonizing

Chapter 6 Governance

The EU Starfish Mission: an Italian perspective

Nicola Casagli
President of the National Institute of Oceanography and Applied Geophysics, OGS

OGS, the National Institute of Oceanography and Applied Geophysics, welcomed the idea to publish a special volume entitled "*The EU Starfish Mission: an Italian perspective*", as a supplement to its international journal "*Bulletin of Geophysics and Oceanography*".

The institute believes in the five missions of the European Union that are an integral part of the Horizon Europe framework programme beginning in 2021, and they are committed to solving some of the greatest challenges facing our planet like fighting cancer, adapting to climate change, protecting our oceans, living in greener cities, and ensuring soil health and food.

In line with its own mission, OGS supports the EU efforts to protect our oceans, seas, and inland waters. To respond to this specific challenge, OGS strategic vision aims at a strong integration between research, innovation, technology transfer, training and dissemination activities, firmly based on the achievement of excellence, openness, cooperation and impact.

The institute scientific research is multidisciplinary and has crosscutting characteristics, where the sea-land interaction represents its main component. The aim is two-fold: to improve the knowledge of the marine environment to promote the sustainable use of its resources, through the skills of its staff, equipment for investigation, monitoring and modelling in the fields of physical, chemical, and biological oceanographic parameters of the water column from shallow to deep seas; and to improve the knowledge on the Earth's interior to promote the sustainable use of its resources through geophysical monitoring and modelling of the subsoil and seabed.

The OGS institutional research includes the design, construction, management and maintenance of large research infrastructures and e-infrastructures, as well as high-level consultancy activities for national and international organizations. The most significant institutional commitment for OGS lies in the management of maritime infrastructures and in particular of the new research vessel Laura Bassi which is part of the alliance of the European marine infrastructures "Eurofleets". The icebreaker R/V Laura Bassi is currently the only national research vessel able to conduct oceanographic studies in polar areas.

In accomplishing its scientific activities, OGS promotes international networks mainly through participation in research projects and international cooperation, often with coordination roles, mainly focused on major geological and geophysical applications, marine observation and monitoring, forecasting and prevention of seismic and other risks.

OGS's Science Diplomacy activities are particularly focused in the geographical regions of the Mediterranean, the Balkans, the Black Sea, Latin America, Central Asia, and the Polar areas. A special effort is strongly oriented towards innovation,

growing international attention to the Mediterranean and to the theme of the sea in general, promoting an extremely attractive context for the productive system of Europe, ease the circulation of talents and consolidate dialogue with neighbouring countries.

This supplement of our international journal represents a way to demonstrate our support to the EU Starfish Mission and our commitment to promote its outcomes for the benefit of our healthy Planet, our people and scientific communities, our societies, and our economies.

Why this volume?

Maria Cristina Pedicchio
Starfish Mission board member

The European Commission has launched the ambitious **European Missions project** as one of the most innovative parts of the Horizon Europe Program and with the aim to contribute to the European Green Deal as well as to the Sustainable Development Goals.

The inspiration comes from the famous Apollo mission to put a man on the Moon, and bring him back safely to Earth. The EU missions' idea is similar but is tackling main European **societal challenges**, more precisely the following 5 challenges: fighting cancer, adapting to climate change, protecting our oceans and waters, living in greener cities and ensuring soil health and food.

The Missions' aim is to achieve a sustainable Europe for all, by translating challenges into concrete actions and results; to do that, there is the need to stimulate a collective effort, a general emotional involvement, together with multidisciplinary projects, public-private ambitious efforts and disruptive changes.

For each Mission the Commission appointed a Board of experts, coming from innovation, research, policy, civil society and relevant organizations, to prepare a proposal for the next ten years.

The "**Healthy Oceans, Seas, Coastal and Inland Waters**" Mission is one of the five; the corresponding board is chaired by Pascal Lamy. The board has decided to rename the Mission, in a more friendly way, as "**Starfish 2030: Restore our Ocean and Waters".** The choice to use a starfish as symbol has various motivations: all kids know and love starfish, even if they do not live near the sea; the starfish with its five arms gives the idea of a synergic and joint approach and, finally, the starfish is a sentinel of climate change.

At the European Research & Innovation Days in September 2020, the Missions' visions and proposals were officially presented and the corresponding reports published.

For Starfish 2030, the purpose of the report is very clear: "Healthy ocean and waters are taken for granted. Yet, they are in trouble and need to be restored. We call on all European citizens and policy makers to take responsibility for protecting and regenerating rivers, lakes, seas and ocean and demand urgent systemic change from our politicians and leaders."

After an analysis of threats and risks for seas and waters and of the impact of human activities, the report proposes **5 main objectives for 2030** (Fig. 1):

- **Filling the knowledge and emotional gap,**
- **Regenerating marine and freshwater ecosystems,**
- **Zero pollution,**
- **Decarbonising our ocean, and waters**
- **Revamping governance**.

These five objectives are mutually supportive and if they are tangibly obtained, the Mission Starfish 2030 will enable the restoration of the water cycle of the whole hydrosphere**.**

For each of the five objectives, a set of ambitious, concrete and measurable targets has been defined. They specifically address the actors, activities, tools and systems that need to be called upon to reach each objective. These targets are considered the indispensable components of a holistic approach to systemic change. Achieving these objectives will require a multitude of solutions and collaboration between a wide range of actors.

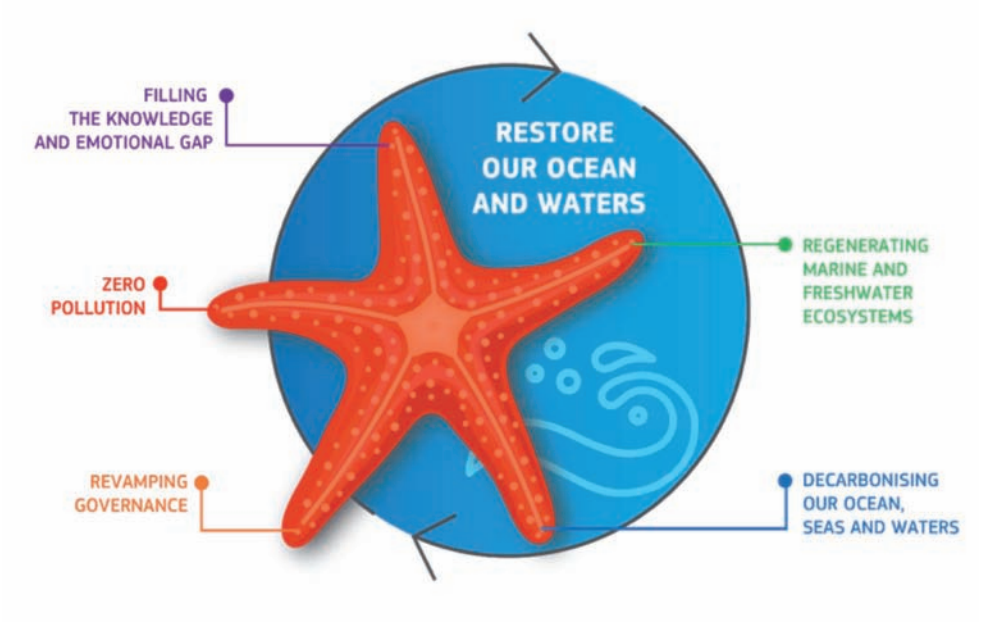

Fig. 1 - The Starfish Mission five objectives.

The Mission's concrete action plan is now in its starting phase thanks to the Implementation Plan that the Commission is preparing, to the new proposals for "Lighthouse demonstrators" and the Horizon Europe calls.

With this volume the National Institute of Oceanography and Applied Geophysics – OGS - intends to enhance a general discussion on the state of seas, lakes and rivers in Italy and to comment on **what the Italian Starfish Mission should be**, presenting **ambitions** and **vision** in a specific national perspective. To do that we asked some visionary people to express their ideas and proposals for the future Italian marine and maritime blue world.

The volume contains 25 articles, organized according to the 5 starfish objectives (plus a chapter on the general context).

The main characteristics of the volume can be summarized in the following concepts:

1. Holistic approach

It is fundamental to bring out the importance of seas, oceans and waters and the strict correlation between humans and the whole hydrosphere. The concept

is easy: we cannot be healthy if the sea and waters are not healthy. And we all have the responsibility with our actions to defend and restore seas and waters. To do that there is the need for a holistic approach and for a collective visionary, courageous and disruptive new way of thinking.

2. Value of diversity

The volume collects opinions from different authors: scientists, businessmen, citizens, sportsmen, each one with his own style, vision, experience and point of view. Only if we success in building a collective, multidisciplinary and multi-actor knowledge will we be able to create a sustainable future for our seas and waters.

3. Italy is its Seas

The volume wants to offer an easily readable integrated overview to be of inspiration for many readers: policy makers, researchers, citizens and, mainly, young generations. At national level, we must get ready for the next steps of the mission implementation plan and of the future lighthouse demonstrators, in the spirit of the UN Ocean Decade. To do that, a better collective awareness of the importance of marine and maritime sectors for Italy and a more integrated and visionary approach must be pursued.

We hope the volume will contribute to stimulating ambitious national thinking together with political support, citizens' involvement and a scientific, innovative and sustainable approach to the marine and maritime Italian sector. The time to act is now!

Thanks to all the authors for their precious contributions.

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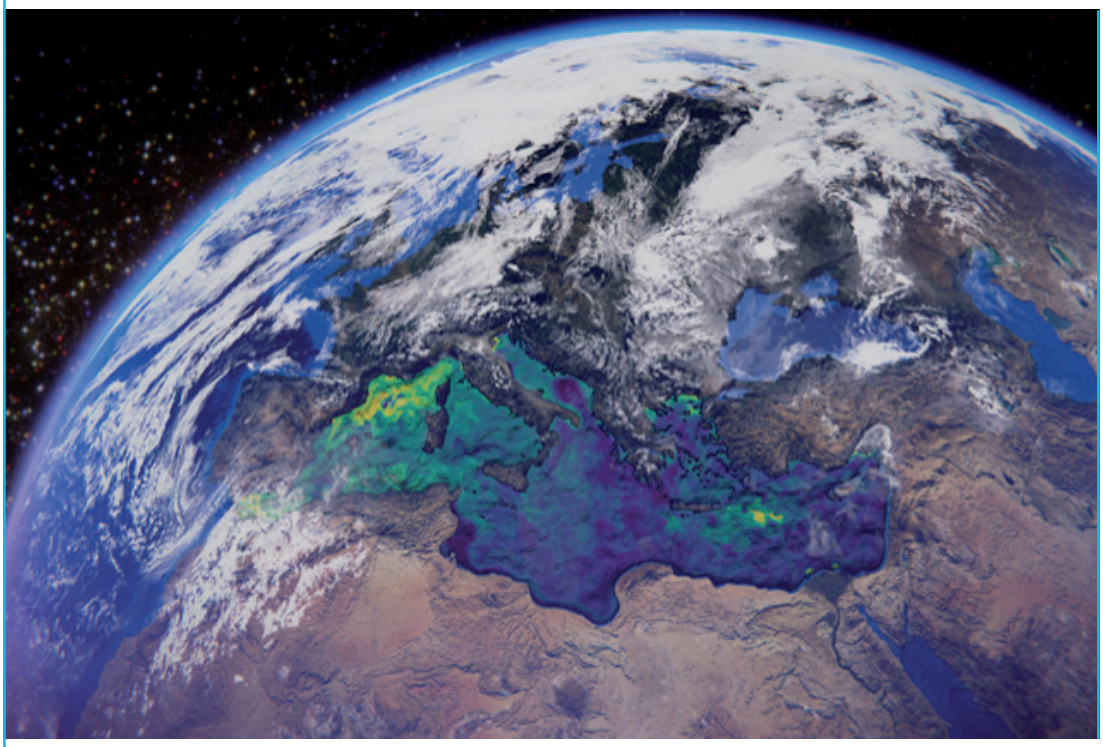
Chapter 1.

The Context



Credit: OGS photographic archive

The Starfish Mission

Pascal Lamy

Pascal Lamy is the President of the Paris Peace Forum and Brunswick Europe Chair. He shares his other activities between the Jacques Delors think tanks (Paris, Berlin, Brussels), the presidency of the UNWTO ethics of tourism committee, of the French Committee of the Pacific Economic Cooperation Council (PEEC), and the Musiciens du Louvre orchestra (Marc Minkowski). He holds positions in various French, European, and global boards or advisory boards and is affiliate Professor at the China Europe International Business School CEIBS, Shanghai, and at HEC (Paris). He held many prestigious positions like: Director General of the World Trade Organization-WT0 (2005- 2013), European Commissioner for trade (1999-2004), CEO of Crédit Lyonnais (1994-1999), Chief of Staff to the President of the European Commission Jacques Delors and his G7 sherpa (1985-1994), Deputy Chief of Staff to the French Prime Minister (1983-1985) and to the French Minister for Economy and Finance (1981-1983. He is presently the Chair of the EC Starfish Mission Board.

1. EU Missions

EU Missions are new tools for policy actions within the European Union that were inspired by the moon-shot Nasa experience of the 1960s, with a sort of triple purpose: acceleration, innovation and participation.

Firstly, acceleration of public action to deliver quick solutions on measuring collective challenges which usually take a lot of time to be addressed, secondly put science and innovation as the main engine of necessary transformation and, thirdly, engage citizens in participating in science and innovation. Missions represent a new concept that was developed some years ago by the Italian economist Mariana Mazzucato, Professor in Economics of Innovation and Public Value at University College, London.

The European Commission has decided to prepare Mission-oriented experiences in five specific areas: cancer, healthy soil, smart cities, climate adaptation and what we called the “clean hydrosphere” which means “healthy and clean oceans, seas and water systems”. We entitled our Mission “Starfish” because there are five major levels that we propose to develop.

Like all other Mission boards, we have set precise targets for 2030, connected with a series of actions that we intend to achieve: mobilizing resources, policy, instruments, programs, private and public sectors at EU level, Member states level, Regional level and local level. All this represents a big collective ambition that is characterized by innovation, participation of citizens and acceleration.

2. Connections between the EU Missions and the Green Deal

Although the themes of the EU Missions were decided by the previous Commission, the five missions are absolutely central to the new strategy which has been adopted following the European Action in 2019, which is about both green transition and digital transition. Each of the five topics, whether cancer, soil, climate adaptation, hydrosphere or smart cities, is a major element of both an ecological transition and the use of digital tools, not least to facilitate citizens' participation and engagement in the realization of the missions.

3. The Starfish mission

The Starfish Mission is one of these five missions. We in the mission board have been assigned the theme "healthy oceans, seas and waters systems", which we have made more precise by expressing it as "regenerating the European hydrosphere by 2030". We took a long time to decide on this very ambitious target, considering the heavy degradation of the EU hydrosphere in recent decades, but we believe that such an ambitious goal is obtainable by 2030: if not 100% of regeneration will be achieved, at least a new process will be started, that not only stops the degradation but embarks on a regeneration path that will continue in the future.

We called the Mission "Starfish" because we believe that to achieve the goals we need to push in five different domains: filling the knowledge and emotional gap, zero pollution, revamping governance, decarbonizing our ocean, seas and waters, and regenerating marine freshwater ecosystems. Like in the real starfish, these five objectives must exist together. This is something very complex which needs a sort of holistic approach by many actors in many areas. It is a systemic issue and after a lot of discussion we thought that the starfish was the best symbol of something that is systemic, you cannot separate one leg from another or the centre from the rest of the body. Plus the fact that the starfish is an aquatic animal that also needs quite a bit of care.

We then broke down these five general objectives into 17 specific targets. Also, we came to the conclusion that, for this program, roughly 500 billion Euros have to be mobilized by 2030 and that we will probably need 2/3 billion of EU research and innovation money coming from the new program that was started this year for the next seven years and is called Horizon Europe.

4. What the Commission expects from citizens

During the Mission Board work, for about 15 months, we have been listening, in order to open our mind, to different experts, both from the board itself and from external groups. In addition to these in-house hearings and discussions we embarked on a large number of consultations and interactions with citizens, involving many member states (not all yet but most of them and we will continue during this year) including Italy, France, Portugal, Ireland, Germany, Malta, Romania. What we obtained from these consultations, which we thought were mostly to get views from stakeholders and to explain to them what we were doing, was most unexpected. With great surprise, we

discovered that for people it was ok to be informed and ok to be asked questions but, even more than that, they wanted to participate and to be engaged!

This does not deal with political or governmental aspects but only with citizens. The reality is that when discussing things that people understand, they are ready to be involved, and citizens understand that cancer is a problem, that towns are polluted and seas, oceans, rivers and lakes are at risk. Once they understand that there is something to be done, they want to be part of that, by acting concretely. This was a positive surprise because it is exactly what missions are about. Missions are about apparently utopian targets and objectives which people understand, like sending a man to the moon at the time, and which they believe to be important and doable. They also fully understand that missions cannot be realized without a very large support that comes not only from stakeholders or people directly involved, like blue economists, navy people, fishermen and so on, but also from the general public.

This has to do with the fact that the hydrosphere degeneration is strongly related with land; it is meant to be a water problem but in reality, it is a land problem, and people live on land, not in water

People also understand that, when talking about cleaning the hydrosphere or about getting rid of air pollution, we are dealing with physics and chemistry, but if we talk about regenerating the hydrosphere then we are dealing with biology.

They also realize very well that it is easier to count on biology to solve the problem because biology is a sort of self-multiplying, self-perpetrating and self-reproducing system. The experience in many hydrosphere areas reports that damage in biosystems can be regenerated by letting living things (molecules, bacteria, animals…) alone so that they can reproduce, grow and be restored.

To conclude, we can say that people's comments show a large understanding and provide a more optimistic view thanks to the general feeling that, with correct and good measures, the situation and problems represented in the mission can be solved.

5. Which objective to start with?

It is difficult to decide, among the five Starfish Mission objectives, from which one to start considering that there are so many things to do. But if I must choose one, I would take the zero-pollution leg and, within zero pollution, I would put zero plastic litter generation as a priority and not zero plastic litter dumping.

This means that you have to move upstream in the productive systems, so that from the very beginning you do not produce litter, which then has a serious chance of being dumped.

If you leave a plastic bottle on the top of Mont Blanc, the odds that it has of ending up in the Mediterranean Sea are above 55%!

6. Balance between economic blue growth and social economic sustainability

We need blue growth, in all its diverse aspects (energy, biotech, etc) but we need it to be implemented in a sustainable way. For this we must put in place a regulatory and investment system to address the potential negative and unsustainable parts of blue growth. For example, we know that aquaculture can be a big resource for the future but, depending on how you catch the fish, it can result in a positive or a negative contribution,

it is a question of infrastructures, equipment, science, innovation and regulation. All these tools have to be used simultaneously.

7. The situation in Italy

It is difficult to make suggestions but, if we concentrate on Italy, I have to say that a main problem is to be found in one of the legs of the Starfish we mentioned before, the one that deals with Governance. I think that in Italy the Governance of the hydrosphere is too fragmented; it could be useful to create a place, a hub, a pilot, that can address marine problems and face as much as possible the 17 targets we listed. Italy's fragmentation concerns many sectors, including science, exploration and regulation; clearly it is a difficult issue since there are different interests at national, regional and local level, but I think that connecting these realities together, not creating a single bureaucratic monster, but a sort of hub with the necessary authority and overview which can coordinate the different levels, including for instance exploration, could create the condition for being much more efficient at EU level.

In the Mission proposal, at European level we recommended creating an EU Ocean agency that would be in charge of steering the starfish program. Of course, I believe that it would be much easier to achieve synergies at EU level if systems of this kind existed in the Member States. The reality is that there are very few countries in which this integrated system has been created, for example Portugal, Malta, Ireland, and France that is roughly at 2/3 of the way.

8. Priorities of the Mediterranean Sea

I think that the main priority for the Mediterranean Sea is regeneration. The Mediterranean Sea is in fact a very degraded place, being a quasi-closed hydrographic system, but regeneration is something that can only happen with a very strong coordination all around the Mediterranean. The reality is that there are big differences in the development and in the governance levels in the different countries. I know that since I am the chair of the Bizerte Annual Forum on the Sea where Tunisia puts together an event refocusing on the old Tunisian country to encourage a better use of hydro systems, coasts, waters, that have heavily degraded in the last thirty years; think for example of the lake that surrounds Bizerte. From this experience, I know that when we put around a table different people from all of the Mediterranean some of them are strong, some are poor, some weak, some rich, some many, some just a few, so it is a real big challenge for governance. We only have a rough idea of what to do.

There are areas that have already improved, some have become marine protected areas, not enough of them, but where there is regeneration there is also progress in preserving some animal species, like a specific kind of tuna that is disappearing because of overfishing. We need more of these actions, we need to act, for example, on fishing practice issues, that are related to the problem of overfishing in the Mediterranean.

In conclusion, in my view, the priority is to have a stronger cooperation, a stronger bond, among the countries that surround the Mediterranean. There are regional organizations and there is quite a lot of money coming from the Euro Med program but I think it is not enough: we still need to face more political problems that concern those areas such as Morocco, Algeria, Tunisia and Egypt.

The UN Decade of Ocean Science for Sustainable Development, challenges and opportunities for the Italian marine sciences community

Francesca Santoro

Francesca Santoro has been working for the Intergovernmental Oceanographic Commission (IOC) of UNESCO since 2011 where she is in charge of ocean literacy activities, and of the coordination of a global partnership to raise the awareness of stakeholders of the importance of the ocean for the planet. Francesca holds a PhD in analysis and governance for sustainable development from the School for Advanced Studies in Venice (SSAV), with specialization in marine environmental sciences, marine governance, science education and communication.

1. Introduction

Like never before the ocean is at the centre of the environmental political agenda as well as in the discussions around sustainability, whether the focus of these discussions is its protection or its exploitation (Ertör and Hadjimichael, 2020). This is reflected, for example, in the adoption of a stand-alone goal on the ocean in the framework of the United Nations Agenda 2030, and its 17 Sustainable Development Goals (SDGs). Unlike the Millennium Development Goals (MDGs), the UN has conducted the largest consultation programme in its history to gauge opinion on what the SDGs should include. This happened through the creation of an open working group with representatives from 70 countries, which had its first meeting in March 2013 and published its final draft, with its 17 suggestions, in July 2014. The draft was presented to the UN general assembly in September. Member state negotiations followed, and the final wording of the goals and targets, and the preamble and declaration that comes with them, were agreed in August 2015. Alongside the Member States' discussions, the UN conducted a series of "global conversations". These included 11 thematic and 83 national consultations, and door-to-door surveys. The UN also launched an online "My World" survey asking people to prioritise the areas they would like to see addressed in the goals. The results of the consultations were fed into the OWG's discussions. Regarding the ocean, although a broad range of ocean-related issues was addressed in Agenda 21, in the Johannesburg Plan of Action (JPOI) 21, and in the Barbados Programme of Action, no MDG was explicitly dedicated to the ocean. Ocean-related targets were defined for MDG7 (Ensure environmental sustainability). In its target 7.B and in its two ocean-related indicators: 7.4 proportion of fish stocks within safe biological limits and 7.6 proportion of terrestrial and marine areas protected. Ocean and seas were centrally emphasized in the Rio+20 outcome document, "The future we want". When the work around the definition of the SDGs started there was a need for extensive mobilization of

Member States and civil society to articulate the centrality of the ocean for sustainable development. Some viewed oceans and seas as mainly an environmental issue, not fully aware of their economic and social importance. Starting in summer 2013, a strong push by Member States, led by the Pacific Small Island Developing States and Timor-Leste, and supported by civil society, articulated the need for an oceans goal for planetary survival and for global and national economic and social well-being. The many opportunities for civil society input contributed to the adoption of SDG 14, which came to be supported by a very large number and range of nations—developing and developed, coastal and inland, small islands and continental nations. The package of ocean and sea issues reflected in SDG 14, "Conserve and sustainably use the oceans, seas and marine resources for sustainable development", with its seven targets and three provisions on means of implementation is a very important one. The goal itself, its targets and means of implementation reinforce and give renewed focus and urgency to existing international prescriptions on oceans and seas.

This is also the case in the most recent climate change discussions. For instance, the 25th session of the Conference of the Parties (COP 25) at the UN Climate Change Conference (UNFCCC) has been named the "Blue COP" and the Intergovernmental Panel on Climate Change adopted the "Special Report on the Ocean and Cryosphere in a Changing Climate" highlighting "the urgency of prioritizing timely, ambitious and coordinated action to address unprecedented and enduring changes in the ocean and cryosphere" (IPCC 2019).

The ocean is also considered the new economic frontier, both at the international level with the initiative led by the Organisation for Economic Co-operation and Development, with The Ocean Economy in 2030 report (OECD, 2016), and by the European Union with the Blue Growth initiative, which identified a huge potential offered by the future development of ocean-based industries. More recently, a new initiative led by the UN Environment Programme, and supported by European Commission and the European Investment Bank as well as by the Swedish Government, has been set up with the intention of providing guidance and frameworks to ensure investment, underwriting and lending activities are aligned to SDG 14, "life below water" enabling financial institutions to rebuild ocean prosperity, restore biodiversity and regenerate ocean health (United Nations Environment Programme Finance Initiative, 2021).

All of these frameworks underline the importance of ocean science and ocean knowledge as the basis for sound decisions. However, it is important to stress in this context that science does not inherently lead to sustainable or unsustainable (or equitable or unequitable) outcomes - the outcomes will depend on how, where, when, and by whom the science is designed, funded, conducted, and used (Singh et al., 2021).

It is in this overall context that the UN General Assembly has declared 2021-2030 the Decade of Ocean Science for Sustainable Development. The vision of the Ocean Decade is the "Science we need for the ocean we want". The mission of the Ocean Decade is "to catalyse transformative ocean science solutions for sustainable development, connecting people and our ocean". The Ocean Decade will be implemented on a voluntary basis within the legal framework of the United Nations Convention on the Law of the Sea (UNCLOS). The Ocean Decade will facilitate the generation of data, information and knowledge needed to move from the "ocean we have" to the "ocean we want". Seven outcomes describe the "ocean we want" at the end of the Ocean Decade, and how this will be achieved, i.e. through the identification of ten challenges, the most immediate and

pressing priorities for the Ocean Decade, and three objectives which go from identifying the knowledge gaps, to generating the knowledge needed to promote an increase in the use of ocean knowledge (IOC-UNESCO, 2020; Fig. 1).

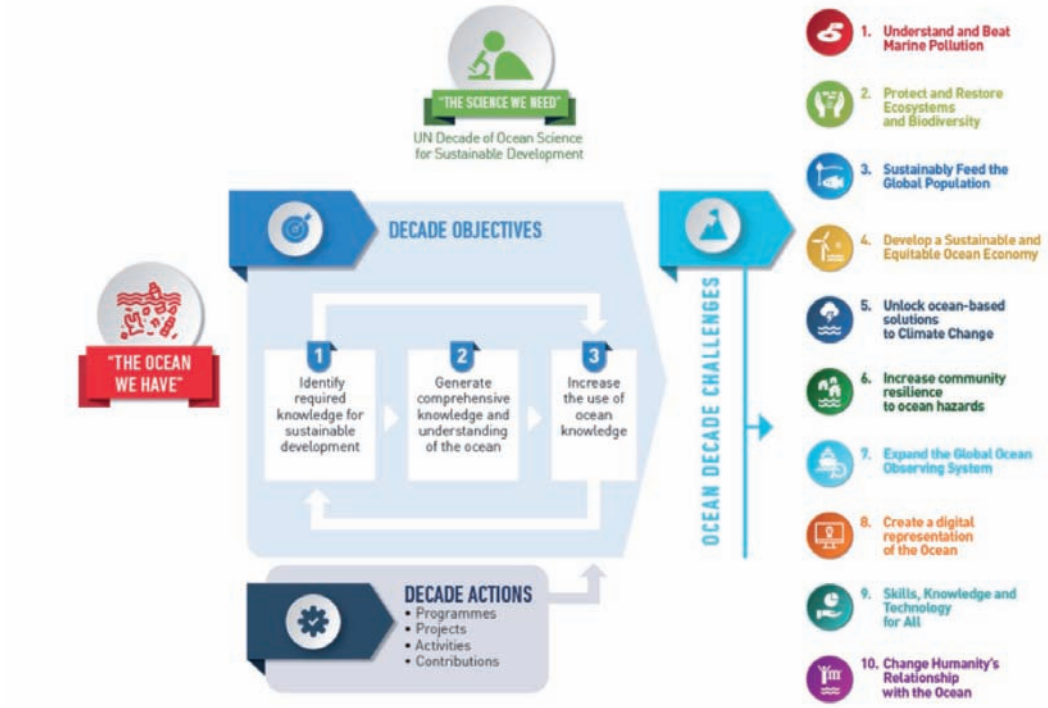


Fig. 1 - The Ocean Decade framework of action (source UNESCO 2020).

It is very important to notice here that the notion of transformative science is central to the Decade. The Decade wants to promote a true revolution in ocean science. The Ocean Decade promotes a science that is co-designed and co-delivered and that, most of all, promotes a solutions-oriented research. The vision of the Ocean Decade echoes what the principles of Mission Starfish 2030 also promote, in particular when it sets its main objective which is to regenerate marine ecosystems by transforming and promoting climate neutrality and the decarbonisation of the blue economy. Very interestingly, Mission Starfish 2030 draws attention to the idea that to fully achieve its vision it is important not only to fill knowledge gaps but also to fill the emotional gaps in order to make sure that "Each European citizen is a citizen of our ocean and waters" (EC RTD, 2020).

How can a country like Italy, with around 7500 km of coastline and an economy strongly linked to its position in the middle of the Mediterranean, take advantage of these new frameworks? According to the recently published Global Ocean Science Report (GOSR), Charting Capacity for Ocean Sustainability (UNESCO, 2020), Italy is in the seventh position in terms of the number of national ocean science researchers employed per million inhabitants, but only in the twenty-second position in terms of the portion of gross domestic expenditure on research and development (GERD) devoted to ocean

science. GOSR2020 highlights as well that research and scientific monitoring furnish the information for nations to benefit sustainably from the ocean's provisioning of food, tourism and coastal protection.

However, to connect with the idea of filling not only the knowledge but also the emotional gaps described above, ocean science can also support the understanding by society of the full array of values that we attach to the ocean, including its cultural and aesthetic ones. This understanding will help countries to develop and implement their sustainable marine development, not only taking into consideration the economic values of the ocean.

These main elements should convince the Italian scientific community, the research institutions, the political sphere but also the society as a whole that investments in ocean science and ocean research should be given a much higher priority than the current one.

It goes without saying that among the most urgent initiatives to be put in place is the idea of introducing more ocean science content in the educational curriculum, and the promotion of a stronger ocean literacy of society. Increasing ocean literacy at the national level, and at all educational levels, is a fundamental element in enabling capacity development in the national marine science sector, but also in encouraging the younger generations to pursue a career in the marine and maritime domain. Furthermore, ocean literacy is not only about increasing awareness of the state of the ocean, it is also about providing tools and approaches to transform ocean knowledge into actions to promote ocean sustainability (Santoro at al., 2017), and therefore promoting the concept of marine citizenship. Marine citizenship, defined by McKinley and Fletcher (2010; 2012) as "individual rights and responsibilities towards the marine environment, having an awareness and concern for the marine environment and the impacts of individual and collective behaviour, and having a desire to have a role in ensuring on-going sustainable management of the marine environment", builds on initial concepts of ocean literacy. However, crucially, an awareness of responsibilities, a desire to be involved and the capacity to take appropriate action for meaningful participation, including knowing how to exercise these rights to participate, are integral components of the marine citizenship model and definition (McKinley and Fletcher, 2010).

In closing, it is therefore important to mention that the science promoted by both the Ocean Decade and Mission Starfish 2030 is very much linked with the concept of the new social contract for science (Lubchenco, 1998). This contract represents a commitment on the part of all scientists to devote their energies and talents to the most pressing problems of the day, in proportion to their importance. The next ten years will be crucial in terms of our society's capacity to reverse the trend in the decline of ocean health, and this will also be possible through the commitment of all the sectors to develop common initiatives that will deliver on the ambitious goals set by the United Nations and the European Commission.

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Climate change: Are we facing a global environmental pandemic?

Filippo Giorgi

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He is an international expert in climate modelling, climate change and impacts, biosphere-atmosphere interactions and chemistry-climate interactions. He has contributed to the first 5 reports of the Intergovernmental Panel on Climate Change (IPCC). From 2002 to 2008 he was one of the vice chairs of Working Group I of the IPCC, which won the 2007 Nobel Peace Prize.

The entire world has been confronted with the global COVID-19 pandemic since the beginning of 2020, a period during which the media attention has understandably focused almost exclusively on the pandemic. However, the climate change crisis has certainly not disappeared, and in fact is more topical than ever. The years 2019-2020 have been characterized by exceptional climatic anomalies, such as the heat wave in western and northern Europe during the summer of 2019 (Vautard et al. 2020), which also contributed to the unprecedented melting of Greenland ice (Sasgen et al. 2020), or one of the most active hurricane seasons of the last decades in 2020 (https://www.nhc.noaa.gov/data/tcr/). In fact, the year 2020 is one of the warmest on record.

There are several similarities between the COVID-19 pandemic and the climate change emergency. The trends of carbon dioxide concentration (Fig. 1), global temperature (Fig. 2) and sea level rise (Fig. 3) show an acceleration in the last decades, i.e. a higher than linear trend similar to that found in the early spread of the pandemic. Similarly, data from the Munich Reinsurance Company show a non-linear increase in the number of catastrophic events of meteoclimatic nature since the 1980s, with a doubling time of 20 years (~200 in the 1980s to almost 800 in 2018; Fig. 4). Another similarity is the global spread of these phenomena. Both the COVID-19 infection and the effects of global warming were first observed in selected areas, but rapidly expanded globally to all continents of the planet (IPCC 2014).

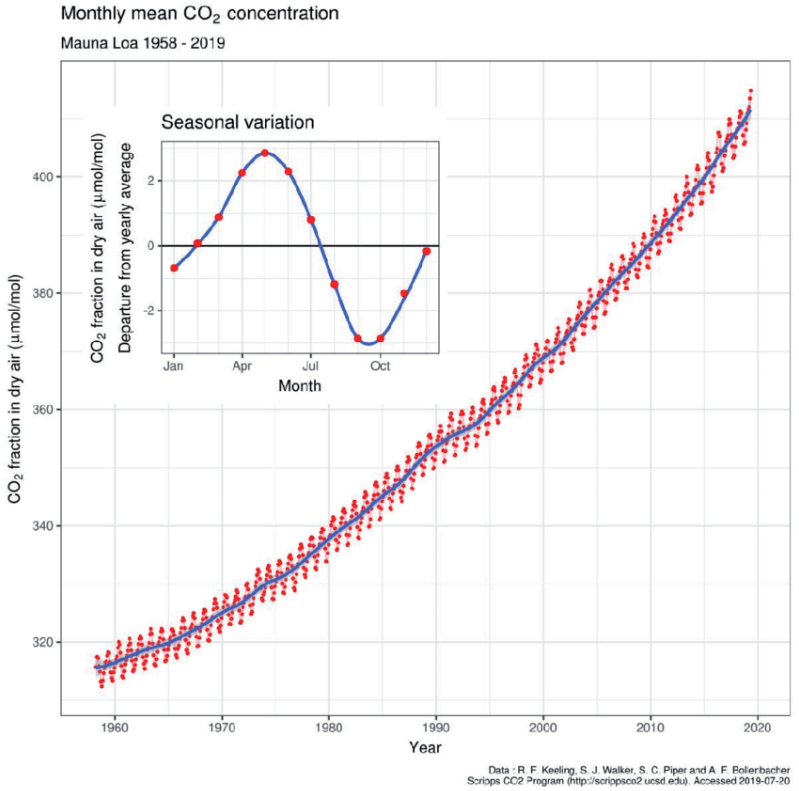

Fig. 1 - Carbon dioxide concentrations at Mauna Loa, Hawaii, from 1958 to 2019.

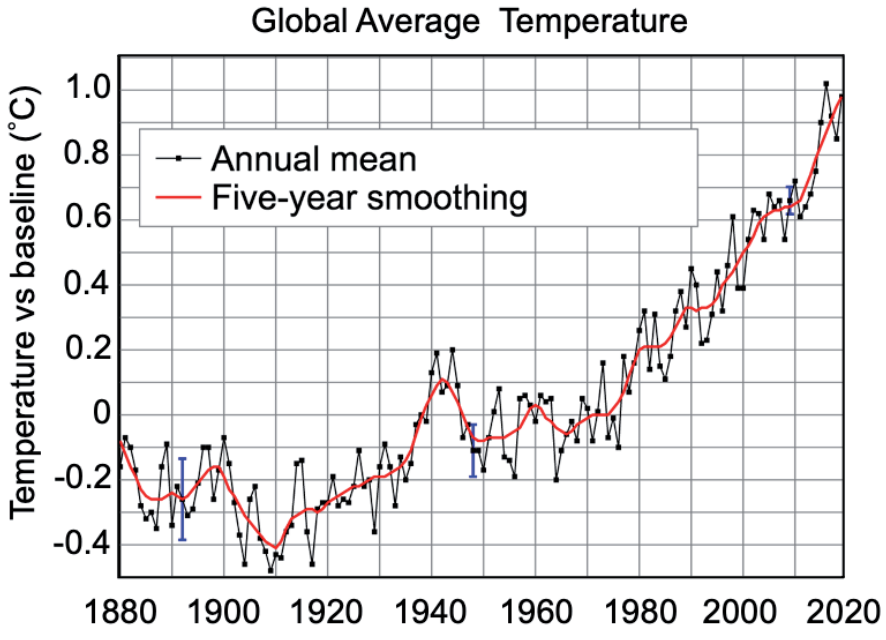

Fig. 2 - Global average temperature anomaly from 1880 to 2019 (data from NASA-GISS).

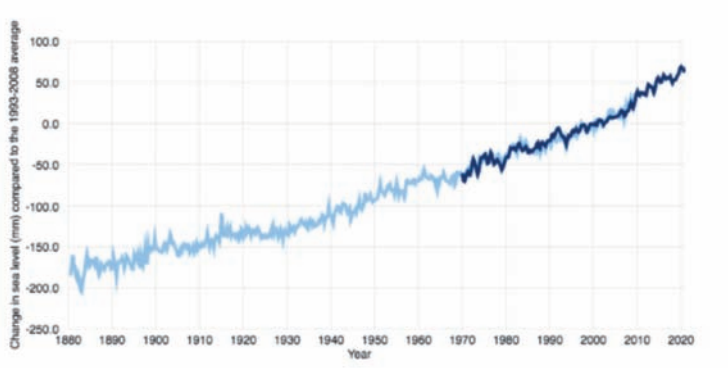

Fig. 3 - Global mean sea level change from 1900 to 2019 (data from NOAA).

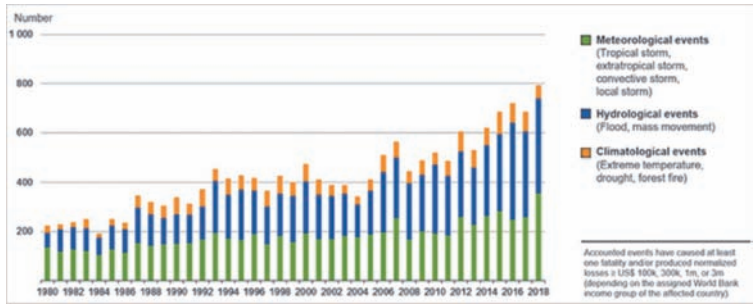

Fig. 4 - Total number of catastrophic events of a meteoclimatic nature from 1980 to 2018 (data from the Munich Reinsurance Company).

The presence of tipping points is another common characteristic of the two crises. In the pandemic, once the growth rate of infection exceeds given thresholds, it becomes essentially unstoppable without drastic measures. Similarly, some phenomena in the climate system show behaviour of a semi-irreversible nature when tipping points are reached. Among them, the scientific community has focused on the weakening and possible collapse of the thermohaline circulation which connects all oceans of the planet (e.g. Rahmstorf et al. 2015) and the melting of the Greenland ice sheet, which is actually proceeding at a faster pace than originally envisioned for reasons that are not yet entirely clear, and could lead to several metres of sea level rise (IPCC 2013). If the thermohaline circulation collapsed, or the Greenland ice sheet underwent considerable melting, the climate system would be affected in a fundamental manner, with huge and possibly devastating impacts on society (e.g. on coastal systems).

In addition, it is worth mentioning the issue of casualties. As of March 2021, about 2.6 million premature deaths have been associated with the COVID-pandemic, i.e. during the course of approximately one year. The study of Lelieveld et al. (2020) estimated that outdoor air pollution contributes every year to the premature death of up to 8.8 million people worldwide. Yet nobody calls air pollution a global pandemic. Extreme events related to climate change can also cause tens of thousands of deaths, such as the European heat waves of summer 2003 (Robine et al. 2008), and it is useful to recall that the conditions of the 2003 summer in Europe are projected to become normal by the end of the 21st century in high-end climate change scenarios (e.g. Giorgi and Lionello 2008).

Our planet is clearly under siege from a number of concomitant environmental stresses that are strongly interconnected: climate change; air and water pollution; deforestation; uncontrolled urbanization and land use change; soil degradation. All these stresses, if not adequately confronted, can indeed jeopardize the sustainable development of society as we know it. There are thus grounds to declare climate change, along with all other environmental stresses, including in particular pollution of the oceans, a Global Environmental Pandemic, which should therefore be treated as such.

But what have we learned from the COVID-19 pandemic that can help us address the climate change crisis? First and foremost, urgency of action. Probably, if some restrictive measures had been taken early on in the expansion of the pandemic, drastic measures such as extended national lockdowns could have been avoided or at least minimized. The same consideration is even more relevant for the climate change emergency. The main greenhouse gases, most noticeably carbon dioxide, have long atmospheric lifetimes, several decades and even more. This implies that what we do today will be felt by the climate system for a long time to come. In order to keep global warming below the danger threshold of 2^{o}C with respect to pre-industrial temperatures (therefore less than 1oC compared to present day temperatures), the Paris agreement of 2015 has set a trajectory which requires to severely reduce (~80%) greenhouse gas emissions by 2050 through a portfolio of mitigation policies, most noticeably the decarbonization of the energy system today based for the most part on the use of fossil fuels. However, although the time horizon for this objective is of a few decades, effective mitigation options need to be undertaken immediately and emissions need to be reduced through structural socioeconomic changes implemented from today.

The second lesson concerns international coordination and cooperation. In our globalized society, in order to eradicate the COVID-19 pandemic, it is not sufficient that some countries become COVID-19-free. This has to happen globally through a coordination in the implementation of pandemic resilience policies and through cooperative efforts aimed at sustaining in particular the more vulnerable countries. Similarly, climate change is a global issue with no borders. Because of their long atmospheric lifetime, greenhouse gases become well mixed throughout the atmosphere, and the non-linear nature of the climate system is such that phenomena in one part of the globe have teleconnection effects in remote regions. No one is thus isolated from the effects of climate change, and everybody contributes to it through the emission of greenhouse gases. Therefore, the solution of the climate change crisis has to be global and based on international coordination and cooperation, with particular attention to the most vulnerable regions.

The role of science and clear and effective communication is central to both the COVID-19 and climate change crises. In both cases, science has been able to identify causes and possible solutions to the problems. But communication has not always been effective, and the scientific community has to be aware of this. Confusion generated by fake news and voices from individual scientists outside the main and more accredited research streams, along with excessively technical jargon, has often confused the public opinion and in some instances delayed action. On the one hand, society has to trust science, a trust that in the past has led to tremendous successes, such as the development of vaccines for a number of illnesses or the phase-out of the use of chemical compounds responsible for the depletion of the stratospheric ozone layer that protects life from dangerous ultraviolet radiation. On the other hand, science has to be responsive to the needs and requests of society and has to improve the clarity of scientific communication

to a broad and not specialized audience. Only in this way can society and the realms of science interact effectively.

Finally, the COVID-19 pandemic taught us that personal commitment is paramount for a successful implementation of national and international regulations, which are clearly not effective if they are not sustained by the behaviour of individuals. In the response to the climate change challenge, cultural changes in personal behaviour, for example the reduction of waste of energy, food and water or the recycling and re-use of materials, have to support the implementation of greenhouse gas emission reduction policies.

During the 21st century, our generation and the next ones will be confronted with multiple environmental challenges, from climate change to pollution of the atmosphere and oceans. This contribution has highlighted similarities between these environmental challenges and the COVID-19 pandemic, similarities that can help us in designing and implementing possible solutions. However, there is a final aspect of the interaction between society and the environment that the pandemic has evidenced. During the time of lockdowns, when our societies were dramatically hit from both the socioeconomic and psychological points of view, the environment probably experienced its best condition in the last 70 years, with clean air and waters even in the most polluted regions of the world and strongly reduced greenhouse gas emissions. This implies that human societies have totally lost synch with the rest of the planet: when one suffers, the other benefits, and vice versa.

Clearly, this situation is not sustainable. Humans have to consider themselves as an integral component of the Earth system and not as external to it. Interestingly, we can see this situation also in climate modelling, for which the so-called human factors (e.g. greenhouse gas emissions or land-use change) are generally considered as "external forcings" to the modelled climate systems. A cultural shift is needed to place humans back into the Earth system and realize that the sustainable development of society has to go hand in hand with the well-being of the environment, because the two are intimately connected and interdependent. This is possible today with available technologies, the so-called "green economy", which can sustain also the development of emerging and poorer countries. It is thus a matter of choice, a choice that needs to be made to preserve a healthy environment for the generations to come.

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Implementing Starfish 2030: the role of Technology Clusters

Roberto Cimino

Roberto Cimino is chairman of the Technology Cluster Blue Italian Growth since 2018, he has spent more than 30 years in the energy Industry in several managerial roles in the research and innovation sector, where he is responsible for Innovation Ecosystems & Partnerships. He contributed to the development and transfer of several technologies in the areas of marine robotics, hydrogen production, natural gas conversion to liquid fuels as technical manager, project manager and project director. Member of the Advisory Board of European Funded projects in the area of Blue Economy and of EMBA Ticinensis (University of Pavia)

1. Mission Starfish 2030: the challenges ahead

How to translate grand strategies into workable actions is a problem that any complex organization faces when the strategic level has to be connected with the operational one, and concrete results are expected to fulfil the strategic declarations (R.D. Kaplan, D.P. Norton, 1992).

This is why a mission-oriented approach has been devised and adopted by the new Horizon Europe Program.

Grand challenges, characterized by complexity, interconnected nature of the underlying problems and urgency, are better addressed by setting objectives and intermediate targets, which allow both the measurement of progress and the involvement of the innovation ecosystems to provide, in a bottom-up approach, ideas, technical solutions and projects (M. Mazzucato, 2017).

Mission Starfish 2030 has been set up precisely to translate the strategic level (Restore our Oceans and Waters) into 5 interconnected objectives and 17 targets for the Mission, which should allow an easier alignment of actors, the progress tracking of the initiatives and the achievement of the desired results. The 5 objectives (filling the knowledge and emotional gap, regenerating marine and water ecosystems, zero pollution, decarbonizing our oceans, revamping governance) are interconnected, and so are the 17 targets: for example, target 11 (climate-neutral waterborne transport) is related both to target 15 (climate-neutral blue tourism) and 10 (underwater noise), since all three targets share the issue of reducing the impact of shipping and port infrastructures.

Another example is given by the interdependence between target 6 (end overfishing) and 13 (Zero-carbon aquaculture), since in a world that is facing a continuous increase in population, the issue of ending overfishing and protecting the natural capital is not decoupled from the problem of providing, in a sustainable way, adequate quantities of high-value proteins to the population.

The most relevant challenge, however, lies ahead and relates to the execution phase of the Mission: important objectives and credible targets have been set but, given the complexity of the challenge, there is the urgent need for an innovative and creating approach in soliciting novel ideas, setting up effective and high-quality project partnerships and - above all - involving firms in the problem-solving activity, which is the core part of innovation.

The European Green Deal, the master plan for the ambitious transformation of the European industrial and production systems, calls for the marriage of environmental protection with job and novel industry creation: the involvement of firms and the promotion of entirely new sectors is therefore crucial.

Connecting academia and research centres with firms, with a special focus on the vital sector of the SMEs, and stimulating innovative entrepreneurship for as much as value creation and sustainment is concerned, is what Technology Clusters are expected to do.

2. The role of Technology Clusters

Technology and Industrial Clusters are an important part of the European Industrial Policy: there are more than 3000 specialized clusters in Europe, often showing resilience in economic downturns due to the value-added created by the facilitation of cross-sectoral exchange of practices and ideas (European Commission, 2021).

Besides, Clusters can provide excellent opportunities for the reskilling and upskilling of people and can contribute to the economy of the regions where they operate.

Technology Clusters, in particular, have the advantage of gathering academia/research centres and firms, with a particular focus on SMEs, and can therefore accelerate both technology transfer and the scale-up and internationalization of SMEs.

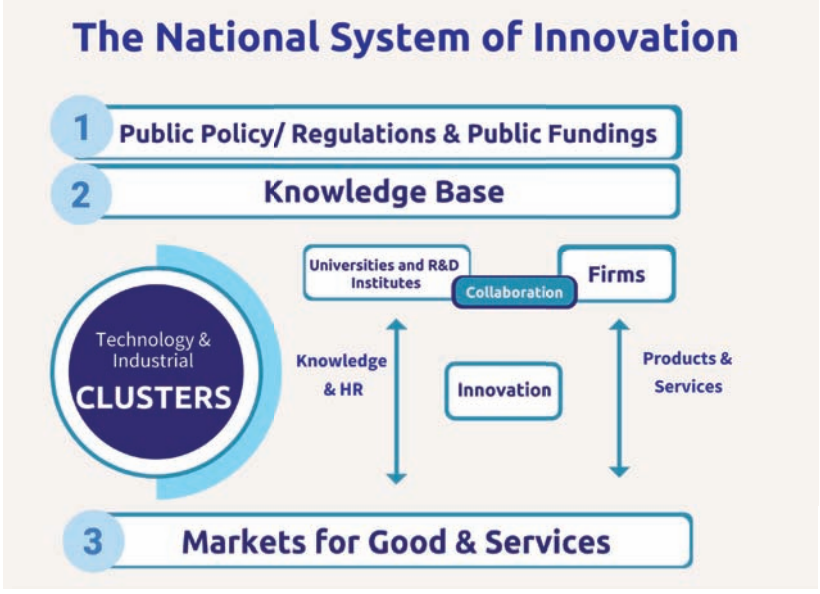

Fig. 1 - The role of technology and industrial Clusters in the National System of Innovation (adapted from M. Mazzucato, 2017).

They are therefore an essential enabler of the National System of Innovation (Mazzucato, 2017) by connecting the major actors of innovation and accelerating the transfer from the knowledge base to the markets (Fig. 1).

The portfolio of services that the excellent Clusters offer (T. Lämmer-Gamp et al., 2014) include scouting for opportunities, matchmaking among partners, acceleration of the idea-to-project and technology transfer phases, funding and reaching out to different sectors.

Their main focus lies with connecting firms of different sectors, academia/research centres and firms, and with facilitating the involvement and growth of SMEs, also by fostering their internationalization.

The importance of the involvement of firms and SMEs, especially in green and blue transformation projects, cannot be overstated: on the one hand, firms can provide the operational arm of the projects by speeding up the deployment and adoption phases and, on the other hand, their learning-by-doing during the execution phase can accelerate the transformation of their current business model, sometimes based on unsustainable practices, facilitating the sought-after transformation of our industrial and productive systems towards the green transition (Fig. 2).

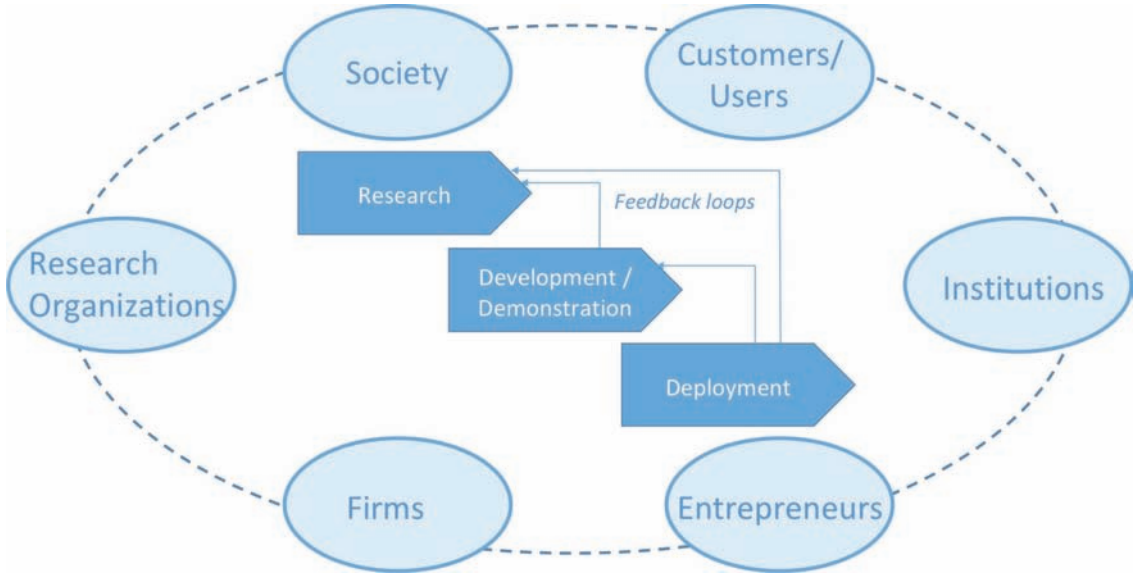

Fig. 2 - The Technology Transfer Ecosystems (adapted from «Energy Technology Perspectives 2015», International Energy Agency).

3. The strategic plan of Technology Cluster Blue Italian Growth

The Technology Cluster Blue Italian Growth (TC BIG) was established in 2018 and is supported and co-financed by the Italian Ministry of Research (MUR): it gathers, as of today, 85 members including all major national actors active in the space of the Blue Economy Research & Innovation: universities, research organizations, large firms, SMEs, category associations.

Its governance also includes 11 Italian regions, which guarantee the necessary connection with the local territories.

The Mission statement of TC BIG envisages the creation of a national community in the context of the blue marine economy to promote an innovation-driven blue growth while preserving natural capital and fuelling private-public research partnerships.

The major activities of TC BIG focus on the preparation of technology roadmaps and scenarios, the support to policy-makers, the promotion of partnerships between academia and firms, the scale-up and internationalization of SMEs and the fostering of projects.

The Strategic Plan of the TC BIG is perfectly aligned with the objectives and targets of Mission Starfish and has been prepared by outlining six vertical technology trajectories and three cross-cutting areas (Fig. 3).

The six vertical technology trajectories include:

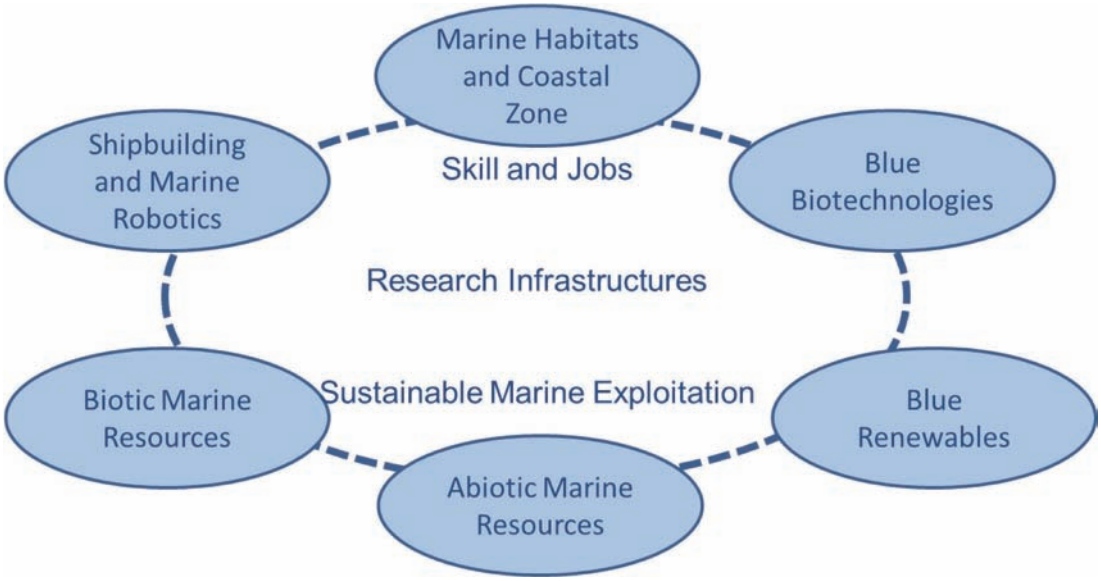

Fig. 3 - TC BIG's technological trajectories and cross-cutting areas.

MARINE HABITAT & COASTAL ZONE: focusing the development of ocean observing systems adapted to the reality of the Mediterranean, with particular reference to coastal & intertidal zones/sandy & rocky shores; of particular importance for this trajectory is the area of digitization, concerning the integration of sensor webs and artificial intelligence technologies. The general goal is the development of quantitative models for describing good environmental status (GES) through KPIs, environmental certification systems applied to marine environments.

BIOTIC MARINE RESOURCES: dedicated to innovation in fisheries and aquaculture. The major themes include ICT for food safety and monitoring of fishing activities, digital technologies for monitoring smart management of aquaculture plants, new sustainable feeds for aquaculture, multi-trophic aquaculture, conversion of waste from fisheries to a high-value product, integration of aquaculture plants into multi-use platforms. Also, marine ecological restoration is of key importance for this trajectory.

ABIOTIC MARINE RESOURCES: aimed at the development of innovative modular offshore platforms for the colocation of diverse technologies (renewables, aquaculture, hydrogen production, seawater desalination: multi-use platforms); it focuses also on the reuse of end-of-life offshore platforms (marine research labs, CO2 underground storage, renewables, aquaculture).

SHIPBUILDING & MARINE ROBOTICS: including the study of fuel-efficient, low environmental impact, safer and autonomous ships; submarine autonomous vehicles for monitoring and operations and the technologies for the reduction of the environmental impact of ports and harbours.

BLUE RENEWABLES: the trajectory deals with the development of low-cost marine renewables taking into account the whole life cycle; exploitation of tidal and wave energy applied to higher-energy cost geographical areas (such as islands); integration of renewable power production and desalination technologies.

BLUE BIOTECHNOLOGIES: remediation of contaminated soils and seabeds through biotechnologies; production of novel pharmaceutical compounds from marine bioactive molecules nano-bio technologies and biomaterials; energy from micro-algae and conversion of fisheries waste to high-value product.

Also, the TC BIG strategic plan includes three cross-cutting areas:

RESEARCH INFRASTRUCTURES: promoting integration and synergies among labs and infrastructures devoted to Blue Economy innovation.

SUSTAINABILITY AND ECONOMIC USES OF THE SEA: aiming at defining guidelines for the development of analytical models of the environmental and socio-economic aspects related to the use of the marine-coastal zones.

SKILLS & JOBS: devoted to the design of innovative training paths in Blue Economy, including the themes of re-skilling and up-skilling, by involving all the actors interested in both training and education.

Finally, to fully capture the potential of its network of academia, research centres and firms, TC BIG has recently launched the initiative “Blue and Green Resilient Recovery”, devised also to offer a blue contribution to the Next Generation EU initiative, via a challenge for ideas among BIG associates which has led to the crafting of a Blue and Green Project Portfolio, aimed at developing initiatives and technologies that are readily deployable, highly innovative and in line with the protection and recovery of natural capital.

4. Conclusions

Mission Starfish 2030 is an important step towards the protection and restoration of our oceans and waters, setting objectives and concrete targets in line with the philosophy of the mission-oriented-innovation approach.

The challenge lies now in the implementation of the Mission and the achievement of the desired targets within the given timeframe: urgency is understandably a top priority.

From this point of view, the industrial world, with its ability to deliver concrete results by effectively managing the execution phases can be a crucial ally: technology and industrial clusters are a key tool to favour partnerships between academia and firms, foster the creation of new enterprises and stimulate the creation of entirely new sectors, in line with the priority of our times, that is transforming our productive and industrial systems sustainably while creating value and job opportunities to the society.

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We are on a Planet with an Ocean

Enrico Bonatti

After his studies at Pisa University - Scuola Normale Superiore, Enrico Bonatti worked at the Universities of Yale, California (Scripps Institute of Oceanography), Miami, Columbia (Lamont Doherty Earth Observatory), plus Pisa, Rome and the CNR. He has led expeditions in the Pacific, Atlantic and Indian Oceans, the Red Sea and the Mediterranean. He has dived several times down to almost 6000 metres.

1. Background

The Planet we happen to inhabit is the only one in the Solar System that orbits the Sun within the so-called "Habitable Zone" (Fig. 1), that is, a zone blessed by a range of temperatures that permits liquid water. Were we a little closer to the Sun, we would end up with surface temperatures close to those of Venus (about 400°C); a little farther, and we would be stuck with below freezing temperatures, as on Mars. Liquid water means life is possible on Earth. It also means that two thirds of the surface of our Planet are covered with oceans and seas. The oceans probably formed early in our history, when our primordial dense atmosphere of CO_2, H_2O, CH_4 and NH_3 started to cool; H_2O condensed and rained in a deluge stronger than the Biblical one.

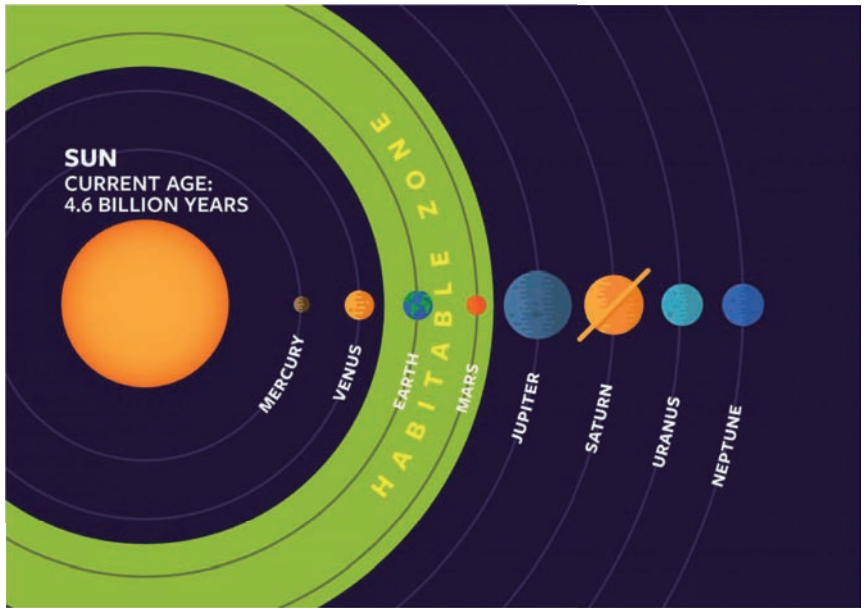


Fig. 1 - Present and future "Habitable Zone" in the Solar system (source PhysOrg, Cornell University: https://phys.org/news/2016-05-hidden-life-worlds-orbiting-red.html)

When over 4 billion years later we humans appeared on the scene, we gradually managed to become adapted to our environment. How did we adapt to the overwhelming presence of the seas? Considering our western tradition, it looks as if our Greek and Roman ancestors were rather frightened by that large expanse of salt water. They proclaimed Poseidon God not only of the sea, but also of earthquakes; both considered equally frightening. In the Bible, among the predictions of a new happy era at the end of the Apocalypse, there was the wish that the sea would disappear. With the Renaissance and Illuminism, our attitude towards the sea gradually changed: less fear, more curiosity. An example is provided by Julian Gottfried Herder (Fig. 2), a prominent philosopher of German Illuminism, member of Goethe's circle. Herder narrated how in 1770 he took off in a small vessel from Riga in the North Sea.

Fig. 2 - Gottfried Herder (1744- 1803), German Illuministic philosopher.

His destination was Nantes in northern France. He was planning then to reach Paris, to learn first-hand about French Illuminism. In an account of his trip, he described how they barely survived a frightening storm in the North Sea; he then recorded this meditation:

> "*…sitting below the mast of the ship in the wide ocean, to be able to "meditate" on the sky, the sun, the stars, the moon currents, fishes, sea floor….and attempting to discover the physics of it all…the seafloor is a new land…! Who knows it? Which Columbus and Galileo is able to discover it? Which new underwater investigation, which new eyeglasses for this immensity must be invented?"*

Two centuries later, Herder's fantasies almost came true. The British launched in 1872-1876 a major oceanographic expedition with the vessel *Challenger*. The sinking of the Titanic in 1912 and submarine warfare during the First World War stimulated the development of acoustic methods to measure sea floor depth. Echosounding was

then used by the German vessel Meteor in the nineteen twenties to explore the topography of the Atlantic. After the Second World War, the systematic scientific exploration of the ocean floor was launched by several academic Institutions in United States and Europe. One example is the legendary small ship *Vema* (Fig. 3) of Columbia University's Lamont Geological Observatory, that for nearly twenty years kept roaming around the oceans collecting acoustic bathymetry and sub-bottom seismic reflection, as well as magnetometric and heat flow data, plus systematically sampling ocean floor sediments and hard rocks. Many of these new data caused surprise in the science community, particularly in the US, where most Earth scientist were resting comfortably within the "fixist" concept of a Planet slowly cooling and shrinking, with a fixed distribution of the continents, and with ancient and stable ocean basins.

Fig. 3 - Oceanographic ships (top to bottom) Bannock (1970), Vema (1970), Urania (2015), and OGS-Explora (2015).

Wegener's *Continental Drift* theory was nothing but an annoying shriek from across the Atlantic. Among the surprising new results, the discovery that heat flow from the ocean floor, particularly close to mid-ocean ridges, is higher than in the continents (Fig. 4) was unexpected, given the higher concentration on the continental crust of heat-producing radioactive elements K, U and Th. The new results triggered within the scientific community endless debates, depressions, conversions, elation, dreams of glory, etc. Things gradually became stable in the late Sixties of last century, with the wide acceptance first of the hypothesis of seafloor spreading and then of the theory of *Plate Tectonics*.

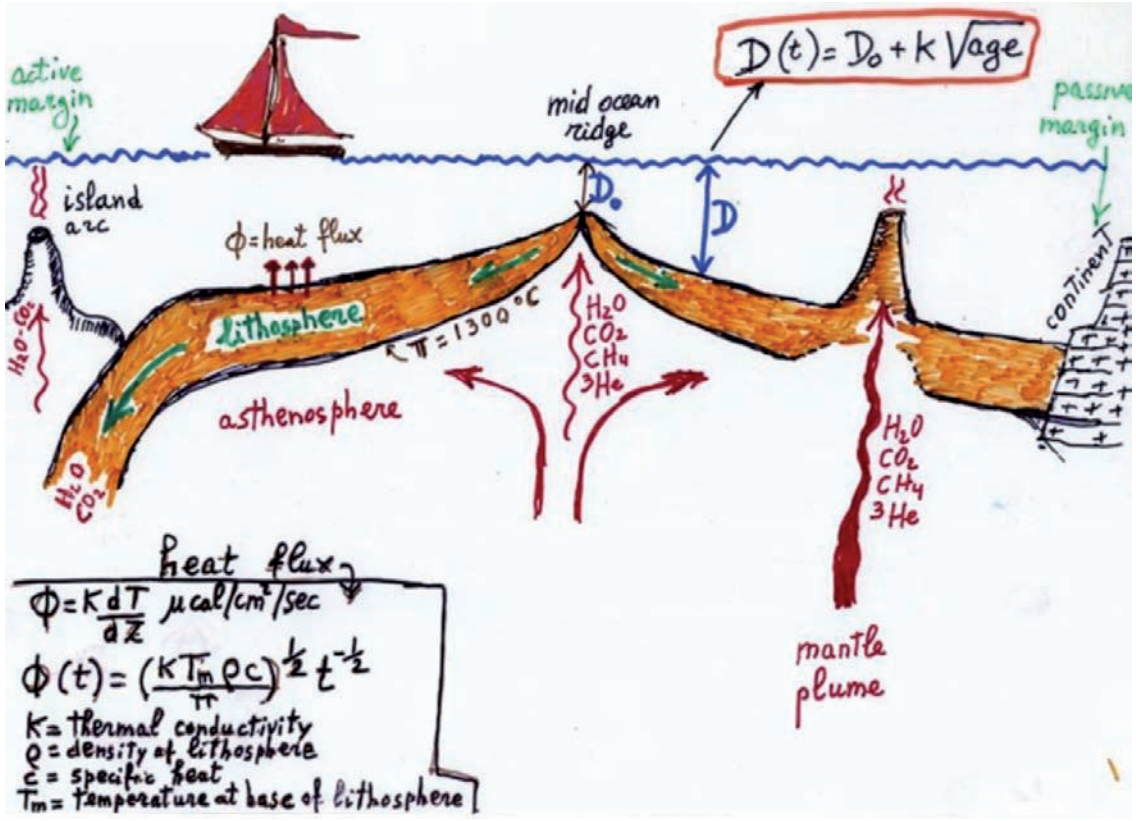


Fig. 4 - Heat flow measured in the ocean floor versus age of the oceanic crust.

2. Italian Research at Sea

Italy's participation in the scientific revolution mentioned above and, more in general, her contribution to marine research in the last half century has been rather marginal. What are the reasons, given that Italy extends into the Mediterranean with a coastline of over 7900 km, and, in addition, it prides itself in being a country not only of saints and poets, but also of navigators? I have only tentative, partial answers.

One reason may lie in the fact that scientific research, and in particular basic research, has generally been poorly funded by Italian governments since the last World War to the present. Physics has been an exception, due to the strong traditions and tight international links of Italian physicists. Endless debates and plenty of petitions, papers, books, etc., have appeared on this subject, down to recent appeals (February 2021) published by Italian newspapers. Not much has been achieved: support for science in Italy has never been much above ~1% of the State budget, significantly less than the Europe average. The Earth Sciences, including Marine Science, have received a small fraction of that already small budget.

Another reason is that research in marine sciences has been distributed in several small centres throughout the Peninsula (Fig. 5).

Fig. 5 - Centres of Marine Sciences distributed in Italy.

Traditionally, marine sciences have been pursued by the *CNR*, by several Universities, and by two institutes, the OGS (*Osservatiorio Geofisico Sperimentale*) in Trieste, and the *Anton Dhorn Zoological Station* in Naples. Within the *CNR*, we had centres of Marine Science scattered in various locations (Venice, Bologna, Genoa, Lerici, Ancona, Lesina, Rome, Naples, Mazara del Vallo, etc.). This tendency to keep many small separate research centres in the same discipline was perhaps due to satisfying local "requests" more than to increasing the level of the discipline. For instance, the *CNR* had developed in Bologna in the Sixties a good centre of Marine Geology under the leadership of *Raimondo Selli*. When new funds became available, the *CNR*, rather than strengthen the existing Bologna Lab to a level where it could compete on the European scene, chose to create a new small centre of Marine Geology in Naples. Italy lacked a centre to coordinate the activities of the various micro-centres, to manage large research projects, etc. Nothing like France, with a large centre of oceanography (*CNEXO*), that apparently was inspired by Charles De Gaulle in person in the Sixties, with a fleet of modern research ships, submersibles, etc.

Another problem has been with research ships. Many (but not all!) marine geologists dream of a situation such as that shown in Fig. 6, that is, an ocean where water has been eliminated. But in the real world the oceans contain water, which means that to study the oceans one needs ships.

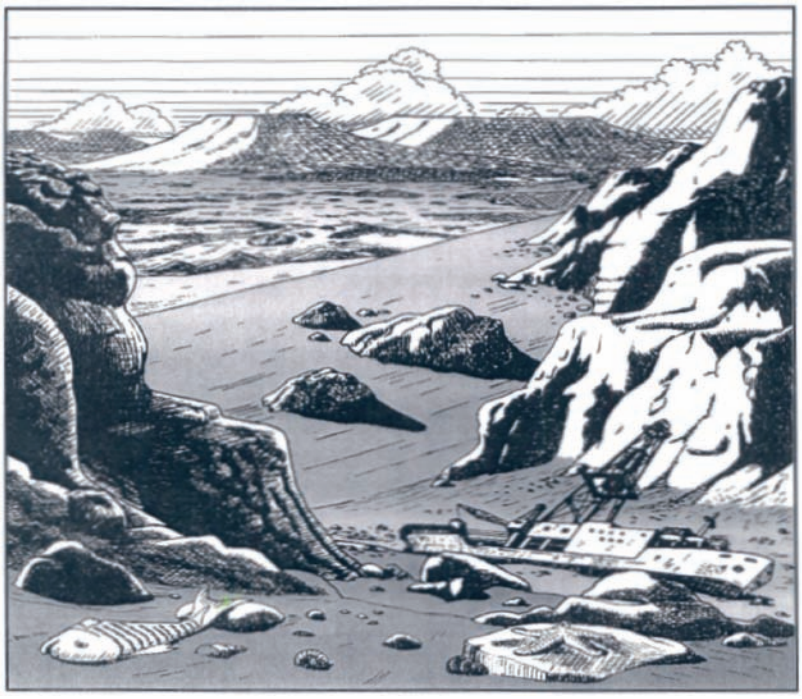


Fig. 6 - The ocean where water has been eliminated.

In the Sixties, the US Navy donated to Italy an ancient Second World War military tugboat, the Bannock (Figure 3). So, finally Italy could boast of possessing an oceanographic research ship that in fact did its honest work for nearly two decades, mostly in the seas surrounding the Peninsula.

Figure 7 displays a rough graph where the cumulative length of oceanographic ships longer than 50 m is shown for a few European countries. The data refer to the year 2010.

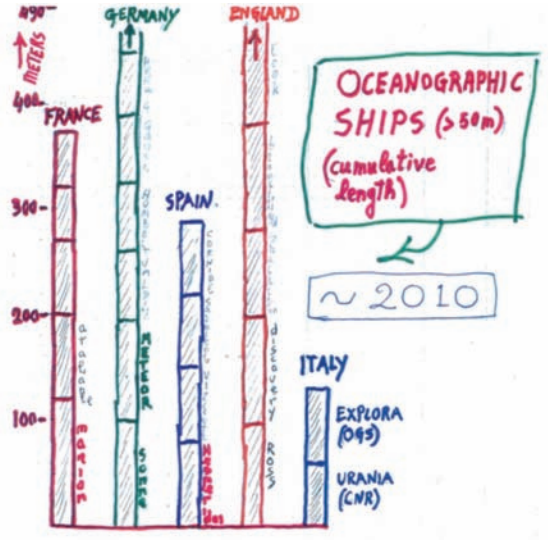


Fig. 7 - Cumulative length of oceanographic ships longer than 50 m for a few European countries (year 2010).

The gap between Italy and the other European countries is obvious. At that time Italy had two >50 m research vessels, the *OGS-Explora* of Trieste's *OGS* and the Urania of *CNR*. Urania was a relatively multipurpose vessel that could operate comfortably in the Mediterranean and Red Sea but not in the oceans. So, the CNR made sure that the recommendation of the Greek poet Pindar, not to sail beyond the "Pillars of Hercules", would be followed by its own marine scientists.

OGS-Explora was a ship specialized in seismic reflection profiling employed by *OGS* mostly for commercial works and to carry people and equipment to Antarctica within the PNRA, i.e. the Italian Research initiative in Antarctica. There were some attempts to coordinate the activities of the two vessels and to build some cooperation between *CNR* and *OGS*, without great success. In addition, the University system operated for a while a small ship, the "Universitatis". Note the contrast with US oceanography, where the main funding Agency (*NSF* or National Science Foundation) imposed a tight coordination/cooperation among the twenty or so major research ships of various Institutions within a public system called *University National Oceanographic Laboratory* System (*UNOLS*).

But Italy never had an independent public Agency (such as the *NSF* in the US and similar organizations in European and Asiatic countries) to evaluate, select and eventually support projects of fundamental research submitted by members of the scientific community.

Going back to the Italian research fleet, the situation has changed since that shown in Figure 7. *Urania* is gone, due a sad unfortunate incident, and the *OGS-Explora* has been replaced with an icebreaker, reflecting *OGS* interests in the Polar regions. The *CNR* has followed: a Polar Institute has just been created within *CNR*, drawing people, spaces and resources from Marine Sciences. It follows that Italy, although it extends in the warm ice-free Mediterranean, now operates a fleet of one single research ship consisting of an icebreaker. The interest of Italian oceanographers in the Polar regions is commendable, as long as it does not take away too much from other branches of Marine studies, and stays away from the "rape" of the Arctic threatened by some countries (drilling for oil, etc.).

In the late ninety-eighties, the collapse of the Soviet Union came to the aid of Italian marine geologists. The Russian fleet of oceanographic vessels had to be grounded due to their grim economic situation. A team of CNR marine geologists managed to obtain at a very low cost the use of one of their ships (*R/V Academic Strakhov*) starting a collaboration that went on for two decades, with several expeditions to the Mid-Atlantic and SW-Indian ridges. It so happened that the first high-resolution map of the Tyrrhenian Sea, right at the core of "*Mare Nostrum*", was obtained with a Russian ship (Fig. 8).

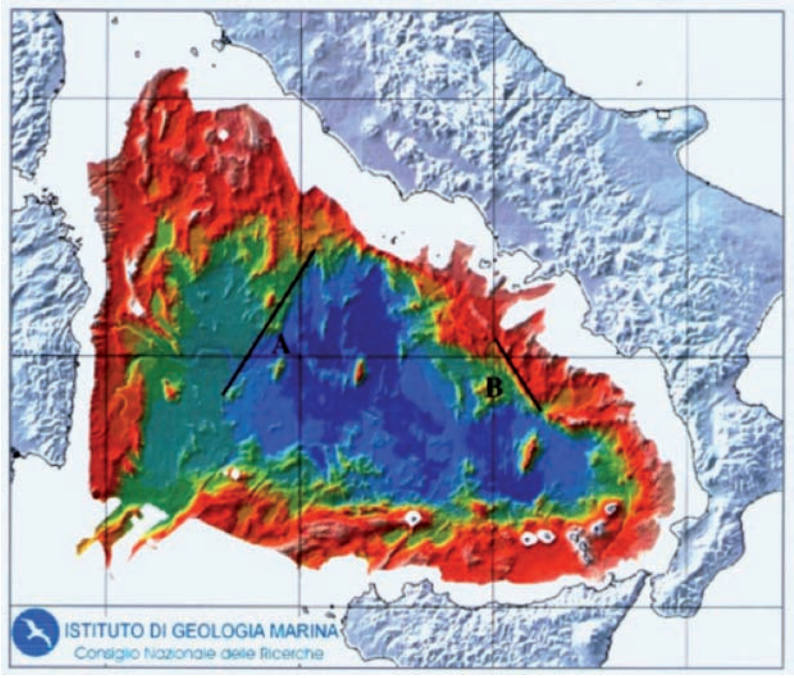


Fig. 8 - High-resolution morphobathymetry of the Tyrrhenian Sea obtained by a multibeam echosounder survey carried out in the 90s by the R/V Akademik Strakhov of the Russian Academy of Science.

3. Concluding Remarks

As already said, humans have faced the sea at first with fear and hostility. Let's quote Horace's odes:

> "*Nequiam deus abscidit prudens oceano dissociabili terras, si tamen inpiae non tangenda rates transiliunt vada…"* ("Vain was the purpose of God in separating lands from the estranging ocean, if in spite of Him our impious ships dash across depths that should never be touched")
> *"O navis, referent in mare te novi fluctus. O quid agis? Fortiter occupa portum.* (O ship, new waves are carrying you out to sea. What are you doing? Struggle to reach the port..")

Then gradually, although fear remained, hostility subsided somewhat, giving rise to cautious curiosity. The meditations of Herder, cited earlier, provide an example of this attitude. But then curiosity joined with the desire to dominate and exploit, limited not just to the sea, but to the entire Earth.

Let's hope that, thanks to initiatives such as the *Starfish Mission*, our greed will subside. Let's then sail up to the Arctic to observe, to study, to contemplate……Let's not sail to the Arctic to drill….!

Acknowledgements. I am grateful to Luca Gasperini and Diego Gasperini for help in putting this paper together.

Chapter 2.

Knowledge and emotions

Credit: OGS photographic archive

What Italian citizens think

Maria Cristina Pedicchio and Maurizio Pessato

Maria Cristina Pedicchio is full professor of Algebra at the University of Trieste. She has great experience in managing public and private Research Institutions. She has been (2011-2019) President of the National Institute of Oceanography and Experimental Geophysics (OGS). She is a member of the European Board of experts for the Starfish 2030 Mission.

Maurizio Pessato is vice-president of SWG SpA. He has directed various research sectors on socio-economic organizations and on public opinion attitudes. He manages the Observatory on social and cultural values of Italian citizens

1. Introduction

"Every European citizen must become a citizen of our ocean and waters". This is one of the objectives of the Starfish Mission: engaging, inspiring and motivating citizens to fully appreciate our ocean and waters as a common good and a natural capital to be preserved.

Protecting the ocean is a vital necessity for future generations, but we will not be able to carry out, by 2030, all the actions necessary to know, protect and restore maritime and land waters if this is not shared by all. A collective effort is the only key for success.

To be able to achieve this objective we must first understand better what citizens know or, think they know, about seas and water and ask them what they would propose if they had the power to decide on the national "blue" priorities.

To develop a strategy that is co-designed and co-implemented by citizens, as the European Commission is asking all Member States, we must listen to them.

For this reason, OGS and SWG developed a joint project to involve a large community of citizens and ask them how they value the ocean and waters. A questionnaire was prepared with the support of scientists and communication experts and it was submitted to 1,500 Italian people.

The project produced an extensive survey on the knowledge and assessments of Italians on the sea and the protection of the environment, by describing the level of closeness and sharing that exists between public opinion and these issues.

The work consists of six areas with 49 questions in total, framing the set of aspects related to the following main issues:

- the importance of the oceans
- threats to the health of the sea
- the defence of the sea
- the economy of the sea

- research on the sea (in Italy and in Europe)
- after Covid-19.

The overall analysis that emerges from the study indicates a widespread propensity to consider the validity of the protection of the sea, water and the environment in general. It also indicates a rather general interest for these topics from public opinion and an increased attention to the environment due to the Covid-19 general context.

The sea is certainly a reality that is part of our life. Its knowledge does not concern everyone, but the consideration of its importance is vast and also includes those who do not live near the sea. It is recognized as a source of many resources and the need for its protection appears to be of great importance.

These are general premises. In the following, going into some of the answers that we consider of main interest, we report specific questions and resulting data as presented in the survey.

2. Some data

Public opinion recognizes the importance of the sea and reports that it is familiar with its fundamental elements. The answers given reveal that:

- about half of the population declares a good knowledge of the sea;
- the relationship between sea and land is correctly indicated by about 2/3 of the citizens;
- knowledge of the seabed is recognized as limited by 3/4 of the sample (the surface of Mars is better known than the seabed!) (Fig. 1);
- almost all citizens believe they can recognize a polluted sea. The proof that is shared by the majority is the absence of forms of life;
- the Marine Strategy Framework Directive is not known and neither is the division of the European seas into regions and sub-regions; a figure in line with what was expected, given the particular nature of the theme;
- as far as the quantities of oxygen and food produced by the sea are concerned, the answer is distributed on the middle range of the proposed scale;
- the knowledge that the sea is a source of various non-biological resources is very wide.

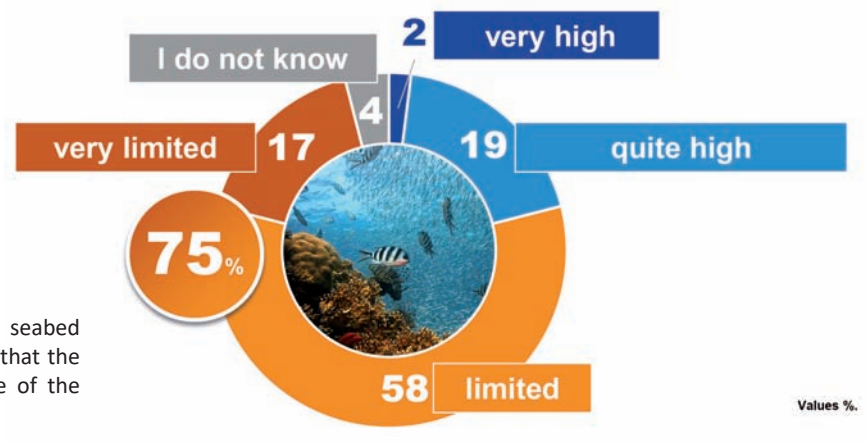


Fig. 1 - Knowledge of the seabed is limited. Q: Do you think that the current level of knowledge of the seabed is…

The importance of the sea and the need for its protection within the environment appears to be of great importance. The verification of threats to sea health is a basic element to anchor the relationship between public opinion and the sea.

- The vast majority of people believe that the health of the sea is already at risk (8 out of 10);
- attention to pollution is high (Fig. 2). The phenomena that have an impact on sea pollution are many: plastics and chemical compounds are the ones that most affect the public imagination. Less well known are the effects of alien species, viruses and bacteria, and the noise caused by humans;
- the condition of rivers and lakes is seen by many as worse than that of the seas.

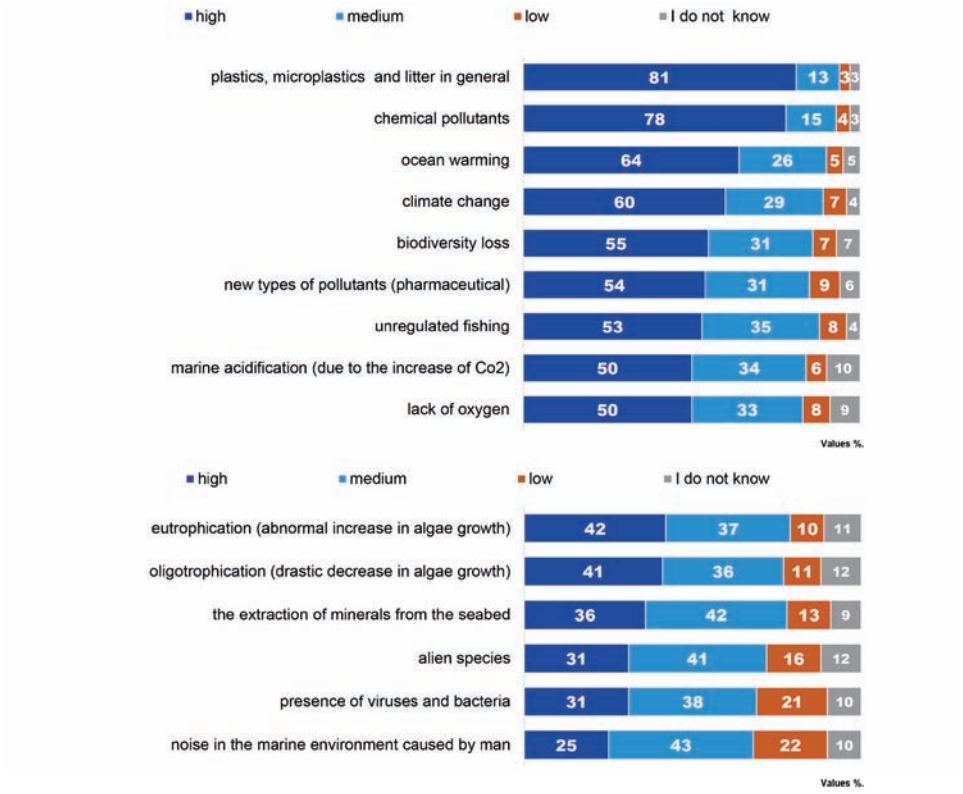


Fig. 2 - Pollution of the sea. Q: In your opinion, what impact do the following phenomena have on sea pollution?

We can conclude that there is a full awareness among public opinion that the gravity of the situation results from a multiplicity of factors. This is because all the waters are in precarious conditions.

This sensitivity also reflects the intensification, in recent years, of the promotion of international actions to protect the environment, the oceans and seas through scientific research, institutional initiatives and personal behaviour.

The reactions of citizens to these new scenarios are the following:

- the vast majority thinks that there is an urgent need to act for the protection of the sea; in particular, it is acknowledged that sea protection is a fundamental component for the equilibrium of the planet;

- in relation to the use and protection of the sea there is a broad consensus for decisions taken by international organizations;
- as far as the coastal sea is concerned, however, there is a preference for national and regional institutions;
- aquaculture is seen more as a resource than a threat;
- there is a high consensus on the extension of actual marine protected areas.

Concerning the economic aspects, the theme of blue economy and development are considered to be strategic, in particular, for the repercussions they can have on the labour market in this difficult moment. It is interesting to observe what citizens say:

- expectations are good for the potential of the sea economy, also in terms of blue jobs (Fig. 3). The sectors that are mainly identified are tourism and fishing. They are the ones that are most striking as they are more generally highlighted;
- there is a broad consensus on support for economic development linked to the sea (Fig. 3), but with some stringent conditions like clear rules for the protection of the environment and biodiversity and for the sustainability of the approach;
- from an institutional point of view there is support from over half of public opinion for the creation of a Ministry of the Sea (Fig. 4);
- the launch of a European Ocean Agency is favourably viewed (Fig. 5). Probably the theme of coordination, already noted above with the role of international bodies, is seen positively.

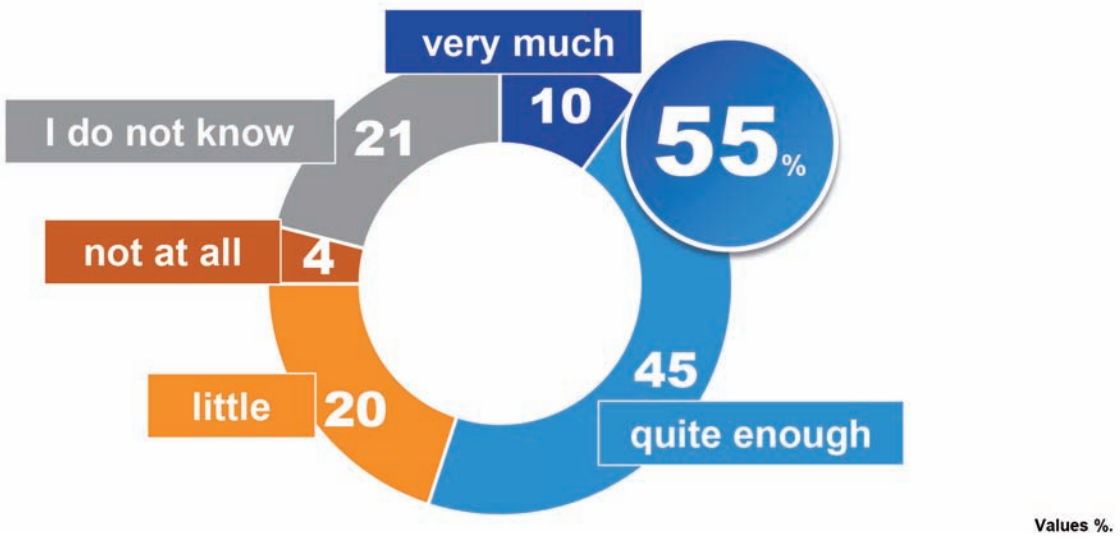


Fig. 3 - The sea could create a significant economic and employment impact. Q: Some say that the economy linked to the sea is growing rapidly and could create many new jobs. Do you agree with this statement?

The combination that citizens make between support for economic development linked to the sea, and the constraints they pose for its implementation appears to be of particular importance. It is an indication that stems from the growth in environmental sensitivity that has occurred in recent years.

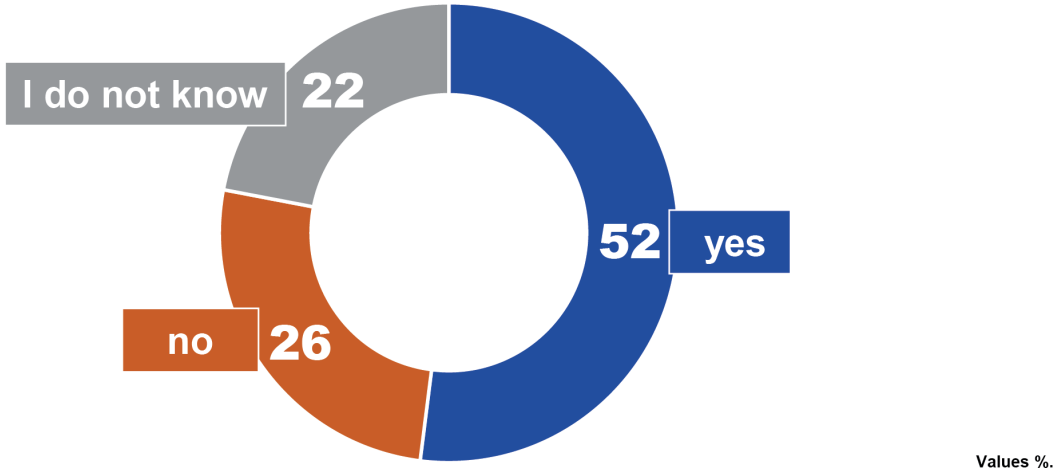


Fig. 4 - Institutions of the sea. Q: In your opinion, could the establishment of a Ministry of the Sea be useful?

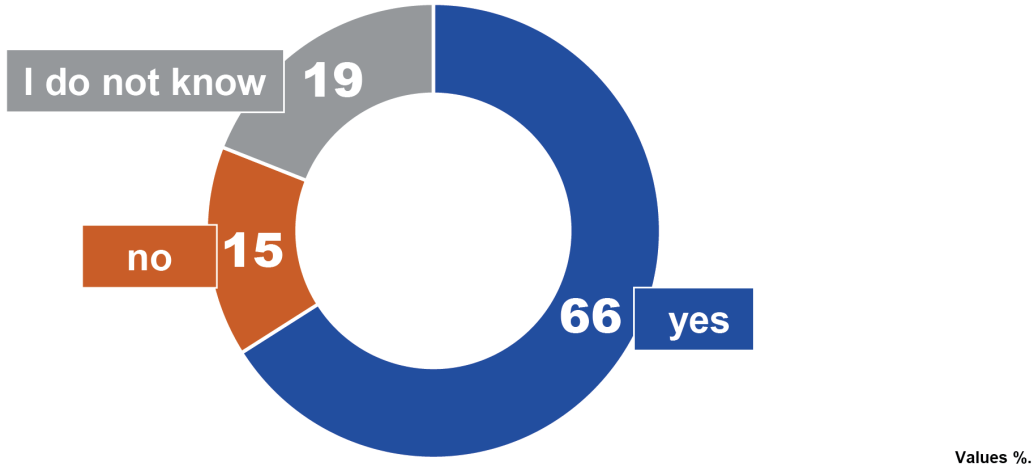


Fig. 5 - Institutions of the sea. Q: In your opinion, could the establishment of a European Ocean Agency be useful?

Moving to the research context, the following opinions express how much is known and what evaluations are given for research work in the field of seas:

- there is little information on the number of people involved in marine research and on the existing marine research infrastructures;
- the answer to the comparison of investments clearly indicates lower Italian investments in marine research than in other European countries. Generally, public opinion tends to believe that Italy is less competitive than the others;
- as regards the skills necessary for research, there is a clear tendency towards multidisciplinarity;
- protection of ecosystems, combatting pollution and mitigation of climate change are indicated as the main sectors that should be studied;

- it seems necessary to try to make available more information on marine research;
- education is considered essential (Fig. 6).

Knowledge of the work carried out by the European Union in the field of marine research is also limited. It is certainly necessary to identify new strategies for a more effective communication.

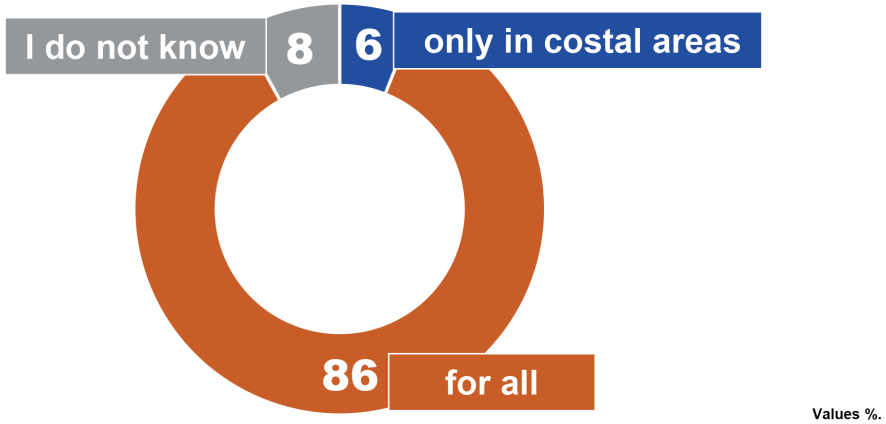


Fig. 6 - Environmental education for all citizens. Q: Do you believe that correct environmental education on sea issues is only useful in coastal areas (seaside cities, islands, coastal countries) or for all citizens?

Fig. 7 - The transition to environmental sustainability. Q: Do you believe that the transition to environmental sustainability is primarily a cost or an opportunity for the purpose of economic recovery?

One aspect to evaluate, in the current period, is the presence, evolution and effects of Covid-19 (Fig. 8). The significance of this pandemic has been enormous, and continues to be. It can be noted that public opinion believes that:

- Covid-19, beyond the known consequences on the economic level, should not be separated from the protection of the sea;

- attention to the environmental conditions of the planet, including the seas, must be increased; sustainability must become a priority;
- a very close and mutual link is recognized between the health of the sea and that of human beings;
- some scepticism still remains about the future improvement of citizens' attention to the sea.

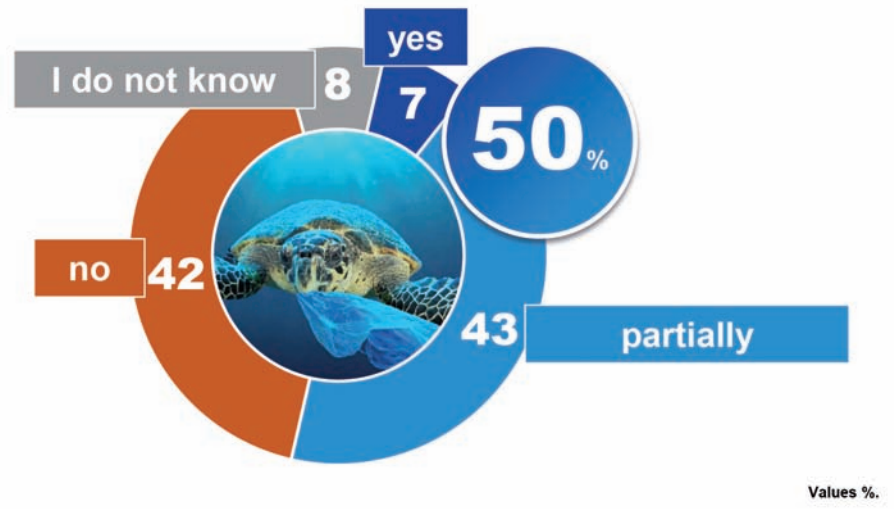


Fig. 8 - After Covid-19 and the protection of the sea. Q: After the Covid-19 emergency, do you think citizens will have a different awareness and greater attention to the protection of the sea?

3. Socio demographic aspects

In the study, we also analysed the responses by looking at the socio-demographic segments of the sample: we can say, as a general remark, that the differences within the population are not high. The theme of the sea, in Italy, is evidently little influenced by the variety of living conditions; these data confirm a rather general knowledge of the sea.

Some traits, however, emerge:

- the basic knowledge of the sea is more developed in the South and in the Islands, in the coastal areas and in couples with children. On the other hand, it appears less present in the North and among young people;
- the comparative assessment of the state of lakes and rivers is more developed among young people and in hilly and mountainous areas;
- the economic opportunities created by the sea economy attract young people, the South and the Islands and the coastal areas. They convince less the inland areas and the North;
- in reply to the question of how to stimulate people to face the challenges related to the sea, young people tend to consider the need of active involvement of citizens; people with children support more the use of social networks;

- the Covid-19 experience leaves a greater awareness of the need to protect the sea, mainly among people over 55 years of age, the South and the Islands, the coastal areas and people with children. Young people, the hilly-mountainous areas and the North and the Centre appear more sceptical.

To summarize: the South and the Islands show more favourable expectations, as do the coastal areas, in relation to the opportunities for development of the marine economy; the North is less confident. The position of young people appears less predictable, open to protection and to the opportunities given by the sea and to involvement, but with less knowledge on the subject and they are more mistrusting of the positivity of prospects. The analysis also shows that, generally, couples with children are closer to the theme of the sea.

4. Conclusion

Following the Italian OGS and SWG project, other countries developed surveys and questionnaires for the general public.

In particular, we can mention France with an important initiative involving citizens, media and policy makers. 6,600 persons answered a national questionnaire on their perception of ocean and waters, the threats to them and possible solutions.

Regarding the threats highlighted by the French participants, pollution and over-exploitation are the two greatest concerns. And it is plastic that comes first in terms of pollution in the responses. Another result that stands out is that education is acclaimed as the first effective measure for the protection of marine ecosystems.

It is also worthwhile to mention a joint project of Denmark, Estonia, Finland, Norway, Poland and Sweden that produced a digital survey with 1,000 participants and a very successful Irish Citizen Engagement process.

In all these cases, as in Italy, the role of research Institutions was fundamental for success.

To conclude, the recent health emergency has made us understand how the alteration of ecosystems and the removal of natural habitats from wild species is dangerous and can also favour the spread of previously unknown pathogens.

The health of mankind and that of the sea are closely connected, indeed the health of the sea is crucial for human health. All in a circular logic of inter-relationships between ocean health, human health and human activities.

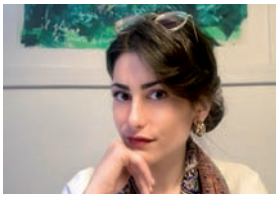
We have deluded ourselves that “we can stay healthy in a sick world,” as Pope Francis has said. It is necessary now to rethink the priorities to be addressed and redesign, with appropriate laws and political choices, a healthier and more sustainable production and consumption system. The paradigms of the past have failed, we need to design others.

Missions have enormous potential for the EU to deliver on these key targets, but they need citizens to participate in the implementation of solutions that have meaning for their lives. The invitation to all citizens is therefore to reflect on the sea and the oceans, on our behaviour, on our responsibility and, above all, to act personally, now.

Filling the knowledge and the emotional gap

Rosalba Giugni and Francesca Borza

Rosalba Giugni is the Founder and, since 1989, the Chair of the environmental association Marevivo. Among other activities, she has developed and realized 15 international campaigns collaborating with Ministries, Universities and other public and private Italian institutions.



Francesca Borza graduated in Diplomacy and International Cooperation at the University of Trieste. Since 2020 she has been part of the Marevivo-FVG Delegation in charge of structuring educational and training projects in collaboration with various public and private institutions.

One of the objectives of the Starfish Mission lies in increasing knowledge of the sea and oceans and bringing citizens closer to the awareness that the blue heritage is part of a wider range of vision that is connected to many issues: pollution, health and politics.

Even well before the beginning of the Starfish Mission and the identification by the European Commission of the objectives that fall within it, several action groups were formed in Italy which, based on stubbornness and commitment, essentially of volunteers, addressed the theme of making citizens aware of seas and oceans.

One of these groups is Marevivo, a non-profit environmental association founded in Rome in 1985 that operates for the protection of the sea and the environment, for the study of biodiversity, the promotion and enhancement of protected marine areas, education in schools and universities for sustainable development and awareness-raising on all issues related to the sea.

Marevivo's activities are reflected in one of the cornerstones of the Starfish Mission: filling the emotional gap. Since its beginning, the Association has tried, through initiatives and informative campaigns, to make as many people as possible understand the importance of the health of the sea and the marine system for humans.

Today more than ever, it is necessary to reach every citizen with this message, especially after understanding, due to the Covid 19 pandemic, that the environmental issue is something that affects human health much more than we think.

A healthy blue planet is fundamental for our future because oceans, seas, coastal waters and inland waters form a single system, covering approximately 75% of the earth's surface, representing the main source of biodiversity, hosting unique habitats and creating an interconnection with other components of the climate system through the global exchange cycle between water, energy and carbon.

It is therefore clear that seas and waters are public assets towards which we are all responsible, individually and collectively. This responsibility involves a change of perspective that leads to the awareness that seas and waters are precious and consequently must be protected and preserved exactly as if they were our own assets.

The Marevivo environmental association was created precisely from the emotional attachment of its founder to the cause of the sea. Rosalba Giugni, daughter of shipowners, a Neapolitan and scuba diver, has always had a strong emotional bond with the sea and when, in the early Eighties she found the first signs of pollution in the sea around Capri with the appearance of foam and plastics, she realized she had to act personally to fight the problem.

Since 1985 a network of volunteers has developed: sportsmen, influencers, experts, scientists, who have contributed to broaden the range of action to reach the whole national territory which, due to its complexity, has required the division into regional delegations that deal with their own portion of the territory according to their needs.

The division of our peninsula into micro-areas has allowed a huge involvement of citizens and it has developed a great ability to manage problems that differ in area and climate. The activities carried out are numerous and deal with issues of extreme importance for the protection of the sea in a differentiated manner, always involving citizens and especially young people through moments of participation, action and training.

Starting with the cleaning of the beaches that is carried out cyclically by the Delegations in their respective territories, there are training and dissemination activities that have allowed citizens of all ages to establish contact with the "sea question" in order to fully understand the causes and consequences of some typical phenomena of recent years: plastics and microplastics at sea, the rising level of the oceans, the invasion of alien species.

Some of these activities, thanks to the success reached, have become real annual appointments with an interdisciplinary nature of a scientific-educational matrix such as Nautici in Blu: a weekly path organized with the Italian Nautical Institutes which includes activities aimed at safeguarding the marine ecosystem and which is divided into a structured program developed through shared workshops that take place in classrooms and outdoors to allow the participating children to learn more about their territory.

A similar initiative that has been going on for more than ten years is the one called: Delfini Guardiani dell'Isola. Delfini Guardiani dell'Isola is a project that was launched in 2009 in Capri with the aim of starting up, with the primary and junior secondary school classes of the smaller Italian islands, educational courses on environmental education and sustainability. During the school year, the pupils, followed by Marevivo operators and teachers, leave the classrooms to deepen their knowledge of their island as regards naturalistic and historical-cultural aspects, but also to deal with the threats affecting the marine ecosystem and the planet in general.

In addition to the numerous training activities, communication and awareness campaigns on various issues are proposed. The latest in chronological order is "Save the sea. Recycle cooking oil!" A campaign that raises public awareness on the dispersion of vegetable oil which, after use, is thrown down the drain or directly into the sea and whose consequences are highly polluting for the environment.

A litre of oil can pollute a water surface of approximately 1,000 square metres. Instead, if collected and properly managed, oil can become a reusable product (production of biodiesel and bio-lubricants, in cogeneration plants, etc.); for each ton of waste oil recovered there is a reduction of 2.3 tons of equivalent CO2!

Filling the emotional gap, getting closer to citizens, spreading information and data in a rigorous but pleasant way, are actions that are part of the path created to reach a more conscientious and consequently active society; it is essential that every citizen becomes aware of what is happening in the sea, it is important that everybody knows the processes and repercussions.

The above actions converge into a time-consuming communication process. Dissemination must have an interdisciplinary approach, it must be involving and clear in order to reach all citizens, and cannot and must not be invasive, but it must induce reflection gradually. Understanding that every European citizen is part of the change, that every small gesture can lead to great goals and that each of us can be the solution: this is the message of the Starfish Mission.

Fig. 1 - #Stopmicrofibre Campaign.

Fig. 2 - #Stopalvolodeipalloncini Campaign.

To get closer not only to children but also to a wider audience with diversified previous education, the information meetings open to the public acquire a considerable importance.

Being able to count on a strong scientific support and on a network of knowledge active on the Italian territory, Marevivo has held many conferences on issues related to the sea sometimes included in various disciplines, not only of a scientific nature, but also of an artistic, literary and sporting nature. From the aforementioned inter-disciplinary nature, for example, the association developed the idea of creating an artistic exhibition linked to the theme of plastic but also to Dante entitling it "From Hell to Paradise: a journey into the Plasticocene".

A sustainable sports competition was then developed, boosting the use of words and images to convey clear and strong messages about the condition of the marine environment. This last tool proved to be useful for the emotional involvement of citizens because it is precisely through awareness campaigns with strong contents that Marevivo has become able to communicate to everyone the problems that our sea is facing.

The indictment campaigns against micofibres and plastic in the sea (Figs. 1 and 2) have gone viral thanks to images with a strong emotional impact that spread rapidly, transmitting the gravity of the situation in which our sea lies due to humans' bad behaviour, which affects the health and balance of the marine system and consequently of the human system.

And then the initiatives against ghost nets with the collection of hundreds of metres of abandoned nets on the seabed and also of 70 tons of tyres and much more.

From the thirty-year experience of Marevivo, the importance of a correct and constant communication with citizens on issues related to the sea is perceived. Following the European Commission and the Starfish Mission directives, it is clear how fundamental it is to increase the involvement of the population to act effectively and concretely, how essential training is for the creation of an aware and active society. It is extremely important to understand how much the disclosure of data, the communication of experts and the awareness of the situation are not only tools capable of becoming a warning for future generations but above all, these tools are the driving force for collective, structured and shared actions focussed on the improvement of our planet.

The Starfish Mission: an Italian Perspective

Federico Morisio

Federico Morisio is a Professional Windsurfer, born and raised in Turin, who competes at international levels, ranked 4th in the general classification of the" International Windsurfing Tour". Using his lifestyle and his activity as educator, as a Marevivo "Cavaliere del Mare" and passionate about nature and sustainability, Federico is well determined to change not only people's lifestyles, but also the way in which our society, culture and economy interact with planet Earth".

As an Italian citizen born and raised in Turin, a big city far away from the ocean, and as a Professional Windsurfer who for the last 6 years has been travelling chasing wind and waves in some of the best locations around the world; I feel I have gone through many different experiences that have permitted me to gather important insights about the people I have interacted with and their cultures and education. What most impressed me was that, no matter whether it was in Turin or in a small village in a South American country, in Hawaii or Sardinia, I have noticed that people still have very little knowledge and there is a great lack of education about the fundamental importance of our oceans and waters. People are mostly disconnected from water and oceans, and even those who are connected in a certain way still do not fully comprehend its role in making life on earth balanced and possible. Catastrophic issues such as the Pacific Garbage Patch are now known and clear to everybody, but it is still hard for people to recycle at home or to avoid buying single-use plastics; and I believe this happens because of a mix of ignorance, regarding the process that our garbage goes through and where it actually ends up, and because people still feel too distant and helpless regarding such issues. We need to explain clearly to society that the marine pollution that we are facing now is the result of years and years of small bad habits by each one of us; and that in the same way, we can all help fight this pollution and improve the health of our waters through little but better, conscious and responsible actions. We need to implement new values in our culture, increase knowledge in society and make each person aware of his impact on the planet, in order to make them feel responsible and accountable. Today, as never in history before, we have incredibly powerful tools to raise awareness and transmit new values through a personalized communication that can resonate with each person out there, making them aware of the importance of their actions and inspiring them to make a positive change. Influencers have a powerful and deep role in this mission as they can properly engage with their audiences, knowing how to communicate with them and lead by example in order to change the mentality and culture of the people who admire them. To do this, engaging, educating, innovative and consistent content through all the relevant digital platforms is needed, so that

we can modify the way people look at things and act in their own lives, becoming themselves “influencers” within their social circle. Finally, I personally really believe in the power and influence that each person has through his words and actions, and that change can come from below, especially in our consumer-centric society, but at the same time strong actions by institutions are needed in order to make it easier for people to become conscious and respectful citizens; for example through economic incentives, functional structures and tougher rules.

Mitja Gialuz

Born in Trieste in 1975 Mitja Gialuz graduated in Law cum laude. He is full professor in Criminal Justice at the University of Genova and he is adjunct professor at Luiss Guido Carli University. He has been writing more than 150 publications and he’s member of scientific committee of sectoral magazines. He is member of Fondazione CRTrieste advisory board and since 2014 he is President of the Società Velica di Barcola e Grignano, organizer of Barcolana, the largest sailing race in the world. Sailor, skipper and lover of the sea, he is a promoter of sustainability, safety of the seas and respect for Mother Earth.

We are all in the same boat

I have been sailing since I was three years old. At first, I sailed a wonderful wooden boat belonging to my parents’ friends. Then, when I was six, I started sailing an Optimist.

I well remember my first day on the sea: I was frightened of the wind and the waves but at the same time I was excited to be part of a majestic element, the Sea. I live this sublime emotion every time I get on a boat; an emotion that, over the years, has melded into an incomparable feeling of freedom.

When you sail you can understand the strength of Poseidon, not by chance the most important and respected of the Greek Gods.

The Sea: energetic, immense, free, source of life but maybe it would be better to prevent him getting angry

When I was elected President of the Barcolana, the greatest sailing race in the world turned into a celebration of the sea, I felt my commitment had to spread the message that the Sea must be saved by all of us. Irresponsible behaviour and mistreatment by human beings, excessive fishing, tourism that is far from eco-friendly, plastics and microplastics, chemical waste discharged into the sea, climate change and global warming resulting in the rising sea level are only the main attempts against healthy seas.

The awareness of the urgency to invert the course led me to choose the claim: “Chi ama il mare ama la Terra - Love the sea, love the earth” as the theme of the fiftieth edition of the event.

This theme was brilliantly developed by Marina Abramovic in our manifesto, icon of the event, in which the artist is holding a flag saying “We are all in the same boat” (Fig. 1). We all belong to the same planet, our Mother Earth hosts us in the universe like a big crew in a big boat, and each one has his role on board.

Fig. 1 - Manifesto of the fiftieth edition of the Barcolana sailing race in 2021, by Marina Abramovic.

The everyday choices of each one of us can make a difference and have an impact on the common good.

The Barcolana has worked hard over the years to guarantee a Zero Impact event, in order to limit the impact in the area in which it takes place, involving both sailors and citizens in environmental actions.

In 2019 we launched a call to collect plastic bottles, which were artistically transformed into a big fish called “Alice”, symbol of the Barcolana mission. Students and teenagers were involved in the study of the reduction of environmental impact of their school buildings and a diving event was organized for yacht members and young sailors to clean the bottom of the Gulf coasts. The artistic transformation of the recovered plastic took place many times thanks to our sponsor, the artists and the Barcolana community.

In 2020 the team of the sailing boat Anywave proposed that we include in the crew lists registered for the regatta a new role named the ecologic manager on board (R.Eco), besides the skipper and the helmsman. This would be the person who takes care of the sustainable participation of the crew, paying attention to the choice of sail, the pantry and the separate garbage collection. I hope this role will soon be adopted also by yacht clubs. And the first rule the R.Eco is supposed to enforce is: “Sail, don’t use engines.”

The starfish is able to regenerate on its own, the sea needs our help to enable its regeneration now.

Ocean knowledge: the role of the International Hydrographic Organization in the incoming decade

Rear Admiral Luigi Sinapi

Luigi Sinapi is a Rear Admiral of the Italian Navy and Director of the International Hydrographic Organization (IHO).. He commanded three military Ships and served as Director of the Italian Hydrographic Institute for 5 years. He earned a II level degree in Physics, a II level degree in International Diplomacy, a II level Master in Marine Geomatics, the IHO-FIG-ICA Category A Hydrography Certificate, and a Master in International Strategic and Military studies. SINAPI was University visiting Professor in hydrography and geodesy, and has published a number of essays in national and international journals and reviews.

1. Background

The actual decade, 2021-2030, will remain in the history of humankind for the many initiatives in favour of the Ocean. At global, regional and national level, we are witnessing a substantially changed frame of mind about the Ocean and its irreplaceable role in guaranteeing human life and regulating the Earth's climate.

The United Nations, the European Union, private Foundations and Associations, as well as the majority of the coastal states, have launched initiatives, missions and projects focused on developing systemic and transformative solutions for healthy oceans and seas, with the aim to know, restore and protect them by 2030.

Ocean knowledge is common and transversal to all those initiatives and it represents the key factor to fill up the significant gaps in our understanding and knowledge of the hydrosphere, predict extreme events such as the rising sea level, invest in a sustainable Ocean and address the various interacting and cumulative threats to our oceans and waters.

The International Hydrographic Organization (IHO) is an intergovernmental organization that works to ensure all the world's seas, oceans and navigable waters are surveyed and charted. Established in 1921, it coordinates the activities of national hydrographic offices and promotes uniformity in nautical charts and documents. It issues survey best practices, provides guidelines to maximize the use of hydrographic survey data and develops hydrographic capabilities in Member States.

2. Hydrography and marine activities

Hydrography is the basis for all activities involving the sea. As a discipline, it focuses on the physics of the marine environment. This includes measuring and charting the

seabed topography but equally importantly sea level, tides, currents, and also elements like temperature and salinity. While it has traditionally been used to make navigational charts, this information is now used by a variety of ocean stakeholders: to develop marine renewable energy projects, operators need information related to the topography of the seabed, or the strength and regularity of currents.

All of these activities will be affected and will need to adapt if the marine environment changes as trends seem to indicate. Up-to-date data, gathered and presented according to international standards, enable countries to monitor changes and adapt their activities. Hydrographic information is essential for the safe, efficient and sustainable conduct of every human activity that takes place in, on or under the sea.

Therefore, hydrography is inherent to the three dimensions of the sustainable development of the oceans, ensuring that the marine environment is respected and that no adverse economic or social impact is incurred.

3. The new IHO Strategic Plan

Although safety of navigation remains a major driver for the IHO, hydrographic products and services are meant to support all activities associated with the oceans, seas and navigable waters.

As every human activity conducted in, on or under the sea depends on knowing the depth and the nature of the seafloor and an understanding of the tides and the currents, hydrography is an essential foundation to the development of the Blue Economy. The seabed provides habitats for marine species, plays a role in spawning areas and for modelling the ocean's effects on climate change, as well as providing information which is useful for deep sea exploration and exploitation, fish farming, blue energy production, cabling and for studying the human pressure on the coastal areas.

Yet humankind has higher resolution maps of the Moon, Venus and Mars than for most of the seas and oceans (see Fig. 1). This has a significant impact on what humankind can do at sea today in a safe, economical and sustainable way. It is impeding progress and economic development in many, if not most, coastal states, and has a major impact on the effective management, sustainable exploitation, and well-informed governance of the seas and oceans.

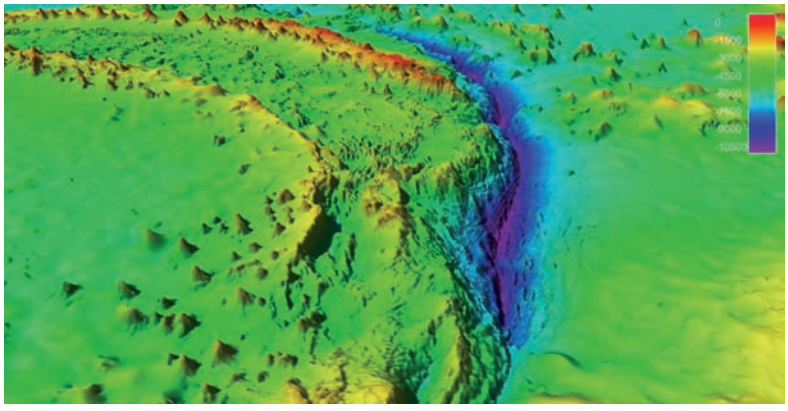


Fig. 1 - The Mariana Trench (Pacific Ocean), the deepest part of the ocean (Photo GEBCO)

To face these and other challenges, and inspired by the old phrase of Jacques-Yves Cousteau, National Geographic, 1981: "*The sea, the great unifier, is man's only hope*", the 94 IHO Member States approved a new IHO Strategic Plan (see Fig. 2). It defines the organization's priorities for the coming years until 2026 and is structured through three overarching goals, focusing the exercise of its mission during this period. It includes Goal 1 to evolve the hydrographic support for safety and efficiency of maritime navigation, undergoing profound transformation, Goal 2 to increase the use of hydrographic data beyond nautical charts and Goal 3 to increase participation in international initiatives on the sustainable use of the oceans.

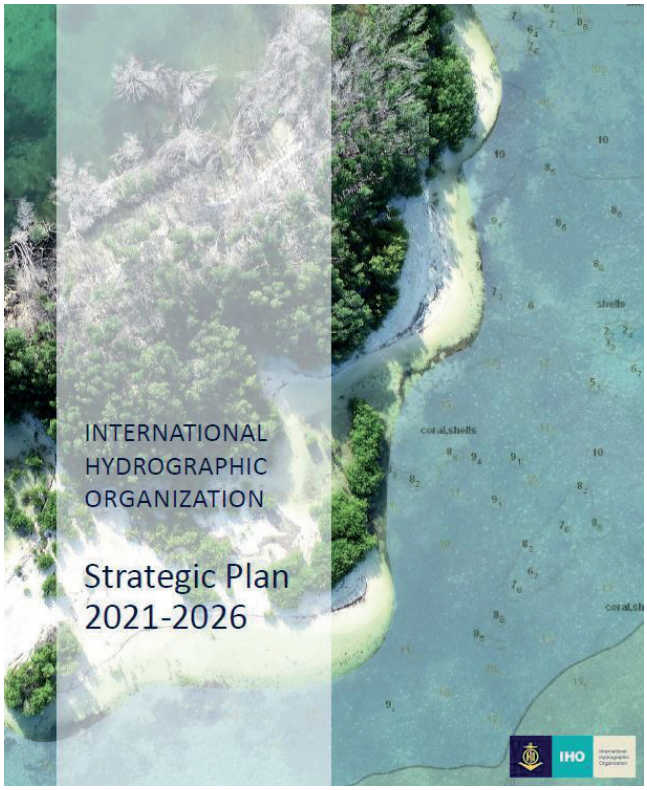


Fig. 2 - IHO Strategic Plan 2021-2026 (Photo IHO)

These three new strategic Goals confirm IHO is now also clearly committed to reconciling the use and the preservation of the marine environment, and motivate IHO to become a relevant stakeholder helping to facilitate a paradigm shift in the design and delivery of qualitative and quantitative ocean knowledge, to inform solutions that will contribute to the 2030 Agenda for Sustainable Development.

4. How to approach Ocean knowledge

IHO standards and guidelines, intended to assist coastal states to meet their obligations and requirements, fall under three main themes:

- nautical charts, produced by national Hydrographic Offices, to support safe navigation in accordance with the requirements of SOLAS;
- the maritime component of spatial data infrastructures being developed at the national and regional levels, which includes in particular high resolution bathymetry (depth data) compiled by national Hydrographic Offices;
- the global reference bathymetric datasets developed and made available through the GEBCO project (General Bathymetric Chart of the Oceans).

The General Bathymetric Chart of the Ocean (GEBCO) is a joint program that is executed under the governance of the IHO and the Intergovernmental Oceanographic Commission (IOC) of UNESCO. Through the work of its organs, GEBCO produces and makes available a range of bathymetric datasets and products, where a significant source of data for these products is the IHO Data Centre for Digital Bathymetry (DCDB).

One of the primary objectives of the IHO DCDB is to provide an authoritative source of bathymetry for ocean mapping requirements. In order to achieve this, GEBCO proactively collects, stores and disseminates bathymetric data for the world's oceans. GEBCO has worked towards improving its participation in regional mapping activities and has appointed representatives to participate in selected meetings of the fifteen Regional Hydrographic Commissions that operate under the umbrella of the IHO. Traditionally GEBCO has focused on waters deeper than about 200 m; however, it is now actively collecting data in shallow water areas to support activities such as coastal zone management and development, and the mitigation of marine disasters such as storm and tsunami inundation (see Fig. 3).

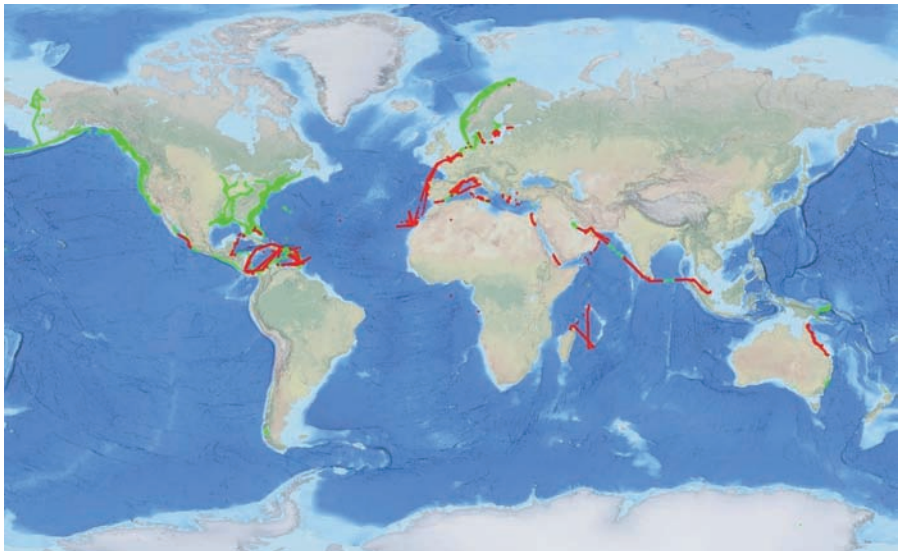


Fig. 3 - IHO DCDC Enhancements 2020 (Photo IHO DCDB)

The GEBCO_2020 Grid is the latest global bathymetric product released by the General Bathymetric Chart of the Oceans (GEBCO) and has been developed through the Nippon Foundation-GEBCO Seabed 2030 Project, which aims to compile available bathymetric data in order to produce a complete map of the ocean floor by 2030. In Fig. 4, the areas

in shades of blue show the coverage of grid cells at 15 arc-second intervals within the GEBCO_2020 Grid, which are based on measured data and pre-generated grids. We have progressed from having a map of 6% of the oceans in 2017, to 19% in 2020.

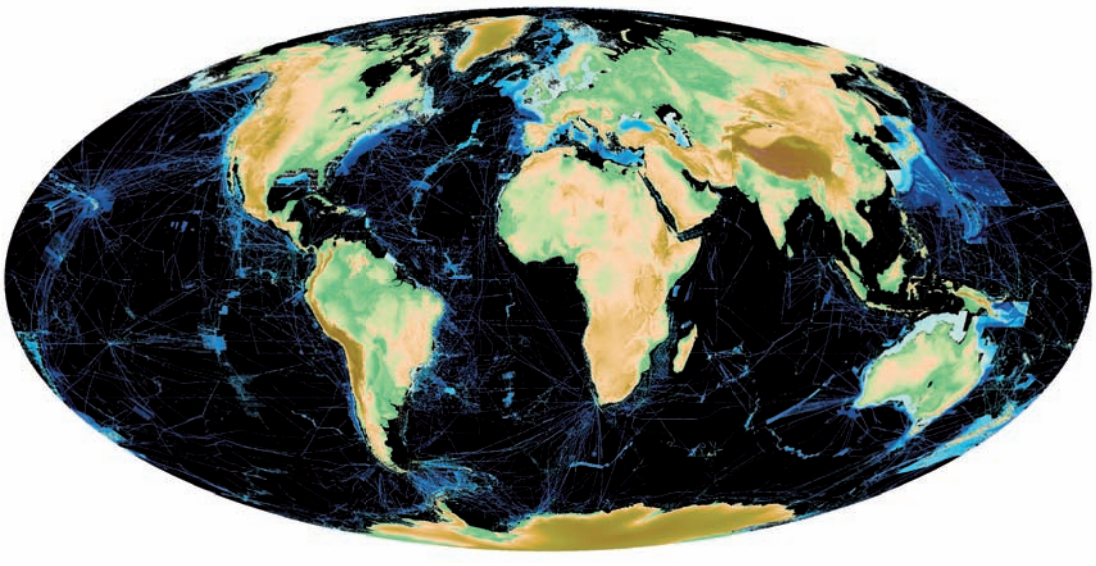


Fig. 4 - The GEBCO 2020 mapped coverage (Photo GEBCO)

Besides, IHO does not limit its activities to governmental bodies, oceanographers and industry partners. IHO´s Crowdsourced Bathymetry Working Group (CSBWG) examined how best to incorporate, manage and use bathymetric data acquired by other than conventional means and develop principles and guidelines to enable the appropriate collection and use of the maritime version of citizen science called crowdsourced bathymetry.

In 2019, the CSBWG finalized the first Edition of a guidance document named IHO B-12 "*Crowdsourced Bathymetry Guidance Document*", that provides general advice and information for those considering collecting or using crowdsourced bathymetry. It is not intended to be either prescriptive or authoritative, but rather to alert those with an interest in crowdsourcing of the relevant considerations to take into account. IHO B-12 also informs how crowdsourced bathymetry data holds limitless potential for myriad other uses, and provides vital information to support national and regional development activities, and scientific studies in areas where little or no other data exist.

In addition to the above, the IHO managed the transformation of nautical chart information from an analogue paper chart explicating coastline, depths, and navigational aids and hazards, to a digital carrier named Electronic Navigational Chart (ENC) in 1990s. The Electronic Chart Display and Information System (ECDIS) fuelled by ENCs has become one of the key information systems in maritime community for the safety of navigation at sea since International Maritime Organization (IMO) adopted the ECDIS carriage requirement on board in 2012. Over 30,000 vessels do navigate with ECDIS around the globe: practically all commercial and navy fleets of this planet.

However, modern information technology has progressed since their inception and

new technical options require their evolution. The IHO has developed a new Standard, the S-100 Universal Hydrographic Data Model, with the aims – by 2030 – to continue to satisfy the SOLAS requirements of enhancing safety of navigation, support the implementation of "e-navigation", which is being led by the UN's International Maritime Organization (IMO), and contribute to a modern comprehensive representation of the marine environment as a whole.

By adopting the S-100 Universal Hydrographic Data Model, the IHO created a versatile standard framework composed of S-100 based Product Specifications (PS) to describe specific aspects of the real maritime world. The advantage of such datasets, based on the same paradigm, is their mutual compatibility and interoperability. The latter supports a multitude of possible combinations of the geo-information encoded in datasets – independent of the scientific domain to which they belong.

Since the S-100 Standard is not limited to hosting data product specifications native to the hydrographic domain, the IHO is proactively supporting the expansion of the S-100 concept to marine-related domains such as maintenance of fixed and floating aids to navigation (IALA – International Association of Lighthouse Authority), weather and sea ice coverage (WMO – World Meteorological Organization), route plan exchange format (IEC – International Electrotechnical Commission), inland electronic charting (IEHG – Inland ENC Harmonization Group) and oceanography (IOC – Intergovernmental Oceanographic Commission). IHO´s S-100 approach is potentially applicable to all sorts of marine information including chemistry and biology of the oceans resulting in interoperable datasets to form "*the digital aquarium*", to help a better and viable Ocean knowledge (see Fig. 5).

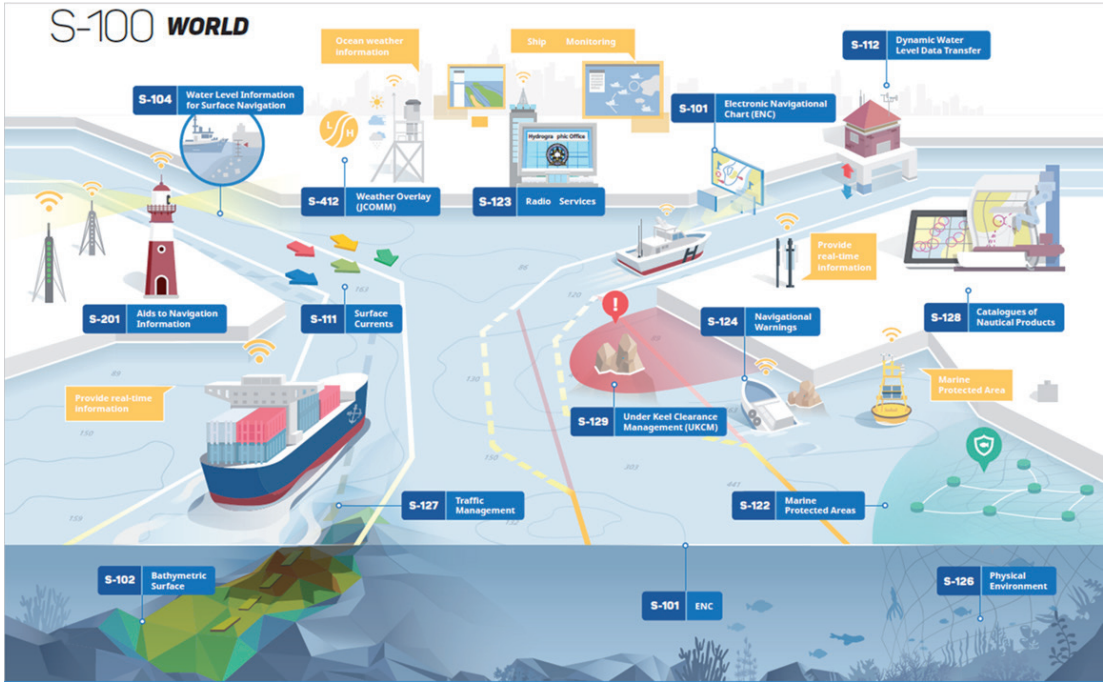


Fig. 5: The digital aquarium (Photo KHOA - Korean Hydrographic and Oceanographic Agency)

5. Conclusions

There is a growing acknowledgement and awareness of the relevance and the underpinning contribution that hydrographic information can make in the context of the 2030 Agenda for Sustainable Development and in particular in support of its Sustainable Development Goal 14 - Conserve and sustainably use the oceans, seas and marine resources for sustainable development.

Consequently, many of IHO´s work items associated with the aforementioned strategic goals, and particularly with the central role of Ocean knowledge in the preservation of the marine environment, are relevant to meet the major objectives of the Ocean Decade, as well as most of the objectives of other regional initiatives, such as "*Mission Starfish 2030*", aimed at addressing the various interacting and cumulative threats to our oceans and waters.

"*Our health depends on the health of the environment in which we live. That is why more than ever before we need to continue our efforts and actions to protect our planet for future generations*", said Prince Albert II recently in a citation on the Ocean in 2020. It demonstrates, once more, that thanks to progress in technology and international cooperation – as the IHO is pursuing with its new Strategic Plan and Goals – we are in a situation where we could succeed in mapping the seafloor within our lifetime, and contribute concretely to the health of our oceans and waters.

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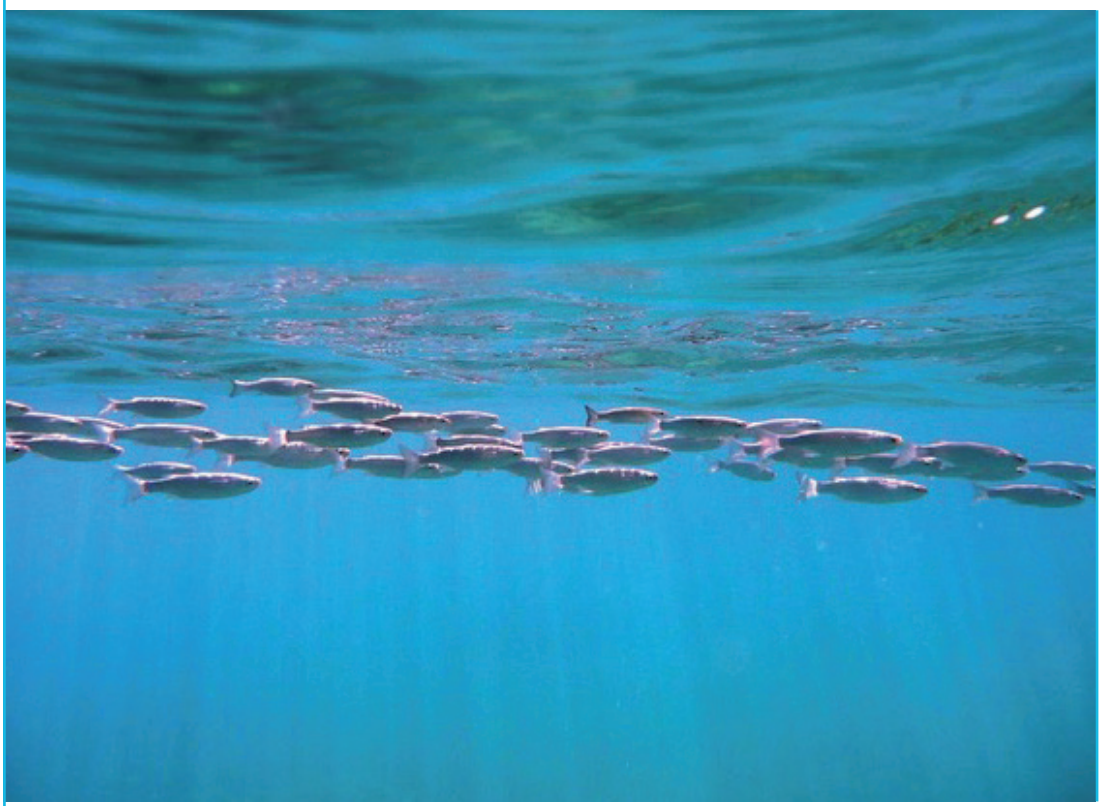
Chapter 3.

Ecosystems



Credit: OGS photographic archive

Challenges and opportunities for the eco-sustainable management of the deep sea in the UN Decade 2021-2030 "Ocean Science for Sustainable Development"

Roberto Danovaro

Roberto Danovaro is Professor of Ecology at the Department of Life and Environmental Sciences, Polytechnic University of Marche and President of the Stazione Zoologica Anton Dohrn, Naples, Italy. Past-president of the Italian Society of Ecology, of the Italian Society of Limnology and Oceanography and of the European Federation of Scientific Societies. President of the Scientific Council of WWF Italy. Member of several international panels (IUCN, UNEP). Member of the EU Academy of Science. Author of about 450 international papers, he received the BMC Biology Prize (London, 2010), the Award of the French Society of Oceanography (2011), and the ENI Award "Protection of the Environment" (2013). In 2020, he was recognized by ExpertScape as the most influential World Scientist in the Category "Ocean and Seas for the decade 2010-2020".

1. Introducing the Ecosystem-based management to the deep sea

Seas and oceans, the largest biomes of the biosphere, show an increasing number of largely degraded habitats. The multiple human impacts on natural ecosystems are causing a widespread habitat loss, with consequent decline of biodiversity and ecosystem services (Danovaro et al., 2017a). To address the dreadful state of the ocean, the United Nations proclaim in 2021-2030 Decades of "Ocean Science for Sustainable Development" and "Ecosystem Restoration". The Decades should turn the scientific knowledge and understanding into effective actions supporting improved ocean stewardship for sustainable development also in the deep sea (Howell et al., 2021) while ecological restoration is the main tool to reverse the decline and recover the biodiversity, along with human health and wellbeing. The UN Decades are just at the beginning but are likely to provide an unprecedented opportunity for relaunching marine science in the next decade towards the sustainability targets.

Ecosystem-based management (EBM) is management that considers the full range of activities and impacts on marine systems (Long et al., 2015). To be effective, EBM requires spatial and non-spatial management tools to preserve and protect marine biodiversity, ecosystem structure and functions, and, when necessary, applies the precautionary principle. The deep ocean requires Ecosystem-based management, but this is largely hampered by the lack, both in spatial and temporal terms, of adequate ecological information (Danovaro et al., 2020a). The variables needed for planning an appropriate EBM should include both seafloor and water column and allow the assessment of both direct and indirect impact, as well as the identification of the

cumulative effects of multiple stressors (Dailianis et al., 2018). Recently, amongst the essential ecological variables proposed for deep-sea monitoring and conservation, both structural and functional biological and ecological variables have been proposed (Danovaro et al., 2020a). These variables include the analysis of pelagic and benthic biodiversity, biomass and production, life cycle and strategies, functional traits, food webs, trophic interactions, C inputs and provision of food resources, organic matter cycling, to mention just a few.

This information also needs a wide array of abiotic measures and a detailed knowledge of the habitat extension and distribution. The absence of an effective research, assessment and monitoring strategy will limit the sustainability of deep-sea economic activities (e.g. fishery, minerals, hydrocarbon, novel molecule extraction) that may interfere with ecosystem functions. The ISA (International Seabed Authority) has started a management path, but this path needs a much more rigorous and systematic approach and strategic vision for the deep sea (ISBA/19/LTC/8, 2013). Already, Sponsoring States of companies exploring for minerals in the Area require those companies to follow the "Recommendations for the guidance of contractors for the assessment of the possible environmental impacts arising from exploration for marine minerals in the Area" issued by the Legal and Technical Commission of the ISA (ISBA/19/LTC/8, 2013). At present, where the ISA and other governance institutions require a scientific basis for spatial planning, companies often use surrogate or proxy indicators in the absence of direct measures for the poorly studied deep sea. This was the case in the establishment of APEIs (Areas of Particular Environmental Interest) for the Clarion-Clipperton zone (between Hawaii and Mexico). Here, bathymetry and models of particulate organic carbon were used (among other proxies) to define representative ecosystems because direct measures of biogeography, biodiversity, and ecosystem functions across this vast region were very limited, and the rate at which vast seafloor areas were being designated for mining required urgent action (Miller et al., 2018). In addition, scientists collected a range of synoptic, sporadic information through *ad hoc* investigations that lack coherence in geographic coordination and coverage.

The paucity of scientific data, particularly in relation to impacts from large-scale human activities, such as seafloor mining, exacerbated by global change, challenges our ability to identify specific priority and/or representative areas for protection through Marine Protected Area (MPA) networks. Nonetheless, the establishment of new deep-sea MPA and of MPA networks (such as the APEIs in the Clarion-Clipperton Zone; Wedding et al., 2015), and their adaptive management, as new scientific information emerges, constitute critical tools to protect deep-sea biodiversity and ecosystem functions.

For effective management at regional scale, we must understand the geographic ranges and population connectivity of a wide variety of taxa in order to design spatial management measures at appropriate scales. For example, our partial knowledge on abyssal species distribution indicates some species span distances of hundreds, thousands, or even tens of thousands of kilometres, in contrast to apparently limited distributions in others. Because of this and many other uncertainties, some advocates suggest that conservative application of the Precautionary Approach dictates setting aside at least 25-50% of any deep-sea habitat to ensure effective protection of the full range of ecosystems and overall biodiversity (Dunn et al., 2018).

Managing resource use sustainably demands a fully multidisciplinary approach, i.e., the assessment of species ranges, physical transport (currents) and population connectivity in the deep sea with a sampling intensity that yields statistically robust results, but this effort far exceeds the means of any one organisation or country. Seasonal- and decadal-scale temporal variability, combined with very low faunal abundances in the deep ocean, can limit the statistical power of spatial studies; a much greater appreciation of change in deep-sea ecosystems with time is also required. These and other critical deep-ocean assessments can only be accomplished through international collaboration and coordination over decadal (or more) temporal scales, using agreed upon standards and protocols.

Deep-sea ecosystem baseline studies and ecosystem monitoring are essential management tools for evaluating impacts of maritime activities in relation to accidents (e.g. the *Deepwater Horizon*, *Prestige*, and *Exxon Valdez* oil spills) and for determining the efficacy of rehabilitation of so-called "time-bomb" sites (e.g. ammunitions disposal, radioactive of chemical wastes sealed in crumbling concrete drums, deliberately sunk navy/military ships and oil tankers, or ships carrying toxic or radioactive waste; Courtene-Jones et al., 2017, Chiba et al., 2018).

National initiatives use different approaches and technologies for Ecosystem-Based Management (e.g. EU-Marine Strategy Framework Directive, MSFD; US-Integrated Ecosystem Assessment, IEA; Arctic Marine Strategic Plan for the Arctic Seas and Coastal areas; Marine Environmental Monitoring Programme for New Zealand, among others). These initiatives share a common philosophy that management actions should perform to a set of agreed-upon criteria, including identification of priority areas for monitoring (selected on the basis of species/assemblages/habitat knowledge) and best monitoring strategies, including adequate spatio-temporal scales. Within national waters, monitoring activities must use reliable infrastructure that includes calibrated sensor deployment, organization of existing monitoring platforms into a coherent network and a data analysis system (e.g. GCOS, Global Climate Observing System /GOOS, Global Ocean Observing System), and private-public synergies for spatial monitoring expansion (scientific research has fewer resources than the private sector). Recently, GOOS has started to identify "essential variables" to monitor in the deep ocean, but that (highly needed) list is yet to be finalised (Constable et al., 2016).

The technology for benthic ecology research continues to improve (Danovaro et al., 2017b), based partly on the deployment of biological sensors in well-established networks in the pelagic domain, such as the OOI (Ocean Observatory Initiative) and Canada's Ocean Tracking Network (OTN) initiatives. Similarly, the ONC (Ocean Networks Canada) network in Barkley Canyon (part of NEPTUNE Canada) is pioneering benthic ecological studies over a large area, deploying a diverse set of biological sensors (e.g. imaging, fluorescence, acoustic methods for assessing zooplankton, fish, etc.) at most stations and introducing the use of mobile seafloor robots. In the US, a similar large-scale deep-sea observatory network has been operational on the Pacific margin since 2015. Isolated stations integrate the OOI initiative from the benthic side, such as the Martha's Vineyard Coastal Observatory, which includes complex assets to image individual microplankton, and the MARS ocean cabled observatory at the Monterey Bay Aquarium Research Institute (MBARI). The latter includes an "Eye in the Sea" camera, which will increase the number of observing deep-sea stations when monitoring couples with the nodes of the growing OOI Cabled Array Initiative network. Thus, deep-sea monitoring technology is advancing, but many "sensory" gaps remain.

2. Expanding marine protected areas in the deep sea

Deep-sea ecosystems are a priority target for bottom trawling fisheries and mining of economically important metals, their protection should be one of the highest priorities. However, only 2.7% of the global ocean area is highly protected, 3.7% is implemented but less protected and ca 2.4% is designated or proposed for protection (Toropova et al., 2010). We are thus far from the targets planned at international level.

The UN Agenda 2030 for Sustainable Development, indeed, has a target of 30% of protected waters within MPAs (30x30). Protecting at least 30% of our ocean is needed to safeguard the global ocean and is part of the CBD Post-2020 Strategy (Johnson et al., 2019). Given the fact that continental shelves cover only <5% of the ocean surface, it is evident that reaching these targets means expanding marine protection to offshore and deep-sea waters. A high level of protection (with no extractive activities) for at least 10% of the Protected Marine Areas is also needed if our ocean and seas are to recover. In addition, highly (i.e., effectively) protected MPAs have shown to yield much greater conservation benefits compared with areas under lesser levels of protection.

A series of recent discoveries has demonstrated that the deep sea contains unique habitats and ecosystems (Danovaro et al., 2014, Danovaro et al., 2017b), hosting previously unknown biodiversity. These deep-sea habitats, which include seamounts, canyons, ridges, cold seeps, hydrothermal vents, manganese nodule fields, deep-water corals, contain a huge, largely endemic, and yet mostly unexplored biodiversity (Fig. 1). Most of these habitats are emblematic examples of the complexity and difficulty in expanding marine conservation into the deep sea.

Protecting the goods and services provided by deep-sea ecosystems requires a profound knowledge of the life inhabiting the deep, which offers major benefits to humankind (Thurber et al., 2014). Furthermore, Ecosystem-Based Management approaches, such as those of the EU-MSFD (MSFD, 2008) and the US-IEA (International Energy Agency), require biological indicators of status (e.g. species distribution, abundance, and local diversities) that current sensors cannot provide (Danovaro et al., 2020b). Strategically, management and conservation require measurements of biodiversity at different spatio-temporal scales for different biotic components (from microbes to large fauna), their functions, metabolic state, biochemical features and the associated abiotic parameters (Danovaro et al., 2020a). To reduce this complexity, we need to identify the variables/indicators able to quantify environmental effects on communities.

A new approach is needed to promote the establishment of deep-sea marine protected areas. To increase our knowledge of these ecosystems and select those deserving protection we need to focus on organisms and their habitats, rather than the physical or chemical environment alone. This approach is needed to oversee the development and implementation of deep-ocean monitoring to include “operational deep-sea biological oceanography” (data acquisition/treatment/analysis). Such a strategy must begin with statements of goals and objectives, and definitions of key indicators. It must also consider appropriate spatio-temporal frequency of biological data sampling to document the ecological heterogeneity of the seabed and water column to enable assessment of biological health at depth. Such a deep-ocean monitoring strategy should be implemented through the establishment of networks of multi-parameter platforms, including time-series imagery of deep-sea communities with associated environmental data (Miloslavich et al., 2018). Video camera installation is pivotally important in sustaining the scientific, management, and societal value of such a network. Combining HD video, new, low-light imaging, and acoustic sensors that require no light could efficiently characterize high-

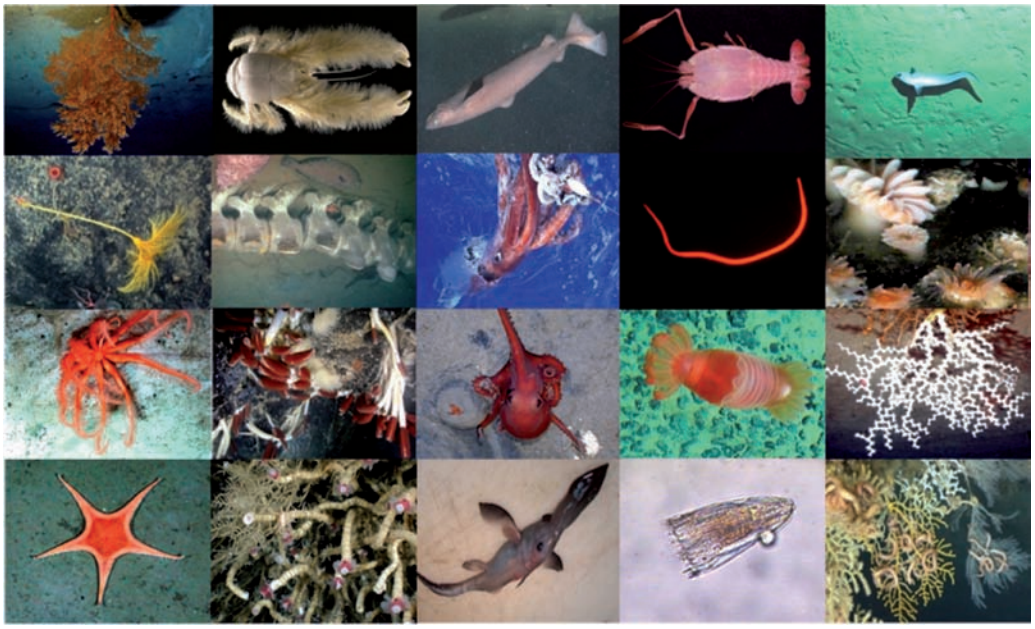


Fig. 1 - A composite picture of biodiversity inhabiting different deep-sea habitats, including seamounts, canyons, cold seeps, hydrothermal vents, deep-water corals.

complexity ecosystem components such as megafauna and bioturbation processes (i.e., biologically-driven mixing of the sediments) of direct relevance to services for human health (e.g. fisheries and carbon burial). Biodiversity status and the presence of key species can be quantified using high frequency time-lapse imaging over long periods of time at appropriate spatial scales (several km^2) (Brandt et al., 2016). Environmental data acquisition can then establish solid cause-effect relationships and reveal benthic community response (e.g. megafaunal community changes) to concomitant modification in habitat, including human perturbations. Gliders, seafloor robots and moorings should be utilised to complement benthic platforms to spearhead a comprehensive benthopelagic monitoring programme of key, representative habitats within the international seabed and overlying water column. Deep-sea tagged individuals could be tracked through space and time within and across networks, delivering knowledge on their biology in relation to concomitant sampling of the surrounding community and environment. In this way, scientists could acquire consistent, high quality scientific ecological data to plan marine protection and to inform ecosystem-based management on ocean-basin scales.

3. Developing and implementing technologies enabling biological observations in the deep ocean

The inherent expense of ocean technologies has contributed to dwindling investment in subsea infrastructure, thus greatly inhibiting advancement in understanding large-scale deep-sea ecology (i.e., macroecology). Expense, rather than current technological *capability* (Brandt et al., 2016), ultimately limits efforts to increase appropriate spatial and temporal sampling scales in the pursuit of data to adequately inform policy and to

provide baseline data to underpin stewardship. However, ecosystem-based management of the oceans will require scientific research that addresses issues at a variety of spatial scales, especially at a large regional level.

The challenge of monitoring the deep sea, particularly in international waters, relates to its vast area (>60% of the Earth's surface), to which its inherent spatio-temporal heterogeneity adds further challenges to the representational power of any data obtained on seafloor biology and surrounding oceanography (Costello and Chaudhary, 2017). The 3-dimensional features of the oceans confound the problem further, with an overlying water column that averages ~4 km in depth that is largely opaque to collection of large-scale data by satellites. Accordingly, any network geometry will influence its monitoring capability, with the latter depending on the degree of *spatial heterogeneity*. Such heterogeneity is hard to capture on all spatial scales, and will require a well-designed, stratified, and highly replicated approach. It simply will not be feasible to monitor all deep-sea habitats simultaneously, suggesting a need to target sites considered representative of major ecosystems and depth zones in each ocean basin. Monitoring should also include, but not be limited to, Environmentally Sensitive Habitat Areas (ESHAs), Ecologically and Biologically Significant Areas (EBSAs), and Vulnerable Marine Ecosystems (VMEs) (Ashford et al., 2019) previously identified and characterized by *in situ* vehicles. Finally, the approach must be nested, with vehicles, such as AUVs and crawlers, that can sample and characterize large areas (many square kilometres) and other tools specialized for study of small-scale heterogeneity (scale of 10s of square metres) (Brandt et al., 2016).

No current funding mechanism can deliver the financial and technological resources for EMB research at a basin scale in the deep ocean. Nonetheless, this research is vital for international organizations (ISA, RFMOs, OSPAR, UNGA etc.) regulating activities in the oceans, and for industries operating therein. This gap may require innovative financial mechanisms that stimulate international, multidisciplinary EBM research in its widest sense. The costs for deep-ocean monitoring will likely decrease progressively as the technologies advance and their use expands. Although this full technological development is far in the future, given present limitations in data storage, processing autonomy, and transmission, we propose one possible array for sensors and technologies that could become available for this need.

The development of a sound monitoring strategy for the deep oceans must include the seafloor and the water column above. To fully achieve this monitoring strategy, technological development should integrate information from the entire water column above the seafloor, the seafloor surface and in sub-seafloor. There is a huge potential for technological development in the next 15-20 years, enabling the sampling and monitoring of different biotic and abiotic targets, within the three-dimensional scenario represented by the water column (including the benthic boundary layer), the seabed surface, and subsurface.

4. International cooperation for a sound management of deep-sea ecosystems

Recently a new global, pan-sectoral, international deep-sea strategy has been proposed (Danovaro et al., 2017b). This strategy presents several important challenges. Among them one of the most challenging is the assessment of the baseline conditions, which enable us to identify and quantify the impacts of human activities over time. This need appears particularly relevant in the occasion of large-scale disasters such as the one of the Deep-Water Horizon. Prior to the 2010 Deep-Water Horizon blowout in the Gulf of Mexico,

detailed deep-sea biodiversity knowledge had been acquired during numerous projects funded by NOAA, MMS, NSF and others, the results of which were synthesised during the international Census of Marine Life programme. This knowledge provided a baseline of scientific information from which to quantify, for the first time, oil spill impacts on deep-water coral and soft-sediment communities (Schwing et al., 2020). Although many of these examples occur in areas under national jurisdictions, they illustrate the challenges and needs of the scientific information for international waters (Orejas et al., 2020).

5. Conclusions

Society must address the lack of rules and appropriate tools for the sustainable use of resources, also by supporting global scientific projects, including a global deep-sea monitoring network. A new cooperation under the umbrella of the United Nations could fill the critical research gaps identified here. This cooperation should be linked to the Intergovernmental Oceanographic Commission of UNESCO and, through a scientific Advisory Board, could provide independent advice, transcending sectoral and jurisdictional limitations: i) sustain a Deep-Sea Ecosystem Monitoring Network for acquiring knowledge necessary for deep-sea management and integrate inputs from research institutions, academia, industries, and international NGOs, ii) make data available to inform policy and resolve critical needs, and iii) facilitate the conversion of scientific knowledge into "good practices" for the best, shared governance of the deep oceans. The cooperation should also contribute to the technological development and implementation of Artificial Intelligence to facilitate operational autonomy and data processing in these remote habitats. In parallel, research on mechanisms and functioning is required, made of ship-based multidisciplinary process studies, *in situ* and in laboratory experiments using the best biological, molecular and bioinformatic tools. The final goal is to create the knowledge able to, on one hand, make relevant scientific progresses and on the other hand identify new management tools, which can produce beneficial effects for our Society.

Planning the eco-sustainable management of deep ocean requires an international initiative and the UN decade 2021-2030 Ocean Science for Sustainable Development represents a unique opportunity to launch a global effort. The expansion of biological and ecological knowledge and the integration of biotic and abiotic information at appropriate spatial-temporal scales represents the major pre-requisite for the new strategy proposed here. Deep-ocean management also requires much wider capacity building than at present and a "global vision" that spans geographic and political borders to make informed decisions on crucial topics, including deep-sea mining, protection of deep-polar regions, and exploitation of biotic resources in the areas beyond national jurisdiction.

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Planning marine sustainability: the future we want

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1. Backcasting vs forecasting

Forecasting uses the knowledge of the past that led to the present conditions, and infers a possible future, based on projections. The sequence is past - present - future.

Backcasting does the opposite: it designs a desirable future and adjusts the present so as to trigger a series of steps towards future goals, treasuring the lessons of past mistakes. The sequence is future - present - past - future.

Sustainability is a future goal and we must plan the unsustainable present so as to reach the future goal of sustainability, avoiding the mistakes of the past.

2. What is sustainability?

We planned our production and consumption systems aiming at the growth of the economic capital. To reach this goal we tapped the goods of nature, i.e. the natural capital: the growth of the economic capital occurs at the expense of the natural capital. The erosion of natural capital, however, invariably leads to the collapse of the economic capital. An economy planned in this way is destined to fail, due to the erosion of natural resources.

This irrational way of planning our relationship with nature led to the concept of sustainability (see Thiede et al. 2016 and Boero et al. 2019, for essays on marine sustainability). The steps towards marine sustainability are marked by a series of Directives of the European Commission that start from the Water Framework Directive, to the Habitats Directive, the Marine Strategy Framework Directive and the Maritime Spatial Planning Directive. The last frontier of sustainability is marked by the advent of the concept of Missions, and is embodied in the Mission Area Healthy Oceans, Seas, Coastal and Inland Waters and the Mission Starfish that stemmed from a group of stakeholders supported by a group of experts in marine science.

3. One health

Our economic systems have focused on the well-being of our species, disregarding the well-being of nature. It is increasingly clearer, however, that if our well-being compromises the health of ecosystems, prosperity cannot last long. Environmental health, societal health and economic health are all connected, as the three spheres metaphor illustrates (Fig. 1).

Fig. 1 - The three spheres.

The sphere of nature contains the sphere of society which, in turn, contains the economic sphere. The rules of nature (the arrow) also regulate society and economy, since both are based on the conditions of nature. The rules of society also regulate economy, whereas the rules of economy regulate only economic issues. Contrary to the ranking of priorities of the real world, we have designed our systems of production and consumption presuming that the economic rules have a bearing on both society and nature, reversing the order of priority. It is dramatically clear that this misunderstanding of priorities is becoming unbearable for both society and the economy. The New Green Deal recognizes the logical primacy of natural assets, and the ecological transition aims at basing our actions by obeying the laws of nature, studied by ecology.

4. The laws of nature

Besides the universal laws of physics, the main laws of nature that regulate a living planet are just two (Boero, 2018), as outlined by Charles Darwin (1859) in On the Origin of Species.

The law of growth says: *all living beings tend to grow in number*. This law is fully embraced by those who postulate the growth of the economic capital to infinity.

The law of the limit says: *The growth of the population of any species cannot be infinite*.

The law of growth is internal to species, and is enforced with reproduction. The law of limit is external to species, and is enforced by natural selection. Growth is buffered

by famine, disease or intra- and inter-specific competition. Our species has detected also the law of limit and we should aim at obeying it without suffering from either famine, disease or war, stopping our run towards growth before the price of the limit becomes unaffordable.

The only way to do so is to remain in equilibrium on the natural resources that sustain us, balancing our exploitation of natural resources with the rate of their renewal: sustainability.

5. The world ocean and the Starfish

The Earth is a living planet because it is covered by water: the world ocean. Even on land, the ocean is visible, up in the sky: the evaporation of marine water leads to cloud formation, and the rainfalls in Italy are mostly of Atlantic water that, then, goes back to the Mediterranean Sea through terrestrial runoffs. Oceanic systems, thus, are crucial also for the well-being of terrestrial animals like us.

The European Commission has launched Mission Starfish to illustrate five crucial points that will be conducive to the future we want:

1. *Filling the knowledge and emotional gap*. We do not know enough about the ocean and we are not fully aware of its importance. Knowledge can be achieved by developing technologies that will allow us to digitalize the ocean, by assembling an observation system that checks the important ocean values, from physics to biodiversity. We must also increase Ocean literacy.
2. *Zero Pollution*. Production systems must be re-designed, planning for goods and services that do not involve waste. Pollution means waste of resources, we cannot afford it.
3. *Revamping governance*. We cannot govern the ocean, we can govern our activities in it. These must be redesigned according to the laws of nature, especially the law of limit.
4. *Regenerating marine and freshwater ecosystems*. Nature knows how to regenerate herself: leave nature alone and the ecosystems will heal with no need of our intervention. Pretending to be able to do better than nature is an infantile expectation, rewilding is the way to an improved state of ecosystems (Perino et al. 2019).
5. *Decarbonising our oceans seas and waters*. This is already covered in point 2, since carbon dioxide is a form of pollution. We are still in the age of combustion, as we were in caves. This silly way of producing energy must be abandoned in favour of more effective technologies.

How to achieve the future we want

The definition of good environmental status (GES) in the Marine Strategy Framework Directive describes the ideal state of our aquatic systems: the ocean we want. The first descriptor of GES is “biodiversity is maintained”; the other 10 descriptors list a series of stressors and prescribe that their impacts do not compromise the functioning of the ecosystems (Fig. 2). Biodiversity and ecosystems, then, are the measure of ocean health and, eventually, of the health of the natural sphere on which the health of the societal and economic spheres depend.

GES is the objective of backcasting. How to reach that future from a present that does not contain its premises? Obviously, we must change our production and consumption systems, redesigning them according to ecological principles. Technological innovation is the key to achieve this objective, but it must be guided by ecologists who judge the viability of the proposed "solutions" in terms of sustainable technologies that make use of renewable materials and that do not require decommissioning.

Fig. 2 - Marine biodiversity and the main human impacts that affect ecosystem functioning (concept: F. Boero; artwork: A. Gennari).

Conclusion: Testing the efficacy of our approaches

The efficacy of any policy for the improvement of the state of the ocean must be tested, hence a global observation system that checks the state of the environment in its significant components is essential. Biodiversity and ecosystems are not covered by current observation systems, which are badly in need of upgrading. This will require a thorough revision of our approach to marine science, focusing on important aspects that, instead, have been neglected. Holistic approaches are increasingly invoked by the European Commission, but the scientific community keeps being reductionist and fragmented (Boero et al. 2019). The unification of marine sciences calls for a re-organization of the research system, so as to avoid the fragmentation of approaches. The state of the environment will tell us if we are heading towards the seas we want.

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Observing ocean state and marine life

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The importance of oceans and seas for the planet ecosystem health and for human wellbeing cannot be overestimated. Oceans cover over 70% of the planet, provide climate regulation by absorbing a massive amount of heat and carbon dioxide from the atmosphere, sustain the hydrological cycle and its components - including rain over land and forests, host an amazing variety of habitats and marine organisms, ranging in size and ecosystem role, from the microscopic photosynthetic organisms that, driven by solar energy, fuel marine life and produce half of earth's oxygen and biomass, to large marine mammals and top predators, from sandy coastal areas to deep sea hydrothermal vents, and more. They provide food, energy, transportation routes, genetic and mineral resources, job opportunities, recreational, cultural and social services. Preserving ocean and ocean life is such a relevant task that it is - per se - one of the UN Sustainable Development Goals (SDG 14), but the ocean role is so relevant that most of the other SDGs cannot be achieved without preserving ocean health (Claudet et al. 2020).

However, ocean health is challenged by a number of co-occurring pressures, and it is easy to foresee that the number and intensity of those co-occurring threats will increase in the near future, driven by the increasing demands of the blue economy sectors and the society components that (rightly) pose great expectations on them. A non-exhaustive list of currently increasing anthropogenic-driven environmental threats includes climate change, ocean warming and acidification, marine litter, a countless variety of marine pollutants (e.g. oil spills, heavy metals, persistent organic pollution, antibiotics, drugs, and emerging pollutants), extractive activities and deep-sea mining, underwater noise, marine litter and marine plastic, genetic contamination, overfishing.

It is therefore crucial to be able to continuously and effectively monitor the state of the marine ecosystems, and to confine the growth of economic activities that have the potential to impact marine environmental status to the principles of environmental sustainability and social equity, so that we do not repeat at sea the very same mistakes made on land while pursuing the illusion of an infinite economic growth.

However, a successful implementation of those actions represents a formidable and multi-faceted challenge. On one hand, there is the scientific and technological challenge of improving our observation and assessment capabilities, with particular

reference to operational systems and biological properties. The need to improve the governance components of efficient, effective and sustained observing systems is a no less demanding effort.

1. The scientific challenge and the biological dimension

The scientific challenge stems from the fact that observing the ocean is difficult, expensive and requires approaches and methodologies quite different from those used on land, since one cannot walk on or though the oceans, but is forced to use boats or underwater vessels, and cannot see through water for more than a few metres. Furthermore, and possibly with the only exception of a tiny coastal strip, oceans are – or are perceived as - far from our "home", cold, dark, and possibly dangerous.

In fact, a large part of the ocean remains not only unexplored, but also hardly accessible to present-day measurement techniques. Experimental surveys do return a snapshot of the state in a given area, but generally have to be limited to a few transects and cannot cover a large area, nor can they be repeated very frequently in time. Coastal monitoring networks, moorings and buoys can provide more regular series of selected parameters with a higher time frequency, but they refer to few specific points. Satellite and remote sensing techniques provide synoptic information over larger areas, but they are limited to ocean surface only, and to few parameters. New unmanned autonomous vehicles (gliders, AUVs), or Lagrangian systems (floats, drifters), overcome some of these limitations, for instance by enabling the observation of subsurface areas, but not completely, because of limitations on space-time coverage and on the type of parameters that can be measured in this way. Similarly, the use of ships can contribute only to a certain extent.

Furthermore, while societal demand mainly refers to ecological assessments based on the integration of ecological, biogeochemical and physical properties, the availability of data on physical properties (e.g. temperature and salinity) is much larger than that on biogeochemical properties (nutrients, chlorophyll), which in turn is much higher than the availability of data on ecological properties (primary productivity, animal densities).

Finally, as ocean life is the product of complex interactions among a number of non-linear processes, the dynamic of extreme events - such as heat waves or bottom hypoxia - is usually very relevant. But - by definition - observing and describing rare events is highly demanding, since it implies the ability to sample continuously - or at least with high frequency- over time.

So, not only is the ocean under-sampled, but most of the data which can be obtained are bound to be biased or incomplete in terms of space (coast vs deep sea, surface vs bottom), seasonality (warm vs cold seasons), frequency (continuous vs discrete), and parameters type (physical vs biological) coverages.

It appears clear, therefore, that there is a need to enhance the existing observing capabilities, up to including all relevant variables with a sampling frequency appropriate to the physical biogeochemical and ecological processes considered (Bax et al. 2019, Benedetti-Cecchi et al. 2017). The ability to provide data in real time is another important aspect to be considered, as are the needs for intercalibration and interoperability among different observing systems. The development of sensors and techniques for unmanned, near-real-time assessment of biodiversity and biological properties is a particularly needed and relevant sector.

2. The multi-level and multi-agenda governance related challenges

The sea has no border, and marine pollution and environmental degradation are paradigmatic examples of threats that propagate in space and time also across political boundaries, and need to be addressed by cooperative transnational coordinated actions based on evidence-rooted common understanding.

The obvious way to implement these actions is to integrate and consolidate the existing observing capabilities into a system of observing systems (Fig. 1). However, existing infrastructures have been designed to meet some specific requirements, so that different infrastructures are managed by different entities, which have different agendas, responsibilities, priorities. As typical examples, scientific institutions have observing capabilities developed for their own scientific purposes and that – while being potentially usable for monitoring purposes - might not include variables and parameters that are mandatory for the environmental monitoring that regional authorities are required to implement. Conversely, different authorities might be responsible for certifying compliance against different legislations, and therefore focusing on different parameters, or use different techniques for the same parameters, or different accuracy, or sampling design. Possibly, more than one responsible entity is measuring the same parameter in the same place, each for its own reason, and this might generate uncertainty as to which is the most accurate description of the reality, and confusing messages to society.

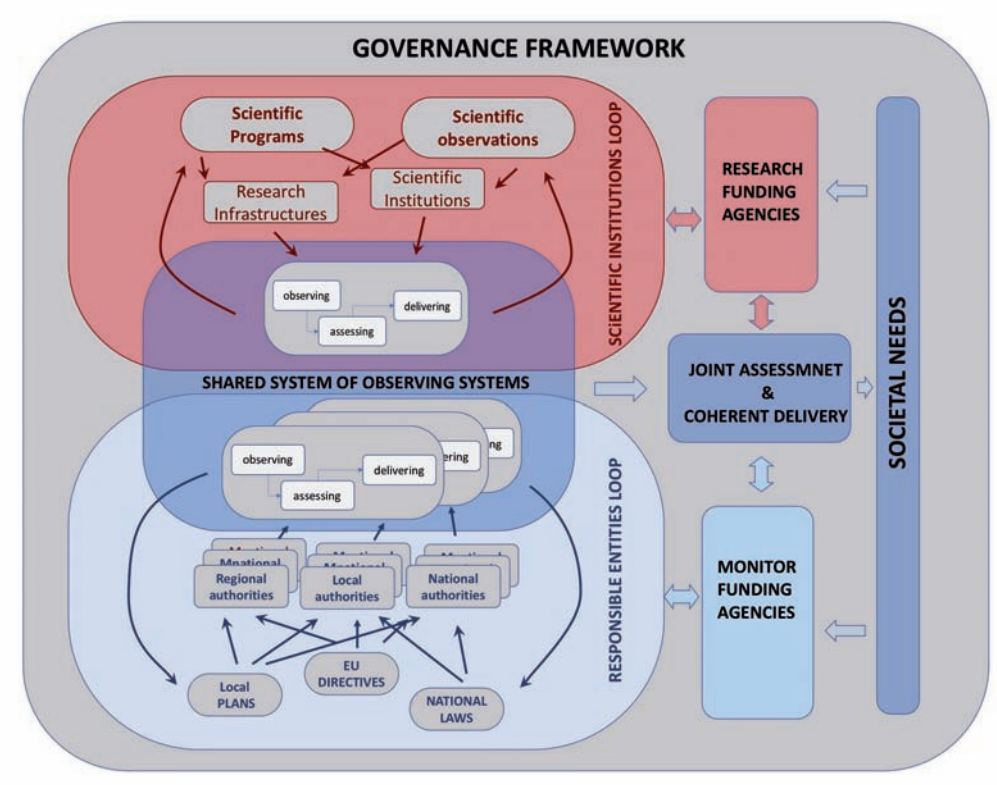

Fig. 1 - The set up of an efficient and sustainable system of observing systems requires the definition of a governance framework for the sharing and harmonization of tools, expertise, data and information able to recognize and accommodate the specific needs, roles and agenda of individual components.

The picture is even more complex in coastal and transnational areas, where the number of coexisting responsible entities increases, and the fragmentation of the governance framework makes it more difficult to have an efficient planning of the area.

Overcoming this fragmentation requires the definition and testing of efficient frameworks for sharing, integration and harmonization of existing information, data, technology, infrastructure and expertise, as well as the enlargement of the ownership and community feeling among a variety of players and stakeholders across different regions and institutional levels. A shared procedure for assessing and a common valuing framework might also be important.

Several frameworks (e.g. IOC-GOOS, GEOOS), consortiums or networks already exist, which aim to promote coordinate efforts for sustained observations of the ocean with reference to both open seas (e.g. the European Research Infrastructure Consortia, EIRC Euro-Argo, Integrated Carbon observation system ICOS, European marine biological resources centre EMBRC, LifeWatch) and coastal seas (e.g. the International Centre for Advanced Studies on River Sea System DANUBIUS_RI or the research consortium supporting the JERICO projects). However, these consortia are typically composed, and ruled by, scientific communities and do not always include, or prioritize the need of national, regional or local authorities. The latter, however, bear the responsibility for the implementation of the monitoring programs prescribed by law and the assessment of water quality compliance with existing legislations, and therefore must have observing capabilities and manage the institutional monitoring systems. The recognition of this gap within the European transnational cooperation program MED led to the top-down MED Strategic Project SHAREMED. Another important point to be considered is the need to harmonize the activities and developments of the different systems that monitor and observe the component of the river-coast-open sea continuum.

An effective and efficient implementation of a system of observing systems needs a cooperative effort based on synergic activities among all relevant actors. Key ingredients to achieve this target are:

- trust, respect, transparency, rigor;
- alignment of participants' agendas, with transparent identification of common priorities, open recognition and acknowledgement of individual specific needs, and consequent planning of the system of observing systems implementation plan;
- a clear identification of the tasks and responsibilities of each participant;
- a clear identification of the governance structure, ownership scheme, property rights.

Furthermore, a clear subdivision of funds allocations among institutional monitoring, research in support of monitoring, scientific monitoring and long-term observation, and scientific programs would also help in clarifying roles, decreasing possible competitive tensions, and in favouring cooperation among the scientific community and the responsible entities.

3. From data to usable information: models, indicators, open data

Collecting data is not enough. Data must be freely available for use for everyone. Today most data are supposed to be open, but in many cases they simply are not available, and even data classified as in the public domain are in practice impossible,

or almost impossible, to obtain. A true implementation of the FAIR (Findable Accessible Interoperable Reusable) paradigm is a prerequisite for efficiently sustaining the advance of knowledge in ocean science. It is also a moral imperative.

Additionally, while many users look for the possibility to access and freely reuse data in assessment, forecast or data products, a very large fraction of users do not ask for raw data, but for the information and knowledge that those data contribute to provide. Indeed, data are not the reality, but a representation of part of it, and need to be processed taking into account their representativeness, uncertainty, and the information embedded in other data. Numerical models can be of great help in this phase, since they allow us to: interpolate experimental observation in space and time, thus including observation coverage; extrapolate missing observation by using theoretical and phenomenological knowledge embedded into model constructions; provide an ideal quantitative representation of the system in normal condition, to be used as a benchmark against which to assess the relative importance of anomalous behaviour captured by observations, release short term forecasts of the expected behaviour of the system; provide scenario analysis of the expected response of an ecosystem to the implementation of alternative management policies. Models, therefore, are crucial components of observing systems, and are increasingly considered into their construction. Of course, their use has to be restricted to models that have been validated against independent observations. Their results have to be viewed within a risk-based framework, with a clear identification of model assumption and limitations (Heymans et al. 2018, Solidoro et al 2009). The Copernicus Marine Ecosystem Modelling System is an excellent example of how the use of models can efficiently integrate an observation network for efficient monitoring of the sea (von Schuckmann et al. 2016, 2018, 2020) However, it needs to significantly improve its capability to deal with the biological and ecological dimension of marine ecosystems.

Ocean indicators are also powerful tools in enhancing user uptake of ocean observing systems. While it is clear that no single indicators can capture the complexity embedded in real systems, an indicator, or possibly a suite of indicators, is a simple and effective tool to describe, monitor, and illustrate the status and the status trends of complex phenomena, such as ocean health. Indicators are essential tools in monitoring and communication strategies of ocean observing systems and can have an important role in the science-policy interface, by bridging the gap between raw and uncertain data and the information required for sustainable management.

Acknowledgment. This study has been partially developed in the framework of the Interreg MED Strategic Project SHAREMED, co-financed by the European Regional Development Fund under the Funding Programme Interreg MED 2014–2020. https://sharemed.interreg-med.eu/.

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Gazing at the sea with new X-ray eyes: the starfish as sentinel of climate change

Pierre Thibault

Pierre Thibault, Università degli Studi di Trieste, Trieste (Italy), originally from Québec (Canada), is an expert in X-ray imaging and tomography. He obtained his PhD at Cornell University and has conducted research in Switzerland, Germany and the United Kingdom. He is now professor at the University of Trieste, where he pursues his EU-funded research project.

On a drizzly morning of February 2020, Ms. Christina Wood, researcher at the National Oceanography Centre of Southampton (United Kingdom) met for the first time Dr. Irene Zanette, a physicist and at that time a Royal Society fellow at the University of Southampton. Ms. Wood was interested in new tools to inspect her precious samples, which she carried in a big jar to show to Dr. Zanette. From this first meeting, a fruitful collaboration started to emerge: the task entailed exactly the type of challenge that Dr. Zanette was ready to take on.

Ms. Wood's samples were small sea stars, *Ctenodiscus crispatus*, commonly called mud stars in English because of the habitat in which they are most commonly found. *C crispatus* is a dominant species across the Norwegian Arctic, comprising more than 3% of the biomass in this region (Wassmann P. et al., 2006) The small sea star - less than 10 cm across - lives in the muddy sea floor along the coast of all the circumboreal regions. It buries itself in sediments and feeds on organic detritus. It is believed to have an important role in "cleaning" the bottom of the sea, through bioturbation, the process of mixing the fine particles that accumulate constantly at the bottom of the sea. The living activities of *C crispatus* - how it feeds, moves and reproduces - contribute to ecological cycles, including carbon capture.

These details were new to Dr. Zanette, an expert in X-ray physics and imaging, as they were to me when I later joined the collaboration. However, we know, as does most of the population by now, that anthropogenic climate change has become an emergency, with observed effects everywhere across the globe. Climate warming and other human-induced environmental changes have complex effects in the balance of all ecosystems. The seas and oceans are not spared. How will *C. crispatus* be affected? How are individuals able to adapt to important changes in their habitat, in particular with regard to their nutrition and reproduction? Can these changes help to monitor and predict the evolution of the ecosystems in these areas? These questions are at the core of Ms. Wood's research project (Solan M., et al., 2020).

Answers can only come from observations and experiments. The stars were obtained by the Norwegian research vessel G.O.Sars, in collaboration with the Institute of Marine Research (IMR) in Norway. During these benthic trawls, the vessel picks up sediments and fauna from the seabed, which are then sieved and

preserved for further analysis. Dissection, the standard investigation technique among biologists, is normally used to determine various anatomical details of the collected animal samples. However, irreversibly damaging samples makes it difficult or even impossible to study multiple characteristics on a single individual. Samples are scarce and thus precious, and the expeditions are rare and costly. An alternative to dissection was needed to study the samples without affecting their physical integrity.

Peering into intact, opaque objects has been precisely the defining feature of X-ray imaging since Roentgen's discovery of the up to then unknown *"X radiation",* 125 years ago. Familiar to everyone for medical diagnostics or security screenings, X-ray imaging has become a versatile tool that fulfils a vast range of needs. Recent research in the field focuses on important technical improvements, e.g. for speed, dose reduction, better resolution and better contrast. Fundamental questions are also investigated, in particular the search for imaging procedures that exploit interactions between X-rays and matter that have been ignored so far.

Much of the cutting-edge research is conducted at synchrotron radiation facilities, large particle accelerators designed to generate powerful X-rays that have laser-like characteristics. In 2018, Dr. Zanette received a University Research Fellowship from the Royal Society for a 5-year project. Her goal is to transfer advanced X-ray imaging methods from the synchrotron to conventional X-ray laboratory sources - similar to those found in hospitals or airports - making them broadly available for the scientific community. My work on high-resolution X-ray imaging methods, in particular *ptychography*, is also concerned with synchrotron-based techniques. Thanks to the support from the European Research Council (ERC Starting grant project OptImaX), some of the techniques and analysis software my group has helped develop are now used routinely in synchrotrons throughout the world. With renewed support from the ERC in 2020 (Consolidator grant project S-BaXIT), I moved my laboratory and group to the University of Trieste, where I pursue my research also thanks to the presence of Elettra, Italy's only synchrotron radiation facility.

In December 2020, we had the first opportunity to examine some of Ms. Wood's sea stars at the synchrotron Elettra. This first round of measurements, on juvenile samples between 1 and 2 cm across, took place at the SYRMEP beamline, an instrument dedicated to X-ray imaging and tomography. To study their capacity to adapt, we imaged samples from two different environments: a sheltered fjord, and the open Barents Sea. We assembled an excellent team of young and motivated researchers. Dr. Adriano Contillo, Ms. Sara Savatovic, and Mr. Stevan Vrbaski all contributed to the results that we have obtained up to now. Unfortunately, Ms. Wood could not join because of the COVID-19 pandemic.

A two-dimensional projection of one of the samples is presented in Fig. 1. This type of image provides a phase-contrast enhanced map, where mostly the exoskeleton of the sea star is visible. Preliminary results of the tomographic reconstruction of another specimen are shown in Fig. 2. A slice through the reconstructed volume shows a large amount of sediments inside the animal's stomach, also depicted in blue in the three-dimensional rendering.

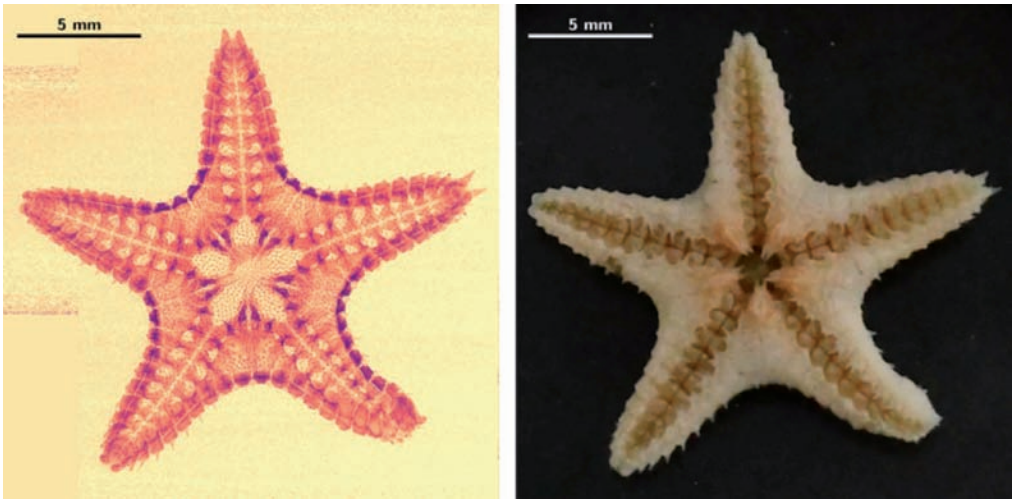

Fig. 1 - Left: radiograph of one of the *C. crispatus* specimens, showing the intricate structure of its exoskeleton. Right: a photograph of the same sample.

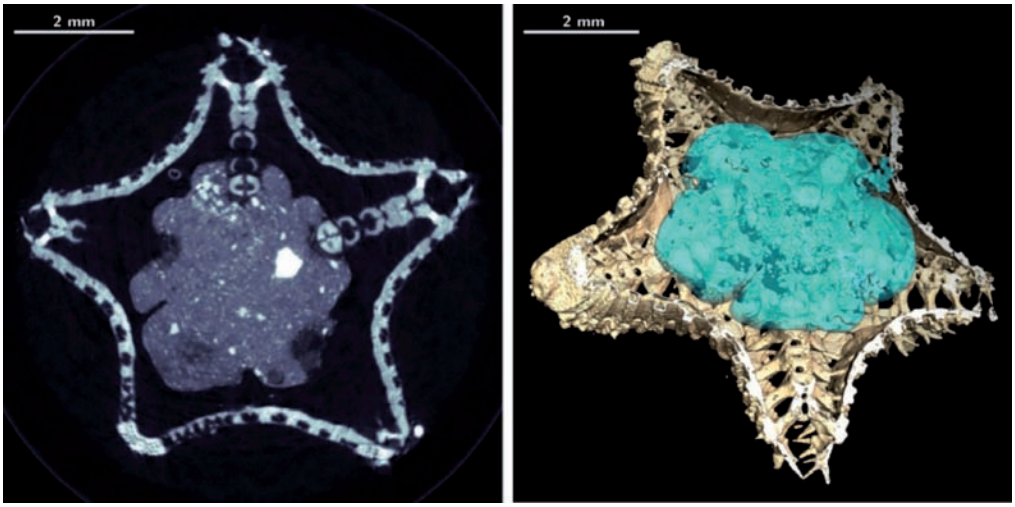

Fig. 2 - Left: tomographic slice of a different *C. crispatus* specimen. The exoskeleton is the brighter part. The grey mass in the centre is sediments and small rocks in the starfish's stomach. Right: three-dimensional rendering of the same dataset.

While the results are already promising, this experiment was the first at SYRMEP for most of the team, with an imaging procedure never tested before on this instrument. During our next measurement campaign, we will apply advanced phase-contrast methods (Zdora M-C. et al., 2020) to push the contrast of soft tissues (e.g. digestive glands and reproductive organs) within the starfish, which are normally much more difficult to distinguish with X-rays.

The collaboration continues. In the near future, more samples from the Norwegian and Barents seas will be scanned. We are also expanding our work to key animals from Adriatic ecosystems, which are rapidly changing.

Within the ERCfunded project S-BaXIT (*Scattering-Based X-ray Imaging and Tomography*), the study of marine samples – among other applications – will be expanded to new and more exotic imaging modalities. Valued at €2.2M, this consolidator grant has as its main objective the development and application of X-ray imaging methods that exploit up-to-now underestimated scattering phenomena that take place in materials. These developments will span the spectrum from theoretical work to simulations, to experimental demonstrations and applications. The synchrotron Elettra, a partner institution in this project, hosts the laboratory for my group, where a dedicated X-ray imaging setup is under development.

C. crispatus, a humble starfish hidden at the bottom of the cold fjords, could hold a crucial role as the sentinel of unfolding climate upheavals. The sea has many stories to tell. It has much to teach us. Trieste, city of science and of the Adriatic, is the ideal location to let X-rays meet the sea.

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Chapter 4.

Zero pollution

Plastic representation of Eurythenes plasticus
Courtesy of Fred Maida @rifiutispeciali

The future challenge of decreasing underwater acoustic pollution

Angelo Camerlenghi

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1. Noise between use and abuse

Mankind is noisy by nature. The impact of noise on human societies is well known. The World Health Organization declared that environmental noise is an important public health issue, featuring among the top environmental risks to health (WHO Europe, 2018). The burden of disease from environmental noise embraces cardiovascular disease, cognitive impairment in children, sleep disturbance, tinnitus and annoyance. A specific European Union Directive relating to the assessment and management of environmental noise was issued in 2002 (European Noise Directive 2002/49/EC). In this time of pandemics, the words of Robert Kock of the Institute for Infectious Diseases, Berlin, Germany, Nobel Prize in Physiology and Medicine in 1905 for his investigations and discoveries on tuberculosis, sound as a precursor of events: "*one day mankind will have to fight noise with similar strength as the fight against cholera and plague pandemics*".

Ocean acoustics is not a new science (e.g. Dosso and Dettmer, 2013). The speed of sound in water was measured with excellent accuracy as long ago as 1862 with the famous experiment on Lake Geneva (Fig. 1). A significant frequently cited milestone was the development in the same year as the sinking of the Titanic (1912) of the first underwater acoustic transducer able to detect the presence of floating icebergs from a ship. Huge developments followed, mainly for military applications, that allowed the fast development of modern oceanography after the Second World War. Since then, anthropic activities in the oceans, shipping, fishing, naval, oil and gas, scientific research, construction, not forgetting leisure, have increasingly disturbed the natural soundscape of oceans, rivers, and lakes on Earth.

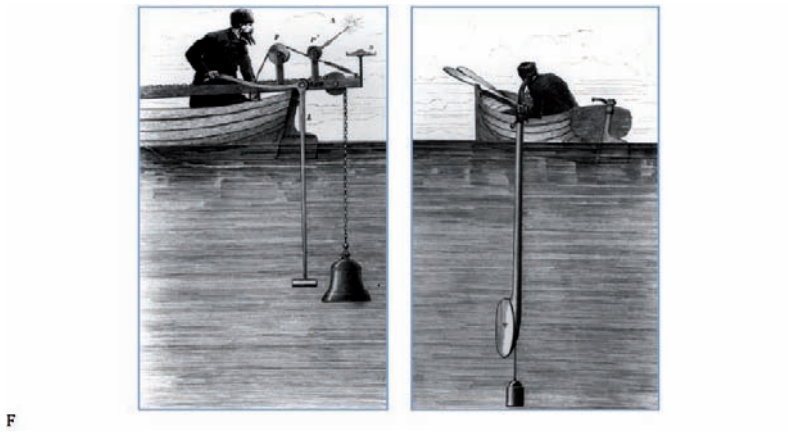

Fig. 1 - Colladon and Sturm's 1862 experiment to measure the speed of sound in Lake Geneva (J. D. Colladon: Souvenirs et M moires, Impr. Albert-Schuchardt, Geneva, 1893).

What is new is the growing awareness at different levels of our society - scientific research, non-governmental organizations, policy makers, and citizens - that anthropogenic noise, always superimposed on natural sound, is a threat for life in subaquatic environments and should be treated as an emerging pollutant. This is very well stated in the Proposed Mission Starfish 2030: Restore our Ocean and Waters, where the reduction and regulation of underwater noise is identified as one of the four targets to achieve the ambitious objective of "Zero Pollution".

Similar trends in the collective awareness of environmental emergencies in oceanic environments occurred with respect to ocean acidification and marine litter. The former is a problem that does not appear to the naked eye of the common citizen. Researchers had to demonstrate that the positive role of the oceans as buffers of increasing concentrations of anthropogenic CO_2 in the atmosphere does not come free. The negative counterpart is that the CO_2 is captured by the oceans at the expense of a decreasing oceanic water pH and, consequently, adversely affects marine life, especially in the lowermost positions in the trophic webs, with huge aftereffects on the survival of biological species and the geographical distribution of fish stock. An easier but equally important message to spread across all levels of our society has been the presence not only of plastics floating on river and ocean waters of the entire planet, but also microplastics permeating the tissues of edible species.

In spite of the efforts of researchers to identify, describe, understand and communicate timely dramatic changes occurring to the environment, resilient measures are often implemented once the impact on economy and society is demonstrated. It is a common opinion among scientists that anthropogenic underwater noise will be the next of such trends in collective awareness.

2. Noisy blue economy

Acoustic pollution has been recognized for its impact on human health, necessarily onshore.

Its impact on marine living organisms has been long ignored, or underestimated, by most.

There are five main types of anthropogenic sources of underwater noise today: Marine traffic (including leisure boats), military sonars, explosions, pile driving (mainly for wind turbines offshore), and seismic exploration (for hydrocarbon prospecting and scientific research). The noise generated by these activities is superimposed on the natural ambient sounds present in the oceans forming the pristine soundscape, composed of biological sounds emitted by living organisms for different purposes, physical (ocean turbulence), atmospheric (meteorological), and geophysical sounds (Fig. 2). The sum of noise and sound has characterized the Anthropocene ocean since the industrial revolution, with impacts on the health of marine animal populations that are still far from being fully understood (e.g., Duarte et al., 2021).

The five types of anthropogenic noise described above are generated by industrial, economic and recreational activities that form the core of the blue economy that will sustain the blue growth (Commission Staff Working Document, 2017; European Commission, 2020). It is important to remember that established and emerging noise-generating industries (Table I) will expand their activities with the implementation of the blue economy with value-added expected to double by 2030 (Fig. 3, OECD, 2020).

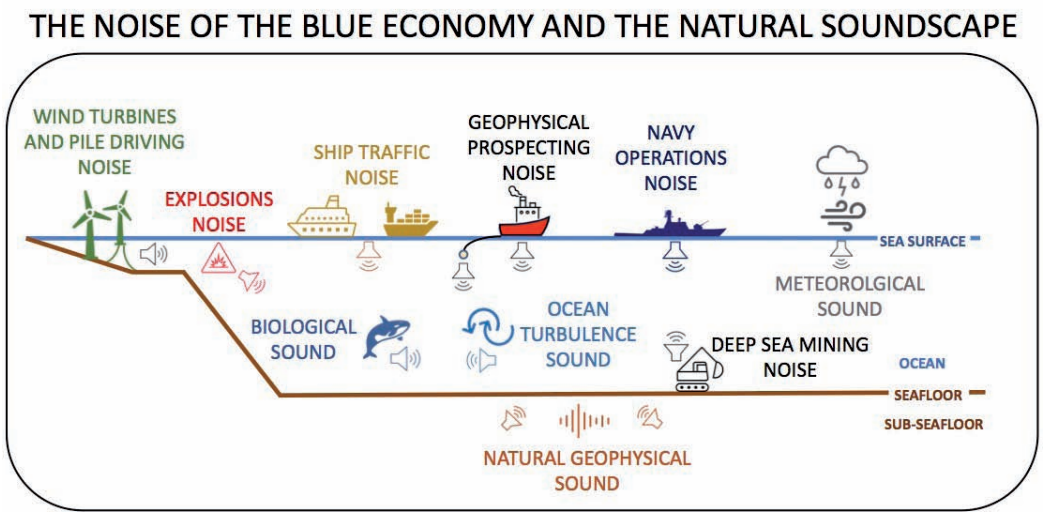

Fig. 2 - Anthropogenic noise vs natural sounds in the marine environment.

The sustainability of the blue growth process should therefore consider the noise levels produced by industrial sectors that are traditionally associated, at least in the general public opinion, with 'green' and 'sustainable' economy, like energy from renewable sources - offshore wind, wave, tides. In general, the renewable energy industry implies, for its success, the implementation of a worldwide network of energy storage, for which the issue of sustainability and ethics of provision raw material is of fundamental importance. The onset of the deep-sea mining industry, driven primarily by the need of energy storage for the renewable energy industry, is therefore expected to increase further the acoustic pollution in the oceans in the framework of the blue economy.

We should not forget to add scientific research to these industry-based activities when considering acoustic pollution. Oceanographic vessels produce noise like any other vessel (with the exception of rare silent research vessels built for hydrographic purposes) and routinely use acoustic devices for data acquisition that affect marine ecosystems in various ways. Research fleets should be the first to adapt to the requirement of silent vessels. A special case in scientific research is the use of impulsive pneumatic acoustic sources for the geophysical prospection of the sub-seabed. These are the devices unfortunately and improperly called 'airguns'. Airguns are not only the tools that enable geophysical service companies to provide energy industry the data necessary to locate offshore oil and gas reservoirs. These tools are employed routinely in scientific research to explore the Earth's interior with the objective of understanding the basic composition of the planet, paleo-climate evolution and submarine geohazards. Marine geophysical research uses noise to provide a service of knowledge and safety to our society. This activity, a pillar in the blue growth, will have to adapt to the concept of sustainability and participate in the decrease of acoustic pollution in the oceans.

Table 1 – Established and emerging ocean-based industries after OECD (2016). In bold the industries that contribute significantly to anthropogenic noise.

Established ocean-based industries	Emerging ocean-based industries
Industrial capture fisheries	**Industrial marine aquaculture**
Industrial seafood processing	**Deep- and ultra-deep water oil and gas**
Shipping	**Offshore wind energy**
Port activities	**Ocean renewable energy**
Shipbuilding	**Marine and seabed mining**
Offshore oil and gas (shallow water)	Maritime safety and surveillance
Marine manufacturing and construction	Marine biotechnology
Maritime and coastal tourism	High-tech marine products and services
Marine business services	
Marine R&D and education	
Dredging	

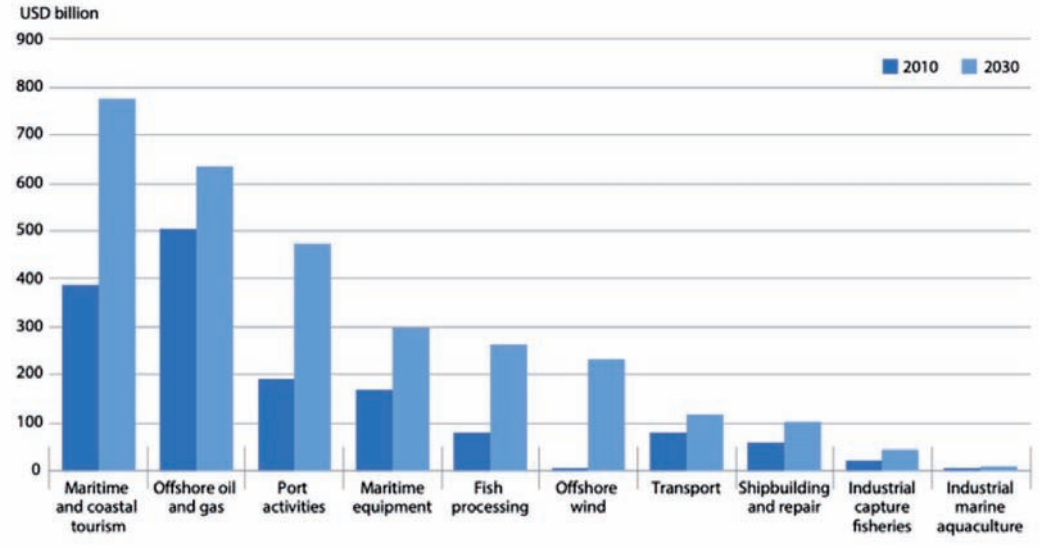

Fig. 3 - Ocean-based industries' value-added was expected to double by 2030 (EOCD, 2020)

3. The future challenge of decreasing underwater acoustic pollution

The objective of decreasing acoustic pollution can be achieved only with large-scale application of innovative technologies that will limit noise levels while ensuring the efficiency of the industrial processes needed to sustain the blue economy.

This process requires the setting of ambitious targets that will stimulate joint academic and industrial scientific and technological research with the support of European and national policies. An example of the challenge can be found in the mitigation measures considered for the limitation of ship-generated noise. One often considered mitigation measure is the enforcement of vessel speed thresholds in vulnerable environments. This attenuates the propeller noise and limits impulses from cavitation. Alternatively, and preferably, technological solutions for building innovative ships that will not emit harmful levels of noise during lifetime operations will more effectively contribute to counteract the trend of increasing noise levels while at the same time stimulating the blue economy.

The challenge of reducing noise emissions while maintaining the efficiency of operations should be governed by a rigorous science-based approach. The identification of acoustic thresholds for a scale of impacts and the implementation of registries of impulsive noise emissions are the present targets of the EU Technical Group on (underwater) Noise. Accordingly, new research should shift towards the understanding of impacts in an ecological framework considering the effects on the whole trophic networks that connect zooplankton to top predators and on fishery activities, targeting the ecosystem rather than individual animals or species and cumulative impacts of activities rather than individual projects or programmes. The improved opportunities for acoustic monitoring of oceanic regions will enable the implementation of widespread experimental activities to define thresholds of impact and to validate numerical models of noise propagation and generate noise level prediction tools for operators in order to transform present-day timely and costly procedures of environmental impact assessment into an affordable and sustainable improved procedure.

Such a shift requires an upgrade of the strategies supporting research that will have to consider the sharing of all available marine infrastructures to participate in experimental activities and monitoring. Mobile and moored marine observatories are now maintained in most world oceans, and in all European marine regions. Acoustic sensors, however, are very rarely planned in the implementation of such observing systems. In addition, a huge potential is coming from the possibility to use fiber-optic cables laid on the seafloor for digital communications as acoustic sensors. With an effort of coordination and cooperation between industry and scientific research, we may find that a global network already exists to accelerate the process of understanding the impact of anthropogenic noise on marine ecosystems.

Scientists, policy makers, private stakeholders and non-governmental organizations should work together to make silent blue economy and oceanographic research become a reality. Cross-disciplinary scientific cooperation embracing from shipbuilding to tourism, technological innovation, big-thinking, and basin-wide approaches will contribute to the achievements of ambitious goals. All European science-polices are pointing at underwater noise as one of the major challenges in the next decade: The Joint Programming Initiative on Healthy and Productive Seas and Oceans (JPI Oceans), The European Marine Board, the proposed European Partnerships on Zero-emission Waterborne Transport and for a

Climate Neutral, Sustainable and Productive Blue Economy are in line with the Proposed Mission Starfish 2030: Restore our Ocean and Waters. The change to a quieter ocean is about to begin.

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Zero pollution and the risk from contaminants of emerging concern

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The progress of modern society has certainly contributed to improve quality of life, but also increased the environmental release of chemical pollutants derived from industrial activities, excessive use of goods, traffic, and energy production. Several studies have documented the entry of synthetic and natural chemicals into aquatic ecosystems with the potential to cause adverse effects on organisms and food supplies. Furthermore, in the last 2 decades, chemical challenges for the environment have been dramatically changed, both in terms of magnitude of disturbance and types of hazards. Beside traditional, legacy chemicals (such as trace metals, polycyclic aromatic hydrocarbons, halogenated pesticides, flame retardants, etc.), for which normative restrictions are relatively well established, new pollutants of emerging concern represent actual examples of worrying stressors for the health status of aquatic organisms and ecosystems. Characterized by different environmental sources and distribution pathways, these compounds have been ignored for a long time, and now represent a growing hazard for their global diffusion, the possibility of being absorbed by several species and their potential deleterious effects.

The first compounds identified as emerging contaminants were the endocrine disruptors (EDs) in the late 60s. From a chemical point of view, EDs are a complex array of compounds including alkylphenols, bisphenols or phthalates in plastics, hormones, pharmaceuticals or personal care products, some PAHs and flame retardants to mention a few. As common constituents of many products used in daily life, EDs can interact with the proper functioning of the hormonal system. Well-documented, long-term effects of EDs have been reported in several species and wild populations, such as the onset of intersex in fish from polluted estuaries, masculinization of gastropods exposed to antifouling paints, embryonal mortality and altered sex ratio in populations of Florida alligators, fragility of eggs in seabirds, immunosuppression and reduction of reproductive success in sea lions from San Francisco Bay, hermaphroditism in polar bears, reproductive failure and increased lesions to the thyroid in Beluga, malformations and mortality in several species and populations of amphibians in US (Sumpter and Johnson, 2008). The scientific evidence of the environmental persistence of EDs, their biomagnification potential and clear toxicologically relevant effects on organisms and populations, has led to the international ban of several compounds, including polychlorinated biphenyls (PCBs), organo-tin compounds in antifouling paints, specific plasticizers and halogenated

pesticides. At EU level, the first important action against EDs was the adoption of a Community strategy in 1999 describing short, medium and long-term strategies. Since then, various regulations have been issued, including the Regulation (EC) No 1907/2006 concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH), the Regulation (EC) No 1107/2009 on the Placing on the Market of Plant Protection Products (PPPR), the Regulation (EU) No 528/2012 on Biocidal Products (BPR), and the final adoption in May 2018 of Commission Regulation (EU) 2018/605, elaborated on the basis of the most recent scientific criteria: these criteria were, however, criticised both by chemical companies claiming that important elements such as "potency" were omitted, and, on the opposite side, also by safety, public health and environmental NGOs considering the new criteria insufficiently protective and ambitious. In June 2018, the European Food Security Agency (EFSA) and European Chemicals Agency (ECHA) provided guidance on how identifying substances with endocrine disrupting properties, and some months later the European Commission published a new strategy on endocrine disruptors aimed at minimising exposure, developing a solid scientific basis for public policies and encouraging dialogue among scientists, public authorities and private actors.

Although these examples show a long-lasting strategy to counteract the impact of chemicals, the objective "Zero Pollution" of the Mission originates from the still actual evidence that all the chemical components of what we produce, utilize and consume are likely to flow into the sea. Chemical pollution thus remains an urgent priority to tackle and, since decontamination of European seas and rivers can hardly be imagined, the most sustainable and cost-effective measure is to prevent pollution at source. To achieve "Zero Pollution", the operative targets of the Mission include "Zero plastic litter generation" and "Zero spill".

"Zero plastic litter generation" is based on the clear evidence of an overwhelming cost-benefit ratio between use/abuse of modern comfort and irreparable environmental consequences. The advantages of plastic, including versatility, resistance and durability to degradation, are well known and led to the actual definition of "age of Plastics", where almost everything contains this material. Global plastic production reached 400 million tons/year in 2015, Europe ranking second, with 57 million tons of plastics produced in 2012, direct employment provided to over 1.45 million people, and ca. 26.3 billion euro generated for public finance and welfare (Avio et al., 2017). However, when not properly disposed or recycled, plastic poses a serious threat to the marine environment, where almost 10 million tons of these materials are annually released. Due to its non-degradability, the progressive accumulation of plastic has transformed this pollution into a large-scale phenomenon, now documented worldwide, from the polar regions to the equator, from intertidal zones to abyssal sediments (Eriksen et al., 2014).

Although the misleading concept of "plastic islands" and media images certainly contributed to the recent rise of public awareness, we are actually aware that large and visible plastics are just the tip of the iceberg, the predominant component of marine debris being represented by invisible microplastics (MPs) and nanoplastics (NPs), from 5 mm to less than 1 μm, which mostly derive from the continuous fragmentation of plastic debris. In this respect, while trends of macroplastics occurrence are highly variable and possibly influenced by future mitigation actions, the formation of MPs and NPs will not decrease, leading to alarming estimates on the presence of these particles in the marine environment.

Attempts to quantify the global abundance, weight and impact of oceanic plastics are often controversial and difficult to compare due to the lack of standardized sampling

methods, normalization units and expression of data, comparability between different matrices (Galgani et al., 2014). The lowest particle sizes that are routinely sampled in seawater are those in the order of 300 microns, thus neglecting the enormous portion of smaller particles, which are those of greater biological relevance. The impact of large plastic debris on the marine environment has long been the subject of environmental debates (Cole et al., 2011). Well recognized effects include loss of aesthetic perception and environmental value, economic repercussions for tourism and for numerous marine-related industries (e.g. shipping, fishing, energy production, aquaculture), and significant biological concerns for the injury and death of marine birds, mammals, fish and reptiles. A recent analysis revealed that 663 marine species experience adverse effects from interaction with plastic (Fossi et al., 2018). Besides entanglement and ingestion of macro debris by large vertebrates, microplastics are up-taken by planktonic and invertebrate organisms, thus being transferred along marine trophic webs with typically almost 25% of organisms containing one or more particles (Avio et al., 2020). Negative consequences can include loss of nutritional value of diet, physical damage, exposure to pathogens and transport of alien species. In addition, plastics contain chemical additives and efficiently adsorb several environmental contaminants, thus representing a potential source of exposure to such compounds after ingestion. Even though microplastics lack of acutely toxic effects of microplastics, the reported susceptibility of the immune system, accumulation of desorbed chemicals and the observed shift from physical to chemical challenge, suggest the possibility of subtle effects on organisms' health status under chronic exposure (Pittura et al., 2018).

Considering the new evidence on the multiple risks that plastics pose to the environment, important financial efforts have recently been directed to characterize the environmental fate and biological effects of MPs. Among these, JPI Oceans launched in 2015 the first call with a total budget of € 7.5 million euros, followed by a second call in 2018 for 10.5 million euros. A total of 10 projects were funded (Baseman, Plastox, Ephemare and Weather-mic in 2016-2018 followed by Andromeda, Facts, Hotmic, I-Plastic, microplastix and Response for 2020-2023), combining a huge network of European Institutions aiming to provide new insights on the ecological fate of plastics, and to identify the most urgent knowledge gaps. Scientific results are providing further evidence on the impact of plastic pollution in the marine environment, contributing to raise public awareness and to prompt important normative and political actions. The European Marine Strategy Framework Directive (MSFD, 2008/56/EC) includes litter amongst the descriptors of good environmental status, and international expert committees (such as ICES and GESAMP) have worked on standardized protocols for monitoring environmental MPs. In 2013, the Barcelona Convention agreed on a Marine Litter Regional Action Plan to prevent, reduce and remove marine litter from the Mediterranean. In 2015, the G7 Science Ministers Meeting acknowledged the global risks posed by plastics to marine life, ecosystems and potentially human health, and committed to a priority Action Plan to Combat Marine Litter. In 2017, the United Nation Environment Program (UNEP) launched an unprecedented campaign to limit the wasteful use of single-use plastic. In December 2017, Italy approved the ban of non-biodegradable cotton buds from 2019 and MPs in cosmetics from 2020, anticipating the decision of the European Parliament to eliminate single-use plastics from the EU market in 2021. The "European Strategy for Plastics in a Circular Economy" was adopted in January 2018, to transform the way in which plastic products are designed, produced, used and

recycled, thereby protecting the environment without limiting technological innovation and industrial growth. To minimize landfill waste the 5R approach is being promoted with four R-actions which should be taken (Refuse, Reduce, Reuse, Repurpose), prior to "Recycling". It is within a similar perspective that the Mission target "Zero plastic litter generation" aims to prevent plastic generation at the source, ending single-use objects and fully recycling or reusing other plastics. Considering the clean-up of actual pollution as virtually impossible, *"achieving zero litter generation means first and foremost a vigorous action on plastics and micro plastics, going beyond the current EU directive on single-use plastics, and setting high levels of mandatory recycling and waste reduction in packaging, construction materials and vehicles under the EU Circular Economy action plan. Ultimately, it should set in motion a European industrial effort to replace plastics and micro-plastics across the board by recyclable, bio-degradable and/or compostable alternative materials. It is also essential to reduce the rate of micro plastics entering the water cycle from industrial products (car tyres, textiles, etc.) and from consumer goods through the sewage network (personal hygiene products). To that end, informing consumers will be key*".

The "Zero Spill" target of the Mission has also a similar approach with the priority of reducing discharges into water of persistent organic and non-organic pollutants by, for example, updating wastewater treatment to treat actually ignored contaminants such as pharmaceuticals, which represent another well recognized and growing threat for aquatic ecosystems. The progress of medical science during the last century and the development of new and more efficient drugs allowed the treatment of several pathologies, with increment of life expectancy, decrement of infant mortality, better prevention of diseases, and improvement of health quality (Deloitte, 2015). The remarkable worldwide increase of medicines has represented one of the greatest benefits of modern society, but it has also been paralleled by the ubiquitous occurrence of these compounds in natural ecosystems. They were first highlighted in the US during the 70s, when clofibric acid, salicylic acid and clofibrate's metabolites were detected in treated wastewater; almost a decade later, the occurrence of anticancer drugs and synthetic steroids was measured in British rivers and effluents of Waste Water Treatment Plants (WWTPs). Further advances of analytical techniques in the mid 90s enabled a more accurate detection of very low levels of pharmaceuticals in aquatic ecosystems, thus allowing the identification of a large variety of pharmaceuticals in WWTPs effluents, surface waters, seawater, groundwater, sediments and aquatic organisms (Mezzelani et al., 2018).

The use of pharmaceuticals has globally reached 4,500 billion doses in 2020, approximately 24% more than in 2015, and 50% of the world population is able to consume more than one dose per person per day (QuintilesIMS Health, 2020). Such large consumption of human and veterinary medicines in conjunction with improper disposal at domestic sites is the major cause for the release of pharmaceuticals into aquatic environments. Major pathways include WWTPs, which conventionally use primary and secondary wastewater treatment processes, rather inefficient in removal of the majority of medicines: the application of more advanced treatments, such as active carbon filtration, ozonation and UV treatment has been implemented only in very few European pilot WWTPs (Bulloch et al., 2015).

As a consequence, pharmaceuticals are released into freshwater and marine environments and their occurrence is extensively documented in aquatic ecosystems

worldwide (Almeida et al., 2020). To date, almost 300 different active principles from different therapeutic classes such as steroid hormones, contraceptives, antibiotics, non-steroidal anti-inflammatory drugs (NSAIDs), antidepressants, antihypertensives and antiepileptics have extensively been measured in seawater and coastal areas with concentrations ranging from a few ng/L to hundreds of µg/L (Mezzelani et al., 2018). Unlike traditional chemical pollutants, medicines are bioactive compounds, designed to be effective at very low concentrations, and in natural ecosystems they potentially affect aquatic species over their entire life cycle (Bebianno and Gonzalez-Rey, 2015). Bioaccumulation of pharmaceuticals has been reported in several marine species including macroalgae, molluscs, crustaceans and fish of different ecological categories in which detectable levels have been reported for oestrogens and other steroid hormones (norgestrel and progesterone), antibiotics, non-steroidal anti-inflammatory drugs (NSAIDs like diclofenac, salicylic acid, nimesulide, naprossen and ibuprofen), antidepressants and anxiolytics (paroxetine, sertraline, venlafaxine, citalopram, lormetazepam, fluoxetine), cardiovascular drugs such as beta-blockers (atenolol, metoprolol, propranolol), angiotensin-converting-enzyme inhibitors, angiotensin II receptor antagonists (e.g. valsartan) and calcium channel blockers (diltiazem), lipid regulators. More than 90% of samples of *M. galloprovincialis* collected from 14 sites in the Tyrrhenian and the Adriatic Seas showed measurable levels of carbamazepine, one of the most persistent active principles in natural environments (Mezzelani et al., 2018, 2020).

Studies on deleterious effects of environmental pharmaceuticals were initially based on acute toxicity tests in bacteria, algae, invertebrates and vertebrates: concentrations causing detectable effects were usually orders of magnitude higher than those possibly found in aquatic ecosystems, indicating that the onset of “acute” toxicity is highly improbable for pharmaceuticals in natural environments. In contrast, the evaluation of sublethal adverse effects related to chronic exposure is certainly more appropriate to characterize the ecotoxicological potential of such molecules constantly present at low concentrations. Pharmaceutical drugs are specifically designed to exert their biological activity at low doses, targeting metabolic, enzymatic, or cell-signalling mechanisms, thus being potentially dangerous for chronically exposed non-target organisms: in this respect, an increasing body of evidence highlights the impairment of multiple biological processes including immunity, reproduction, growth, metabolism, feeding, locomotion, colour physiology and behaviour in fish, molluscs and other aquatic invertebrates exposed to pharmaceuticals at environmentally relevant concentrations (Mezzelani et al. 2016, 2021; Miller et al., 2019). An additional environmental concern has recently arisen from the development of antibiotic resistance in microorganisms with several direct and indirect risks also for human health (Zheng et al. 2021).

These examples highlight the emerging threat that pharmaceuticals may pose to aquatic organisms, and the importance of characterizing potential adverse effects in non-target species. However, pharmaceuticals are neither included in any environmental regulation, nor routinely monitored: among over 4000 substances classified as APIs, only seven (two oestrogens, 17-α-ethinylestradiol; 17-β-estradiol, and five antibiotics, erythromycin, clarithromycin, azithromycin, amoxicillin and ciprofloxacin) are included in a dynamic watch-list of the European Union Water Framework Directive (2018/840/EU), based on their potential adverse effects for the aquatic ecosystem (Miller et al. 2018). The European Commission (EC) recently acknowledged the importance of environmental pharmaceuticals, and in March 2019 a communication was adopted outlining a set of

actions toward the multifaceted challenges of those residues in natural ecosystems. The “Strategic Approach to Pharmaceuticals in the Environment” (COM/2019/128 final) emphasizes the need of gathering data on their occurrence and ecotoxicological effects as important prerequisites to develop appropriate Environmental Risk Assessment (ERA) procedures for such emerging pollutants, allowing also the clarification of potential risk for human health.

At present, available data are still too heterogeneous and fragmented to allow us to define a list of environmentally priority substances and a close integration among different crosscutting expertise will become necessary to deal with this complex problem adequately (Fig. 1).

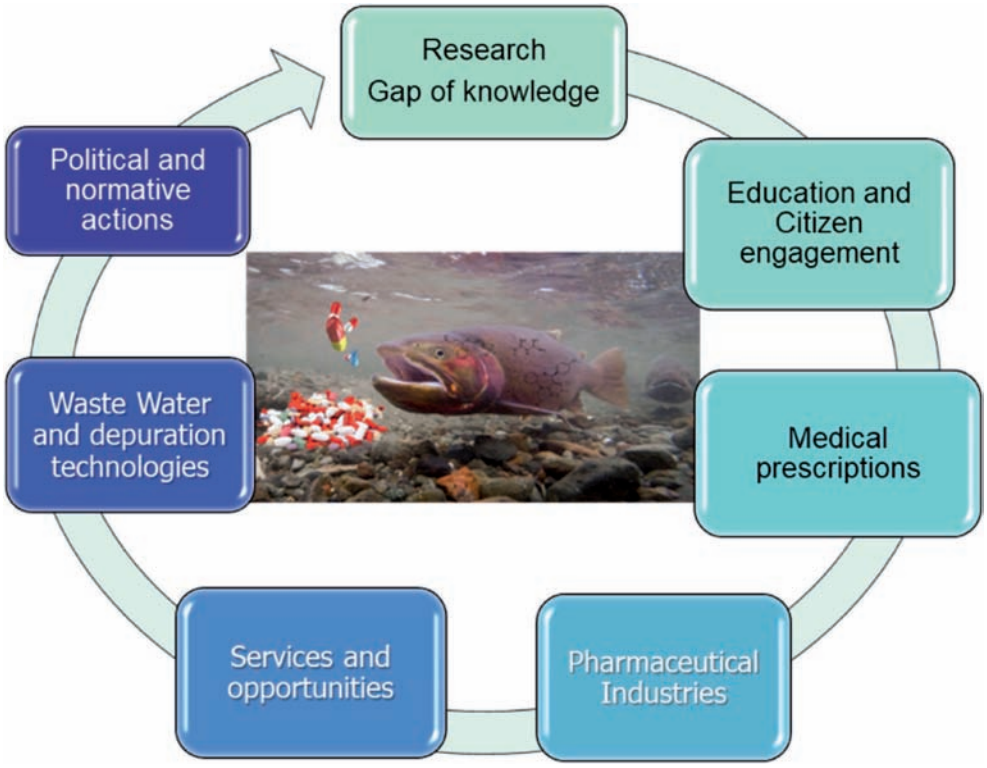

Fig. 1 - Suggested circular approach to pharmaceuticals for sustainable pathways of drugs according to “Zero pollution” target.

The improvement of scientific knowledge is required to define the environmental occurrence of various therapeutic classes and their ecological impact in terms of toxicity to aquatic organisms, bioaccumulation and trophic transfer in wild species, implications of long-term exposure at environmentally relevant concentrations. Future challenges will also be faced with pharmaceutical metabolites as well as mixtures of contaminants and interactions with multiple stressors, so far scarcely investigated. Scientific progression must be paralleled by education programmes, increased public awareness and citizen engagement, since the promotion of more appropriate disposal of domestic medicines and the concept of sustainable pharmaceuticals can both orientate the choice of drugs and reduce unintentional input of pharmaceuticals into aquatic ecosystems. At the same time,

research impetus is expected to drive medical doctors in considering the environmental fate of drugs when prescribing a specific principle within a wide range of molecules having similar therapeutic effects: as a general consequence, pharmaceutical industries could be motivated to include the characterization of the environmental impact of active compounds and metabolites as an additional requirement to optimize the molecular design of new drugs. Opportunities might arise for new companies offering services in collection and reuse of expired, domestic drugs, while technological innovations are expected from engineers in designing new WWTPs, more efficient in the removal of pharmaceutical compounds. New scientific data and technological opportunities are necessary to support political authorities in developing reliable normative guidelines and knowledge-based strategies appropriate for reducing the environmental risk of pharmaceuticals. All these measures, which involve science, education, prevention, "green pharmacy" principles and innovations would define an innovative "circular knowledge" approach, enabling the development of more sustainable pathways for synthetic drugs production and degradation in wastewater in line with the principle and target of "Zero pollution" defined by the Mission.

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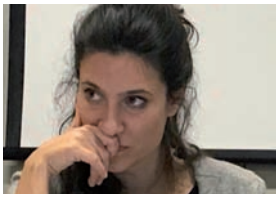
The BlueMed Pilot Action Healthy Plastic-Free Mediterranean

Fedra Francocci, Margherita Cappelletto, Fabio Fava, Fabio Trincardi



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1. The global ocean as a trash bin: what you get is not what you see

Global effort has been made to determine the amount and location of plastic debris in our seas and oceans but, despite this, precise figures for plastic occurrence and accumulation are still uncertain. With the aim to give an overall assessment and estimate the global plastic flow to the oceans, Gayer and colleagues (2017) analysed the global plastic production to final fate over the period 1950 to 2015. According to their study, 2500 Mt of plastic is currently in use; this number represents 30% of the plastic ever produced, of which only 9% has been recycled while about 60% were discarded in landfills or accumulated in the environment. Jambeck et al. (2015) estimate that between 4.8 and 12.7 million metric tons entered the ocean in 2010 on the basis of global plastic production, solid waste data and population density.

Unless the trend of waste management changes, the flux of plastics to the oceans is expected to increase in the future. Even if the plastic end-of-life management has largely increased in the last 20 years in Europe with encouraging figures, a “zero landfilling” policy is needed to fully achieve the circular economy of plastic (PlasticsEurope, 2020) and

have an impact on the marine environment in the long term. Future emission scenarios modelled on buoyant macroplastics show that, if plastic entry points are stopped right now, the plastic debris would decrease by about 60% on the global ocean surface and coastlines by 2050 (Lebreton et al., 2019).

Representing only 1% of the total ocean surface, the Mediterranean is impacted by 7% of the global plastic offshore and it is estimated that in the Mediterranean any plastic debris floating offshore is expected to come ashore in less than 10 years (WWF, 2019).

2. Mismanaged plastic waste and the Mediterranean "garbage patch"

Every year, 0.57 million tons of plastic enter Mediterranean waters and this number will keep growing as plastic waste generation in the region is expected to quadruple by 2050, reflecting multiple failures across the entire life cycle, including production, consumption, waste management, and secondary markets for recycled material (WWF, 2019). The Mediterranean region is the world's fourth largest producer of plastic goods (38 million tons) where residents and visitors generate 24 million tons of plastic waste each year, of which 3.6 million tons leak into the environment (WWF, 2019). Before the COVID-19 pandemic, tourism alone was leading to waste increases of up to one-third during the summertime in some countries, putting under pressure the overall insufficient waste management facilities. The mismanaged plastic waste includes 0.2 million tons (1 per cent) ending up in uncontrolled landfills and 2.8 million tons (12 per cent) dumped illegally. The 6.6 million tons of plastic waste uncollected, openly dumped, or disposed of in uncontrolled landfills, referred to collectively as mismanaged waste, is the main source of plastic leakage into the Mediterranean Sea (WWF, 2019; Galgani, 2015). Additional losses of plastic occurring directly offshore include illegal dumping, accidents to cargo ships and a relevant amount of fishing gear either lost or discarded at sea; altogether this material is estimated to account for 20% of the total plastic leaking into the Mediterranean Sea. Fig. 1 portrays schematically the interaction between economic and natural paths in the plastic value chain leading to the leakage and accumulation of plastic in the environment.

A growing interest and increased awareness of the problem by citizens, stakeholders and governments is directed on the plastic floating offshore or accumulating on Mediterranean beaches, where plastic is estimated to return in ten years; less attention so far is dedicated to the increasing amount of plastic accumulating, largely undetected, on the seafloor from shallow lagoon environments (Madricardo et al., 2019) to slope canyons (Pierdomenico et al., 2019) to abyssal planes (Canals et al., 2021). Clearly, planning to retrieve this plastic debris from the seafloor is at the moment technically impossible or economically too expensive, but it is important to let the public know how pervasive and far reaching is our impact on the face of the deep; preserving these hidden environments should therefore rely on choices made on the value chain of plastic and prevention of pollution before plastic reaches the ocean.

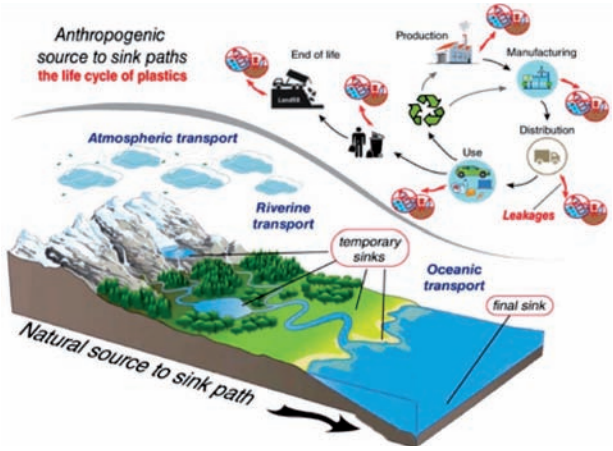

Fig. 1 - A twin source to sink path: the natural hydrological cycle conveys water-transported plastic waste ultimately through deltas into the world oceans; the second path is the plastic value chain, driven from production to transport and consumption in all directions across the territory until intercepted as mismanaged waste by the hydrological cycle.

3. Regulatory and policy framework

Appropriate policies are needed to unlock the potential and to maximize the impact of new actions and partnerships to reduce plastic pollution. The European Marine Strategy Framework Directive (MSFD, Directive 2008/56/EC) specifically requires EU Member States to ensure that marine litter does not affect the coastal and marine environment and highlights the need to act by tackling the problem at its source. The MSFD is the legal tool for a modern assessment, monitoring and achievement of the "Good Environmental Status" (GES) of the European seas through the monitoring of 11 environmental descriptors, which include marine litter.

The implementation of the MSFD has led to a better understanding of the marine litter issue also in relation to the identification of the main sources coming from anthropic activities such as tourism, urban waste management, industrial activities, maritime transport, fishing and aquaculture. To counteract the increase of marine litter, European Member States can also refer to - and adopt - existing EU laws, which include the directive on waste management in ports (EU Directive 2019/883). According to their national programs, Member States are also adopting measures to improve waste management in the fishing sector, the extended producer responsibility scheme of producers and other actions aimed at limiting the use of single-use plastic products (SUPs) (EU Directive 2019/904). The EU also provided public support to mitigation actions including fishing for litter by the European Maritime and Fisheries Fund 2014 – 2020 (EMFF). As far as regulatory frameworks are concerned, regional differences between EU and non-EU countries, as well as from country to country within Europe, further complicate the path towards solutions and the role of international organization is the key to further promote dialogue and define common measures, in the framework of the Barcelona Convention for the protection of the Mediterranean (UNEP, 2019). Furthermore, the policy framework in use lacks a coordinated approach aimed at preventing and managing polluted areas and overcoming the limits of the fragmentation of the policies and measures adopted (Francocci et al., 2020).

The European Commission launched in 2018 "A European strategy for plastics in a Circular Economy" (COM/2018/028 final), setting the scene for a change that with the new Circular Economy Action Plan of 2020 better focuses not only on addressing the entire life-cycle of products, design, processes, consumption, reuse but also on the sustainability of the supply chains. In this regard, the Bioeconomy Strategy (EC, 2018) played a role by promoting sustainable resource-efficient bio-based products alternatives to plastic or plastic additives. This common long-term goal specifically aligns ongoing work of the BlueMed Pilot Action on policy effectiveness for a Mediterranean partnership on plastic pollution. The moment is favourable for projecting and further consolidating the Pilot achievements not only at European level with the upcoming implementation of the Horizon Europe Mission Starfish 2030: Restore our Ocean and Waters (EU, 2020), but also at global level in the framework of the UN-Decade of Ocean Science for sustainable development (2021-2030, https://www.oceandecade.org/) underpinning the Agenda 2030, with particular reference to the outcome on "A Clean Ocean" (Ryabinin et al., 2019).

4. The Pilot Action on A Healthy Plastic-Free Mediterranean Sea

Since 2014, the BlueMed has been put in place to promote research and innovation actions toward a sustainable blue economy in the Mediterranean region (Cappelletto et al., 2018). All the member countries of the intergovernmental BlueMed Research and Innovation Initiative for blue jobs and growth in the Mediterranean area (www.bluemed-initiative.eu/), co-chaired by the European Commission (EC) and the Union for the Mediterranean (UfM), agreed on the urgency to join forces and act together to support the implementation of shared measures to prevent and mitigate the impact of plastic pollution in the Mediterranean area. Then they launched, in 2018, the **BlueMed Pilot action on A Healthy Plastic-Free Mediterranean Sea** (www.bluemed-initiative.eu/pilot-action-on-a-healthy-plastic-free-mediterranean-sea/, Fig. 2). The Pilot is set up to promote the circulation of good practices for the prevention, management, recovery and mitigation of the effects of plastic pollution in the marine environment of the Mediterranean region as well as to enhance the educational component by means of transfer and circulation of knowledge, including by local communities. The launch of the Pilot Action was formalized at the second meeting of the Euro-Mediterranean Group of Senior Officials BlueMed Working Group (GSO BlueMed WG) steering the Initiative, held in Barcelona in October 2018 at the UfM headquarter. During the ensuing third GSO BlueMed WG meeting held in Brussels in April 2019, **National Hubs** were set-up in all Countries participating in the Initiative as a system to support the overall action and strengthen local networks by creating national-community ecosystems contributing to the pilot project.

11 Countries (**Algeria, Egypt, France, Greece, Israel, Italy, Malta, Morocco, Spain, Tunisia and Turkey,** Fig. 2) started the phase of **assessing and mapping** the actions in place (Fig. 3) regarding marine plastic pollution, including the analysis of ongoing local, national and European projects as well as initiatives with actual impact on preventing, reducing and mitigating plastic pollution. The BlueMed Pilot brings together actors coming from multiple sectors with diverse expertise and socio-economic relevance, also reflecting the complexity of the factors that lead to plastic pollution as a result of socio-economic forcing and differentiated environmental/climatic conditions (river regime,

coastal geomorphology, dominant oceanographic processes, etc.) as represented in Figure 1. They also mirror the variety of measure that are implemented at Country level to tackle the problem. The BlueMed stakeholders' network is thus represented by Research Institutions and Universities, private companies and SMEs, innovators, associations, including environmental, policy makers, municipalities and regional authorities.

The BlueMed Pilot adopted the **SEMED digital Platform** (https://semed.eu/search?q=bluemed), to facilitate the connection among National Hubs and their stakeholders, projects and initiatives, setting the framework to accelerate the implementation of solutions (Fig. 3). The following GSO Meeting in Venice (Italy) "A Plastic-free healthy Mediterranean Sea: operationalizing the BLUEMED R&I Pilot Action" on 20 January 2020 valued this instrument as a multi-stakeholder ecosystem to share the mapped initiatives and projects, providing a hub where partners can work together on concrete solutions to this global environmental issue.

Fig. 2 - The BlueMed Pilot and National Hubs. BlueMed Countries that joined the Pilot Action and set up National Hubs are Algeria, Egypt, France, Greece, Israel, Italy, Malta, Morocco, Spain, Tunisia and Turkey.

In two successive workshops, organized at the Ecomondo Exhibition in 2019 and 2020, the BlueMed GSO and the plastic producing and transforming operators of the area, in collaboration with PlasticsEurope, opened a dialogue for a common strategy in plastic economy, including the neighbouring Black Sea. New alliances among various stakeholders of the local plastic value chains and new sustainable economic models for the Mediterranean plastic industry were also promoted (Fig. 3).

Fig. 3 - The BlueMed Pilot process phases. The shared process of Countries at MED level started from the mapping of good practices, projects and initiatives to set up a digital platform and with the final aim to build a broad partnership for the implementation of concrete actions.

An additional step to further increase the results of the activities was made in February 2021 through a fruitful dialogue with key actors such as the General Fishery Commission for the Mediterranean, the United Nations Environmental Action Plan (UNEP/MAP), and the World Bank, in the framework of the event "One Mediterranean: practices, results and strategies for a common Sea", the final conference of the BlueMed Coordination and Support Action (CSA), the EU funded project that has been supporting the Initiative since 2016. The upcoming BlueMed Pilot Hackathon for valuing best ideas was promoted in the same event.

5. The Italian contribution to the Pilot Action on A Healthy Plastic-Free Mediterranean Sea

The Italian hub associated with the "BLUEMED Pilot: Towards a Healthy plastic-free Mediterranean Sea" was launched on July 25, 2019 under the coordination of the Ministry of University and Research and in close cooperation with the Italian unit leading the BlueMed CSA project and was followed up by a highly participated national event in October 2020 organized in collaboration with the Technology Cluster on Blue Italian Growth. Over 70 public and private stakeholders joining the Initiative work on monitoring, prevention, mitigation and overall management of marine litter in the Italian seas and the Mediterranean Sea basin. Over 30 of the invited delegates represent ongoing initiatives coordinated by industries, private and public -even consumers- associations, NGOs, public institutions and municipalities, and about 15 are representing prominent ongoing national and EU R&I or educational projects. Their activities revolve around 5 pillars as reported in Fig. 4.

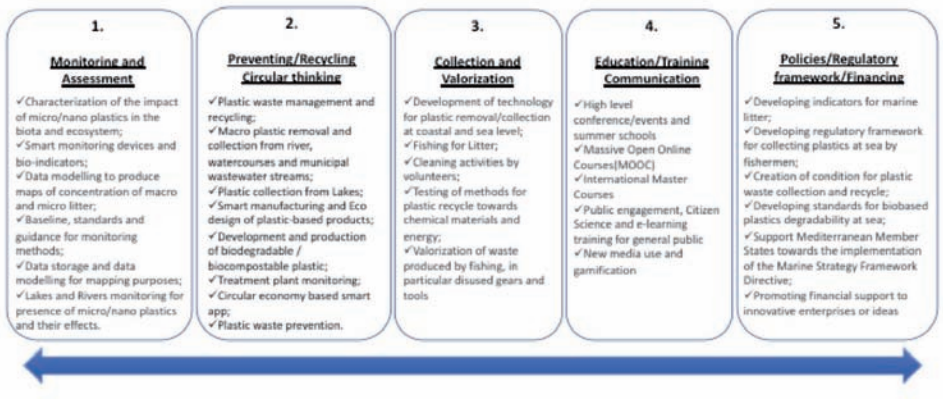

Fig. 4 - The five Pillars of the BlueMed Italian Hub. The Stakeholders of the Italian Hub agreed on the need to systematically address the following five pillars to have an impact on the plastic challenge.

The Italian hub aims to make a substantial contribution to reducing plastic pollution at sea by running complementary activities to address the problem of plastics in urban, coastal and marine environments, identifying the most relevant human activities responsible for the impact. Particular attention is dedicated to recycling systems,

collecting, waste management and eco design**,** social innovation, plastic monitoring, impact assessment, education and policy evolution. To be effective, actions should require the commitment and collaboration of science, governments, business and civil society, engaging individuals, associations, local Authorities, and Regions.

6. Conclusions

The EU Horizon Europe Mission Starfish 2030 identifies "zero pollution" as one of the pillars of ocean research and policies in the years to come. Zero plastic by 2030 is an ambitious but necessary target for the heavily polluted Mediterranean basin and can foster activities towards two additional very important goals: 1. make the public and decision makers aware that the plastic problem is not restricted to the pollution we can detect as floating at the sea surface or littering beaches; and 2. direct our attention to all forms of pollution of marine and coastal environments, including those that, unlike most plastic pollution, cannot be easily detected and observed but, nonetheless, are extremely dangerous for humans and biota. The BlueMed Pilot Action on a Healthy Plastic-free Mediterranean Sea offers the appropriate transnational and cross-sectoral science cooperation framework to enable the fulfilment of such goals.

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Chapter 5.

Decarbonizing

Credit: Trieste Port Authority photographic archive

Green technologies: an opportunity to guide the maritime sector into the future

Giuseppe Bono

Giuseppe Bono, Born in Pizzoni (Calabria, Italy) in 1944, he has been CEO of Fincantieri since 2002. He is Chairman of Fondazione Nord Est, a Member of the Council of Confindustria and Chairman of Confindustria Friuli Venezia Giulia.

The maritime sector has established itself as one of Europe's economic pillars. According to recent figures, the EU blue economy directly employed close to 5 million people and generated around euro 750 billion in turnover and euro 218 billion in gross value added in 2018[1]. Transition to zero-emission waterborne transport is a necessity for contributing to reach climate neutrality by 2050, which is crucial for the sector to remain in the lead as a means of transport and an important driver for innovation. It offers the opportunity to expand markets in the longer term following the Covid-19 crisis; nonetheless an incoherent landscape of policies, rules and regulations complicates the process.

Indeed, today the maritime sector counts several structural challenges. First, with the increasing size of the vessels, the total amount of power needed to propel ships increases as well. For the largest ships, engines of up to 70 MW are used. This energy demand has hindered initiatives aimed at the transition of the sector, as many feared that the renewable energy available would not be sufficient. Furthermore, it must be considered that at the moment there is no cost-effective and widely available alternative for fossil fuels. Possible alternative fuels include biofuels, such as either bioliquids or biogases, as well as energy carriers based on hydrogen, but none of these fuels is currently available in large amounts around the world. The port sector is also essential. With the transition to alternative fuels, new refuelling infrastructures must be developed both in sea ports and along European rivers. For instance, charging on board batteries for operations at sea will require a much larger throughput of electricity. As I recently said during a hearing to the Transport Commission of the Italian Chamber of Deputies, ports are the fundamental sector on which to set up a growth policy. They must have the best infrastructure in Europe, with development areas alongside, in order to fulfil their role as a hub for freight purposes.

The diversity and fragmentation of the sector is another obstacle that hinders the change towards zero-emission transport. Shipyards, ship owners, maritime equipment manufacturers, flag states, waterways and port authorities and operators, river commissions, classification societies, energy and infrastructure companies,

1 The EU Blue Economy Report 2020

environmental non-profit organizations, research institutes, universities, citizens' associations, as well as relevant authorities, banks, insurance companies: there is a lack of a common innovation agenda that takes into account the different needs and potentials of the waterborne transport sector. Last but not least, the obsolescence of the fleets requires zero-emission retrofit solutions which should be implemented as soon as possible. This need is even more urgent for short-sea navigation, since the average lifetime of inland vessels is even longer (40-60 years), with consequent lower energy and environmental efficiencies of old vessels. Indeed, for inland waterway vessels, the western European market is characterized by a relatively old fleet. Half of the active fleet in Germany, the Netherlands and Belgium, as well as 80% of the French fleet, was built more than 50 years ago, while 15% of the European fleet was built more than 75 years ago.

Today hydrogen has the potential to become the cheapest source of renewable energy technology in the middle-long term, especially in northern parts of Europe, where solar power plants are less competitive, making ports ideally placed to become large renewable hydrogen production and distribution hubs and to demand dedicated centres. But the discussion on the sustainable fuel of the future is still ongoing. It lies essentially in a trade-off between cost and the ease of storing energy on board, which from a technical point of view represents the main challenge. There are also questions regarding how energy is generated on board ships. Hydrogen can be considered a real candidate as a solution. It can be used in multiple ways, either in fuel cells or in internal combustion engines. However, it is not the easiest to store if compared to other fuels made from hydrogen (ammonia, e-LNG, e-methanol and e-diesel), which have a better volumetric energy density. The relatively low volumetric energy density of hydrogen is, besides high production costs, the biggest techno-economical barrier for the large-scale adoption of hydrogen in maritime applications.

Although there is certainly a potential to improve the energy-efficiency of the existing fleet, pure hydrogen as a fuel for existing ships is technically challenging. Hydrogen-based fuels are more promising since they can be burned in internal combustion engines. In order to tackle the emissions of the biggest emitters, which are deep-sea ocean-going vessels, it will first be necessary to further upscale hydrogen and hydrogen technologies through more research and innovation with inland and short sea shipping potential incubators for solutions in deep-sea shipping. There are still hurdles to overcome, namely the price and the storage on board and the lack of consolidated and standardized solutions, just to name a few. In many cases, where the need to store large amounts of fuel ensuring autonomy or where the power needs are significant, technological solutions are still to be identified and research and innovation will represent a significant enabler for the development of a zero-emission ship at cost-competitive conditions. This is notably the case of highly specialized large vessels, large passenger vessels and long-route shipping vessels.

In the very short term, the greatest potential lies in inland shipping and so-called vessels in ports and port areas such as urban ferries, tugboats and small dredging ships that maintain the depth of channels and rivers, as these ships have a relatively small fuel demand and can be supplied from a single location. Super-yachts operating on hydrogen are also now early movers, demonstrating the potential of this fuel. Current projects depend on a patchwork of national legislation not designed for hydrogen aimed at maritime applications and this slows down the process. A broader EU and

IMO (International Maritime Organization) harmonized regulation will be necessary to enable the construction of larger ships and to pave the way for designing ships with innovative components at cost-competitive conditions. It has to be said that these vessels have a range of options where some solutions are not so suitable for deep-sea shipping, for example batteries or compressed hydrogen.

The focus on small zero-emissions vessels will now lead to dedicated hydrogen supply chains for short-sea larger ships (short-sea-shipping) taking into account that the largest emitters, namely deep-sea vessels, will likely use hydrogen-based fuels for their main engine power and this will require different supply chains. As a first step, it is likely that smaller ships in ports will be supplied with hydrogen from hydrogen tube trailers and fixed compressed hydrogen tanks. There are also several plans to build dedicated stations, but more pilot projects are needed.

All that being said, the world of navigation, whether cruise, merchant or naval, must go through an evolution process under the principles of sustainability and under circular economy. For Fincantieri, this scenario is already a consolidated reality and, with a series of specific projects tied to its Sustainability Plan, the company is literally redesigning the future scenario of navigation, at a strategic and technological level. The ships under construction will increasingly look like a large, hyper-connected, energy self-sufficient, digitalized, lighter and green or hybrid propellant floating city, capable of recycling up to 90% of the produced waste. With the technologies already applied, today we are able to cut 1,200 tons of fuel per year on a ship of about 130 thousand gross registered tonnage. We consider the Green Ship to be a cornerstone of our vision. Recent contracts, whether related to the new construction or refitting sectors, are characterized by the use of advanced technologies, such as liquefied natural gas, batteries, modern systems for the reduction of pollutants and energy efficiency. Fincantieri intends to apply a holistic approach in design and construction, integrating all on-board systems in the best possible way, pursuing a continuous improvement in energy efficiency and supporting the introduction of new green fuels, technologies for decarbonization, including fuel cells, as well as the study of high performance materials. I can mention the collaboration with the Consiglio Nazionale delle Ricerche (CNR, National Research Council) and the Universities of Genoa, Naples and Palermo, with the contribution of the Italian Ministry of Economic Development. Together we have developed a project to create a laboratory ship, approximately 25 metres long, to study power generation technologies with low environmental impact (Fig. 1). The ship, called Zeus, Zero Emission Ultimate Ship, will be powered by electric propulsion engines, a fuel cell system of about 144 kW and a battery system capable of ensuring around 6 hours navigation autonomy at zero emissions, thanks to about 50 kg of hydrogen contained in metal hydride cylinders. Zeus will be the first marine vessel powered exclusively by fuel cells, and led the European Commissioner for Energy Kadri Simson, during the European Hydrogen Week held at the end of last November, to declare, “Fincantieri is an excellence in the new economy of hydrogen”.

Fig. 1 - Rendering of the Fincantieri Zero Emission Ultimate Ship (Zeus).

Fincantieri is renowned for its ability to make strategic decisions looking to the future and for having a vision statement that is strongly oriented towards tackling sustainability and innovation-related challenges. Our group views these elements as the key to maintaining a world leading position in all the different sectors making up the high added-value naval engineering industry. We have never been afraid of the future, have always been ahead of it, and will continue to focus on paving the way for the future of our sector.

Italian seas - the next wave in the energy transition

Stefano Porcari

Stefano Porcari, graduated in Mechanical Engineering from the Milan Polytechnic, began his career with Saipem in 1987 as Deputy Project Manager and has held various positions worldwide since then, among which Offshore Office as Area Manager for the Mediterranean, the Middle East, India and Azerbaijan, Chief Executive Officer of Saipem Asia Sdn Bhd, Saipem (Malaysia) Sdn Bhd and PT Saipem Indonesia and Senior Vice President of Saipem SA and Chairman of Saibos s.a.s. He became Executive Vice President of the Offshore Division of Saipem S.p.A in 2013 and held the position of Chief Operating Officer of the Offshore E&C Division from 2017 to 2019 and Chief Operating Officer of the Onshore Drilling Division in 2019. Today he heads the E&C Offshore Division.

Nowadays humanity is facing many crucial challenges. Among these, climate change certainly stands out as a major threat for the world.

To overcome these challenges, the countries of the European Union set the targets and the strategy to be adopted to reach an increasingly more sustainable future and, ultimately, to have net-zero greenhouse gas emissions by 2050.

It is a difficult journey that every country has to undertake with commitment and focus.

Under the NextGenerationEU plan, Europe has put in place a temporary recovery instrument to help repair the immediate economic and social damage brought about by the Coronavirus pandemic. Post-COVID-19, Europe will be greener, more digital, more resilient and better equipped for the current and forthcoming challenges.

Just like every country in the European Union, Italy is proposing innovative projects to enable the energy and ecological transition.

It is undeniable that Italy is known the world over for its artistic and natural uniqueness as well as for its limited geographic extent and varied topography. These particularities do not allow for an extensive utilisation of soil. On the other hand, Italy boasts around 8,000 km of coasts and a strategic position in the Mediterranean Sea. That is why the Italian energy transition cannot be separated from a responsible use of the sea.

In this context, there are very interesting offshore projects currently under development and potentially fundable by the NextGenerationEU.

Certainly, it is worth mentioning the AGNES project (Adriatic Green Network of Energy Sources; Fig. 1) developed by the Italian energy solution provider Saipem and QINT'X, an Italian company specialising in renewable energy, specifically solar, wind and hydroelectric energy and e-mobility (electric vehicles).

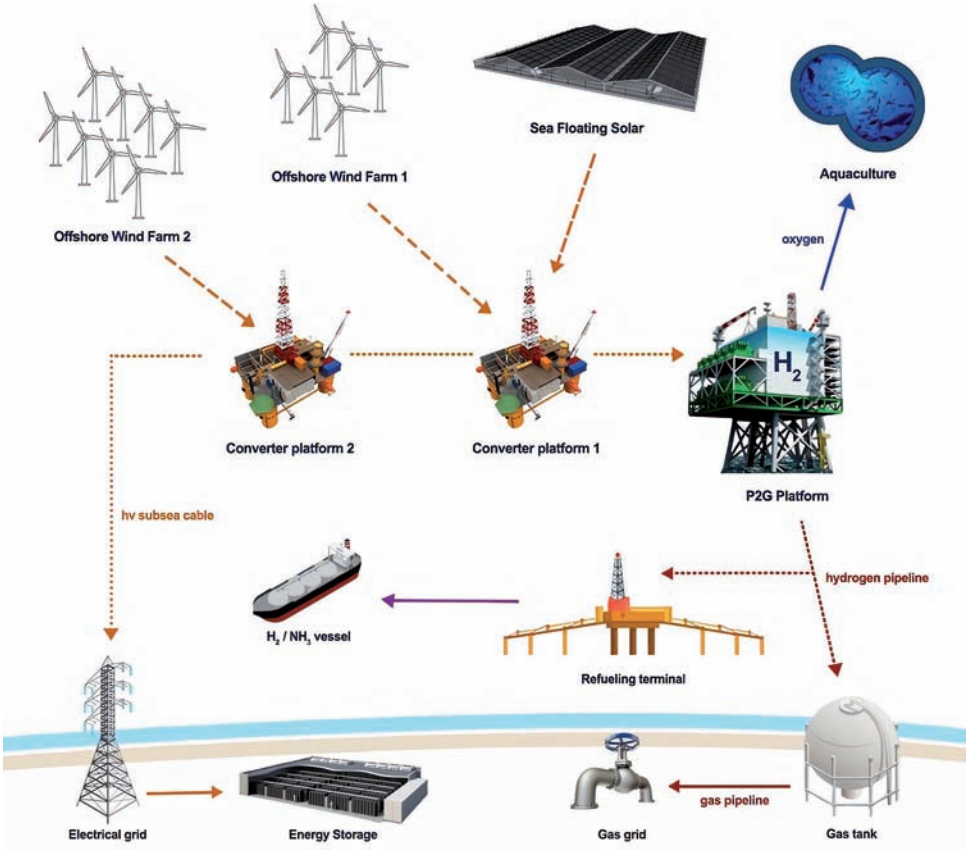

Fig. 1 - AGNES project scheme.

The AGNES project consists of an integrated marine district in the field of renewable energy off the coast of Ravenna. The aim is to convert the Oil & Gas sector and create beneficial synergies between various natural energy sources such as the sun, wind and hydrogen.

The project will involve the installation of approximately 56 turbines on fixed foundations on the seabed at two different sites: one located more than 8 nautical miles from the shore, and the other more than 12 miles from the shore, which should allow for minimal visual impact of the installation.

The overall installed power will be approximately 450 MW. As part of this project, innovative technologies will also be used such as floating solar technology based on the proprietary technology of Moss Maritime, which is part of Saipem's XSIGHT division dedicated to developing innovative solutions to speed up the decarbonisation process in the energy sector. Furthermore, there will be a battery energy storage system and the generation of green hydrogen at sea and near the port, powered by the same renewable sources.

It is one of the first offshore wind projects to develop such integrated solutions in the Mediterranean Sea, offering the opportunity to find an alternative solution to decommissioning Oil & Gas platforms in the Adriatic Sea and it is the first in which hydrogen production and floating solar platforms at sea will be carried out on a commercial scale.

This project will be implemented in a highly industrialised area and local industries will be involved in supporting it.

This is a good example of how innovation and technology can pave the way towards new solutions, leading to a more sustainable energy paradigm.

In the case of AGNES, one the key technologies to integrate the system is floating solar (Fig. 2).

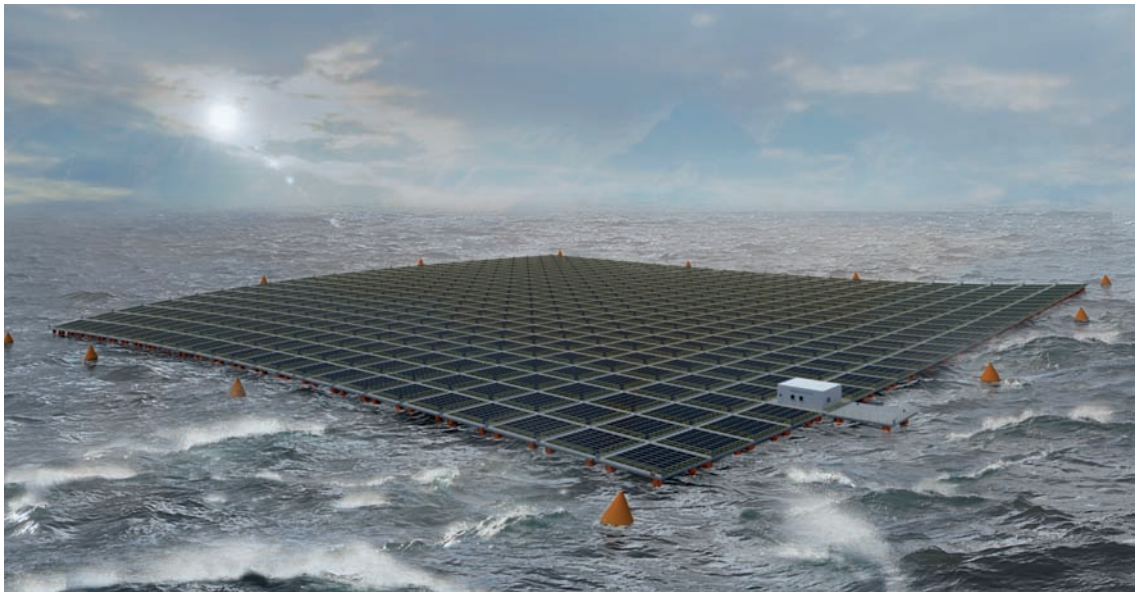

Fig. 2 - Floating Solar.

Floating solar is one of the new frontiers of offshore technologies with promising growth trends. According to the World Bank, the potential floating solar capacity that could be installed globally is as much as 400 GW, or approximately the same generation capacity as all the solar panels installed in the world until 2017. According to research conducted by Wood Mackenzie Power & Renewables, at the end of 2019 at least 2.4 GW of solar panels were installed on the water, in 35 countries worldwide.

One of the advantages of floating solar technology is the zero consumption of soil: in recent years, we have seen the number of such installations growing precisely in those areas where the space dedicated to energy systems must compete with that reserved for other equally strategic sectors, such as agriculture or industry. For this reason, floating solar has been widely tested in countries such as Japan, China and in general in Southeast Asia which must, in fact, cope with the lack of available land. In addition, the performance of floating solar panels is higher than in ground installations: water and ventilation, in fact, help cool the cells and dissipate the heat created, improving their efficiency and productivity. For this reason, floating solar is often used in closed reservoirs, such as lakes or ponds, but there is no shortage of applications in the open sea. In addition, a floating solar system can reduce the evaporation of water during periods of drought and helps limit the production of algae, which can jeopardize water quality, especially in freshwater basins.

The Asia-Pacific region plays a leading role in the dissemination of floating solar technology: 87% of the global floating solar capacity is currently concentrated there. Today, China has the largest number of plants installed, with a capacity of around 1.1 GW. Japan and the United Kingdom follow suit, but India has also recently announced a plan to develop 10 GW of floating solar plants. These are all countries where the presence of free and under-exploited lands is scarce, and where there are - at the same time - numerous water basins, scattered over their territories, as is the case in Italy.

When we talk about offshore wind, we should mention that, depending on the depth of the seabed, the installation of wind turbine foundations could be difficult or impractical. Even in this case, innovation plays an important role to overcome obstacles.

Saipem has a proprietary patent called HEXAFLOAT, consisting of a floating pendular foundation for wind turbines (Fig. 3).

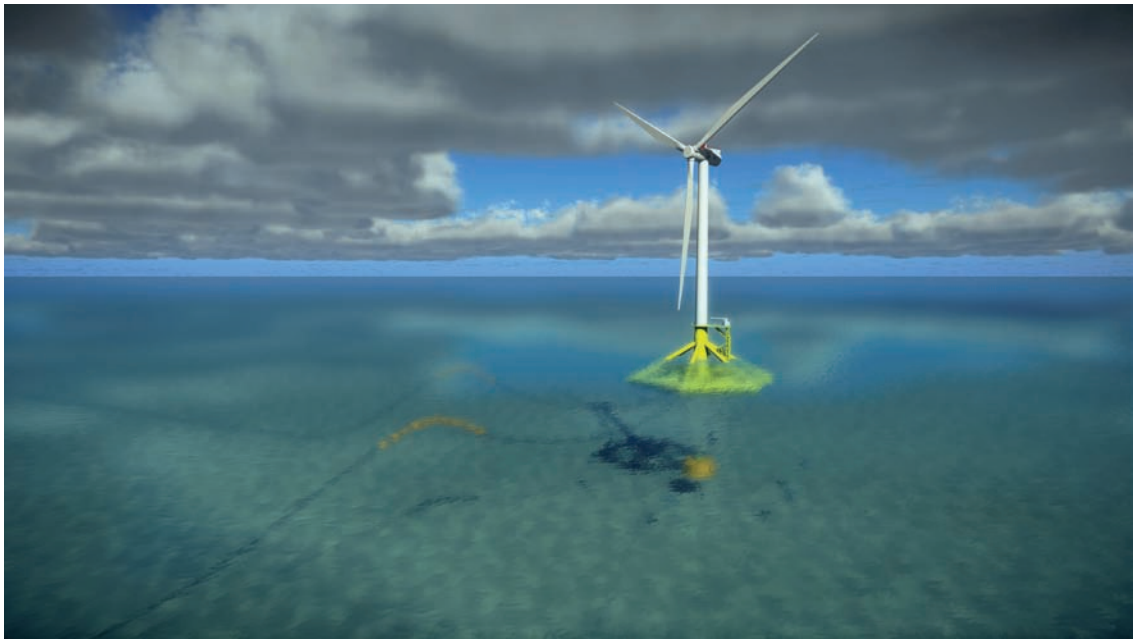

Fig. 3 - Hexafloat, floating wind.

With the floating solar solution, solar parks can prove to be very flexible, with modular systems adaptable for installation both near the coast and in areas where there are no large water reserves as well as in very windy areas.

In conclusion, Italian seas have a great potential to offer innovative and technological solutions that will reduce the overall carbon footprint by enabling the growth of green energy and the reconversion of Oil & Gas platforms.

In Italy, the sea will be the next wave towards a new and ever more sustainable world.

The role of technology and digital innovation in sustainability and decarbonization of the Blue Economy

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The development of a sustainable technology for the Blue Economy (a new Blue Technology) sets out three core research objectives, reflecting key challenges to be tackled by the sea industries and scientific and technological communities: The fast development of doable decarbonization processes through development and demonstration of deployable, competitive, and sustainable technological solutions for energy transition (climate neutral blue economy), a sustainable exploitation and exploration of oceans, seas and coastal areas to provide new resources, from raw materials to products, including food (sustainable use and management of marine resources), and the development and exploitation of digital-based knowledge while accumulating data from new observation networks (persistent monitoring and digitalization of seas and oceans).

To meet these operational objectives, different topics and related technologies need to be further developed. A possible list of disciplinary objectives is the following.

1. Climate neutral blue economy

Sustainable solutions for energy transition and decarbonization processes are already technologically possible in many fields of the blue economy. An example is the Ocean Energy, which is relevant for the achievement of the energy transition objectives towards low carbon emission sources (e.g., EWTEC, 2019). New power plants should be designed while paying attention also to the protection of biodiversity, thus favouring the adoption of an ecosystem approach. Sea industries must improve

technologies and devices for the production, storage, and distribution of energy and for the integration of different forms of renewable energy (wind-tidal-wave), including advanced artificial intelligence (AI) tools for intelligent smart grids. The methodologies for the choice of installation sites should also be improved by introducing measures to mitigate the impact of the structures on the marine environment and the invasiveness of probing strategies for site selection (Bui et al., 2018, Coro and Trumpy, 2020). The design of new production plants should include the evaluation of end-of-life effects on the marine environment. It is also fundamental to advance the efficiency of the storage systems as a major factor leading towards greater energy system integration of renewable energies.

In addition to increasing renewable energy and promoting energy efficiency and conservation, capturing and storing CO_2 is a cost-competitive and safe way to achieve large-scale reductions in emissions (Bui et al., 2018). A complete carbon capture and storage system (CCS) relies on three technological components: capture, transport, and storage. Capture technologies can be divided into post-combustion, pre-combustion and oxyfuel combustion. Once the CO_2 is separated and captured, it must be compressed to reduce the volume of gas for transportation to an appropriate storage location. Ships are cost-effective only if the CO_2 must be moved more than 1,000 miles away. It is possible to store CO_2 in the ocean, but public opposition to the idea of injecting CO_2 directly into the deep ocean has prevented some research on this option, despite the ocean's natural capacity to store most of the CO_2 currently emitted into the atmosphere.

2. Sustainable use and management of marine resources

Sustainable decommissioning and conversion of offshore platforms has recently attracted great interest and represents a great opportunity for the enhancement of marine resources (OECD, 2019). Each option determines environmental and socio-economic impacts that must be considered in the conversion process, which overall calls for identifying and investigating scenarios of possible alternative solutions. Attention must be focused on developing models for the analysis and evaluation of decommissioning projects that include the main environmental sustainability parameters, while identifying new materials and technologies for the design and construction of platforms that consider also their end of life. Efficient and sustainable technologies for maintenance and intelligent monitoring of platforms, and predictive methods for knowing their status and the decommissioning risks will benefit from the use of sensor development, AI, and Digital Twin technologies.

Understanding the ecosystems in which aquaculture plants operate, in terms of abiotic variables (e.g. currents, thermo-salinity, etc.) and biological variables (from productivity to the natural recycling of elements), represents a fundamental research objective in the sector (OECD, 2019). Technological innovation must aim, above all, at reducing the environmental impacts of existing aquafarms, while improving their maintenance and operativity through intelligent autonomous vessels, and ICT systems. Dedicated ecosystems modelling that considers plant location characteristics and environmental impacts and costs is necessary in this context.

The seabed of the oceans is largely unexplored. Preliminary explorations have revealed the presence of raw materials essential for the green economy (e.g. poly-

metallic nodules, sulphides, cobalt-rich ferromanganese crusts, methane hydrates), in concentrations generally much higher than on land, that may represent - in the future - a solution to the increasing demand for mineral resources and supply risks. In this context, preliminary seabed mining activities have already started. However, the current technology is primitive, and the devices designated to collect and analyse these resources have the potential to annihilate the marine ecosystem of the seabed, which must still be studied and understood (Barbier et al., 2014). This is one of the most critical points of the entire sustainable blue economy. The research roadmap should include the development of sustainable exploration devices, with minimum (and reversible) environmental impacts (e.g. dedicated new autonomous underwater vehicles capable of reducing sediment removal, new underwater communication systems, intelligent strategies for exploration, etc.).

The coexistence of multiple economic activities needs to be carefully planned to avoid conflicts and promote synergies while preserving the marine ecosystem. Therefore, the full development of Maritime Spatial Planning (MSP) is urgent to implement a sustainable sea and ocean blue economy, which requires a multidisciplinary effort to create new supporting tools that can integrate many different aspects and disciplines, including socio-economic and political factors (Zaucha and Gee, 2019).

Maritime Surveillance – i.e. the protection of marine resources (illegal fishery control, oil spill detection, environmental degradation monitoring, etc.), food security, transport safety and the monitoring of critical marine infrastructures (renewable energy and aquaculture offshore platforms) - is key for a sustainable growth. Different observation systems for data acquisition (satellite, in situ, AUV, social media, etc.), data sharing and management are the fundamental tools for Maritime Surveillance. Integration platforms and services through data sharing between the existing EU and national platforms will have to be developed, together with platforms allowing Big Data Analytics and social sensing data integration (Claramunt et al., 2017).

3. Developing “blue technology” for the sustainable “blue economy”

New advanced technologies are becoming available at an unprecedented speed. A non-exhaustive view of all emerging technologies which focusses on the technologies that are favourable to collaborative research within the Blue Growth context might be the following:

- **Marine Robotics:** Remotely Operated Vehicles (ROVs) and Autonomous surface/ underwater vehicles (ASVs, AUVs) are used to perform missions that cannot be easily accomplished by other marine vehicles or by humans because of the costs, the harsh environment, or because they involve risky operations (surface and underwater observation and monitoring, SAR, deployment, inspection, maintenance and recovery of structures, identification of mines and unexploded ordnance). The goal is to improve endurance and navigation for extended exploration, improve hoovering stability for high-resolution imagine analysis and automatic identification of objects/ species also using AI approaches, lower the acoustic signature for underwater noise minimization, introduce solutions using swarms of small, low-cost, single task, easily deployable autonomous vehicles.

- **Advanced Materials and Manufacturing:** New materials and developments in material technology are fundamental to meet new environmental regulations, operate in adverse environmental conditions (e.g. deep-sea operations) and improve the capabilities and performance of marine robots. Possible applications regard deep-sea technology, soft robotics, nature-based solutions for offshore infrastructures, smart and intelligent materials for structural monitoring, energy harvesting and storage.
- **Advanced computational methods**: modelling and simulation are becoming increasingly powerful tools because of hardware and algorithmic constant improvement, which also allows for assimilating past and new data with physics-based computational models. New computational capabilities will enable the development of advanced modelling and simulation tools for the design and optimization of new marine energy plants, and the introduction of tools to observe, monitor, and simulate marine environment dynamics, and for virtual prototyping and next-generation energy management.
- **Sensors are Everywhere**: Advances in material technology is allowing the reduction of the cost and size of sensors, while fostering their ubiquitous incorporation into a wide range of inexpensive objects. In medium-to-long terms, every object will be a potential source of sensor data. Advanced computational techniques to integrate sensor data will lead to the possibility to sense the environment as well as the anthropogenic impact at significantly greater ranges and with a richer context than what is currently possible. In this context, it will be fundamental to develop specific biochemical sensors for monitoring contaminants at low concentrations, and in general to estimate the environmental status.
- **Tools for digital transition**:
  - **Everywhere computing**: Technology is rapidly connecting devices to each other, to benefit from distributed data structures and cloud computing services. Everywhere computing also encompasses software-driven functionality, the ability to process environmental data at the sensor before transmission: Advances in learning and recognition will enable fast response to build up reaction strategies and decisions in real time. Decision-makers will therefore have access to sophisticated simulation models to support time-sensitive decision-making.
  - **Predictive analytics:** Understanding, generating, inferring and forecasting future environmental states from Big Data will be fundamental for digital transitions. Huge amounts of data collected through new networks of sensors (Sensors are Everywhere), and the re-use of past research data are of great support for analytical systems to discover new knowledge from the collected data. These will be sensor-based predictive models that will outperform the traditional state-of-the-art predictive methods especially in uncertain environments.
  - **Artificial Intelligence**: One key application of AI is machine learning applied to Big Data, which requires considerable computational power for training and executing the models. Applications will grow in scope and sophistication as data become more widely available and more members of the maritime community become familiar with machine learning technology and tools.

4. Persistent monitoring and digitalization of seas and oceans: The Ocean Digital Twin

Seas, oceans, and coastal areas are stressed by multiple factors (pollution, heavy maritime traffic, overfishing etc.) uniquely caused by human action (and inaction) whose severity, if not adequately managed, will deplete the marine ecosystems and destroy the biodiversity, with serious environmental, economic, and social damage. In this context, new Blue Economy strategies are pushing for further investments to allow a more effective exploitation of marine resources.

One key question is: Should we proceed in planning and developing a sustainable use of the Oceans, or should we abandon this idea, since the development of an adequate sustainability policy is too slow in producing effects when compared to the rapidity (and ubiquity) of the exploitation of marine resources?

These conflicting views on development strategies encapsulate, in essence, the dilemma in which all industrial countries find themselves nowadays. The correct, sustainable exploitation of marine resources calls for an integrated management of maritime activities that must be carefully planned, monitored, and adapted through the development of advanced integrated models capable of considering many different systems and their mutual interactions, e.g. the performance and the effects of different economic marine activities together with ecosystem and conservational models.

What we foresee here, is the rapid development of a new digital tool (Ocean Digital Twin, ODT), environment-centred, to help in analysing and preventing human-caused crises, i.e. a digital tool for climate change adaptation and protection of biodiversity and ecosystems.

The availability of Findable, Accessible, Interoperable, and Re-usable (FAIR) Big Data, the development of innovative sensors and sensor networks, and the continuous enhancement of digital technologies will be the key elements of the new approach based on the ODT concept.

Oceans are not digital, but digital is the way we have been looking at them recently and in the near future. The ODT will introduce a dynamic new paradigm for marine research, which will integrate and facilitate the combined use of existing models, technologies, and tools with new key enabling technologies, including predictive analytics, artificial intelligence, internet of things, cloud and everywhere computing, high-performance computing, virtual and mixed reality, all operating within an Open Science context.

The ODT will follow marine environmental changes over time and assess the ecosystem health, while predicting its evolution in the short and long term. It will also allow the suggestion of sustainable economic activities and the simultaneous development of biodiversity conservation strategies, through an intelligent Decision Support System able to generate different scenarios and to guide policymakers in their decisions. A virtual environment will be used to communicate and disseminate the results and to increase the involvement and the sense of responsibility of coastal communities.

New collected data will be integrated with existing data sets (the enormous amount of heterogeneous data, so called “data lake”): the ODT will assimilate past and new data through physics-based and/or data-driven models, allowing the intelligent reuse of past heterogeneous data and models via AI, cloud-based analyses, and digital data distribution.

5. Developing the Ocean Digital Twin (ODT)

The ocean, as an integrated system, can be analysed in principle by identifying the different systems of which it is composed, and their mutual interactions and hierarchies: circulation and currents, waves, tides, interaction with the atmosphere, the seabed and the sediments, coasts and estuaries, animal and plant life, the ecosystem as a whole. Some of these systems are universal, others specific to a basin, some of their mutual relations are well established and clear, others are still far from being considered consolidated.

Nevertheless, all these systems, in principle, can be dynamically "simulated" ; some using solvers based on first principles (e.g. geofluid dynamics and its equations can be used to analyse and simulate ocean circulation, currents, waves and their interaction with the atmosphere, the relative heat and momentum exchange, the transport of pollutants or sediments, etc.), others by means of data-driven models, i.e. formed by learning networks or state-space models that learn to read the data relating to a certain system (using for example, biochemical-physical sensor networks and remote sensing, and different data: oceanographic, taxonomic, bio-acoustic, bio-optical, genomic, etc.) and return a "closed box" model that learns from the data and that is able, after a training period, to return a predictive response.

Once the simulators have been developed and their mutual interactions understood and modelled, the ensemble will constitute a sort of virtual (digital) twin of the physical environment. By continuing to collect data from sensors, the ODT will follow the environment's real dynamic evolution with increasing accuracy: the ODT will evolve after the environment's life, and can be used to predict scenarios, provide intelligent management tools for planning rapid responses to unexpected and potentially harmful or catastrophic events. Examples of modelled features are the study and analysis of the evolution of marine ecosystems and their interaction with human activities, the integrated management of the coastal zone, the analysis of sedimentary processes, the examination of areas with high anthropogenic impact, the development and testing of Rapid Environmental Assessment techniques.

For the development and implementation of the ODT, it is necessary to combine different disciplinary sectors, from marine sciences to applied mathematics and Big Data analytics, digital technology and sensor development, and marine ecosystems knowledge representation. The establishment of a complex and articulated virtual environment will also become a fundamental research supporting tool, allowing data to be available with related classification, cataloguing and query environments, accompanied by new tools and analysis environments based on artificial intelligence, visualization methods in virtual and augmented reality, new integrated and intelligent management approaches for planning and carrying out missions, measurement campaigns, and collection.

6. Scalability of the model

Today it is impossible to model the full problem addressed by the ODT, i.e. the Digital Twin of Oceans or large sea basins. Major development hindrances are the lack of validated models (especially ecosystem models), the lack of data, a scarcity of sensors, computational platforms, and robustness of computational models. Fortunately, the ODT has implicit characteristics of modularity, scalability, and adaptability. At an initial stage,

ODTs will be able to manage a spatially limited area (spatial scale limit), or a limited number of systems (scale of complexity limit). In this context, the possible number of interactions between systems can be varied (scale of integration) as well as the sensor network data and data typology (sensitivity scale), naturally with attention to the Big Data minimal requirements for the analysis.

These four scales, or dimensions, of the ODT can be varied starting from an initial level, relatively easy to design, build and validate, and then expanded to larger scales, enriching the ODT in complexity, depth, and utility. This will allow the model to be applied in the operational reality of marine zone management, while initially operating in parallel to more traditional management models. The ODT will support the traditional models and will learn from them, before it can be operational. At a mature stage, it will progressively explore its capabilities in practical applications.

7. Digital and human dimensions

The ODT will provide an intelligent digital environment able to overcome the limitations of the existing tools, and methodologies to integrate and process a huge number of different types of descriptors (ecological, physical, socio-economical, etc.) and to guide decision-makers in managing and planning the sustainable use of the marine resources, while offering tailor-made solutions for different areas.

The ODT virtual environment can be used to share data for research and development purposes and to provide services, as well as to communicate and disseminate the results of the analyses to stakeholders and citizens. Integral to the development of this paradigmatic system is the availability of FAIR data that come with standardized descriptions and access protocols. At the same time, compliance with the Open Science paradigm (i.e. producing re-usable, reproducible, and repeatable Science) is crucial, as it guarantees fast cross-domain applicability and flexibility in using new types of input, while supporting the repetition and reproduction of the experiments. Guaranteeing transparency in the production of results is a key feature to make them accepted by decision makers.

The ODT will be based on a hierarchy of AI models, running both at the edges of the network and on a centralized e-Infrastructure endowed with high-throughput and high-performance computing platforms. AI models will be responsible for simplifying the information flow coming from the network within a higher and higher decision hierarchy. Models will run on smart sensors in the network to activate the information flow when a particular event occurs (e.g. a concentration of vulnerable species in a certain area) and their results will go into other models that mix heterogeneous information (e.g. maritime traffic, fishing activity, area biodiversity, commercial stocks, etc.) to estimate risk indexes related with the particular event, but also with the entire ecosystem. The employed models will be heterogeneous, ranging from pure machine-learning models - that correlate sensor information with a particular phenomenon (e.g. environmental information with species habitat) - to state-space models that predict complex system dynamics with the support of natural laws as likelihood functions (e.g. population dynamics in stock assessment). By definition, the overall ODT will be a multi-disciplinary system connecting expertise from computer science, physics, engineering, and biology. Therefore, its implementation will necessarily require the use of collaborative tools.

The ODT might be offered as a network of Web Service with interfaces that follow a recognized standard to maximize its re-use from other systems external to the network of a single site. Decision tracking might be supported via computational provenance tracking at all processing levels, to maximize the transparency of the results and the understanding of the chain that brought the system to a particular decision. Finally, collaborative research in model building might be supported via Virtual Research Environments (VREs), Web-based environments that foster collaboration between users working on the same topic. VREs will also manage data and service-access policy aspects: access, security and accounting services will monitor the availability of all data and processing resources and will prevent policy violations. Using this technology, and generally Open Science-oriented facilities, will guarantee a fast development of the ODT components and the interconnection of many AI models.

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A Green strategy for ports

Zeno D'Agostino

Zeno D'Agostino, manager with expertise on local economy, logistics and freight transport, has been the head of the Port Authority of Trieste since February 2015. He is currently Vice-President of ESPO, the European Sea Ports Organisation, and Sole Director of RAM, the in-house company of the Italian Ministry of Infrastructures and Transport, in addition of being Member of the Board of MIB Trieste School of Management. During his career, Mr. D'Agostino was Chairman of Assoporti, the association of the Italian Port Authorities, Secretary General of the Port Authority of Naples, CEO of LOGICA, the Agency of the Campania Region for the promotion and research in logistics and freight, Director of strategy, development and marketing at Consorzio ZAI - Interporto di Verona and General Manager of Interporto Bologna. He was recently included in the 2020 ranking drawn up by Forbes Italy of the top 100 Italian entrepreneurs and top managers.

1. The problem of giant ships

Giant ships are an issue that ports are having to deal with today and that recently hit the headlines with the incident in the Suez Canal. The issue is to understand to what extent we can afford to leave a whole series of decisions, such as the one concerning giant ships, to the market. The European Union should be able to provide ship-owners with a series of constraints on this aspect, which Brussels is unable to reconcile. If we make a general assessment, the big ships, these giants of the sea, are only found on the Asia-Europe route and are not found, for example, on the Asia-United States route because the United States prohibits the arrival in its ports of ships above a certain size. There is also one thing to be said: the United States does this because it is easier, in the sense that the Panama Canal does not allow ships carrying over 12,000 containers to pass through; it is therefore clear that a ship coming from China to the west coast of the United States and then having to go to the east coast is limited by the size of the Panama Canal. So when the United States tells ship-owners that they cannot enter its ports, even those on the west coast, such as Los Angeles and Long Beach, with ships carrying over 12,000 containers, it makes things easier for them, because clearly ships coming from China to Europe, for example, do not have this bottleneck at Suez. There is a strong relationship between top-down and bottom-up interventions, which we always find in port management; in fact, certain dynamics and phenomena start from the bottom and must be helped in some way, while for others there must be a top-down role that imposes certain behaviours and standards that must be in line with a series of objectives that we set ourselves. On this point, even as vice-chairman of ESPO (European Sea Port Organisation), I think that the role that Brussels should play

in this respect does not actually exist. The issue of giant ships has now reached the point where ever-larger ships are not giving any advantage whatsoever, not even to the ship-owners themselves, because the economies of scale that could be reached have already been achieved with the ship sizes of just a few years ago. Growth continues, and there are a whole series of elements, including stamps and financial aspects that lead to this, but there is no stance taken by Brussels. We need to understand to what extent the state, the public administration and the European Commission are willing to impose a whole series of behaviours and standards. In this respect, Europe is a little weaker than the "real" states, such as the United States or China, and as a result we pay the price, especially when we have to be united on specific policies.

On the subject of giant ships, we can comment on the recent incident in the Suez Canal and all the reactions it generated.

Since this is a simple world that needs simple messages, on the Suez Canal we had, I believe, an excess of simplicity; I have heard talk about billions of damage or something like that, but fundamentally, it is not as if the goods coming through Suez evaporated in the week they were laid up. So the damage is not billions, the goods that pass through are "the billions". If anything in the meantime was perishable and was therefore lost, there was some small damage but I believe that the damage is basically related to the fact that global logistics chains are now so strained that clearly one day, two days or a week's delay of a ship is enough to cause very strong effects. Of course, many people exploit these things and this aggravates what is the real effect of the Suez incident. Clearly, it allows someone to say, "tomorrow morning I will raise the price of this item rather than of something else". I am convinced that the after-effect of everything that has happened is that more than one person, not the ship-owners, not the logistics people, but those in the industrial companies who have seen the delays of this week, will review the extent to which these value chains, these supply chains are stretched at global level and will make them a little more flexible. I am telling everyone that this means that in the next few years we will see a much more important role of something I have not mentioned so far, but which is typical of Trieste, and that is the free port. Free zones at a global level will become important because they will give the possibility to have goods arriving not attracted by demand, stored in areas where they do not pay VAT, taxes, excise duties and so on, as happens in Trieste. Then, if incidents occur such as the one in the Suez Canal, there is still a stock that will allow the supply of necessary goods to Europe, for example. Today, incoming goods are sent immediately to the final recipient because the logistics chain is so tight. I am convinced that the logistics chains will become a little less strained in the near future, and at this point the territories that are organised from a logistics point of view, and above all those that have the possibility of having advantages such as those of the free zones or the free port of Trieste, will be the ones that can benefit from a whole series of important investments.

2. Green Port Strategy and the decarbonisation of seas and oceans

The Green Port Strategy and the Next Generation itself envisage a transition from the point of view of energy and a carbon-free strategy. With these documents we have more than 400 million in funding from the Next Generation and therefore a whole series of actions that we are carrying out, linked to the ecological transition from the energy point of view; however, this means converting what we already do today in order to use carbon-

free energy. So, using port vehicles that are electrically powered, for example, but then we obviously need to find out what energy source will supply these vehicles: we are also thinking of in-port handling, such as hydrogen-powered barges, or something like that. At this point, too, there is the fundamental question of what is the source of this energy, which locally is clean but we do not know whether it has been produced in green terms or not (see hydrogen, for example: green hydrogen, blue hydrogen, grey hydrogen). In short, there are various methods, and so the issue can be tackled by the individual port, but there must be a broader approach, at least on the part of the supply chain, if not by the government and the state. At that point, a further, much more revolutionary element comes into play: on the one hand, there is the issue of the energy transition of the port as we know it today, that is fundamentally as a transport hub, and on the other hand there is the role that ports can play as producers of carbon-free energy. For example, I have seen some debate on this, but I must say that there is also a great deal of personal experience: there is a rather strange phenomenon going on, namely the fact that the big players in the oil and gas sector, and therefore in the carbon sector, are becoming pioneers in the carbon-free sector. They are doing this because it is a very strong trend, and they have a much greater financial capacity to deal with investments of this type than many other players. On the other hand, there is something interesting, and that is that we can think about converting energy infrastructures, such as pipelines or storage facilities, which until now have transported and stored gas, for example, and which tomorrow could instead store and transport hydrogen. So, from this point of view, those who own infrastructures of this type are facilitated in the process of transition to these new energies, these new technologies. is exactly what ports need to do, on the one hand they must make what we are already doing more sustainable, and on the other hand find a new role within the overall energy chain, even in the production of carbon-free energy, for example, in the production of hydrogen rather than the use of photovoltaics, wind power and so on. In this respect, however, ports need to open up their minds a little, not only in terms of port management, but above all in terms of the great resource that is the sea and how to make a series of investments in order to achieve these goals.

3. The importance of human capital and of Blue jobs

Let's talk about the blue economy, even if I don't like the term very much; we are now at a level where we can consider how investing in the blue world leads to economies, to development and the creation of value. There is a global awareness of the problem, a global awareness that the blue supply chain, blue growth and so on, represent an important sector, to the extent that they have become a business sector, the blue economy. At this point, it is clear that there is a need for human resources who are able, on the one hand, to manage this whole business component which needs new skills, but on the other hand also to see the blue supply chain as an opportunity to create value, not just economic value. That is why I do not like the term blue economy very much, because it gives it a meaning that has to be market-oriented.

On the subject of resources and human capital, a series of new initiatives must be taken, which can only involve integration with subjects that already exist in the blue world. It is useless to go out and build new intellectual/training contexts, or at least it can be done, but it must start from an existing base. This is something that Trieste already has in abundance,

much more than many other territories in the world. Trieste's opportunities in the world of research, and in this case in the blue world in particular, are extremely rich and important. We must bear in mind that there are ports competing with others in developing initiatives such as energy transition, exploitation of the sea and so on, that are lucky to already have factors, competitive advantages linked to skills that others do not possess. I like this theme, which we are pursuing in many ways. As the Port Authority of the Eastern Adriatic Sea, we are currently managing or are taking part in 26 European research projects, while five years ago there was only one. We have done a lot, but there is always more to do; so I conclude that on this specific issue, cooperation with universities and research bodies is desirable and should be cultivated, and this is what we will do in the near future.

4. What kind of Governance

It is clear that governance can only be transnational, and if we then talk about Trieste, it is clear that it is fairly automatic. This takes me back to the theme of Brussels, which must take some kind of action in this aspect. Governance must not be restricted to individual sectors, and as a result it is highly complex; it is true that this is not being done, but it is also true that it is difficult. There are maritime areas that are disputed between parties; within these areas, however, there is a whole maritime economy, transport and so on, ports competing with one another. These are not easy issues, but if today's ports have to understand that they have a future in this type of activity, it is clear that it also becomes an opportunity and almost a duty for ports to protect certain assets and therefore try to reconcile ecological and business interests. First of all there is a difficult administrative management, which we have to deal with every day: this includes the maritime authority, that is the harbour office and the coastguard, the port authorities and the various ministries, often with conflicting interests and competing with other countries, and therefore involving cross-border areas, so the situation is not easy at all. But we have to make a start, especially the issue is complex, we have to be able to do these things. Maybe this is where we need to invest in as much training as possible to have competent people who can deal with difficult themes that are evolving rapidly. We must start as soon as possible, even if only by brainstorming, but sitting around the table and discussing matters in order to find points of reconciliation. It is not easy, in the sense that we also have to deal with public administration, state administration, regional and transnational interests. We need only think of fishing, which falls under the jurisdiction of the ministry of agriculture, but shares issues with what is now called the ministry for ecological transition, transport and research. So it is clear that there is a whole cross-section of issues that are very difficult to manage, and if we then go to a transnational level, everything becomes more complex. If we do not make a start, we will never get to grips with the situation.

5. Trieste and its port

Trieste and its port certainly play a strategic role on a geopolitical level. This is due to a whole series of conditions: the Europe that is growing, or at least the Europe that produces, that consumes, therefore the historical central and northern Europe, is the one that lies behind the port of Trieste. To this must be added, since the fall of the Berlin

Wall, the growth of the entire eastern part as a market and as an economically important territory. We are in the right place at the right time. We trembled over the Suez Canal incident, because if Suez has a problem, it is clear that the Adriatic will be wiped off the map. If ships had to circumnavigate Africa, entering via Gibraltar, our port would be virtually unreachable. Instead we are in an ideal geographical position for ships entering or leaving the Suez Canal, just on the opposite side of the Mediterranean.

Then there is the recent issue with China, which is growing in terms of geopolitical power, and this is causing a clash between blocs with Europe in the middle. And the Europe that is in the middle basically always refers to this area of ours, namely Germany, which is important in any case, and all the countries in the East, which somehow dialogue or do not dialogue with China rather than with the United States. So we are indeed in a fundamental area, and if you are also a logistics centre, not only for transport, the situation of Trieste is difficult to replicate elsewhere in Italy, from the point of view of ports. As a North Adriatic port, we are competing with Koper, rather than perhaps with Rijeka in Croatia. In short, the game is between the duo Trieste-Koper. As Chairman of the Port Authority and as a transport expert, I therefore find myself having to deal with geopolitical issues often involving polemical discussions or even global conflicts where we are at the centre of attention. The only way out is competence, innovation, and the ability to monitor ideas. If you need others, at that point the conflict hanging over you becomes crucial in deciding your future. If, on the other hand, in your search for a vision you manage to be autonomous and in my opinion Trieste has an advantage over other ports, thanks to the world of research that is behind Trieste, at that point you have a whole series of elements, of ideas that allow you to be innovative, even though you may be only a small wheel in the global dynamic. I have always counted on this, and we have always played a game of this type, that is, we build our own scenario and our own vision, where there is room for everyone, but room for all those who accept our vision and not the opposite. Some people have not understood this, thinking that if we engaged in a dialogue to the right or the left, we wanted to form an alliance with one or be colonised by the other. This is a place that is lucky at the moment and will continue to be so. It has the opportunity to carry out many important projects and at this point the people who come and invest - and this is the important thing - enter within a vision that has been built at local and national level. In my opinion, this is our real strength, but it is a strength that we can maintain only if we have the brains, and I always come back to this point: if you do not have these skills, you can have all the money in the world, but in the end you will be colonised by someone. I think that the strength of Trieste is precisely that of having so many researchers and talents, and the only problem is that we have to network with them, and try to build a future.

Chapter 6.

Governance

Credit: OGS photographic archive

Coasts, inland waters and tourism: three aspects, the same sustainability challenges

Stefano Laporta

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With D.P.R. on 11/15/2016 he was appointed President, with internal organizational coordination functions, of the ISIN Council (National Inspectorate for Nuclear Safety and Radiation Protection).
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He is adjunct professor at the Faculty of Political Science of the "La Sapienza" University of Rome.

1. What actions should be taken to control and defend the coastline, with particular attention to the expected effects of climate change

The issue of the coast and its defence is strategic not only for experts in the field but also for the general public. It is important to inform and interest citizens about these issues that only a few years ago were considered almost a niche for insiders. However, unfortunately thanks to the pandemic, we have now discovered that they concern us directly because they affect the quality of life of each one of us every day. The coasts of our country are a great topic, because Italy is a peninsula and we are surrounded by the sea. We have a very beautiful coastline from a landscape and naturalistic point of view, but it is also very fragile in some respects because the Italian coast is exposed in various ways to the effects of natural and anthropic pressures, with varying levels of vulnerability depending on morphological characteristics and the presence of works and settlements. We have some of the most sensitive stretches of coastline, at risk of coastal flooding, which is the part consisting of the beaches and which measures about 3400 kilometres, so it is a considerable stretch that corresponds to about 45% of the entire natural coastline. About 90% of the Italian coast is natural and the remaining 10% is man-made - I will come back to this aspect later - with mainly defence works and infrastructures, first and foremost port infrastructures, which also represent an important area for our production system.

As the Higher Institute for Environmental Protection and Research (ISPRA), we address the issue of coastal protection through the environmental characterisation of the entire coastal strip. We have carried out numerous studies and, from the analysis in 2020 of the evolutionary trends of the so-called coastline, it appears that about half of the beaches in our country have shifted since 2006, that is in about 15 years of observation, while

the other half has remained stable. In the definitions given by ISPRA, we start talking about erosion or coastal advancement when the shoreline is more than 5 metres away from the previous survey. So we are going to focus on these two aspects: the time frame I have indicated and the threshold value we have for the shift. On the whole, it emerges that the length of the advancing stretches is slightly greater than that of the eroding stretches. If, on the other hand, we look at the extent of our beaches, and I hope that we will soon be able to visit them freely again, we have to deepen this analysis by referring to the so-called backshore line. These are technical concepts that I will try to explain quickly so they can be understood by those who are not experts. The boundary between the beach and the rest of the territory behind it is precisely the backshore line so, thanks to the coastline and this second backshore line, we can obtain the shape and surface of each beach and consequently the variations that have occurred over time. Between 2006 and 2020 we noted an overall loss of surface area of Italian beaches of about 150 hectares, that is one and a half million square metres. However, I would like to outline briefly some aspects that need to be taken into account. Many of the current erosion processes are compensated for by the effects of rigid defence works, such as reefs and beach nourishments. This occurs especially in areas of increased urbanisation with actions to protect infrastructure and human activities related to seaside tourism. The consequence is that many of the most eroded stretches are natural areas often adjacent to urbanised areas because there is an induced effect that is not secondary from an environmental point of view. Another important point is that many beaches tend to shrink. This is something that many of us have noticed, and many citizens point out to us every year; even where the shoreline remains stable, it is often human activity, human constructions and natural phenomena that cause our beaches to shrink.

Then we have pressure elements, such as the dynamics of marine forcing, the reduced supply of sediment by watercourses, the actions of man, which can be more or less effective. These are all factors that vary with respect to time and the position of the individual coastal areas, and so we can only briefly note a few homogeneous trends at national level that indicate, in general, a constant increase in the use of the coasts with their gradual artificialisation. Pressures due to meteo-marine phenomena also vary, and these are partly variations that depend on ongoing climate change. This is a phenomenon that we cannot ignore and that produces effects both in the rise of the average sea level and in the increased frequency of flooding of coastal areas. These are relatively recent phenomena that we are investigating in depth, on which it is not easy to obtain scientifically sound data. As far as protection, prevention and preparation measures are concerned, we must note that, until a few years ago, coastal defence was mainly dealt with using an engineering approach. There is nothing wrong with this type of approach, only that it was preferred to defend the coasts by carrying out rigid defence works integrated with beach nourishment. Today the action of these interventions has been queried, that is, it has been re-evaluated as a whole because of certain intrinsic limits that characterise it and that in some cases end up by highlighting a lack of substantial effectiveness when the interference of the works with the dynamics of the coast is not duly considered. In order to better orientate intervention strategies in the coastal environment, we have contributed to the drawing up of a document called “guidelines for the defence of the coast against erosion phenomena and the effects of climate change”, which dates back 6 years and was drafted by the then Ministry of the Environment for the protection of the territory and the sea, now renamed Ministry

for the Ecological Transition (MITE), and by the Regions under the technical-scientific coordination of ISPRA. The guidelines promote an integrated management approach, with a change in philosophy and structure compared to the past. What has emerged is that pressures on individual stretches of coastline need to be analysed and addressed by linking anthropogenic effects (urbanisation, ports, sewage discharge, etc.) with local weather and marine forcing, allowing for certain advantages such as enhancing the resilience effect. Resilience is a concept that has been much discussed in recent years, indicating a system of self-defence of our natural elements. We have seen that, with this approach, the resilience effect is reinforced by interventions to preserve the characteristics of the coastal ecosystem.

There is also an effect of restoring and preserving coastal strips and defending existing wetland ecosystems to complete this integrated approach, which generates positive effects that are reflected in territorial planning instruments and actions. We still have to reckon with urban and landscape planning and programming, and we cannot consider these aspects as not integrated in the territorial context in which they are located. All these aspects do not play an insignificant role with respect to the exposure of populations, infrastructures and the coastal territory to risk, because interventions on the coasts are not only an environmental, engineering or scientific issue, but they have direct consequences on the overall safety of the infrastructures in the territory and of people.

As the Institute for Environmental Protection and Research, we have a role as a national reference for on-site monitoring of the physical state of the sea. It is important for the public to know that we are responsible for managing three major systems for detecting meteorological parameters: the national wave network, the national tide network, and the tide network for the Venice lagoon and the upper Adriatic. This monitoring system is particularly important because it includes buoys moored offshore and fixed stations along the coast for real-time detection of wave motion parameters, tidal oscillations, and related weather forcing. These systems contribute to fulfilling and guaranteeing the tasks assigned to ISPRA for the organised and integrated management of the national warning system for hydrogeological and hydraulic risks by the National Civil Protection Department. The collection of observations on the state of the sea carried out with a widespread coverage of the entire national territory represents, in addition to a database that is also necessary for civil protection actions, a wealth of information that we consider fundamental and necessary to update wave motion statistics on sea storms and the relative growth trend of the sea level along our coasts. The continuity of these observations must necessarily develop over decades in order to obtain significant trends.

2. Is tourism a threat to the environment? Can tourism and environmental protection be reconciled?

Referring to tourism as a threat to the environment is a very strong stance, although obviously it is an issue we have to consider. Tourism has always been, even from a historical perspective, society's response to a necessary human need for well-being, for personal, physical, psychophysical development, not only through interaction with other people but also through interaction with the environment. As long as the relationship between functional operational services related to tourism and the natural and cultural

attractions of our landscape is maintained in such a way that the former does not harm the latter, the future of tourism as a healthy, resilient and sustainable socio-economic sector will not be undermined. And this is the principle behind sustainable management of the tourism sector. If we preserve this balance, we cannot consider tourism as a threat to the environment. But there is one issue, which we have been seeing for years, whereby the tourism sector has been considered purely as an economic sector, and therefore only intended to produce an economy, to produce GDP points.

This is not a bad thing in itself, but in the wake of this pandemic, which is so devastating for everyone and in particular for the tourism sector, it has emerged that respect for the environment must be one of the pillars on which the sector's recovery must be based. As the national environmental protection system, we offer our contribution and will continue to do so, to ensure that the tools are in place to promote and protect the sustainability of the sector.

There is a European tourism ecosystem covering a range of activities - travel, transport, accommodation, catering, outdoor water recreation, cultural activities in contact with nature - which contributes almost 10% of the EU's GDP and has made the EU the most popular tourist destination in the world. In the last year of reference – I am talking about 2018/2019 - we had 563 million arrivals, which corresponds to about 30% of the total worldwide. Europe continues to be the number one tourist destination in the world and the main source of tourists from around the world; in 2019 there were more than 1.5 billion international arrivals, an increase of 3.8% compared to the previous year.

Before the pandemic, it had become natural for everyone to take a plane or a train, even for business reasons. According to ENIT, the national tourism board, Italy, with 94 million visitors, was the fourth most visited country in the world in 2019, and in 2018 this sector generated more than 5% of the national GDP, rising to 13% if we also consider the so-called indirect GDP (that which arises and derives from sectors related to the tourism sector) with a percentage of employment between 6 and 8% of the active population working in our country, so it really is an important resource. For years we have tried to highlight the relationship between the environment and tourism, also drawing inspiration from what was happening at international level. Between 2013 and 2017, we participated in a specific work group, and from March this year we will be coordinating a specific interest group that we have asked to have set up within the European Environment Agency, precisely because we want to ensure that the sector has an outlook focused on sustainability. We want to take up this challenge with the other European countries and suggest, as far as possible, particular initiatives to the EU legislator. European policies consider sustainability to be an essential element of tourism, the references are there and they are well oriented. We wanted to set up this interest group because we realised that the various economic sectors involved were fragmented, with negative consequences on planning and coordination activities not only for the public sector and the research world but also for the private sector, industry and all other players.

I would like to point out that in last year's European Union Green Deal, although not specifically covering tourism, reference is also made to the transport, construction, waste production, food processing and energy sectors, in other words all sectors that are in some way related to tourism. We hope that some of the instruments that were adopted last year by the European Commission, starting with the Green Deal, will then be decisive in defining a new agenda for tourism 2050. In this respect, I must say that

the statements made by the Italian Minister Franceschini are particularly comforting, as he has stressed on several occasions that sustainability is the key concept that must inspire action in our country in the tourism sector. For several years now, there have been Community initiatives that have also been proposed in our country and that can facilitate this sustainable vision of tourism. For example, I am referring to environmental certification, the European Union's ECOLABEL, which distinguishes products and services characterised by a reduced environmental impact throughout their entire life cycle. In our country we have 54 ECOLABEL-certified facilities. This figure is not of minor importance because, at least as long as the pandemic allowed it, many people and tourists from certain parts of Europe, Germany and central-northern Europe in particular, chose tourist destinations precisely on the basis of environmental certifications. So the ECOLABEL is not just a label that you stick on the structure rather than on the reception of the structures, but it is a real guarantee mark that is sometimes a discriminating factor in the choices of many citizens when deciding on tourist destinations. In Italy we can certainly improve, but in relation to certifications we are second in Europe after France.

These are structures that provide for a whole series of mechanisms that in some way go in the direction of sustainability, for example, saving water and energy resources, sources that are also produced from renewable sources, a different management of the waste produced; in short, there is a sense of involvement of the citizen, of the tourist with respect to the structures, and this is very important because it generates a dual positive effect. In addition to enjoying the natural benefits of mental and physical rest from spending days in beautiful areas, one feels an active part of the process. For some years now, we have chosen to ensure the populating of environmental indicators on tourism in the yearbook of environmental data and in the data collections that we make always in relation to the quality of the urban environment. In 2017, to coincide with the international year of sustainable tourism, we introduced a specific report that we will then update in 2022, that is five years after the date of the first report, called "Environment, challenges and opportunities for tourism", which sought to help highlight the links between tourism and the environment. We have to make sure that tourism and the environment are in harmony. Tourism, especially in a country like Italy, cannot possibly be a threat to our environment.

3. The threat of anthropogenic activities to rivers and underground water

Italy is an extraordinary country also because it has a wealth and heterogeneity of watercourses that is truly unique in the world. Not only seawater but also freshwater, inland, surface and underground watercourses are elements that have historically favoured the anthropisation of the entire national territory. Man's works have in fact caused very significant pressures that have substantially modified the watercourses in our cities. Maps of our territories over the last 100 years show "plastically" how watercourses have been modified. In the last century, this has also been the result of the construction of dams and crossings, the development and implementation of river sediment removal, large diversions and the engineering of watercourses in general with the construction of many embankments. These works have undoubtedly had a collective, overall safety function, but they have caused substantial changes to the structure of the watercourses, such as the lowering of the riverbed, the so-called incision, from three to ten metres, or

even the narrowing of the riverbeds themselves, in some cases by more than 50%. These situations are not without consequences, because these pressures generate alterations to the hydrological regime and sediment dynamics, which in turn result in the deterioration or disappearance of habitats and hydraulic disconnection with underground waters. These pressures have also led to instability in crossing or defence infrastructures, such as the collapse of riverbanks, which then drags entire houses or production facilities into the river bed, partly because safety criteria have not always been respected or were not known at the time of construction. As Ispra, we have studied these factors and carried out pressure analyses at catchment area level, which have shown that dams, crossings, large diversions and hydraulic defence works are an important cause of the risk of deterioration of river water bodies. These works also cause instability in the riverbed structure and affect the propagation mechanisms and the effects of floods. I believe that there is a real need to implement a series of measures for the sustainable management and rehabilitation of watercourses, enabling them to be reconnected with their plains wherever possible, encouraging the downgrading of certain stretches of embankment and, if possible, eliminating certain obsolete structures, such as dams and crossings that no longer fulfil their purpose, using lightweight or filtering structures or bypasses instead. Finally, we must carry out a complete and accurate census of the works in operation and be informed about the availability of water withdrawal. This high level of data is not insignificant for understanding the degree of sustainability in the use of water resources. The design and programming of structural or non-structural measures will have to be based on a knowledge that we have yet to gain of river systems, their hydrological regime, sediment dynamics and the continuous, systematic monitoring of all these components. The European initiative linked to the so-called Copernicus programme, with the availability of complete and high-resolution data such as those coming from the Sentinel satellites, will make it possible to support traditional monitoring by evolving towards different forms of monitoring in line with technological and scientific progress, integrating different monitoring operations and optimising costs. We are developing ad hoc processors that will also make it possible to recognise changes in the availability of habitats, which are needed to assess the deterioration in the ecological quality of water. The focus on in-situ monitoring remains unchanged, but we need to combine new forms of monitoring through satellite observation with traditional monitoring systems. At the same time, we should also think about the qualification and specialisation of human resources in the monitoring and hydro-morphological assessment of watercourses in a country that is strongly characterised by rivers and lakes, where catchment areas are strongly affected by human activity and rivers are highly dynamic. It is very important to boost the knowledge and monitoring activities that are necessary to implement the river basin plans and the sediment management programme. Technical-scientific programmes, the activities of research bodies, the river basin authority can really be a turning point to achieve a more effective and coherent planning of integrated and coordinated qualification and mitigation measures. The aim is to guarantee the status of water bodies, to mitigate the hydraulic risk and to ensure a sustainable use of water resources.

Science diplomacy to boost cross-border Blue Economy alliance for youth employability in the Mediterranean

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The world ocean is the largest existing ecosystem on our planet. Oceans cover over 70% of the Earth's surface, carry out about 50% of global primary production and support the greatest biodiversity. They are also one of the largest carbon reservoirs in the Earth's system, holding up to 54 times more carbon than the atmosphere. The oceans, seas and inland waters are therefore very important to regulate the Earth's system, supply living and non-living resources and provide social and economic goods and services.

Water gives life, it provides humanity with food, energy, oxygen and regulates climate, but can take life away as well when its scarcity leads to hunger and poverty and its excess causes floods, landslides and extreme hydrogeological instability. Anthropogenic activities are damaging the planet by overexploitation, leading to the depletion of natural resources, destruction of ecosystems and pollution, causing socioeconomic and environmental impacts, and therefore it is fundamental to reverse the process and maintain an ecological balance to benefit from the myriad opportunities that emerge from nature and in particular from oceans.

In the Mediterranean Region, many countries are facing severe social problems and suffering economic challenges along with serious threats such as geopolitical instability, economic crises, youth unemployment, climate change and sea level rise, drought and floods, amongst others. As coastal nations, much of Mediterranean countries' social and economic activities relies on the marine environment and maritime services.

Youth unemployment is on the rise in the Mediterranean Basin. According to the Union for the Mediterranean (UfM, 2021), "almost 60% of the regional population, is today under the age of 30, and the number of young people under the age of 15 is forecasted to increase over 18%. This represents an asset for the region, and therefore, a positive and action-oriented regional agenda on youth employability is indispensable to unleash the region's human and economic potential capital. As requisite for peace and

stability in the region, priority actions must be built on promoting competitiveness and enhancing job opportunities, in particular for youth."

This chapter focuses on the role of Science Diplomacy in facilitating cooperation amongst countries in the blue economy sectors, promoting youth employability, and valorising investment conditions to ease the interconnection between governance, industry and academia.

1. Governance, industry and science

Interactions between academia (scientific research and university), industry (business and labour market) and governance (policy and state) are important. More overlap between the three components contributes to generate ideas for innovation coming from industries to universities, to feed jobs with required skills according to the labour market needs and to create dedicated financial schemes to respond to the socioeconomic requirements.

Government should raise awareness about the potential of the blue economy and learn from the industry on how to develop more innovation to minimize loss of jobs and to ensure viable and lasting solutions for creating new opportunities and should encourage private public partnership and ease the dialogue between academia and the productive sector.

Today, as in all moments of historical change and because of the drastic economic situation caused by the COVID-19 pandemic, we have the opportunity to steer our future in a better direction to rebuild our economies and societies. To do this, there is a need for building trust in institutions and government engagement, reducing financial concerns, eliminating emotional distress and preparing new leaders. A new generation who will lead the change and introduce a new development model.

2. The Mediterranean and youth unemployment

Unemployment affects 67.6 million young women and men, which means 13.6 per cent of the youth labour force (ILO, 2020). Youth unemployment is highest in Northern Africa and in the Arab States, at around 2.2 and 1.7 times the global rate, respectively.

Despite youth in the Southern Mediterranean being the most educated generational group ever, young graduates in the region, especially in North Africa, experience the highest level of unemployment among higher education graduates in the world, around 29.8%[2] (Fig.1).

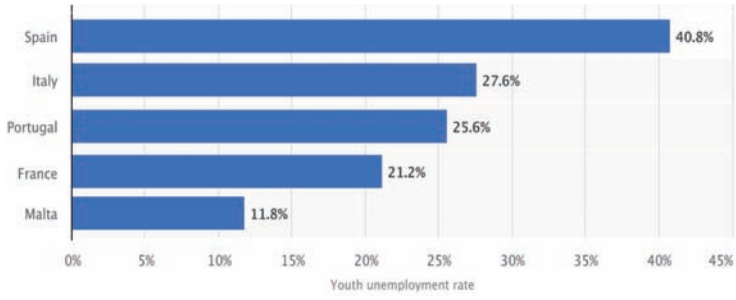

Fig. 1 - Youth unemployment rate in EU member states of the 5+5 Dialogue as of June 2020 (Up to 25 years old) (source: www.statista.com).

To improve the current situation characterised by politic instability, economic difficulties, social regression and environmental problems, national labour markets in the region need to focus on job creation for youth based on innovation and employability. Thus, universities and research centres are key actors for generating innovation and developing skills that help build vibrant and sustainable development in the Mediterranean and contribute to the knowledge transfer to their societies and economies. The recent pandemic has made the socioeconomic situation more critical and urged quick and strong policy responses.

One of the immediate actions is to look for a way to use available skills to end unemployability by matching skills and jobs (the job I need, needs me). Another remedial action to unemployment is to develop those skills that are needed by the existing labour market (reply to the requested workforce). For a long-term strategic plan, developing specific skills taking into consideration the labour market needs should be applied to both the evolution of the global labour market and the availability of skills, thus responding properly to local economies. By skills we mean both vocational education and training (VET) and higher education (HE). VET responds to the needs of the economy (productive sector), but also provides learners with skills that are central for personal development and active citizenship, whereas higher education helps create new profiles, managers of the marine and maritime sectors (the leaders of tomorrow).

To consolidate the development of skills, there is a need for partnerships to foster joint education programmes in higher education: joint masters and Ph.D. programmes, as well as themed-short courses and workshops; fostered scientific mobility and international science cooperation to establish joint university departments/labs in the region, including teaching exercises and enhanced curricula that can respond to the labour market at any age.

3. Required skills to feed jobs

In line with the EU skills agenda for sustainable competitiveness, social fairness and resilience and the EU strategy for blue growth, the National Institute of Oceanography and Applied Geophysics, in partnership with other partners from public and private sectors (universities, research institutions, governmental bodies, industries), is promoting an articulated training path that aims at overcoming the existing “skill mismatch” in the Mediterranean region between education and training offer and the labour market needs. This programme has been evolving and a project has been submitted to the national authority (Ministry of University and Research – MUR) and positively evaluated and approved. This project, named BlueSkills, is being labelled by the Union for the Mediterranean (UfM) to be considered one of the successful best practices to be included within the framework of the Med4Jobs initiative and often included in a number of initiatives such BlueMed, WestMed, EUSAIR and the Western Mediterranean Forum.

This training-offer promotes opportunities for “Blue” marine and maritime careers by developing skills, exchanging knowledge and valorising research for a more sustainable Mediterranean Sea. It aims at developing new curricula and increasing employability in the marine and maritime sectors. By supporting the Euro-Mediterranean communities of the Blue Economy stakeholders through higher education, research and innovation, the project enhances shared knowledge of the overall Mediterranean region.

Beside developing skills and building capacities, BlueSkills aims at enhancing the geopolitical dialogue in the Western Mediterranean region through increased international scientific cooperation and science diplomacy.

4. Science Diplomacy: The intergovernmental Forum 5+5 Dialogue

In 2015, ten Ministers in charge of Research, Innovation and Higher Education of the 5+5 Dialogue countries of the Western Mediterranean met on the occasion of the Ministerial Conference on Research, Innovation and Higher Education in Madrid in the presence of the European Commission, the Secretariat General of the Arab Maghreb Union, and the Secretariat of the Union for the Mediterranean. The Ministers signed a declaration, which aims at strengthening cooperation in research, innovation and higher education for promoting sustainable economic growth, social inclusion and creating new opportunities for youth in the Western Mediterranean Region.

As a Trans-Mediterranean initiative in the Western Mediterranean, the "raison d'être" of the 5+5 Dialogue is to ensure closer cooperation between the five EU Member states and the five Arab Maghreb countries through political dialogue and cooperation and by encouraging more effective resource management as a means of strengthening interdependence and regional development.

The Declaration underlines the importance of research, innovation and higher education for addressing challenges such as unemployment, economic underdevelopment, environmental degradation, shortage of natural resources, water scarcity and food and energy security. Ministers emphasise the common determination to strengthen collaboration for reinforcing the potential of youth and the access to higher education as fundamental to the development and prosperity of the Mediterranean region.

5. From Science to Policy

Today what is needed in the Mediterranean is an overarching framework to address the Sustainable Development Goals of the United Nations (SDGs) of particular importance to the region such as combating climate change, increasing food security, managing natural resources, reforming health systems, creating opportunities for social inclusion, economic prosperity and human equality, reducing risks for geopolitical instability, etc. This can be done through science to policy dialogue using a multi-stakeholder method, strengthened research cooperation mechanisms, and institutional partnerships, all together in a shared ownership approach.

To stimulate growth and employment, the 5+5 Dialogue countries are deploying more efforts to promote entrepreneurship, a powerful engine of shared prosperity. In fact, the creation and growth of enterprises promotes employment and development of new skills, reinforces innovation and increases market potentials.

Many countries are engaged in processes of reforming their political, economic and social systems to stimulate investment, to encourage initiatives and to foster strong economic partnerships that are essential throughout the Western Mediterranean region.

The 5+5 Dialogue member countries need to revitalize their economies to promote smart, sustainable and inclusive growth for the purpose of developing disadvantaged

regions and enhancing job creation in line with international labour market standards. Research, innovation and higher education play a key role in job creation. There is a need for a framework of cooperation and synergies among the ten countries. Confronted with several challenges, the 5+5 Dialogue member countries are invited to deepen their partnership to further stimulate economic growth and social stability.

6. Sustainable blue economy: The Italian contribution to the 5+5 Dialogue

Italy as member country of the 5+5 Dialogue has taken on the commitment to develop, create and maintain a Sustainable Blue Growth platform for the benefit of the Western Mediterranean Countries. This initiative has been expanded to all Mediterranean countries and has been strongly supported by the Union for the Mediterranean (UfM).

The main goal is to create the conditions to promote joint, complementary and concrete actions to maximise the impact of investing in improving existing skills (upskilling) and training new skills (reskilling) in the identified field throughout higher education (university degree such as advanced master and training-of-trainers such as summer schools) and vocational education and training (VET) and to bridge the gap between government-industry-academia in the blue economy sector through building strong skills partnerships in the Mediterranean region with particular focus on youth. Specific goals are:

- promoting capacity building and training offers on Sustainable Blue Growth in the Euro-Mediterranean region;
- knowledge transfer, citizen science and involvement of stakeholders;
- boosting innovation, generating transferable skills and promoting youth employability;
- raising awareness on ocean governance, climate change and sea level rise, marine biodiversity and ecosystem functioning, sustainable blue economy and ecosystem-based management, maritime spatial planning (MSP), and all fields related to the marine and maritime sectors; and
- strengthening regional cooperation and networks on blue growth in the Euro-Mediterranean region (Science Diplomacy).

To reach these objectives, a tailor-made method has been developed and it is articulated in a training path, which includes:

- a yearly summer school in collaboration with the Euro Mediterranean University addressed to young scientists and researchers (45-50 participants) from the Mediterranean countries;
- an advanced master degree in sustainable blue growth jointly organised with the University of Trieste (25 students per year);
- access to research infrastructures, international mobility programme and job shadowing (10-12 fellowship grants per year);
- support of 2-3 scientists and researchers for conducting Ph.D. research studies;
- alternation school-job through internship for the youngest (vocational and education training);
- public outreach, divulgation and scientific communication for the benefit of local communities.

Throughout this training path, young scientists, researchers and Ph.D. students have benefitted; project managers, economists, engineers and other professionals have updated their skills; policy-makers, administrators and the public have been involved, young individuals and children have been reached.

7. Boosting cross-border Blue Economy alliance

Aiming at strengthening partnership and scientific and technological cooperation among member countries of the 5+5 Dialogue and the Mediterranean region as a whole, member countries encourage and support the links between the academia (training and research centres) and the industries of the Northern and Southern shore of the Western Mediterranean. Partner countries believe in Science Diplomacy, understanding scientific cooperation as a mean to boosting cross-border alliance in the Blue Economy sector.

The objective is to encourage researchers of the 5+5 Dialogue Member Countries to develop North-South networks dedicated to the public and private research through the formation of panels of experts on skills and disciplines defined according to the theme. These networks will address priority issues with anticipated scientific, technological and societal impact. This enables researchers from both shores of the Mediterranean to formulate European collaborative research projects and submit them successfully.

Blue Economy is the sustainable use of ocean resources for economic growth, improved livelihoods, jobs, and ocean ecosystem health. The BE concept was introduced in 2004, by the Belgian, Gunter Pauli, who launched it "based on the ZERI (Zero Emissions Research & Initiative) philosophy, to engage a global network of experts and creative minds to seek solutions inspired by nature's design principles" (https://circular-impacts.eu/blog/2017/07/19/what-blue-economy). His book - The Blue Economy: 10 years – 100 innovations – 100 million jobs - released in 2010, highlights that the "Blue Economy business model" will shift society from scarcity to abundance by using available resources and tackling ecosystems' issues in an innovative way.

Several initiatives fostering the Blue Economy ecosystem in the EU have seen the light. According to the European maritime policy (https://ec.europa.eu/maritimeaffairs/policy/sea_basins_en), macro-regional sea-basin initiatives are being implemented in the seas bordering Europe, promoting growth and development strategies that exploit the strengths and address the weaknesses of each large sea region in the EU.

The cross-border Blue Economy alliance has been nurtured by some specific bilateral cooperation agreements that strengthen and consolidate integration among partner countries, like the partnership agreement signed between the cluster Blue Italian Growth (BIG) and Cluster Maritime Tunisien (CMT) in June 2020 (https://www.clustercollaboration.eu/news/italian-and-tunisian-maritime-clusters-boost-collaboration-strategic) as drivers to accelerate employability, entrepreneurship and capacity building especially in Southern countries.

The importance of the marine and maritime industries will continue to grow in the Mediterranean region. The Blue Economy sector is an engine of human and economic development for the entire region. Taking full advantage of this sector's potential will require a multi-skilled workforce from a wide variety of marine and maritime professional backgrounds, which necessitate new knowledge, skills and innovation. In order to achieve

this goal, higher education and vocational education and training (VET) have to innovate and gain in relevance and quality.

Therefore, digital transformation and ecological transition along with the development of skills (higher education and VET), clusters development and marine spatial planning (MSP), represent key tools to "drive" priority actions at national and regional levels and build a conscious governance at local, national, macro-regional and Mediterranean levels, and thus to optimize the skills and improve existing investment mechanisms.

In conclusion, establishing strategic partnerships to foster synergies with the existing platforms for developing blue skills and making available investment tools and financial services at the disposal of all Mediterranean countries is the only key to success. "If you want to go fast, walk alone. If you want to go far, walk with others." African Proverb.

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The Arctic Strategy

Franco Frattini

Franco Frattini is an Italian Magistrate, appointed State Prosecutor in 1981 and State Councilor in 1986. Today he is Section President of the Council of State, President of the Italian Society for International Organization SIOI and President of the High Court of Sport Justice (CONI). He has held important government positions. He served as Minister for the Public Function (2001-2002), twice as Minister of Foreign Affairs (2002-2004 and 2008-2011) and as Vice-President of the European Commission and Commissioner for Justice, Freedom and Security (2004-2008). He has received numerous honors, both foreign and italian, among which the "Knight Grand Cross of the Order of Merit of the Italian Republic" and the "Golden neck-chain of the Olympic Order".

1. The Italian role in the Arctic Council

In my capacity as Italian Minister of Foreign Affairs, I found it extremely important to revitalize the Italian interest in the Arctic. Bearing in mind the exceptional and unique experience many, many years ago made by Umberto Nobile - who was one of the first to explore the Arctic in close cooperation with famous "explorers" from Arctic countries such Norway, Finland, or Sweden - it is clear that at that time we already realised that the Arctic is a key region in the geo-strategic equilibrium for the rest of Europe and for Italy. Interestingly, if you visit Longyearbyen, which is the capital city of the Svalbard, or Spitsbergen archipelago, you will find there a small Italian museum, managed by an Italian, where you can see the original papers on which Nobile signed his commitment to visit the Arctic. So, also with this tradition in mind, I thought it was important to ask for Italy to be one of the permanent observers at the Arctic Council, which is an international body where the most important and powerful countries in the world are present, from the United States to China, to Russia, to Canada. This is also one of the reasons why it was important for Italy to go ahead with research in this area, in particular with good projects to combine exploitation of resources while preserving the environment and playing a role as in the past. These are the reasons behind my decision taken already in 2008, when I attended the Arctic Council in Tromsø and I presented the Italian candidature, which became a reality a few years later, and now Italy is a permanent observer of the Arctic Council.

2. Sustainable development and environmental protection in the Arctic

First of all, I have to say very clearly that in the world of today, which is not an easy one, since there are tensions and situations of crisis in many parts of the world, the Arctic

Council is probably the only international, or supra-national body where countries that usually have very harsh relations sit together and cooperate. I have seen the Americans and the Russians working together many times, and China attending the meeting with the spirit of open cooperation. The Arctic Council does not have the power to impose binding rules, it does not issue rules, but this does not mean it is not important. The Arctic Council is very important because in a spirit of cooperation, in a spirit of open dialogue, we can hope to mitigate tensions that emerge in other fields, concerning security, the geo-strategic attractiveness of some territories (the Arctic is becoming very attractive for many important countries!) and other elements. If you visit another small village in the Svalbard Islands, Ny-Ålesund, you can see the building that houses the permanent headquarters of the Chinese delegation. It is an enormous building, with two stone lions before the entrance, like a pagoda, and its presence in Ny-Alesund shows how highly they consider their geo-strategic presence. Furthermore, the Arctic Council studies, develops and implements a number of policies concerning all the key issues related to the Arctic region. First of all, sustainable development: how to develop activities while preserving sustainability for the ocean, for wildlife, for natural resources. Secondly, how to combine commercial and economic interests with the need to guarantee the equilibrium. Many used to say, "What happens in the Arctic doesn't stay in the Arctic", which means it has a worldwide repercussion. Thirdly, there is a human factor. It is not widely known that in the Arctic region as a whole, there are some 5-6 millions of native people who have been living there for centuries, and you have to consider that you cannot think about transforming their lives, or even forcing those people to migrate. Imagine the idea of a "climate migration" from the Arctic region because of the melting, because of the transformation of the environment. This would be a nightmare. When you go to some parts of the Arctic, where unfortunately you can see the first symptoms of this degradation, you see those people whose ancestors used to hunt seals to survive and who are now trapped by alcohol, and their daily life is destroyed. What happened to the Indian people of Northern America must never happen to the people living in the Arctic.

3. Diplomatic capacity

We have to make full use of our diplomatic capacity and this is why Europe, and Italy in particular, can play an important role. Italy has a good scientific tradition in Arctic science, as is shown by the fact that there is a permanent centre – operating in both winter and summer - that is located in Ny-Ålesund, in the extreme north of Svalbard, which is managed by the Italian CNR, the National Research Council, and hosts researchers and scientists. Furthermore, Italy also has a great tradition in cooperation with everyone: we can easily speak to the Americans as well as to the Russians, with no problems at all. But Italy also has an important economic interest in the Arctic. ENI has an important concession on oil fields, particularly off-shore north of Norway, and Italy has an interest in keeping that opportunity to exploit off-shore natural resources, particularly oil, always while being very attentive to nature, and avoiding any kind of degradation of the ocean. Italy also has a great attention to combine development and sustainability. It is not by chance that now, in the current government, led by the Prime Minister Mario Draghi, we have a ministry for ecologic transition. We want to avoid opening a rush to Arctic and opening ways through the Arctic regardless of their impact. It is so fragile, so vulnerable,

that - frankly speaking - I certainly do not want a future where the next generation sees the Arctic crossed by thousands and thousands of vessels and commercial boats, with no attention to what happens to the nature that lies below the oceans.

4. The role of the United Nations

I think the United Nations have to implement their priorities and one of the most important priorities is the protection of the oceans and natural resources. If I look at the oceans, I see vulnerable oceans, particularly in the Arctic and Antarctic polar regions. The United Nations are focusing on a strategy for 2030, but what is also very important is the so-called "COP25", the Paris agreement on the environment as a special focus on vulnerable areas and vulnerable territories. We are celebrating 75 years since the charter of San Francisco, the founding charter of the UN, and it is now more important than ever that the UN is focusing on rebalancing the equilibrium between exploitation of resources and protection of the environment. Hence, if we consider the UN Decade of the Ocean 2021-2030, it must absolutely deal also with the Arctic and Antarctic areas, taking them into strong consideration.

5. Risks of an uncontrolled development in the Arctic

Uncontrolled development of the Arctic strategy could be dangerous. In fact, we run the risk of focussing only on opening new routes, exploring new opportunities for exploiting natural resources, increasing commercial revenues by crossing the Arctic Ocean, without considering the other side of the coin. Once the ocean and the Arctic are degraded, it will be difficult to restore the equilibrium. So it is easy to be trapped by "enthusiasm": "Oh! We have new shipping routes, crossing the Arctic Ocean in two months faster than in the past." Is that an opportunity? If so, please, take this opportunity while seeking to maintain the equilibrium with the impact of these new routes. I see a risk and this is why the Arctic Council is the right place in which to launch an open dialogue. I shall give you one more example, which has nothing to do with shipping routes, but is quite similar: in the recent past there have been some attempts on the massive exploitation of Greenland's natural resources and minerals, and the former President of the United States even made a proposal to buy Greenland. There was a rightly furious reaction from Greenland, of course, and fortunately this idea was put aside. This is just one example: if you open the way to the uncontrolled exploitation of Greenland then you destroy the permafrost, you destroy the wildlife, you destroy everything.

Considering another question, that of a possible militarization of the Arctic, we can say that there is some tendency to increase military presence: Russia and China, of course for deterrence, and America too. But I am very optimistic about that. All the countries that have an interest in the Arctic region are well aware of the fact that they must not destroy this unique opportunity to have a place, the Arctic Council, where they can engage in dialogue, instead of confrontation. This is a unique opportunity and considering my personal experience - I have attended a number of meetings of the Arctic Council - I have always seen all the members, observers and full members, talking about what can unite more than what can divide, and this is a good message also to be kept

on the table for the future. In the world of today, which is so divided, at least one place where we talk not about more weapons and militarization, but about more development and sustainable development is badly needed, and this is why my optimism comes from direct experience. I am sure that President Biden, for example, with Mr Kerry and his attention to environmental protection and to preserving resources, can be a strong factor in preserving cooperation rather than confrontation.

6. The importance of training

I decided 7 years ago to launch the first SIOI master class on Arctic studies. Now, we are about to start the 7th edition of this master class which has already attracted a number of participants, obtaining more instruction and more training. Meanwhile, SIOI has decided to promote better cooperation with the network of international universities dealing with Arctic studies, and since 2019 we are very proud to be a member of EU Arctic, which is the international network of universities dealing with the Arctic. The headquarters are in Finland, but the network exchanges best practices, experiences, training courses. Our idea is to help train the younger generation - we are talking about post-graduates - to consider the holistic vision of the oceans and the Arctic region in particular. Adopting a truly holistic vision, the European plan is named after the young generation: Next Generation EU. So our investment is to train as many young people as possible who are interested in dealing with the Arctic and to consider it as a whole, and not simply from the points of view of oil production or shipping routes, or of the simple protection of the animals that we love so much. What is important is to keep everything together. This is the scope and the origin of the master class that SIOI has been organizing for the seventh time this year.

The PRIMA Initiative: together for more sustainable agrifood systems

Angelo Riccaboni and Giovanni Stanghellini

Angelo Riccaboni is Chairman of PRIMA Foundation, created by 29 Countries and the EC to fund agrifood innovation, located in Barcelona. He chairs the Santa Chiara Lab, an innovation center at the University of Siena. Former Rector of the University of Siena from (2010-2016), he is a member of the Leadership Council of the United Nations' Sustainable Development Solutions Network, Chair of the Regional Centre of the SDSN for the Mediterranean, Co-Chair of the SDSN Europe. Full Professor in Business Administration at the University of Siena, his main research interests relate to businesses' governance and management systems for sustainability and to innovation in agrifood systems. He was Chair of the Association of Italian Rectors Foundation. He is also a Member of the EC sub-group on Mission Area Soil Health and Food of the 'shadow' strategic configuration of the Horizon Europe Programme Committee.

Giovanni Stanghellini (Phd EU Law; LLM in International Human Rights Law) – Project Manager at the Italian PRIMA Secretariat, responsible for Institutional Relations, regularly interacts with relevant units of the European Commission, major institutions (e.g. FAO, UNEP) and EU initiatives (e.g. PRIMA Foundation, EIT Food) related to the food sector. Ha also acts as focal point for public entities (e.g. Italian Ministries), as well as for local stakeholders on sustainable development. He is currently focusing on the PRIMA Initiative, Horizon Europe and the EU Regulatory Framework, after the adoption of the Green Deal.

1. The need for Synergies and Complementarities in the Euro-Mediterranean Context

The challenges that the Mediterranean is facing are multiple and all very crucial: loss of biodiversity, soil degradation, climate change adaptation and mitigation, water scarcity, food loss and food waste, food safety and quality, unsustainable farming practices. These challenges are coupled with social challenges related to higher youth unemployment, limited integration within the region, increasing disparities and unequal distribution of resources and opportunities, imbalances in the demographic trends and overexposure to intense migration flows.

In addition, the current pandemic situation has exacerbated the situation, especially in the initial phase. In fact, the agrifood ecosystem was among the most affected sectors due to the closure of international borders, national lockdowns and the enforced

restrictions on mobility and flow. Farmers were not able to reach their own farms and their ordinary willingness to purchase products and services was seriously affected. The farming industry in general had to deal with a huge set of problems from uncertainty in supply and demand to labour shortages to family needs and personal health.

The relevance of these issues and the need for effective solutions is at the centre of the European Green Deal and its new sustainable strategy. In particular, the Farm to Fork and the Biodiversity Strategies, together with the Action Plan on Circular Economy constitute the key framework documents that will help the implementation of the green transition in sectors related to the use of natural resources, the food industry, agriculture and blue economy. In these areas, the role and impact of the Common Agriculture Policy will also be essential to ensure that territories, communities and SMEs can offer their positive contribution in terms of sustainability, while maintaining livelihood and productivity.

With the overarching objective of carbon neutrality by 2050, the EU has shown its ambition in aligning its growth strategy with the environmental targets and priorities. The new framework programme Horizon Europe will also support and boost further such new priority. It is now evident that economic growth, social inclusiveness and environmental protection can no longer be pursued separately. Interestingly, the European Union also has the ambition to play a more prominent role at the global level and it has reiterated such ambition by framing the European Green Deal also as an external policy, able to orient the relations with the other international partners. In that perspective, the EU Green Deal and the related Strategies are of key relevance also for the Mediterranean area and beyond.

With this in mind, it is not surprising that in the Joint Communication recently issued by the European Commission for a New Mediterranean Agenda the issues of sustainable food systems and water management are prioritized. Similarly, in the EU-Africa Research and Innovation Agenda, it is underscored how knowledge and innovation should tackle the challenges related to the sustainable use of natural resources and climate change related issues. This is even more critical for the Mediterranean, which is recognisably a hot-spot for climate change.

Furthermore, the EU has also adopted a mission-oriented approach, which has the merit of fostering impactful research, valorizing co-creation through the experience of living labs, promoting stakeholder and community engagement, fostering lighthouses as demonstration places where research and innovation can be tested and become tangible.

2. Main features and achievements

To tackle the above-mentioned challenges in agrifood systems, research and innovation are crucial. Given the size of the problems, Euro-Mediterranean Countries need to pool their resources, laboratories, ideas and experiences.

PRIMA (*Partnership for Research and Innovation in the Mediterranean Area*) was created to promote such a joint answer. It is a Euro-Mediterranean Initiative, jointly funded by the European Commission and 19 Euro-Mediterranean States (Algeria, Morocco, Tunisia, Egypt, Jordan, Israel, Lebanon, Turkey, Croatia, Cyprus, Greece, Malta, Italy, Spain, France, Germany, Portugal, Luxembourg and Slovenia). It operates in the Euro-Mediterranean area by funding research and innovation projects over a period of 7 years, focussing on the efficient management of water resources, sustainable farming systems and agro-food value chain, with a total budget of 500 million euro.

Established under art. 185 of the Treaty on the Functioning of the European Union after five years of negotiations, PRIMA has been described as the most important research and innovation Initiative for Science Diplomacy in the Mediterranean region and it constitutes the first experience of public-to-public partnership. The institutionalized level of the cooperation is based upon the principle of equal footing and it has required a high degree of co-management, co-organization and co-decisions among the 19 Countries involved.

Irrespective of the different financial commitment expressed by each Country, these important principles have characterized the establishment of the PRIMA Foundation, the *ad-hoc* legal entity created in Barcelona for the management of the calls and the monitoring of the funded projects, and any activities of the Programme. The launch of the Programme was also possible thanks to the signing of several International Agreements between the European Commission and several Third Countries.

Now entering its fourth year of activity, since the start PRIMA has funded 129 projects involving more than 1100 research units, for a total of approximately 165 million euro. More specifically, PRIMA has funded projects on issues such as aquaponics, precision agriculture, conservation of local plants' and animals' genetic resources, animal welfare, value creation along the food chain on a variety of products and species, adaptive and resilient agriculture. Moreover, projects have tested solutions to address food loss and waste, the competitiveness of traditional Mediterranean products, traceability of Mediterranean productions, land degradation, integrated solutions for sustainable irrigation and water management. The funded projects are proposing and testing solutions that need to be *brought to the market* and implemented to ensure that they can have a concrete impact on the lives of consumers, smallholders, communities, the Countries and the environment.

Each proposal was presented by a partnership composed of at least one research unit from both the Northern and Southern Med Countries, thus confirming PRIMA's role in terms of Scientific Diplomacy. Within the Partnership, Italy has since the start played a key role in promoting, supporting and valorizing PRIMA and its potentials. Italy has also performed very well in terms of research and innovation funded projects, with 97 projects and more than 38 million euro allocated to Italian researchers, who are coordinating around 33% of the entire projects.

Among the five Missions identified at EU level, both the Mission on Soil Health and Food and the Mission on Ocean and Water have direct complementarities and synergies with PRIMA priorities and projects.

In order to explore these synergies, PRIMA is oriented to further promote joint calls with Mission Soil Health and Food, in order to transfer the Mission model as much as possible into the Mediterranean area. In this area, in fact, soil degradation is of utmost importance, the potential beneficiaries are multiple, from local farmers to cities, and the experience of co-creation still very limited.

3. Final Remarks

In line with the regional Agenda under discussion in the context of the Union for the Mediterranean as well as at EU level, PRIMA is willing to serve as a platform and infrastructure for the effective application of the innovative solutions needed to meet the global challenge of an effective implementation of Agenda 2030 and de-carbonization. It

is contributing to the consultation just launched by UfM for the definition of its Research and Innovation Agenda, and it will carefully listen to the outcomes of such consultation. The partnership with UfM is considered by PRIMA as a strategic one, given the relevant political and institutional role of that organization in the Mediterranean area.

The global Food System Summit promoted by the UN Secretary General this year and several key Conferences of the Parties on Climate Changes reveal that, besides and beyond the dramatic pandemic of COVID-19, other pressing needs require our joint efforts. In a context where the President of the European Council C. Michel is calling upon the international community for a global treaty regulating the response to other possible pandemics, it is clear that, as well represented by SDG 17, the challenges we are facing require a partnering approach. Public and private, local and international stakeholders, as well as institutions and civil society shall come together for this common goal. In that sense, the role and experience of PRIMA, which has been able to establish fruitful synergies with a variety of stakeholders (SDSN, Anna Lindh Foundation, Parliamentary Assembly for Mediterranean) national and International Institutions (FAO, WFO, European Commission, Union for the Mediterranean, UNEP, UNIDO) and Initiatives (EIT Food, JPI Water, CBC Med), turns out to be of great relevance.

In the Euro-Mediterranean region, there is an incredible need of a major transformation of food and water management systems. However, a successful transformation needs to be underpinned by innovation systems. It is critical that research efforts are targeted towards end user needs and are underpinned by robust partnerships to ensure adoption and societal outcomes at scale. Even more crucial is to foster an ecosystem where the adoption of innovation is possible and accessible to SMEs, companies, farmers, communities and end-users. By exploiting the results of research and innovation projects funded, in order for them to have a tangible impact, PRIMA is a good experience to look at. By doing that, PRIMA and similar experiences could truly contribute to the resilience and recovery of the Mediterranean region.

Youth employability in the Mediterranean region: a top priority for the UfM

Nasser Kamel

Nasser Kamel is Secretary General of the Union for the Mediterranean. A career diplomat for the Egyptian government, Nasser Kamel held the position of Egyptian Ambassador to the United Kingdom from 2014 to 2018. He was also Ambassador to France in the period 2006-2012, during which he took part in the drafting of the Joint Declaration of the 2008 Paris Summit that marked the launch of the Union for the Mediterranean. Furthermore, between 2012 and 2014, he was Assistant Minister for Arab and Middle Eastern Affairs. From 2004 to 2006, he was the Director of Egypt's Public Information Service. Prior to this position he served in various embassies, including Washington (1984-1988), Lisbon (1990-1994), Tunis (1994-1998), Brussels (1999-2001) and Paris (2001-2004).

The Mediterranean region holds in its sea, which separates and unites us, one of its greatest opportunities. The sustainable exploitation of its marine and maritime resources is therefore one field where we all share a clear advantage to cooperate, in order to achieve economic growth, job creation and regional integration.

This becomes clear even with a quick overview of our shared sea. Migratory fish stocks, maritime cultural heritage, and sea currents often straddle political boundaries, making the case for basin-wide cooperation. In the same way, sea-borne shipping, blue energy, and maritime transportation would not generate prosperity with hard borders. Similarly, the same commonality can be seen in threats such as waste circulation (i.e. plastics and microplastics), acidification of the oceans, depletion of regional fish stocks, and sea level rises.

All this reminds us that our sea is fragile, yet resourceful. It is up to us collectively to steer its direction towards its sustainable use as leverage for growth, or towards its becoming a source of economic and environmental disruption, for instance vis-à-vis the small coastal fishing communities.

This is clear at a global level, especially when considering the UN Agenda 2030, which has included in its Sustainable Development Goals a specific point on the seas (the 14th: "*Conserve and sustainably use the oceans, seas and marine resources for sustainable development*") and the importance of a global Climate Pact, such as the 2015 Paris Climate Conference.

It is within this global framework that the 42 UfM Member states agreed this year on a UfM Ministerial Declaration on Blue Economy, aimed at improving maritime governance and at intensifying joint efforts, activities and projects in various blue economy sectors while addressing the growing environmental and climate-related challenges that the Mediterranean region is currently facing.

Tapping the potential of our sea becomes all the more important at this time, when we are collectively redesigning our economies and our societies for a post-pandemic recovery, based on resilience, sustainability and on building back better.

If we want to make such ambitious goals attainable, we need to work on mobilizing the best assets we have available in our Mediterranean region. It follows logically that empowering our Mediterranean Youth is our best hope, and this means that we cannot but place knowledge, skills, and innovation at the centre of our recovery.

In fact, the need for a timely and strong recovery in the face of the damage caused by the COVID-19 pandemic further highlights the case for investing as much as we can in universities and research centres, where innovation is nurtured and encouraged, where ideas are made reality, and where life-saving vaccines can be developed at record pace. But there is more than one active agent in the process of seeing a healthy higher education and research sector flourish. This is why we need to foster conducive ecosystems where universities and research centres can indeed become powerful drivers of innovation for our society, and support our youth.

It is with this spirit that the Union for the Mediterranean has established higher education and research as one of its main pillars of action, be it by supporting the creation of Euro-Mediterranean universities, research initiatives, or education projects.

Investing more in skills and employability is indeed vital for a region with 25% youth unemployment. In the Southern and Eastern Mediterranean, where 40% of the population is under the age of 25, youth unemployment has been among the highest in the world for more than two decades. We all need to step up action in improving such figures if we want to support a more resilient future Mediterranean based on its workers of tomorrow.

At the same time, a particularly troubling datum is that unemployment in our region tends to be higher amongst those with tertiary education (as opposed to those without), reaching an average of 30% across the region. While we cannot reduce to a single factor such a complex topic, employability stands among the top fields for action. We cannot ignore, for instance, that according to 32% of interviewed enterprises in the Southern and Eastern Mediterranean, skills mismatch is one of the main barriers to hiring.

In view of this, the UfM recognizes the gap between academia and business as one of our major challenges, especially since the Euro-Mediterranean region, combining the North, South and East, boasts more than thirty-three million students.

We can support the careers of our students by promoting academic cooperation and regional science diplomacy. Luckily, plenty of excellent best practices and initiatives already exist, and many committed stakeholders have been tackling the issue for decades.

This is even more evident in the context of the blue economy, which stands at the crossroads of the UfM action for human and sustainable development, as it addresses three main priority areas of the UfM: Higher Education & Research, Water & Environment and Blue Economy, Business and Development.

Sustainably exploiting this field offers a way to embrace our joint growth potential and to spread it to communities often hard hit by traditional and new challenges, such as youth unemployment and climate change, in a way that does not threaten their long-term existence.

More concretely, cooperation opportunities offered by “blue” technology transfer, co-research, sharing of best practices, training and ex-changes of students and researchers can create avenues for spreading common positive solutions for human and sustainable development between the two rims of the Mediterranean.

The region's international institutions, universities and university networks, projects and programmes offer extensive experience on the key elements where work is needed, including internships, industrial doctorates and university-business dialogue.

In this spirit, the Union for the Mediterranean will continue fostering dialogue, promoting the creation of projects and initiatives, supporting all stakeholders involved in advancing skills, careers, knowledge, and crucially, research and innovation.

A clear example of the implementation of such principles is given by the UfM-labelled project "BlueSkills", which promotes opportunities for "Blue" marine and maritime careers by developing skills, exchanging knowledge and valorising research for a more sustainable Mediterranean Sea. It aims to develop new curricula and increase employability in the marine and maritime sectors.

According to the European Marine Board dossier on the 21st century marine professionals, graduate programmes and career developments are fragmented and specialized, and some of them are explicitly marine while other opportunities are often integrated within other disciplines. The BlueSkills consortium, led by the Italian National Institute of Oceanography and Applied Geophysics (OGS), aims to gather their knowledge and networks in order to propose a comprehensive training offer that can suit the long-term education and immediate up-skilling experience, circular mobility and knowledge transfer.

Another example is given by the BLUEMED initiative, which aims to advance a shared vision for a healthier and more productive, resilient, better known and valued Mediterranean Sea, promoting the citizens' social well-being and prosperity, now and for future generations, and boosting economic growth and jobs. Along the years, the UfM has supported its extension to Southern and Eastern Mediterranean countries, promoting the establishment of a truly Mediterranean Strategic Research and Innovation Agenda. Its Implementation Plan presents shared priority goals and addresses thematic and structuring activities to be developed in order to kick-start a transformative process at Mediterranean level.

As we can see, there is an incredible amount of room to promote the employment of our youth in different policy sectors in the Mediterranean. In the case of the maritime economy, it already accounts for over five million jobs generating almost €500 billion a year in the EU alone (according to Federazione del Mare, €33 billion directly generated in Italy).

Higher education and research can empower our students and graduates by increasing their employability, in turn fostering their active participation in Mediterranean economies and strengthening their resilience. Therefore, the Union for the Mediterranean will keep stepping up dialogue with all interested stakeholders, in order to support the sustainable future of our youth, our best asset.

Types of contributions Scientific and technical papers, and review articles are the main contributions accepted. Moreover, the journal will also publish short notes, limited to a length of four pages including references; technical notes dedicated to the presentation of current research activity or significant original data. In the case of articles of strictly regional or local interest, the contribution should be limited to the essentials.

Submission of papers The manuscript should not have been published or submitted for publication elsewhere. Submission of a multi-authored manuscript implies the consent of all participating authors. Manuscripts shoud be submitted online at this web address: www.editorialmanager.com/bgta.

Reviewing process Before publication, each manuscript will undergo a reviewing process. The Editor-in-Chief will assign the manuscript to an Associate Editor who is directly in charge of the reviewing process of the manuscript and will send the manuscript for evaluation to reviewers. The final decision on publication will be made either by the Associate Editor or by the Editor-in-Chief. Editing and styling will be done at the discretion of the publisher.

Manuscript preparation All papers must be written in English and should not normally exceed 20 printed pages, including figures and tables. The manuscript should be written in maximum consistency with the style and layout of the journal.
The title of the paper should unambiguously reflect its contents. A suggestion for an abbreviated running title should be given.
The author name(s) and affiliation(s) should follow the title. Where an author has moved permanently or temporarily to a new address, this should be indicated as a footnote on the first page. An author to contact should be specified with full postal address, phone, and e-mail.
Each paper must be provided with an Abstract of about 150-200 words, describing concisely the purpose and results of the paper. If the paper was presented at a meeting, mention should be made thereof in the acknowledgements.
The SI system should be used for all scientific and laboratory data: if it is necessary to quote other units, these should be added in parentheses. Abbreviations for units should follow the suggestions of the American Institute of Physics (AIP) Style Manual. Where abbreviations are likely to cause ambiguity or to not be readily understood by an international readership, units should be written in full. The full stop should not be included in abbreviations, e.g., m (not m.), ppm (not p. p. m.), "%" and "/" should be used in preference of "per cent" and "per".
Footnotes should be avoided, especially if they contain information which could equally well be included in the text.
The use of proprietary names should be avoided. Papers essentially of an advertising nature will not be accepted.

References should be cited at the appropriate point in the text with the author's name followed by the year of publication; thus, "according to Finetti (1982)" or "as shown in an earlier paper (Marussi, 1983)". When there are two or more papers by the same author published in the same year, the distinguishing letters, a, b, etc. should be added to the year. The name of two coauthors must be linked by "and"; for three or more, the first author's name must be followed by *"et al."*. References should be listed together at the end of the paper and arranged alphabetically without numbering. Only cited references should be included in the list. Examples of layout of references are given below.

Slejko D., Caporali A., Stirling M. and Barba S.; 2010: *Occurrence probability of moderate to large earthquakes in Italy based on new geophysical methods*. J. Seismol., 14, 27-51, doi: 10.1007/s10950-009-9175-x.

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Figures . jpg, png, or .tiff files of each figure, with a 300 dpi resolution, should be provided upon request. Colour Illustrations are accepted, and will be not charged to the authors.
Size of characters should be such that after reduction the smallest character will not be less than 1.5 mm.

Numbering and captioning Each illustration should be given a figure number in Arabic numerals. Each table should be given a table number in Arabic numerals.
Figures and tables must have a caption or title which is referred to in a list at the end of the manuscript. Captions should never be incorporated in the drawings. Scales should be indicated graphically and not numerically.
Equations should all be numbered sequentially with Arabic numbers, and refered to within the text by Eq. or Eqs. followed by the pertinent number.

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