GLIDERS FOR RESEARCH, OCEAN OBSERVATION & MANAGEMENT : INFRASTRUCTURE AND INNOVATION

Project acronym: **GROOM II**

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Key societal benefits of a sustained glider infrastructure

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Table of Contents

Executive Summary

As members of the GROOM II Project, we organised a working group to explore and subsequently provide an **analysis of the societal benefits of a sustained Glider Research Infrastructure**. A working group authored this report titled, "GROOM II - Key societal benefits of a sustained glider infrastructure" which is summarised below. The working group focused on **three main types of benefits** of the GROOM RI:

1) **Reducing the number and/or impacts of environmental emergencies** (e.g., preventing, predicting, mitigating harmful algal blooms, geohazards, extreme meteorological events) and operational monitoring in general (addressed in section 3.6).
2) **Improving** the quality, reliability, interoperability, availability, and findability of **marine data products and services**; Forming dedicated services for climate studies and model assimilation. (addressed in section 4.3)
3) **Helping** public authorities to **establish policies and EU Marine directives** with relevant observational data. (addressed in section 3.5)

Both the estimated capital expenditures (CAPEX) and operation expenditures (OPEX) of a glider RI network have been categorised in a previous project. This report categorises the potential **benefits** of ocean observation activities **that help improve ocean and atmosphere predictability** from scales of days to decades. This report also addresses the numerous **benefits** of better ocean science **for the private sector**. They include cost savings, operational efficiency, increased market shares, predictable and stable supply chains, enhanced relationships with stakeholders, improved access to markets and customers, as well as attracting new investments.

The bulk of this report addresses the **six types of societal benefits**, following the conceptual framework of research infrastructures described in Florio et al., 2019.:

1) Technological externalities

GROOM RI's mission is to provide access to platforms and services to the broadest range of scientific users, as well as ocean observing RIs. It will maintain a unique centralised provision of cyber-infrastructure, data, and knowledge for the optimised use of MAS to study climate and marine environments, and to support operational services, and the Blue Economy.

2) Human capital formation

GROOM RI will provide means to train the next generation of European scientists and career-minded individuals looking to upskill.

3) Demand and value of knowledge output

GROOM RI will enable standardised high-quality long term ocean data and bring together different ocean datasets from different countries and distinct types of platforms. The data produced by GROOM

RI will support decision-making for ocean management and climate actions, in addition to stimulating scientific studies, modelling, and forecasting.

4) Outreach and cultural impact of the RI

Members of a future GROOM RI will increasingly continue communicating science-based knowledge to the public and through the increased means of a European-wide RI -- including providing material for educational programs.

5) Services provided by the RI to third parties and consumers

Since GROOM RI aims to provide high-quality ocean observation data to the broadest range of scientific and industrial users, GROOM RI will also offer the public sector, private sector, and NGOs data for their specific applications.

6) Non-use value of Discovery: a pure public good

In addition to "use-benefits" of GROOM RI, the future RI will also provide "non-use benefits" – the possible effects of any discovery. The pure value of knowledge as a result of these discoveries are a public goods.

From our analysis, it appears that compared to many other investments in European research infrastructures, the **return on investments of GROOM RI is very likely to be positive** and **rapidly achieved** considering the l**arge and long lasting potential societal impacts** and the **relatively low level of investment required** to develop the existing national glider infrastructure into a European Research Infrastructure Consortium.

I. Introduction

The GROOM Research Infrastructure (RI) will provide ocean observations, knowledge and innovation from Autonomous Underwater Vehicles (AUV) to science and society. The activities within the GROOM RI target services that shall address the needs of its respective stakeholder groups. The stakeholders are somehow defined by the large-scale framework the GROOM RI is operating in (or is contributing to) and that is the European Research Area (ERA). To identify an initial set of services, it is crucial to evaluate the needs of the users. This evaluation can be a two-stage process: (1) starting with a first guess of the services based on former requests of stakeholder groups or (2) by presenting service activities to potential users of this service and then structuring the service in a co-design process with the stakeholder in such a way that it provides the greatest benefit for the user.

Any long-term investment into a RI requires a critical evaluation of its impact. Which type of benefit it creates and for whom. For a European RI such as GROOM RI, it is key to understand the benefit that is created out of the ERA and which is not already created via a national or even institutional dimension that would not need a RI. Ultimately all operations with the GROOM RI are related to the provision of trusted and interoperable observational data that follows the FAIR principles. In that sense the GROOM RI operations will assist scientists in their research which in turn is related to societal benefit via innovation and products but in many cases not directly traceable back to the origination of the data.

Before starting any assessment of the societal benefits of the GROOM RI, it is important to remember that contrary to many other types of infrastructure, Research infrastructures are not directly used or accessed by the "society"; the scientists are the major users of the GROOM Research Infrastructure and also the service providers. Consequently the societal benefits are mostly indirect. This specificity is increasing the difficulty of this task: identify, describe and estimate the anticipated indirect impacts of the RI on society, as impartially as possible.

The cost-benefit analysis (CBA) is a common tool in economics and is based entirely on monetary values of the costs and of the benefit of a certain project or activity. In the last three decades CBA design and applications to ocean observing challenges have been discussed in the literature, mainly focussing on the application of a CBA to ocean observing systems. On one hand, the **costing** aspect of the CBA for glider operations and for an umbrella coordination programme such as a RI can be calculated with reasonable certainty using published approaches. On the other hand, the calculation of the economic and societal benefits will be limited because of a number of fundamental problems, such as the unknown and wide spectrum of direct and indirect users of the ocean observational data, and consequently the benefit to them. The major bottleneck that hinders the assessment of the user benefits is that currently data is not "traceable" from the time of recording to its universal use. This is related to the fact that existing identification approaches (e.g. data DOIs) are not sufficient for the purpose of a CBA and other approaches such as block-chain may be needed (e.g. as tested in fisheries). However, even in the case that all users would be known, it would still be an ominous task to assess the monetary value for the entire spectrum of economic and societal benefits. Besides, an additional way to increase economic and societal benefit, but not measurable in a strict CBA sense, is to ensure that observational data and the data infrastructure is used for as many studies and services as possible and outside the "core" observing objectives. This is exactly the point where we see a clear value in a European RI in comparison to national or PI only operations. Opening up that data and infrastructure is clearly an optimization of investment into observation data that will add value by enabling a wider community to access data but may also improve data products for the core requirements, either through additional sensors that may fill spatial gaps but also by adding additional data types (e.g. oxygen) that may open up new scientific approached to be used for the core mission.

I.1 The Cost-Benefit Analysis approach

The following example from a business perspective introduces the general thinking and approach behind a cost-benefit analysis (CBA). This method is used by businesses to analyse decisions. Monetary value is assigned to the benefits of taking a decision, and the costs associated with taking that action are subtracted. A CBA involves measurable financial "metrics" such as revenue earned or costs saved as a result of the decision to pursue a project. A CBA can also include intangible benefits and costs or effects from a decision such as employee morale and customer satisfaction (e.g. Layard and Glaister 1994).

A CBA requires compiling a comprehensive list of all the costs and benefits associated with a project. In general, the costs involved in any type of operation might include the following:

CBA Direct costs	● Direct labour involved in manufacturing ● Inventory, raw materials ● and manufacturing expenses
CBA Indirect costs	● Electricity, overhead costs from management, rent, utilities ● Intangible costs of a decision, such as the impact on customers, employees, or delivery times ● Opportunity costs such as alternative investments, or buying a plant versus building one ● Cost of potential risks such as regulatory risks, competition, and environmental impact

For the CBA in economics the benefit might include the revenue and sales increase from increased production or new product, intangible benefits, such as improved safety and morale, as well as product user satisfaction due to enhanced product offerings or faster delivery, and competitive advantage or market share gained as a result of the decision.

For projects that involve small- to mid-level capital expenditures and are short to intermediate in terms of time to completion, an in-depth cost-benefit analysis may be sufficient enough to make a well-informed, rational decision. For very large projects with a long-term time horizon, a cost-benefit analysis might fail to account for important financial concerns such as inflation, interest rates, varying cash flows, and the present value of money. Alternative capital budgeting analysis methods, including net present value, could be more appropriate for these situations. The concept of “present value” states that an amount of money or cash in the present day is worth more than receiving the amount in the future since today's money could be invested and earn income. However, with any type of model used in performing a CBA, there are a significant number of forecasts built into the models. The forecasts used in any CBA might include future revenue or sales, alternative rates of return, expected costs, and expected future cash flows. If one or two of the forecasts are off, the CBA results would likely be thrown into question, thus highlighting the limitations in performing a CBA.

Costs

It becomes clear that only certain facets of a CBA can be analysed in the context of operating ocean observational assets as being part of a European RI contrary to nations-alone operations (the baseline scenario). In the H2020 project AtlantOS (Deliverable D1.4, section 3.6.4 Estimation of current Glider network costs) a cost model separating Capital Expenditure (CAPEX) from Operational Expenditure (OPEX) for the infrastructure lists the following items:

CAPEX	• Costs for planning • Costs of coordination • Instrument purchase • Training of personnel • Cost of facilities
OPEX	• Expenses for the functioning and maintenance of the infrastructure • Costs of procurement of lost or depreciated equipment, consumables • Costs for status monitoring and tracking (real-time data, personnel) • Costs for shipping expeditions and logistics (infrastructure, personnel) • Personnel costs for coordination and preparation of infrastructure & cruises, cruises execution, data conversion and quality control, management

Societal benefits

A categorization of potential benefit areas that are linked to observing activities that help improved ocean/atmosphere predictability (see also Jackman, 2001; Di Jin et al. 2005) may include:

- ***Multiannual to multidecadal prediction***
    - CO_2 emissions policy (e.g. UNFCCC global stocktake)
    - Climate prediction
    - Resettlement strategies
    - Protection Coastal construction
    - Facilities planning
- ***Seasonal to Interannual predictions***
    - Energy forecast
    - Crop yield forecast
- ***Monthly to seasonal prediction***
    - Agriculture projections
    - Fisheries utilisation
    - Energy management
    - Transportation planning
    - Land management
- ***Daily to weekly forecast***
    - Safety warning & Hazard Prevention
    - Fishing operations
    - Ship routeing
    - Offshore oil and gas operations
    - Search and Rescue
    - Defence

A recent review on benefits from ocean observing has been executed in connection with setting up a European Ocean Observing system (EOOS) (O'Kane et al. 2018)[1]. This review emphasised that ocean observing is a "public good" that should serve as the starting point for data collection. The data is critical to deliver the products and services that provide benefits to society and consequently to enable benefit, it is key that all users are able to access all data in a timely fashion. European agencies always recognise their obligation to contribute resources and skills pro rata to the global observing system, and likewise it is important to Europe that the global infrastructure is designed so as to guarantee the required data products and benefits needed by Europe.

Business benefits

Addressing private business benefits from better ocean science, the UN Global Compact and IOC-UNESCO released a report[2] ("Advancing Science for Sustainable Ocean Business: an opportunity for the private sector"). They identified numerous benefits for the private sector, including cost savings, operational efficiency, increased market shares, predictable and stable supply chains, enhanced relationships with stakeholders, improved access to markets and customers, as well as attracting new investments. An important factor also is the application of ocean science for societal benefit, including knowledge transfer and applications in regions that are lacking science capacity. Scientific research is clearly a benefit since scientists will be able to conduct research starting from a basis of a much more complete description of the environment in which they work.

However, OECD ("Rethinking Innovation for a Sustainable Ocean Economy", 2019)[3] listed the following questions as being highly relevant for CBAs on ocean observing:

- Are we becoming more efficient in using marine ecosystem services?
- Is the natural asset base of the ocean being maintained?
- How does a sustainable ocean economy benefit people?
- What are the opportunities arising from promoting a sustainable ocean economy?
- What policy responses are needed to speed up the transition?

[1] StudyCostEOOS.pdf (europa.eu)
[2] https://www.unglobalcompact.org/library/5744
[3] https://doi.org/10.1787/9789264311053-en

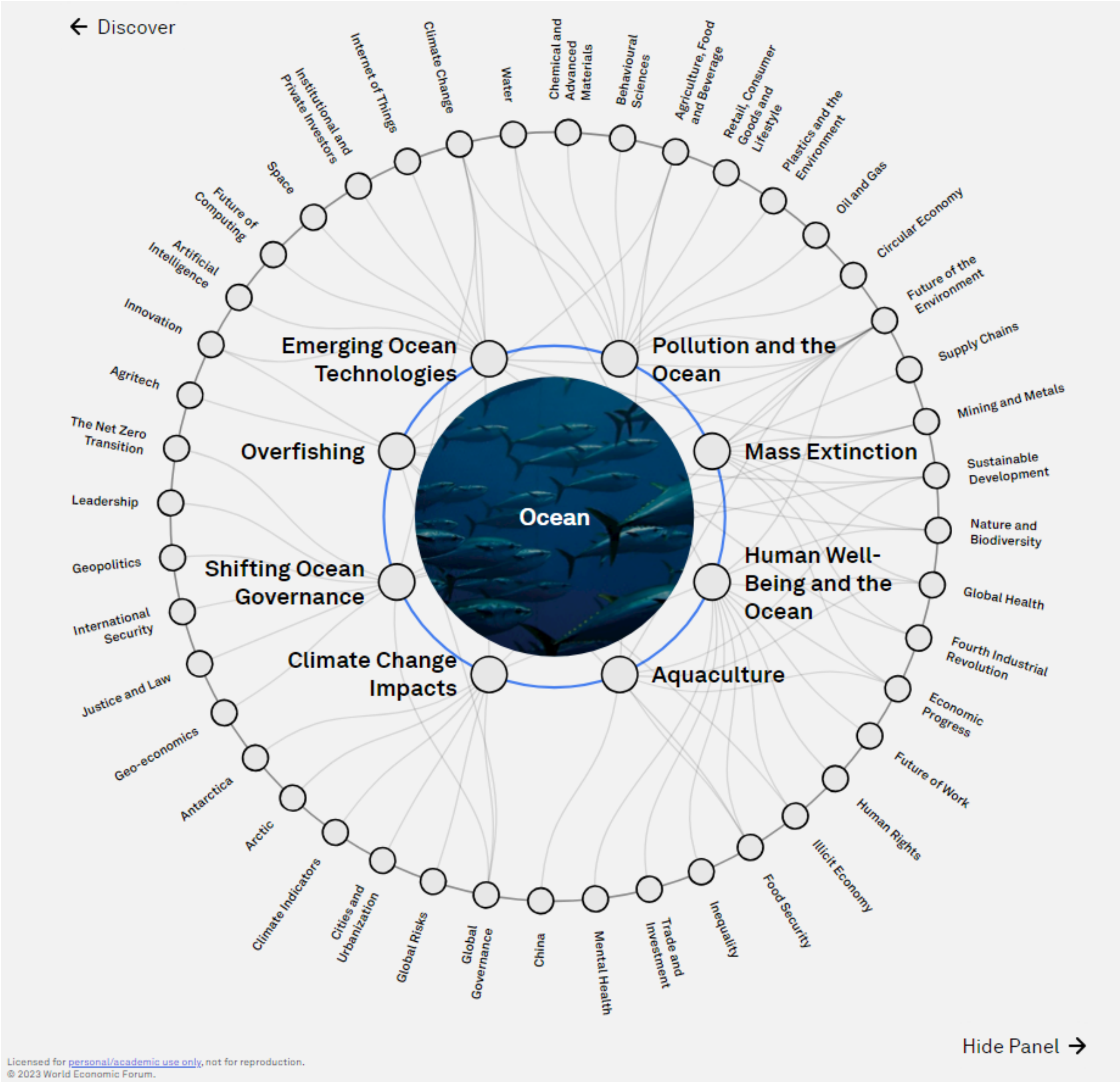


Figure 1 - Extract from World Economic Forum website: [Strategic Intelligence (weforum.org)]

I.2 Scope of this report

This report has been inspired by some costs and benefits analysis framework adapted to research infrastructure. Although a cost estimate could be feasible, estimating the overall socio-economic benefits of an RI is nearly impossible. The social benefits from a RI are easy to recognize and likely to occur, but widespread among different actors, domains and areas. Moreover research benefits are very difficult to anticipate and not framed by any market mechanisms. Also, as the length of time horizon of the infrastructure is undefined, it leads to inaccurate assessment of the potential benefits.

And finally, we should keep in mind that the GROOM RI is only in its design study phase, the full and precise data sets and services provided by the GROOM RI are still to be investigated (the output), which impedes an accurate calculation of the benefits (impacts).

We have therefore focused on three key use cases of the GROOM RI, that is 1) Emergency response, 2) data products and services and 3) public policies, and we made the choice to avoid an exhaustive overall quantitative assessment of social benefits of the GROOM RI. Instead we explain for each key area and the different types of expected societal benefits, based on solid qualitative research, that will draw a clear picture of the added European value of the GROOM RI.

I.3 Reading guide

The first section of the report will review the societal benefits of the GROOM RI following the approach described in (Florio, 2019). Six types of societal benefits will be discussed qualitatively, and examples will be provided. In a second time, we will review GROOM RI societal impact on the Sustainable Development Goals[4] of the United Nations.

The second section of the report will focus on three key areas of direct relevance for public authorities and ocean forecast agencies. Public policies and EU marine directives, Improving data products and services, and Emergency Response. We will demonstrate and assess when possible the multiple social benefits of a well-coordinated European glider infrastructure in those three domains.

In the final section of the report the conclusions are listed.

II. Evaluating the societal benefits of the GROOM RI

II.1 GROOM RI : Ticking the boxes of a Research Infrastructure

What are the ingredients of a research infrastructure? What services provided by the GROOM RI do we need to consider in this study to answer the question of the key societal benefits of the GROOM RI? These are points we should address before starting this review.

The conceptual framework of RI (Gramlich, 1994, Bagott, 2012, Florio, 2015) identifies the commonalities of research infrastructure as follow: (a) high-capital intensity, (b) long-lasting facilities or networks, (c) typically operating in 'monopoly' or 'oligopoly' conditions, and affected by externalities, (d) whose objective is to produce social benefits through the generation of new knowledge, either pure or applied.

a) High-capital intensity

GROOM RI is emerging from the assessment that none of the national infrastructure can develop individually all the potentialities of gliders for research and innovation. Linking together the multiple European glider infrastructures, GROOM RI can easily be considered as high-capital intensive (see

[4] https://www.globalgoals.org/

AtlantOS D1.4, section 3.6.4). The unicity of GROOM RI is that most of the initial investment has already been made. The extra investment cost to become an RI is relatively low compared to the total cost of the RI. It is interesting to keep this aspect in mind when comparing societal benefits of the RI to costs.

b) long-lasting facilities or network

GROOM RI aims to unlock the potential of gliders that the national infrastructures cannot develop individually. It brings together many national glider infrastructures whose existence range from a year to more than a decade. With the increasing demand of ocean data by the general public for ocean health assessment, weather and climate forecast and ocean services it is likely that the need for ocean data, ocean knowledge and innovative observing capacities produced by the GROOM RI will continue and further expand in the next decades or so. Consequently, GROOM RI can be considered as a long-lasting facility.

c) operating in monopoly or oligopoly and affected by externalities

The aggregation of the national glider infrastructure under the umbrella of the GROOM RI will create the condition to open a market that cannot be reached at the moment by national infrastructure or individual companies. GROOM RI will then operate in a monopoly setting, acting in a market that only the consortium can enter, and will contribute to develop the market for national glider infrastructures through innovation. Indeed, most of the benefits (and costs) caused by the GROOM RI will not financially be incurred or received by the GROOM RI.

d) objective is to generate new knowledge

New knowledge, whether it is ocean data, innovations through new services and technological developments or scientific productions, is the overarching outcome of the GROOM RI. Acquiring new knowledge will pilot the development and implementation of the GROOM RI.

Obviously, GROOM II is ticking all the boxes of a RI.

II.2 A TYPOLOGY OF SOCIETAL BENEFITS

Now that we have demonstrated that GROOM RI is complying with the framework of Research Infrastructure, we will now look at the societal benefits of RI. We will examine the societal value of the RI through six main types of benefits: (a) Technological externalities, (b) Human capital formation, (c) Demand and value of knowledge output, (d) Outreach and cultural impact of the RI, (e) Services provided by the RI to third parties and consumers, (f) The non-use value of discovery: a pure public good.

Since GROOM RI is under its design study phase, the societal benefits highlighted hereafter remain hypothetical, although based on sound analysis of proven examples taken from other comparable, operational environmental research infrastructures (ICOS, EMSO, EuroArgo) and illustrative examples from practice.

II.2.1 Technological externalities

Externalities occur in an economy when the production or consumption of a specific good or service impacts a third party that is not directly related to the production or consumption of that good or service. A well-known example of technological externality is the invention of the World Wide Web at CERN in 1989, initially conceived as a tool to improve the sharing of information between scientists working on CERN experiments.

GROOM RI's mission is to provide access to platforms and services to the broadest range of scientific and industrial users, as well as other ocean observing RIs. It will maintain a unique centralised provision of cyber-infrastructure, data and knowledge for the optimised use of MAS to study climate and marine environments, and to support operational services and the blue economy.

This mission lays the foundation for multiple developments and progresses with high potential of externalities like:

- High standards will drive technological improvement. GROOM's effectiveness in unifying the European glider observation for ocean and climate sciences fields will have effects on technology and innovation. The stronger the GROOM RI will be, the bigger its impact on technology and innovation. GROOM will develop industrial partnerships and drive the development of new standard or improved measurement methods, hardware innovations and increase the quality of their product.
- The development of underwater and multi-platform communications will be investigated to encourage the use of multi-platform experiments to take advantage of capacities of many instruments operating at the same time, to observe under the ice in real time or in extreme deep ocean without the need for surfacing.
- Autonomous piloting will be developed to free glider pilots from on-call piloting period and develop piloting of a coordinated (or not) fleet of gliders at the same time.
- Underwater guidance is also a field of investigation of the GROOM RI to allow offshore docking for file transfer and offshore energy recharge
- Software communications between platforms (i.e. the glider) and sensors on board is something scientists and data managers are really interested in to facilitate data and metadata sharing.

Marine Research Infrastructure like (EuroArgo, EMSO, JERICO), any ocean scientists operating at sea, navy, offshore industries, divers, real time monitoring of marine sites, etc will benefit from the technological spillover of GROOM RI as well as the improvement of standards.

Take for example a similar research infrastructure on carbon observations (Integrated Carbon Observing System, ICOS), aiming to produce standardised, high-precision and long-term observations and facilitate research to understand the carbon cycle and to provide necessary information on greenhouse gases. The technological impacts (i.e. technological externalities) have been assessed in a report that demonstrates the high benefit of ICOS on industries. Similar impacts can be expected from the GROOM RI.

II.2.2 HUMAN CAPITAL FORMATION

The national glider infrastructures that will be part of the GROOM RI are working with universities attracting Ph.D. students and junior scientists who want to discover this technology and benefit from its capacities to explore the ocean. The distributed approach of GROOM RI will leverage this capacity to gather new resources willing to be part of this great international, scientific and technological adventure. GROOM RI will provide means to share resources (financial, logistic, access to instruments, etc.) to increase the engagement and the quality of the formation of the new generation of ocean scientists. A nice example of human capital formation comes from international organisations, (e.g World Meteorological Organisation), with the Junior Professional Officer program (JPO) to enrol and train new young talent for a limited period of time. Such types of programs will be investigated by GROOM RI to enhance its societal impact. From this point of view, by contributing to the training of European young scientists, GROOM RI is similar to research universities about which the societal benefits on human capital formation is obvious.

GROOM RI aims at developing training on many aspects related to the glider technology (piloting, sensor integration, operation), ocean science (data management, use of the glider data, thematic scientific summer schools), and Research Infrastructure management (regulation, logistics, management of RI, etc.). Europe is currently lacking such training that must be coordinated by an international infrastructure to be really profitable. The great example of the Glider school, organised for more than a decade by PLOCAN (Spain), is showing the desire of young and career change scientists to be trained on gliders. The PLOCAN glider school was the only public international glider training recognized in Europe since very recently. The first edition of the Swedish International training on ocean gliders opened in 2022 and will continue next year. This is showing the increasing demand on training with gliders and the need for coordination between academic training programs to propose the best offer possible with beginners, intermediate, advanced training courses for instance, or even thematic training.

Training program of the GROOM RI will answer a real demand from the scientific community (operator, scientist and data managers, industries) and boost GROOM RI societal impact on human capital formation. The training program will be further shaped early in the GROOM RI implementation phase.

II.2.3 DEMAND AND VALUE OF KNOWLEDGE OUTPUT

- High-quality long-term ocean in situ data

GROOM RI will enable standardised high-quality long-term ocean data, bringing together different ocean datasets from different countries and different types of platforms. It will reinforce European capacity to provide longer term observation, as funding will be secured for a longer period, reducing the risk of a single glider group operating on key sites to stop its observation effort. It will also contractually set a level of standardisation shared by all members of the infrastructure leveraging the use of the data at the European scale.

This highly coordinated European approach will result in:

1. Increasing the volume of FAIR (Findable, Accessible, Interoperable and Reusable[5]) data.
2. Enhancing the amount of measurements and the data quality of many observation sites that are lacking knowledge, funds and instruments to meet GROOM RI standards.
3. Improving access to data and data uniformity throughout its members and beyond
4. Developing measurement standards and protocols
5. Providing reference data sets for dedicated studies (model validation, satellite calibration).

- Supporting decision-making for ocean management and climate actions

GROOM RI data will help to give an account of the ocean system and its response to climate change, anthropogenic impacts and other environmental challenges. GROOM will produce data to increase knowledge of ocean processes necessary to assess the environmental status of ocean regions. This assessment is critical for policy makers to make informed decisions. Data provided by GROOM will fill the gap left by other MRIs to multiply the number of observations closer to the coastline, where human activity and impact are increasing.

- Stimulating scientific studies, modelling and forecasting effort providing new ocean sampling capacity

Through a rigorous data management plan strategy, bibliometric analysis of GROOM RI publications and impact on operational services will be enabled. The FAIR data produced by the infrastructure will be tracked routinely and automatically to assess the impact of the infrastructure on scientific production. Data produced by GROOM RI will be made available in real time for operational use. If at the time of writing it is not possible to measure the use of European gliders data in ocean and climate forecasting systems, the data management road map (see GROOM II - D6.2) will allow such evaluation.

It is expected that, with the implementation of the research infrastructure, the number of scientific publications and the amount of data used operationally for ocean and weather forecasting and climate reanalysis, will step up in the future and will result in more valuable outputs.

II.2.4 Outreach and cultural impact of the RI

- Communicating science-based knowledge toward society

Many future members of the GROOM RI already conduct programmes of outreach and events to raise awareness of the public about advances in science and technology. These activities will be highly encouraged, supported and monitored by the RI through the sharing of outreach material and increased volume of resources.

Note that local and regional scientific tourism should not be neglected when drones and robots are playing the leading role, and when local, regional and global scientific knowledge can be presented. There is a growing interest of society in those questions. As an example: the French glider

[5] Tanhua Toste et al., (2019)

infrastructure showcases its glider activities and tools every year during open days events with great interest from local communities.

- Supporting local education

The distributed approach of the GROOM RI provides a serious advantage in terms of outreach and impact on undergraduate education. While a centralised RI will concern one geographic area only, distributed infrastructure will multiply this local impact by the number of its members. Educational programs are regularly engaged with local schools, often on voluntary demand for the teacher interested in this topic. But this exercise requests some preparation that is an extra burden on the shoulders of the scientist and operators. The GROOM RI can facilitate engagement of its members by providing materials for such educational programs. The ENVRI[6] community (GROOM RI will be part of) is already providing nice examples on the kind of educational program to be implemented by the infrastructure.

Ocean literacy is certainly one of the great challenges of the next decade[7] that the GROOM RI can contribute to tackle locally and regionally with great impact, through a coordinated approach.

II.2.5 Services provided by the RI to third parties and consumers

GROOMII aims to provide high-quality ocean observation data and services to the broadest range of scientific and industrial users, as well as other ocean observing RIs. Third parties are therefore explicitly addressed by the GROOM RI next to the scientific community. The public sector, the private sector and the NGOs offer a large panel of fields of applications (non-exhaustive list below):

- Marine Strategy Framework Directive application
- Common Fishery Policy application
- Emergency response
- Wind farm, fish farm monitoring
- Marine Protected Areas monitoring
- Sea Mammal survey
- Ocean health assessment
- …

Those sectors often lack the capacity (financial, knowledge, time) to develop the knowledge, the tools, the services and the procedures to engage in the glider technology to comply fully with their requirements in terms of ocean observations. GROOM RI will offer the possibilities to those sectors to benefit from this international high level public expertise.

[6] ENVRI : Environmental Research Infrastructure Community
[7] https://oceanliteracy.unesco.org/fr/

II.2.6 The non-use value of discovery: a pure public good

In the five previous sections we discussed what we can consider as the "use-benefits" of the GROOM RI. In a context of global warming, and increasing ocean usage with its anthropogenic consequences, this should be enough to justify a well-designed RI. But it is worth mentioning the concept of "non-use benefits" to complement the overview of societal benefits.

"Non-use benefits" refer to the future possible effect of any discovery that the RI might find, and the pure value of discovery per se. Knowledge as a public good.

"Use-value" refers to direct or indirect benefits arising from the actual use asset (e.g. using a water reservoir for energy production) or its potential use of the value attached to future use of the good (e.g. recreational use of the reservoir).

"Non-use values" refer for example to the social value of preserving a natural resource compared to non-preserving it, regardless of its actual or potential (known and unknown use).

That said, one can consider that beyond the well identified social benefits of the GROOM RI, contributing to expanding ocean knowledge, ocean literacy and ocean monitoring, exists societal benefits that we cannot anticipate and societal benefits that the GROOM RI will contribute to preserve.

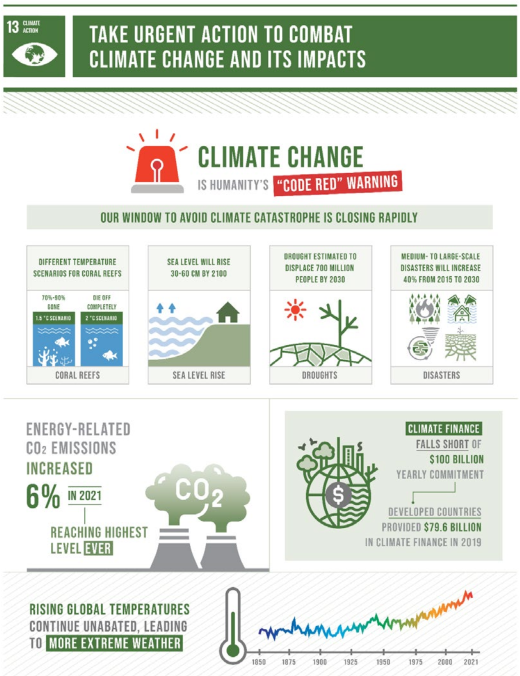
II.3 Support to the UN Sustainable development goals

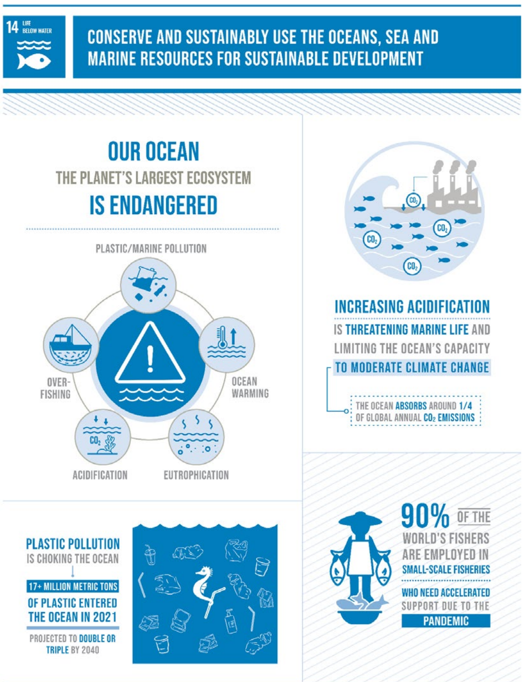
GROOM RI data will help to give an account of the Ocean system and its response to climate changes and impacts of human activities on the ocean. It generates scientific knowledge which contributes to fulfil the United Nations' Sustainable Development Goals[8].

The Sustainable Development Goals (SDGs) adopted by the United Nations (UN) in 2015 are global goals set to solve economic, social and environmental (i.e. societal) challenges by 2030. GROOM RI will contribute to these SDGs in many ways.

[8] https://sdgs.un.org/fr/goals

Direct impact on SDGs:





Indirect Impacts of scientific excellence and knowledge production and sharing:

Providing FAIR (Findable, Accessible, Interoperable, Reusable) data for scientists, students, citizens and policy makers. GROOM RI will support research and innovation to adapt agriculture, water management, energy provision and city planning to the challenges related to climate change and its impacts.

Indirect impact on society and institutional SDGs

GROOM RI will be fully aligned with the OceanGliders program, that is the glider programme of the Global Ocean Observing Systems, jointly coordinated by UNESCO and WMO. This direct cooperation with UN organisation as well as international scientific partnership and education program support the following Sustainable Development Goals:

II.4 In summary

In this first section, we have identified **potential societal benefits of the GROOM RI considering six areas of applications**, following the conceptual framework developed by Florio et al., 2019. We have also **identified societal benefits** with regards to the Sustainable Development Goals developed by the United Nations in 2015. Both approaches show a **great potential of societal impact of a well organised research infrastructure**, highlighting the need to integrate education, communication and knowledge transfer, international partnerships, services to third parties and, research and innovation in the scope of the activities of the RI, in addition to ocean observations.

Considering this large and long lasting potential societal impact and the relatively low level of investment required to coordinate the already existing glider national infrastructure towards an European Research Infrastructure Consortium, the return on investments of the GROOM RI is likely to be positive and also rapidly achieved compared to many other investments in European research infrastructures.

III. Three use cases of key societal benefits

In this section we will focus on three of the use cases identified in WP6 to further substantiate the benefits of the GROOM RI. We will detail how the GROOM RI, in the boundaries of the "rapid response to emergency", the "data product and services" and the public policies (i.e. the MSFD, the CFP and the MSP)[9] provide key benefits to society.

III.1 Emergency response

The sea is currently exposed to numerous emergency situations, caused by both natural phenomena and anthropogenic incidents that severely damage marine ecosystems. In addition, these events can also affect the socioeconomic infrastructures built in coastal regions, as well as impact on the economy and society in general.

[9] MSFD: Marine Strategy Framework Directive, CFP: Common Fishery Policy, MSPFD: Marine Spatial Planning Framework Directive.

Among the natural phenomena that cause emergencies, the storms, tsunamis, and Harmful Algal Blooms (HABs) are probably the most obvious, but others, like marine heat waves and volcanic eruptions can also be catastrophic. Regarding the anthropogenic incidents that cause emergency situations, it is worth highlighting oil and gas spills, chemical pollution, radioactivity, navigation incidents, and others. To provide a legal framework to answer these phenomena or incidents, the 1982 United Nations convention agreed in the so-called Law of the Sea the obligation to protect and preserve the marine environment among the signatory countries of the agreement. These countries have the shared responsibility to respond effectively in a timely manner to any phenomenon or incident, in addition to providing continuous surveillance by having the necessary equipment, along with qualified personnel as and when needed both in territorial and international waters.

Nowadays, emergency situations at sea are initially responded to by the affected country, which, in turn, usually has an institution/agency or consortium of institutions responsible for giving the response. These responses are defined by the nature of the event/incident. In addition to the direct response to the emergency, a quick and continuous monitoring during and after the event is always necessary. This monitoring can help in decision-making for response management, as well as in monitoring the effects caused by both the emergency and the response decided by the institutions in charge. In recent years, MAS fleets have come to help in that type of monitoring, generating very good prospects in collaboration with the agencies responsible for actions in cases of emergency. In addition, the autonomous vehicles, given their peculiarity of being operated remotely, would favour the total safety of the people who operate them during monitoring in those areas where hazardous emergencies derived from volcanological phenomena, contamination by oil, radioactivity or gases, could cause problems to the people involved in observing the phenomenon or incident.

Below we present some of the main emergency events/incidents at sea where MAS acted as determining factors in observing the development of the event.

III.1.1 Storms

Storms / cyclones are meteorological phenomena that usually cause major disasters in coastal infrastructure and in the most extreme cases life deaths in the population (https://en.wikipedia.org/wiki/List_of_European_windstorms#Since_2019). The prediction of these phenomena has advanced significantly in recent decades, thanks to the development of new observation technologies that have provided numerous new data, which in turn have helped to improve the forecasting models. MAS (Marine Autonomous Systems) technologies are currently contributing to improve the knowledge about the interaction between atmosphere and ocean during the phases of formation and propagation of the storms. Several examples where MAS were used inside of these weather structures have shown the evolution in the Temperature and Salinity of the upper ocean (e.g. Le Hénaff et al., 2021, Miles et al., 2021). The Atlantic Oceanographic and Meteorological Laboratory (AOML) is currently working in the 2022 Hurricane Field Program with the goal to improve hurricane forecasts with upper ocean observations. The MAS are essential during the observations due to the fact that they permit the monitoring of these hazardous weather structures without any risk for the operators.

III.1.2 Volcanic eruptions, Earthquake and Tsunamis

The topic of marine geohazards has been discussed at the European Marine Board (EMB) since 2015. This Board is the unique strategic pan-European Forum for seas and ocean research and technology. The aim is to direct political attention to the topic at European and international level by highlighting the impacts on society and the Blue Economy while also highlighting the need for increased knowledge on processes, triggers and precursors of marine geohazards.

Marine geohazards are generated from diverse geological conditions, ranging from broad-scale to local scale. At any time, they may develop into a situation that poses a direct threat and disaster risk to coastal communities and the Blue Economy. Historically, the marine geohazards impacted on coastal communities affecting livelihoods and causing losses of lives. Three mean examples were the 1755, 1908, 1999 Lisbon, Sicily and Eastern Marmara earthquakes and tsunamis. Nowadays, marine geohazards can cause severe problems in the shoreline and offshore facilities of vital importance to socio-economic activities such as handling shipping, refineries, communication and transportation infrastructures, wind farms, etc.

The EMB report (2021) have suggested how science can transform geohazard assessment in Europe by proposing the statistically characterization of past geohazards events and assessing their frequency, monitoring active processes to understand their dynamics and mechanisms, recording and recognizing precursors to geohazards and finally, defining them through numerical and physical modelling. Among these suggestions, the report included the MAS fleet to be important in the monitoring of active processes. These vehicles are essential due to the capacity to carry out underwater missions without a constant operator control and the variety of the sensors that they can bring attached to. The monitoring using these vehicles augmented with remote sensing and data assimilation will improve unprecedentedly spatial and temporal resolution to study these phenomena/ events.

III.1.3 HABs

Harmful Algae Blooms (HABs) have been increasing during the last decades. The main causes appear to be eutrophication and warming (O'Neil et al., 2012), in addition to others. The principal effects on the population come from respiratory irritation, poisoning and even death by consuming contaminated organisms (Backer et al., 2010). But they also usually produce massive marine fish and mammal mortality events (Gannon et al., 2009). To mitigate the HABs effects, continued monitoring is being suggested by the scientific community and established by the authorities in the areas more affected.

MAS technologies with suitable sensor payload can help in the detection of HABs in complementarity with other observational platforms such as remote sensing, mooring, etc. The existing program for HABs detection in the southwest Florida Shelf in the last decade (Turley et al., 2022) is a good example where remote sensing, mooring and MAS fleet collaborate in this duty.

III.1.4 Oil Spills

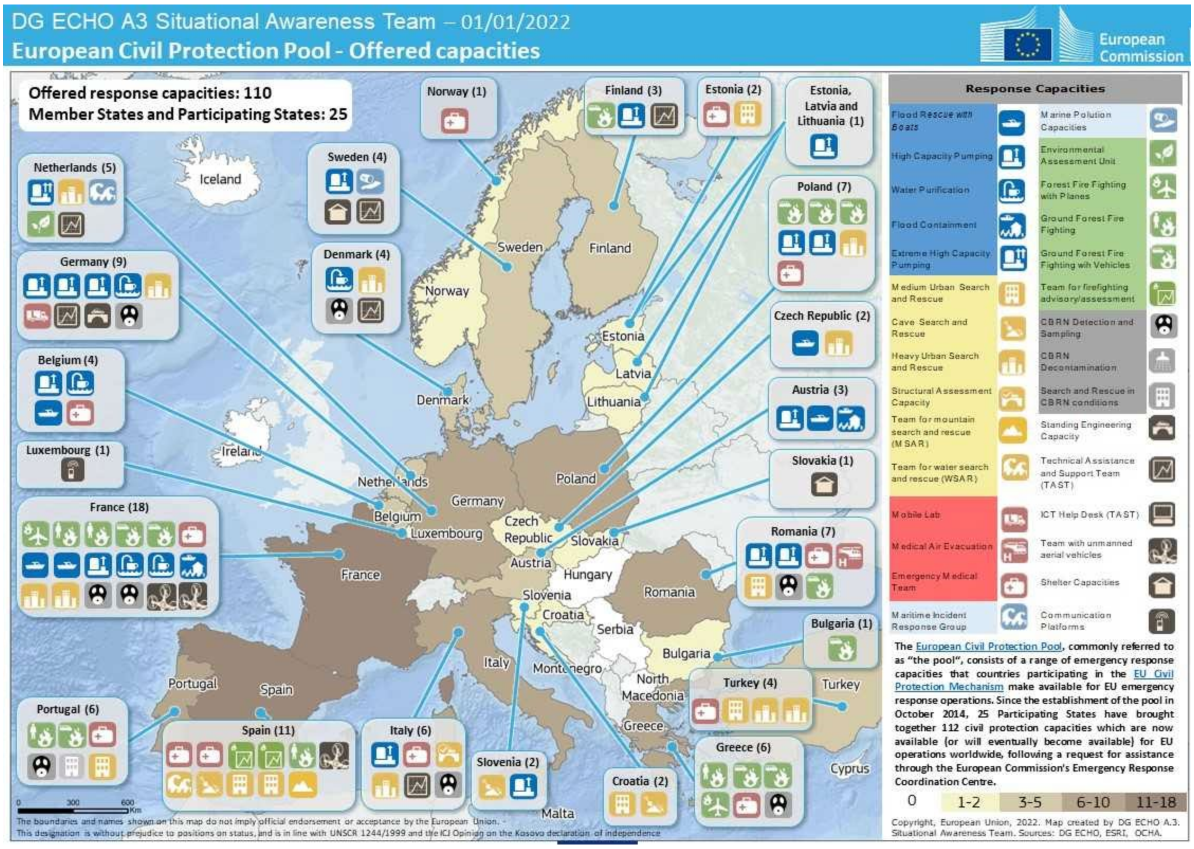
Oil spills usually have significant consequences for the environment and a strong impact on society too. After an oil spill, the recovery of the environment is difficult as a consequence of the type and volume of oil spilled, meteorological/oceanographic conditions, etc. Monitoring how and where oil is moving through the water column is crucial to get success. Spills may take weeks, months or even years to clean up.

One of the most important events where gliders were involved responding to an oil spill occurred in 2010 in the Gulf of Mexico (Perry et al., 2013). Several gliders were used to help during the cleaning duties. The gliders produced subsurface observations of temperature, salinity, and velocity to determine where oil was likely to be swept by currents. Real time data were made available to a central database for all interested parties to access freely. The fluorometers installed in the gliders acted as sentries for subsurface plumes of hydrocarbons. More recently, the damage on the Nord stream pipeline released high quantity greenhouse gases in the ocean and atmosphere. With no observing system in place, it was not possible to assess the amount of greenhouse gases released and the impact on the local marine ecosystem. This case is an example where rapid response capacity to deploy an observing system would have been beneficial for environmental monitoring.

III.1.5 Procedures of response to marine emergencies

Nowadays, most of the emergencies occurring at sea are responded from the affected country (national waters) or the nearest countries if the emergency/ incident occurs in the international waters. The marine emergencies mostly responded (following protocols) are mainly those caused by navigation incidents, oil spills or those that require the protection of the population. The responses usually involve institutions from the civil protection and scientific institutions or even the navy/ army depending on the protocols of each one of the affected countries.

The EU established the European Civil Protection Pool to progress European cooperation in civil protection with the aim to activate a faster, better-coordinated and more effective European response to human-induced disasters and natural hazards. These capacities cover a wide range of services, such as search and rescue, medical treatment, or forest fire fighting and they are coordinated from the Emergency Response Coordination Centre (ERCC).



This type of organisation, made up of collaborating countries (see figure), has demonstrated the capacity for a rapid aid response when a country is overwhelmed by the emergency situation. However, and distinguishing the various services that ERCC manages, those aimed at marine emergencies are scarce. We can mainly distinguish rescue services and help against marine pollution but they are only in some national nodes.

GROOM RI could offer operational monitoring services, by use of the MAS fleet with specific sensors according to the emergency, from a distributed European infrastructure in coordination with the ERCC through the access protocols. Thus, any European country, if it was necessary, could request help for the monitoring of a marine emergency event, and depending on the nature of the event/incident would be responded to by the infrastructure with the closest and the most adequate service to cover the corresponding needs. GROOM RI will have a pool of services aimed at hydrological and biogeochemical monitoring, training and data processing in real time, in order to have the required information available as soon as possible and thus favour decision-making.

III.2 Data product and services

III.2.1 Improve data management to improve data usage

D6.2 (i.e GROOM RI data management road map) demonstrates the difficulty faced by the European glider community to improve the flow of data, harmonise the data management procedures and engage new members without the support of a research infrastructure.

One of the first outcomes of the GROOM RI will be the strengthening of the European glider data management thanks to technical support and endorsed guidelines to facilitate data delivery to EU Ocean data repositories (EMODNET Physics, SeaDataNet and Copernicus Marine Services). The societal benefits related to the improvement of the data flow, data quality and data delivery (see section II.I.3) are detailed below.

III.2.2 Improve data management to increase diversity and consistency of data products

Ocean Data products is a generic concept describing a numerical product built from different data sets. In the glider convention, a data set is the collection of the data acquired by a glider during a mission (i.e. a mission starts from the glider deployment to its recovery, it can last from a day up to six months). Without the coordinated data management approach promoted by the GROOM RI, glider data sets are only useful for the glider groups (i.e. glider operators and scientists) operating the mission. To extend the use and the impact of these observations, data sets must be accessible and acquired by EU data aggregators where users can create data products from it.

For instance, a simple data product will be the aggregation of multiple data sets on a specific observation site, providing then a longer and coherent time series on a specific region. More complex data products integrate multiple data sources with higher levels of analysis, like interpolated or gridded data products. Such data products are developed by data aggregators to serve specific requirements for multiple types of users like fisheries, ocean recreation, maritime transportation, weather forecaster, etc. By improving and increasing the data flow, the GROOM RI will contribute to serve the user of the existing marine data products with better products and increase the number of data products in the catalogue to serve more and more users.

III.2.3 Improve data management to improve operational marine data services

Marine data services refer to the operational use of ocean data to produce regular marine, weather and climate information. The two scientific methods commonly used to produce this kind of information are the “data assimilation method” and the “numerical model validation method”. Here we consider it necessary to briefly explain the two methods in order to capture the importance of improving the glider data flow for those applications.

Numerical ocean modelling refers to the techniques of mathematical modelling, performed on a computer, which is designed to reproduce or predict the behaviour of the ocean. Numerical ocean modelling provides an estimated state of the ocean, based on our scientific understanding of the different physical, chemical and biological processes involved in the ocean, and our capacity to represent those processes in a numerical model. By definition - after all we are talking about a model - the state of the ocean produced by a numerical model is wrong. To assess the error of the model and to continuously improve it (i.e. through parametrization of the model for example) high quality observations are needed. Ocean observations is an essential element of numerical ocean modelling and gliders provide physical and biogeochemical observations in regions where numerical models are highly dependent on it (i.e. ocean shelf and coastal ocean).

The same case can be applied to satellite ocean observations that are now relying on ocean data availability to validate the product they deliver for many maritime applications, like the data assimilation for instance.

Data assimilation consists in correcting the Ocean, Weather or Climate estimation from numerical ocean modelling with the most up to date ocean observations available. This technique allows us to reanalyse the past state of the ocean and forecast the future. The difference with numerical ocean modelling is that ocean observations are used not to assess the error of the numerical ocean modelling but to correct it in delayed time (in the case of reanalysis) and in real time (in the case of forecasts). If data assimilation for physical global forecast and reanalysis are well established (e.g. Copernicus services), the biogeochemistry, ecology and regional data assimilation are fields where ocean observations are absolutely crucial and where gliders data can bring a lot of precious information.

Data services produced by numerical ocean modelling and data assimilation are strongly dependent on ocean observation. Glider data represent a strong potential to contribute to improve marine services and even develop new ones like regional, biogeochemical and ecological marine services with strong societal benefits. To do so, the EU glider community needs to improve the data delivery to EU ocean data infrastructure. The GROOM RI will undoubtedly accelerate and sustain this essential piece of the ocean data value chain.

In many cases that opt for real-time and forecast, the operational services make use of the Global Telecommunication system (GTS). Through the GTS data is accessible in globally agreed on formats (TESAC, BUFR, …). These data standards are under the auspices of groups with the World Meteorological Organization (WMO). The data sharing within the WMO is through the WMO Information System (WIS). Currently WMO has put into operation the WIS 2.0 and which provides a framework for WMO data sharing in the 21st century, for all WMO members and all the WMO disciplines in domains to embrace the Earth system approach, enable the WMO unified data policy, and support the WMO global basic observing network. The GTS data find entry into the operational services via the WMO Global Information System Centres (GISCs; see a list here). GISCs are operated by WMO Members as a major component of the WIS. At the GISCs information about the agreed on standard formats can be found (e.g. for TESAC here). The data from the GROOM RI can find its entry into the GTS via the established pathways in the partner nations to submit data to the GISCs.

III.2.4 MONITORING THE USE OF OCEAN DATA FOR A BETTER ASSESSMENT OF THE SOCIETAL BENEFITS

We have demonstrated that data products and services with high societal impact will strongly benefit from the improvement made by the GROOM RI in terms of data management (quality, accessibility and flow). In order to better assess the impact of the gliders data products and services mixing many sources of observations, the GROOM RI, through a robust data policy on citation, will be able to improve the monitoring of the gliders data uptake. This will allow the EU glider community to better measure the societal benefits of the data acquired by the RI and to actively steer on maximum impacts.

III.2.5 CONCLUSION ON DATA PRODUCT AND SERVICES

This section aims to describe how the improvement of the data flow in Europe made possible by the GROOM RI will impact society indirectly. Even though it is currently impossible to quantify it, the demonstration has been made that, in the case of "data product and services", important societal benefits are expected from the GROOM RI.

III.3 PUBLIC POLICIES

In this section we will investigate the case of three European public policies related to ocean management. The Marine Strategy Framework Directive (from here onwards MSFD), the Common Fishery Policies (from here onwards CFP) and the Maritime Spatial Planning Framework Directive (from here onwards MSPFD). Those three European public policies have obviously strong societal impacts. In the following we will shortly introduce them and the goals they pursue and how GROOM RI will contribute to the implementation of those policies.

III.3.1 THE MARINE STRATEGY FRAMEWORK DIRECTIVE

"The European Union set up the Marine Strategy Framework Directive (MSFD) in 2008 in order to more effectively protect the marine environment across Europe. The MSFD requires member states to achieve or maintain Good Environmental Status (GES), which is a qualitative description of the state of seas. To help EU countries achieve a GES, the directive sets out 11 illustrative qualitative descriptors and obliges the member states to monitor, achieve and maintain GES of their marine waters and to take measures to meet the established targets. Member states have been required to provide documents describing the current environmental status, the GES to be achieved and what targets will be set to achieve this every six years." - GROOM II D3.4

The MSFD obliges the member states to monitor different Essential Ocean Variables in order to determine the GES of the ocean every six years. To assess the GES, the MSFD provides a series of indicators describing the different components of the GES. Monitoring the GES of the European seas includes the choice of the parameters to measure, the sampling sites, the periodicity of sampling, the processing of the sample and the measurement of the parameter value, as prescribed by the MSFD. It does not include calculation of metrics and classification. In conclusion, the role of gliders (and other observation platforms?) is to monitor the ocean under certain guidance to provide the data that allow assessment methods to classify a marine area as reaching or failing to reach GES.

This assessment of the GES requires a lot of high and standard quality data. The marine autonomous system (including gliders) provide cheap observations (compared to other observation mean), address observational gaps in ocean observing, the first being the transition region between the open-ocean and coastal area above the continental slopes (or shelf seas) and can be routinely deployed to observe the identified areas.

In 2012, the Joint Research Centre - Institute for Environment and Sustainability (from here onward, JRC-IEC), whose mission is to provide scientific-technical support to the European Union's policies for the European and global environment, assessed the potential of gliders in providing data to produce the indicators necessary to describe the GES[10]. This report demonstrates the crucial role gliders could play in this field.

However, despite this evaluation made 10 years ago, the potential of gliders to serve MFSD with ocean data has not reached the expectation. This situation could well be caused by the uncoordinated European glider community approach to GES monitoring and the lack of clear guidance on how to practically use the glider in this context of MFSD.

Why would a GROOM RI be relevant in the MFSD context?

- It will provide a European response (as European RI) to a European directive
- It will harmonise the process and adaptation of glider capacities to the specific requirements
- It will produces best practices for MSFD monitoring
- It will address technological gaps with technological development (for example, biological sensors integration on gliders and scientific validation)
- It will make available quality controlled, yet cheaper data for MSFD assessments in order to assess trends.

The GROOM RI will contribute to a better assessment of the environmental status of the European seas. This will have key societal impacts on European society in general and on people living and working close to the Ocean. Access to a healthy ocean has been declared as a human right by the United Nation Right council in 2021[11] [12].

[10] https://mcc.jrc.ec.europa.eu/documents/201702065135.pdf
[11] https://news.un.org/en/story/2021/10/1102582
[12] https://documents-dds-ny.un.org/doc/UNDOC/LTD/G21/270/15/PDF/G2127015.pdf?OpenElement

III.3.2 The common fishery policy

The Common Fisheries Policy (CFP) is the European Union's (EU's) instrument for the management of fisheries, aimed at enhancing the sustainability of fish stocks and the economic competitiveness of the fishing industry.

Originally part of the common agricultural policy (CAP), the common fisheries policy (CFP) started with the same objectives:

- to increase productivity
- to stabilise the markets
- to provide a source of healthy food and
- to ensure reasonable prices for consumers

In the course of time, the CFP obtained a separate identity: a specific legislation and structural policy for fisheries, in particular the common market organisation[10], was introduced in 1970.

As more and more countries joined what is now the EU, some with important fisheries resources and fleets, it was also necessary to deal with specific fisheries problems such as the conservation of resources and international relations after the introduction of the exclusive economic zones (EEZ).

With its latest reform from 2013, the common fisheries policy is the first comprehensive legal framework considering the **environmental, economic and social dimensions** of fisheries (key societal benefits).

Why ocean observation for CFP?

The EU’s data collection framework (DCF[11]) outlines the EU countries’ obligations to collect, manage and make available a wide range of fisheries and aquaculture data needed for scientific advice.

This includes biological, environmental, economic, and social data. Member States’ data collection activities are financially supported by the EU. Data collection needs to ensure accuracy, reliability and timeliness, safe storage and improved availability of data.

Many recent demonstrations have been made that fisheries and fisheries management stakeholders benefit from the ocean observations (Turpin et al., 2018 ; Tommasi et al., 2021) leading to the following statement: “Ecosystem processes can impact fish stock abundance, productivity, distribution, and life history, with implications for stock assessment”. For example, environmental variability can drive changes in:

- Recruitment: through variable survival of early life stages
- Life history: through environmentally dependent growth or reproduction
- Distribution: as fish move to follow environmental conditions
- Natural mortality: via events such as red tides

- Survey effectiveness: if survey footprints no longer capture the same proportion of the stock.

Why would a GROOM RI be relevant in the CFP context?

In most of the domains cited previously, gliders have demonstrated their capacity to provide essential sustained high-quality data in real time and delayed time. It is important also to highlight that most of the world's fisheries are in ocean margin (see figure 1) where gliders and Marine Autonomous Systems are designed for.

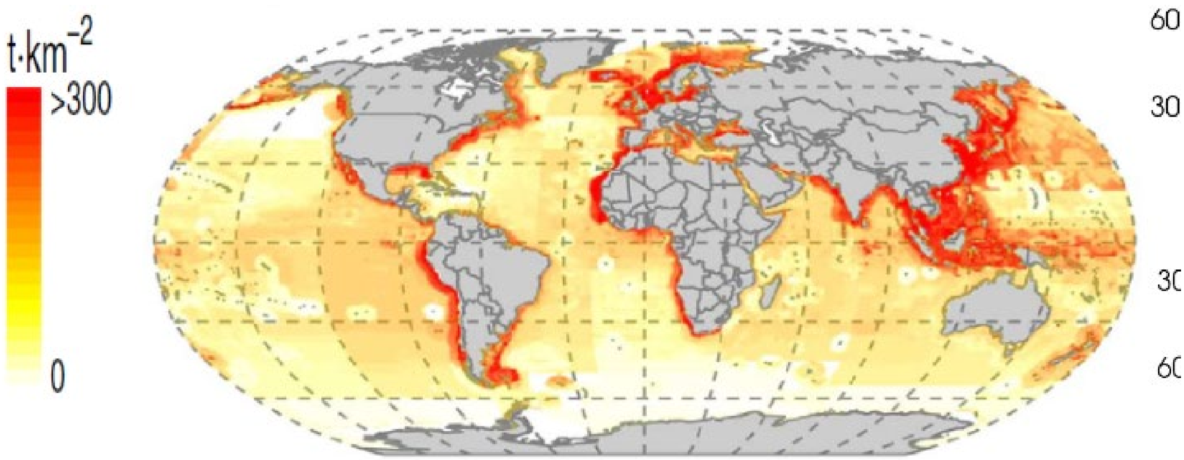


Figure 2: Tickler et al., 2018. Far from home: Distance patterns of global fishing fleets. Science Advances.

The GROOM RI will strongly contribute to provide the physical, biogeochemical and biological insitu profiling data needed to comply with the CFP requirement on environmental data to assess fish stocks. This data will serve both the operational services related to fishery and the fish stock management organisations (international organisations, ministries, NGOs).

For CFP, GROOM RI will:

- provide a European response (European RI) to a European directive
- harmonise the process and adaptation of glider capacities to the specific requirements of each country
- produces best practices for CFP environmental data
- address technological gaps with technological development (for example, biological sensors integration on gliders and scientific validation)
- make available quality-controlled data for fish stock assessments

III.3.3 The Marine Spatial Planning Framework Directive

MSPFD processes simultaneously address ecological, economic, social and cultural objectives, and develop marine plans to safeguard long-term ecosystem health and the well-being of human communities.

It is a solution for implementing ecosystem-based management and developing integrated, multi-objective marine plans that were comprehensive, participatory, and changed the status quo of governance structures or frameworks that were failing to address the complexity of decisions confronting governments.

MSPFD can result in plans, permits and other administrative decisions that decide on the spatial and temporal distribution of relevant existing and future activities and uses in the marine water.

Since 2014, in Europe, the 22 coastal Member States have been obliged to develop a national maritime spatial plan. Member States are free to design and determine the format and content of their maritime spatial plans leading to great diversity between countries in the implementation of the MSPFD. Despite this divergent situation, a second version of the MSPFD data framework has recently released emphasising, amongst other priorities, the need for:

- “Marine and coastal environment data” (including eutrophication level),
- and “Oceanographic characteristics, coastal climate and hydrography data”.

Why would a GROOM RI be relevant in the MSPFD context?

Similar to the two previous domains, GROOM RI will:

- provide a European response (European RI) to a European directive
- harmonise the process and adaptation of glider capacities to the specific requirements of each country
- produces best practices for MSPFD data
- address technological gaps with technological development (for example, biological sensors integration on gliders and scientific validation)

III.4 Use case conclusion

EU directives and public policies are edited by the Europe commission to better serve European interests. Those interests are the key societal benefits we are considering in this document.

In this section, we have demonstrated the role that the GROOM RI could play to support the implementation of the MSFD, CFP and MSPFD by providing high quality, low cost, sustained, real time and delayed time, coastal, profiling environmental marine data in a harmonised and standardised way to serve the purpose of the European directives and policies.

That data will strongly contribute to the implementation of the directives and policies and will provide the means to the country state to achieve the requirements of the different policy and directives data framework.

While directives and policies provide the "what" with regard to data needs, GROOM RI will provide the "how" and "who" to policy implementers. GROOM RI will then become an essential piece toward a more efficient implementation of the maritime European directives (MSFD, MSPFD) and policy (CFP).

IV. Conclusion

To achieve this prospective exercise of assessing the key societal benefits of the GROOM Research Infrastructure, we took two different approaches. A theoretical and academical approach based on a methodology described in Florio et al., 2019. And a more concrete approach, based on documented use cases.
Both qualitative approaches showed that **GROOM RI will have positive and significant social and environmental impacts** by **increasing European capacity to observe the ocean**, **facilitating access to AUVs** for emergencies and operational application and contributing to promoting AUVs to a larger audience through **training and outreaching**. In addition, the expected scientific results made possible by GROOM RI, by **aligning its requirements with European and international standards**, will benefit society by increasing knowledge and allowing more discoveries for the future.
The GROOM RI appears to be an **essential milestone** to continue progressing toward a **better use and management of the Ocean** as a common good.

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