Data Insight through the Value of Eco-marine-robotics (DIVE)

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Summary/Abstract (max. 250 words)

New robotic platforms significantly enhance ocean observations and can fill crucial data gaps - near shore, off-shore, in the deep sea, near and under ice - as they can reach some of the most remote areas of the planet. However, these platforms and the data they acquire are missing a fundamental element that is hindering their uptake into the global ocean observational system: clear FAIR (Findable, Accessible, Interoperable, Reusable) data policies.

The primary outcomes of observational oceanographic missions are data and physical samples, but data policies applied in ocean sciences are not fully adopted by the marine robotics community, possibly compromising the quality of the data and limiting its broad use. This is because of the lack of data standards in marine robotics research.

DIVE aims at advancing best practices used in marine sciences data management and at ensuring their implementation on behalf of the marine robotics community. These practices include categories such as mission planning strategies, operational procedures, sensor configurations, data formats and post processing standards. Within these categories, there will be instances of calibration and logging requirements, as well as data treatment and processing protocols, and finally metadata attribution and dataset publication guidelines.

Marine robots capabilities and the needs of oceanographic observations are continuously evolving; this co-evolution poses a considerable challenge when establishing comprehensive data and observational standards.

Ultimately, DIVE wants to explore existing standards that can be harmonised and established within internationally recognised bodies such as ISO (International Organization for Standardization) or IEEE (Institute of Electrical and Electronics Engineers).

Scientific Background and Rationale (max 1250 words)

Background: scientific observations and marine robots

It is crucial to better understand ocean processes and their dynamics. Hence, we need new oceanographic observations in unexplored areas of the planet.

Emerging technologies , of which autonomous marine vehicles and remotely operated / tethered underwater robots are representative examples, have tremendous potential to push the boundaries of ocean observations, because they are capable of reaching the most remote areas of the planet and the harshest sites, while removing people from harm's way[1] and decreasing the carbon footprint of ocean observations[2].

Ocean technological development needs to liaise with the observational needs of the oceanographic community. Often, during field campaigns it is necessary to reconfigure new ocean-observing technology. This requirement has led to the development of modular and flexible technology capable of quickly adapting to specific challenges posed by the required types of observations . This capability holds a huge potential for ocean observations in areas that are very seldomly monitored, but there is a gap in knowledge and communication between the two communities from the fields of oceanography and robotics. DIVE creates a space where robotics and oceanographic knowledge can interlock and, together, guide the design of observational platforms, in order to deliver observations of the highest international standards. The lack of standards thereof identified represents the main working area of DIVE.

Novel marine robots - meaning non commercialised mechatronic systems - are often created in labs, prototyped, and published. Few exceptions are scaled and commercialised - gliders[3]; argo[4] floats, which continue to evolve, see BGC argo and Deep argo, and then also Wave Glider[5], Saildrone[6], ASV Global[7].

Focusing on the oceanographic data challenge brought by novel marine robotic platforms will have major impacts on the broader scientific community by:

- ➔ reconfiguring robotic designs to adapt to different ocean data collection challenges
- ➔ rendering each deployment repeatable to build consistent time series
- ➔ enabling the reproduction and simulation of in situ missions in digital twins of the ocean and the platforms used.
- ➔ planning data expeditions and then facilitating the dissemination of FAIR datasets
- ➔ accelerating the technological uptake into the Global Ocean Observing System and the Blue Economy

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[1] Aracri, Simona & Giorgio Serchi, Francesco & Suaria, Giuseppe & E. Sayed, Mohammed & Nemitz, Markus & Mahon, Stephen & Stokes, Adam. (2021). Soft Robots for Ocean Exploration and Offshore Operations: A Perspective. Soft Robotics. 8. 10.1089/soro.2020.0011.
[2] National Oceanography Centre - NZOC: Net Zero Oceanographic Capability Summary Report - https://noc.ac.uk/files/documents/nzoc_summary_report.pdf
[3] https://cordis.europa.eu/project/id/284321
[4] https://argo.ucsd.edu/outrea8ch/publications/bibliography/
[5] https://robots.ieee.org/robots/waveglider/
[6] https://www.pmel.noaa.gov/ocs/saildrone
[7] https://www.l3harris.com/all-capabilities/asview-control-system

Currently marine technology development is often driven by offshore industry demands[8,9]. However, in light of the climate crisis and the ocean decade[10,11], a scientific task force bound to collect data for unprecedented climatic conditions is now needed more than ever.

Although marine technology, operating in the gap left by more established platforms - ships. Argos, gliders - is on the rise, the missions performed with groundbreaking platforms have already produced unique and crucial datasets that are yet to be valued and shared within the community. The Institute of Marine Engineering (INM)[12] of CNR, for instance, has a long tradition of marine robotics deployment in harsh environments such as the poles, but the datasets and the data protocols in place are yet to be shared with larger data providers to ensure the appropriate resonance within the scientific community. With the publication "A framework for FAIR robotic datasets" by Motta, Aracri, Ferretti et al.[13] we took a first step into a standardized approach for marine data gathered by waterborne robots. These valuable datasets have not been shared with the community because they need to be polished, interpreted, and integrated, but lack clear data management policies. Designing comprehensive data policies is paramount. Delivering datasets that comply with FAIR policies is the key challenge DIVE will address, to assure the timely treatment and publication of future observations. Such policies and guidelines aim at accelerating the presence of unique datasets into established data providers, e.g. Copernicus and SeaDataNet.

Few fully operational robots enable marine monitoring in extreme environments such as the poles. This is the case, for instance, of AUTOSUB[14], PROTEUS[15] (Portable RObotic TEchnology for Unmanned Surveys) and SWAMP[16] (Shallow Water Autonomous Multipurpose Platform), which took part in data campaigns in the Svalbard Archipelago (Arctic) and in the Ross Sea (Antarctic). Extreme environments have an impact not only on the design of the robots and on the sampling strategies, but also on the logistics of the expedition itself, which is an important challenge for polar missions.
Having a set data policy, encompassing probes calibration, sensor integration, sampling methods and data dissemination is part of the layout of an in-situ expedition. Minding the data exploitation of oceanographic expeditions that include marine robots influences the expedition preparation, which must also include the creation of an appropriate logging

[8] Hastie, Helen & Lohan, Katrin & Chantler, M. & Robb, David & Ramamoorthy, Subramanian & Petrick, Ron & Vijayakumar, Sethu & Lane, David. (2018). The ORCA Hub: Explainable Offshore Robotics through Intelligent Interfaces.
[9] Sayed, Mohammed E., Markus P. Nemitz, Simona Aracri, Alistair C. McConnell, Ross M. McKenzie, and Adam A. Stokes. 2018. "The Limpet: A ROS-Enabled Multi-Sensing Platform for the ORCA Hub" Sensors 18, no. 10: 3487. https://doi.org/10.3390/s18103487
[10] Visbeck, M. Ocean science research is key for a sustainable future. *Nat Commun* 9, 690 (2018). https://doi.org/10.1038/s41467-018-03158-3
[11] Guan S, Qu F and Qiao F (2023) United Nations Decade of Ocean Science for Sustainable Development (2021-2030): From innovation of ocean science to science-based ocean governance. *Front. Mar. Sci.* 9:1091598. doi: 10.3389/fmars.2022.1091598
[12] http://www.inm.cnr.it/
[13] Motta, C., Aracri, S., Ferretti, R. *et al.* A framework for FAIR robotic datasets. *Sci Data* **10**, 620 (2023). https://doi.org/10.1038/s41597-023-02495-3
[14] https://noc.ac.uk/facilities/marine-autonomous-robotic-systems/autosubs
[15] Bruzzone, Gabriele, Angelo Odetti, Massimo Caccia, and Roberta Ferretti. 2020. "Monitoring of Sea-Ice-Atmosphere Interface in the Proximity of Arctic Tidewater Glaciers: The Contribution of Marine Robotics" *Remote Sensing* 12, no. 11: 1707. https://doi.org/10.3390/rs12111707
[16] Angelo Odetti, Gabriele Bruzzone, Marco Altosole, Michele Viviani, Massimo Caccia, SWAMP, an Autonomous Surface Vehicle expressly designed for extremely shallow waters, Ocean Engineering, Volume 216, 2020, https://doi.org/10.1016/j.oceaneng.2020.108205

software, discussions around the data format and nomenclature[17], and future use and dissemination of the data. Together with environmental data, robotic data, e.g. battery performance, geolocalisation, and platform motion data , constitute a key part of the environmental dataset, as they allow for a better understanding of data and for the repeatability of the deployment.

All the aforementioned elements render each data point gathered from marine robots extremely valuable. In such remote and pristine environments, the employment of robots not only minimises the environmental impact of the observations, but it also drastically reduces the danger for personnel.

The need to harmonise robotic data has been recognised also by programmes such as the Ocean Observatories Initiative in the US[18].

Ultimately, rendering the coupled scientific and robotic datasets available for the wider scientific community serves multiple purposes: maximising the usability and impact of cost-effective platforms with a broad geographic reach, making the deployment repeatable and consistent with previous campaigns, creating a hub of information capable to feed, for instance, the rapid growth of Digital Twins of the Ocean and supporting the development of machine learning tools.

Challenges

The major challenges for the DIVE WG (Working Group) will be to create data standards encompassing the key features of both oceanography and robotics.

To create new data standard DIVE will:

- create a structured interdisciplinary community to foster interdisciplinary exchange of environmental data coming from emerging marine technologies.
- review the novel marine robotics status, including all the related rising disciplines, such as marine soft robots[19,20].
- map the oceanographic variables onto the robotic measurements, i.e. select characteristic robotic variables that are also useful to interpret environmental data.
- set deployment and logging protocols
- outline the FAIR data dissemination process for marine robotics data through the established data portals (SeaDataNet, Copernicus, ECMWF).

Working group Motivation

[17] Aracri, S.; Ferretti, R.; Motta, C.; Ferreira, F.; Bibuli, M.; de Pascalis, F.; Odetti, A.; Bruzzone, G.; Caccia, M. OPEN SCIENCE IN 863 MARINE ROBOTICS. In Proceedings of the International Conference on Open Data (ICOD 2022): Book of abstracts, 2023, pp. 864 96–100. https://doi.org/10.5281/zenodo.8071065.
[18] https://oceanobservatories.org/
[19] Workshop: Aquatic Soft Robots at Robosoft 2019 https://sites.google.com/view/aquaticsoftrobots/home?authuser=1
Simona Aracri, Markus P. Nemitz, Pablo Valdivia y Alvarado, Giuseppe Suaria
[20] Workshop: Ocean Soft Robots: Exploration and Data Challenge at RoboSoft 2023
https://softroboticsconference.org/workshop-info/
Simona Aracri, Ditzia Susana Garcia Morales, Zurong Zhang, Jan Peters, Francesco Giorgio-Serchi, Prof Annika Raatz, Corrado Motta, Roberta Ferretti, Francesca De Pascalis, Massimo Caccia.

Structuring coupled data policies for emerging emerging ocean observing technology is a new endeavour that needs wide discussion to be outlined and structured in the future into a grant proposal. For this reason, a strong international consortium is necessary to create a space where a community of experts can liaise and collaborate.

Terms of Reference (max. 250 words)

Goal 1: Community
Decio Crisol Donha and Simona Aracri

DIVE will create a website and an online forum (Discord or Slack), with the aim to extend the discussion to the broader community involving early career scientists in marine sciences and robotic sciences.

Goal 2: Data Mining and Value
Simona Aracri and Dana Yoerger

Analysis of the state of the art of current practices, namely those applied to Argo floats and gliders, to outline future directions for best practices. DIVE will identify datasets created within one of the active or concluded projects within the consortium. The datasets are going to implement the guidelines identified during the state of the art analysis. Also, the analysis of the datasets will highlight the gaps about specific variables and scientific questions, which is critical for the preparation of field missions - sensory payload, platform configuration, data software architecture for FAIR and timely dissemination.

Goal 3: Guidelines and Best Practices
Antonio Pascoal and Pramod Maurya

Ultimately, the concrete output of this WG will be to develop a set of guidelines, protocols and procedures to use as standards / best practices by officially recognised bodies such as IEEE or ISO. Standards in data policy ensure repeatability and traceability of a deployment and its data, hence actually bridging the gap between prototyped technology and commercialised platforms, which can be readily adopted in oceanography.

Deliverables (state clearly what products the WG will generate. Should relate to the terms of reference. Max 250 words). A workshop is not a deliverable. Please note that SCOR prefers that publications be in open-access journals.

- ➔ D1 - Open Access review describing the potentiality of a comprehensive data management in marine robotics, including a review of current practices in established robotic platforms such as Gliders and Argo floats. When these platforms were initially introduced, it was necessary for bespoke data policies and data management to be designed so that the data could be disseminated. The article would analyse the current ocean robotics scenario and assess its gaps and

obstacles to wider usability. Potential target journals are Science Robotics[21], PNAS[22], Nature Communication[23]. (Due submission month 12)

- ➔ D2 - Open Access perspective describing the impact of unprecedented data collected by novel robotics platforms. In this article DIVE will bring to light all the data from field campaigns that have been overlooked. Potential target journals are Earth System Science Data[24], Annual Review of Marine Science[25], Limnology and Oceanography[26]. (Due submission month 16)
- ➔ D3 - Publication of the recovered datasets, when possible in SEANOE[27]. Such article will deliver to the community new data and will describe the data management that DIVE is fostering. Emerging marine robots are modular and reconfigurable, in the same way the data management related to novel observational platforms will be flexible and compliant to the different configurations of the robots (Due submission month 24)
- ➔ D4 - Best Practices publication in https://www.oceanbestpractices.org/journal/. (Due month 36)
- ➔ D5 - White paper outlining the structure of a marine robotics data internationally recognised standard which will serve as a metric of DIVE engagement in the community. (Due month 48)

Working plan (logical sequence of steps to fulfil terms of reference, with timeline. Max. 1000 words)

Towards goal 1:

Slack and Discord invitations will use established mailing lists[28] to extend DIVE's community and foster discussion on the impact of data policy on the robotic architecture, on the field missions of observational platforms and on the oceanographic-robotics gap as far as data protocols are concerned. Argos and gliders data policies have paved the way for marine robots designed for ocean observations and will enable an analysis of past and future coupled datasets (robotic and environmental), from field campaigns involving marine technology and will allow the working group to extract the elements that hindered the dissemination and the validation of the environmental and robotic data. With robotic data, it is important to prioritise variables that facilitate the repeatability of a given deployment. The discussion will revolve around questions like: how data policies impact the design/architecture/operability of an ocean robot? How does it impact mission planning? What data protocols from Earth Sciences can and should be implemented in marine robotics for new platforms to be absorbed in oceanographic missions? What variables, sampling strategies and locations can we solve with novel marine robotics to find the answer to outstanding oceanographic questions?

Via Slack, Discord, website and social media we will advertise bimonthly round tables, focussed on the ongoing discussions on the team communication platforms.

[21] https://www.science.org/journal/scirobotics
[22] https://www.pnas.org/topic/eng
[23] https://www.nature.com/ncomms/
[24] https://www.earth-system-science-data.net/
[25] https://www.annualreviews.org/
[26] https://aslopubs.onlinelibrary.wiley.com/journal/19395590
[27] https://www.seanoe.org/
[28] https://www.lists.kit.edu/sympa/info/robotics-worldwide and https://lists.egu.eu/mailman3/lists/os.lists.egu.eu/

Towards goal 2:

The outcomes of the goal 2 discussions will allow us to revise the datasets created during past projects and during active ones within DIVE's lifetime. The members of DIVE will compile a review and a perspective on data management in marine robotics for environmental data campaigns examining the current landscape of ocean robotics and evaluating its promise. This analysis would detail the pathway to a FAIR data management in marine robotics apt to collect environmental data. As an example a first dataset publication limited to the manoeuvrability of a marine vehicle is reported in Ferretti et al. 2023[29].

Towards goal 3:

DIVE's work towards the creation of a common standard will also build on the work led by CNR-INM in the past two years[13,17], which automates the creation of a FAIR coupled dataset, via a open source software pipeline[30]. The concept: FAIR by default ties together all the phases of the life of a marine robot from design, to deployment, to data publication. The software will support the working group in understanding the gaps and development needed both on the robot architecture and in the open source pipeline. To accelerate the technological uptake in marine sciences (e.g. Ocean Best Practices[31], EOOS Technology Forum[32]) DIVE will liaise with official standard bodies such as ISO and IEEE to lay the foundation for an official data policy capable of enabling the consistent deployment of diverse platforms, in order to create valuable inter-platform data series and unprecedented data.

Timeline

The first - build a community and discuss the current data protocols, ubiquitous in oceanography, and their adoption into the marine robotic domain. DIVE's website will share the progress of the group and an online forum to host the discussion. These two tools will catalyse a proactive community around DIVE. The first WG meeting, at American Geophysical Union (AGU) Fall Meeting 2025 (USA), which will happen in hybrid form to enhance inclusivity and minimise environmental and economical impact. During the first WG meeting we will discuss the appropriate locations for future meetings. Relevant conferences might be ICRA 2026 (Europe), and OCEANS 2027 or alternatively Breaking the Surface[33], moreover KAUST (Saudi Arabia) (Martin Visbek) offered to host one meeting. In 2026 and 2027 DIVE will contribute to the conference with a scientific contribution such as conference paper/talk/poster. In addition to the Working Group's members hybrid meeting (virtual and in person), we will organise a

[29] Ferretti, R., Motta, C., & Bibuli, M. (2023). Maneuverability Characterization of Autonomous Surface Vehicle (ASV): ITTC zig-zag test dataset [Data set]. Zenodo. https://doi.org/10.5281/zenodo.7825000
[30] https://corradomotta.github.io/FAIR-Data-in-Marine-Robotics/html/index.html
[31] https://goosocean.org/our-work/ocean-best-practices/
[32] https://www.eoos-ocean.eu/wp-content/uploads/2022/08/EOOS-Tech-Forum-report-2022.pdf
[33] https://bts.fer.hr/

hybrid workshop (e.g. Ocean Soft Robots workshops[34,35]) dedicated to the DIVE's community. These interconnected workshops, in addition to the DIVE virtual forum, will establish a continuous communication among disciplines with active participation of members belonging to both communities, linking together an extended cross disciplinary network. Such an extended network will promote funding opportunities for early career scientists, for instance through the SPARX program[36], and not only to travel to such workshops. The exchange around robotic data policies will reverberate through robots architecture, mission planning and data dissemination. During the first year the outcomes of the community bi-monthly meetings and discussion will feed one publication: a review article about data management in emerging marine robotics.
Second year - focus on the exploitation of existing datasets and datasets in the making within DIVE's members projects. One of the aims of the second DIVE meeting will be to identify funding opportunities to support the activity of the group in future years. DIVE will also support early career scientists via the POGO-SCOR Fellowship Program to host an early career researcher from a underrepresented country at one of the member institutes, for them to have access to the local facilities and to accelerate their learning process in marine robotics with a particular focus to the data management impact. The second year will produce a perspective on the impact that neglected datasets might have on marine sciences. At the end of the year DIVE will publish at least three of the identified datasets to be valorised within the working group's community.

During the third year DIVE will lay out a structured data policy and best practices, stemming from the work of the first two years. We will liaise with an internationally recognised standard body such IEEE SA[37] (if possible also ISO[38] or BODC[39]). The standard that we envisage aims at treasuring the oceanographic observations and the robotic data gathered by emerging marine platforms.

Budgeting

An approximate distribution of expenditure would be a mean of 1500$ per member per meeting (3 meetings x 10 members x 1500$). For instance AGU would cost approximately 1800$ if travelling from South Korea -500$ (early bird registration), 500$ (accommodation) and 650$ (flight from Seoul), 150$ (meals) -. The same conference would cost 1200$ travelling from Italy -500$ (early bird registration), 500$ (accommodation) and 50$ (flight from Milan), 150$ (meals) -.

[34] Workshop: Aquatic Soft Robots at Robosoft 2019 https://sites.google.com/view/aquaticsoftrobots/home?authuser=1
Simona Aracri, Markus P. Nemitz, Pablo Valdivia y Alvarado, Giuseppe Suaria
[35] Workshop: Ocean Soft Robots: Exploration and Data Challenge at RoboSoft 2023
https://softroboticsconference.org/workshop-info/
Simona Aracri, Ditzia Susana Garcia Morales, Zurong Zhang, Jan Peters, Francesco Giorgio-Serchi, Prof Annika Raatz, Corrado Motta, Roberta Ferretti, Francesca De Pascalis, Massimo Caccia.
[36] https://www.ieee-ras.org/educational-resources-outreach/support-program-to-foster-academic-relationships-and-exchange
[37] https://standards.ieee.org/
[38] https://www.iso.org/home.html
[39] https://www.bodc.ac.uk/

Capacity Building (How will this WG build long-lasting capacity for practising and understanding this area of marine science globally. Max 1500 words)

Early Career Scientists Community

One of the important legacies that DIVE intends to leave is a vibrant community of scientists at all career levels interested in broadening the impact of technology in marine sciences. Special attention will be dedicated to early career scientists. The online forum and the hybrid format of the interconnected workshops are meant to catalyse the interest of early career researchers and to enhance inclusivity. During such workshops smaller thematic tables (breaking rooms) will stimulate participation. The DIVE website will keep the recordings of the workshops, as well as reports and publications. DIVE will meet during marine conferences (robotics and Earth sciences) that encourage early career scientists participation and have in place funding opportunities for early career researchers and scientists coming from underrepresented countries to travel to the same conference.
Moreover bimonthly round tables are going to be advertised through virtual communities on slack, discord, website and newsletters; such meeting are going to encourage participation with i) motivational talks, ii) sharing of articles of interest, iii) on-line visualization of activities in the water, iv) active participation in the creation and dynamization of thematic subgroups.
DIVE will reach out to the Oyster network[40] in Euromarine and the European Marine Board Youth Ambassador's programmes[41]. DIVE will include IAPSO ECS[42] and UN ECOP[43] as well.

Co-funding

A strategic choice of conferences will allow the WG to benefit from the research funding of the members who would independently travel to the conference (co-funding). Such choice will widen the discussion to experts in both disciplines, in fact (early career) scientists belonging to the research groups of the WG members could pertain to both the robotics and marine realm, given the nature of the choice of the consortium constituents.

Underrepresented countries participation

When choosing the location and conference for the WG annual meeting DIVE will consider events taking place in or close to underrepresented countries. A good opportunity will be the Marine Robotic School at CSIR National Institute of Oceanography (NIO) in Goa, an event that has successfully been attracting a broad spectrum of participants from Europe and the Indian / Pacific ocean rim for more than 10 years; the school addresses timely and challenging issues at the forefront of marine science and technology[44]. The November 2023 edition was co-organized by CSIR-NIO, India, and IST-U Lisbon/ Univ. Coimbra Portugal, the next one is planned for 2025.
In addition, DIVE will leverage the contacts established worldwide in the scope of the

[40] https://euromarinenetwork.eu/oyster/
[41] https://www.marineboard.eu/emb-young-ambassador-programme
[42] https://www.iapsoecs.org
[43] https://www.mtsociety.org/ecops
[44] https://mrs2023.nio.res.in/

MIR MSc Erasmus Mundus programme in which IST-Univ. Lisbon participates. that has witnessed widespread interest from students from developing countries across the world, including South America and Africa, see https://www.master-mir.eu/. Moreover, online participation in the meetings and workshops will be open for young researchers coming from underrepresented countries. DIVE will place considerable emphasis on the sharing of publications, lectures, and grey literature branching from the WG on the dedicated website.

Workshop network

Alongside the WG annual meeting, DIVE will create a workshop series open to all the interested scientists with the aim of nourishing the marine technology interdisciplinary community. The workshop series will also share DIVE progresses with the wider scientific community. The workshops, discussions and resulting reports will be freely accessible on DIVE's webpage and online forum to allow interactive and inclusive discussion.

Funding applications

Over the course of DIVE's activity, especially starting from the second yearly WG meeting, the members will come together to apply for further funding to finance the enterprise of the WG. In addition to this, DIVE will seek funding through the POGO-SCOR Fellowship Program to host an early career researcher from an underrepresented country at one of the member institutes.

Commercialisation

DIVE's mission, centred on environmental and robotic data gathered by emerging marine technology, will identify the commercial gaps that hinder the ocean robotic uptake, hence the working group will take care of disseminating its outcome also within its industrial network. The Synthesis of the Dialogues with Industry Report[45] recently published by GOOS (Global Ocean Observing System) also includes a discussion about the role of data and data access in the business development of ocean technology.

A further development of DIVE will also be to facilitate the commercialisation of those fully operational marine platforms that are needed the most and are already employed in ocean observations.

Working Group composition (as table). Divide by Full Members (10 people) and Associate Members, taking note of scientific discipline spread, geographical spread, gender balance, and participation by early-career scientists (max. 500 words)

The aim of this SCOR working group is to create an interdisciplinary focus on the integration of emerging marine technologies and ocean sciences. Hence the chosen members belong to institutes and research groups which contribute to both oceanography and robotics. DIVE members will then represent their multidisciplinary groups.

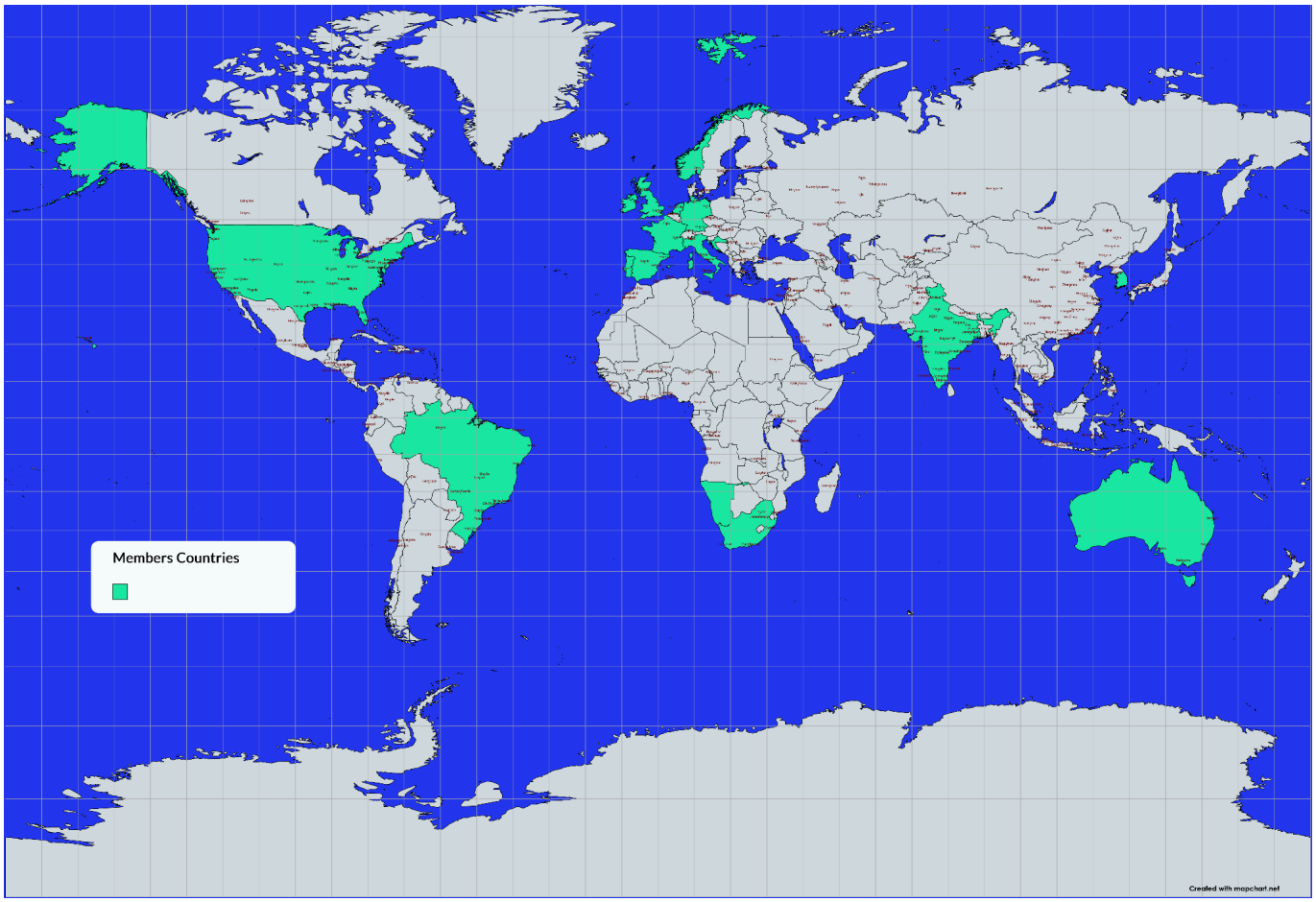
[45] https://goosocean.org/index.php?option=com_oe&task=viewDocumentRecord&docID=32076

Moreover, marine robotics is a strongly male dominated environment[46], therefore the creation of a gender balanced group is particularly challenging. DIVE will promote diversity within its upcoming community, starting by fostering an inclusive environment among early career researchers during the annual meetings and workshops.

DIVE's consortium is made of 10 full members and 10 associated members, coming from Oceania, Africa, Europe, North America and South America for a total of 17 countries involved.

The composition of the working group encompasses both senior members with extensive experience in their respective fields and early career scientists, i.e. within 10 years from their PhD - as Simona Aracri, Elena Ceballos, Johanne Vad, Koena Mukherje.

Full Members (no more than 10, please identify chair(s))



Name	Gender	Institute	Country	Expertise	Early career status

[46]Lupu et al. Women in Blue: Toward a Better Understanding of the Gender Gap in Marine Robotics [Women in Engineering], IEEE Robotics & Automation Magazine. 2022, 29, 4, 138-140. doi: 10.1109/MRA.2022.3213467. https://ieeexplore.ieee.org/document/9975182

1 Simona Aracri (Chair)	F	CNR-INM	Italy (Europe)	Marine Science/Robotics	Early Career
2 Samuel Mafwila	M	University of Namibia (UNAM)	Namibia (Africa)	Marine Science	
3 Thibaut Pollina	M	FAIRSCOPE	France (Europe)	Marine Robotics	
4 António M. Pascoal (Vice-chair)	M	IST-ISR Instituto Superior Técnico-Institute for Systems and Robotics	Portugal (Europe)	Marine Robotics	
5 Johanne Vad	F	The University of Edinburgh	UK (Europe)	Marine Science	Early Career
6 Jinwhan Kim	M	KAIST	South Korea (Asia)	Marine Robotics	
7 Pramod Maurya (Vice-chair)	M	NIO National Institute of Oceanography	India (Asia)	Marine Robotics	
8 Dana Yoerger (Vice-chair)	M	WHOI Woods Hole Oceanographic Institution	USA (North America)	Marine Science/Robotics	
9 Decio Crisol Donha (Vice-chair)	M	University of São Paulo	Brazil (South America)	Marine Robotics	
10 Beatrice Tomasi	F	NORCE	Norway (Europe)	Marine Robotics	

Associate Member (no more than 10)

1 Elena Ceballos	F	University of Sevilla, ETSIE WHOI Woods Hole	Spain and USA (Europe and	Marine Science	Early Career

		Oceanographic Institution	North America)		
2 Andrew Young	M	Marine Robotics Unit at the Nelson Mandela University	South Africa (Africa)	Marine Robotics	
3 Stefan Williams	M	University of Sydney	Australia (Oceania)	Marine Robotics	
4 Tommy Bornman	M	Nelson Mandela University	South Africa (Africa)	Marine Science	
5 Alejandra Sanchez-Franks	F	NOC	UK (Europe)	Marine Science	
6 Koena Mukherjee	F	National Institute of Technology Silchar	India (Asia)	Marine Robotics	Early Career
7 Fausto Ferreira	M	University of Zagreb	Croatia (Europe)	Marine Robotics	
8 Martin Visbeck	M	KAUST	Saudi Arabia (Asia)	Marine Science	
9 Christoph Waldmann	M	MARUM	Germany (Europe)	Marine Robotics	
10 Fiona Grant	F	Marine Institute	Ireland (Europe)	Marine Policy	

Stakeholders

IEEE	associate members Christoph Waldmann and Fausto Ferreira - chair and secretary of the IEEE Oceanic Engineering Society Standards Committee
ISO	associate member Christoph Waldmann - German representative for TC 8/SC 13
WDC (World Data Center)	http://wdc.org.ua/en

Working Group contributions (max. 500 words)

Detail for each Full Member (max. 2 sentences per member) why she/he is being proposed as a Full Member of the Working Group, what is her/his unique contribution?

Simona Aracri - permanent researcher at the Italian National Research Council - Institute of Marine Engineering - is the coordinator of DIVE, and the co-chair of Goal 1 and Goal 2. As a sea going scientist and physical oceanographer she has extensive experience in oceanographic observations and a postdoc in offshore robotics.

António M. Pascoal - associate professor of IST, senior researcher at ISR - is the co-chair of Goal 3. He has coordinated and participated in a large number of international projects that have led to the design, development, and field-testing of single and multiple autonomous marine vehicles and systems in cooperation with partners in India, USA, Korea, and Europe

Pramod Maurya - principal scientist at CSIR – National Institute of Oceanography, Dona Paula, Goa - is the co-chair of Goal 3. His research encompasses marine Robotics, coral reef monitoring and the interconnection between science and technology.

Decio Crisol Donha - head of the mechanical engineering department at the Polytechnic School of USP - he is co-chair of Goal 1. Decio specialises in naval and oceanic engineering and control/automation of vehicular systems. Their expertise.

Dana Yoerger - senior scientist at the Woods Hole Oceanographic Institution and a researcher in marine robotics - he is the co-chair of Goal 2. His research applies automation principles to remotely operated and independent underwater vehicles, enhancing their capability, enabling them to explore ocean depths, and making them easier to use.

Samuel Mafwila - Director of Sam Nujoma Marine and Coastal Resources Research Centre (SANUMARC), University of Namibia, Henties Bay, Namibia - he is a marine scientist specialised in physical and biological oceanography. He will contribute to DIVE with his more than 20 years working experience in both the public and private sectors, in fisheries and international projects.

Thibaut Pollina - inventor of PlanktoScope, a groundbreaking high-throughput microscope, he has led the project since its inception, serving as chief coordinator. Thibau's role involves managing a vibrant user community and spearheading research and development initiatives, enhancing his project management and cross-functional coordination skills as PlanktoScope gains global adoption. To expand his invention's reach, he founded FairScope, a company dedicated to manufacturing and distributing PlanktoScopes, advancing the democratization of scientific tools..

Johanne Vad - postdoctoral research associate, School of Geosciences, University of Edinburgh - she will provide her expertise about marine habitats, in particular sponge grounds, anthropogenic impact in the marine ecosystem. Her knowledge will be important to design a meaningful robotic deployment and subsequent data interpretation.

Jinwhan Kim - professor, Department of Mechanical Engineering (co-affiliated with Graduate School of Ocean Systems Engineering and Robotics Program), KAIST, Korea - His expertise in marine robotics, vehicle guidance and navigation will facilitate DIVE to adapt the robot control to a particular data mission.

Beatrice Tomasi - senior scientist at the Norwegian Research Center, Bergen, Norway. Information scientist and technologist, PI of the MarTERA UNderwater robotics with multi-moDal communIcation and Network-Aided positioning system (UNDINA) project. Her knowledge of underwater robotics, underwater communications and positioning systems will contribute to the appropriate data transmission and localisation during marine robotic deployment.

Relationship to other international programs and SCOR Working groups (max. 500 words)

DIVE will interface with the SCOR Working Group 164 CoNCENSUS[47]: Advancing standardisation of COastal and Nearshore demersal fish visual CENSUS techniques. DIVE's coordination, in fact, already collaborates with CoNCENSUS's associate member, Laura Ghigliotti. The common intent of standardising oceanographic data coming from emerging marine robotic platforms and visual underwater data overlaps not only in the data policy realm, but also in the instrument integration with the observational platform and the field mission planning.

Members of DIVE - A. Pascoal and P. Maurya- participated in the SCOR Working Group 118 - New Technologies for Observing Marine Life[48] which aimed at making marine scientists aware of novel methods (that included the use of marine robots) to dramatically improve the techniques available for ocean and marine life observation. The new proposed group, DIVE, goes one step further, because it wants to address important issues related to the methodologies used for proper data acquisition including strategies for ocean data acquisition at the proper spatial and temporal scales, data interpretation and classification and standards for data dissemination.

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Appendix

For each Full Member, indicate 5 key publications related to the proposal.

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16 May 2024

Application for SCOR Working Group: Data Insight through the Value of Eco-marine-robotics (DIVE)

To Whom it May Concern,

I am writing to support the Working Group proposal DIVE. This working group wants to facilitate in-depth knowledge sharing between marine scientists, robotics developers, and data scientists. The group's reach extends beyond its own members, to include expert networks and the wider community. DIVE will keep marine scientists and roboticists informed of new marine observation platforms, as well as provide a platform for discussing the political and technical intricacies that may arise, to finally deliver coupled environmental and robotic datasets following the FAIR principles.

Best regards,

Brandy Armstrong

Brandy Armstrong
IEEE Oceanic Engineering Society President
(president@ieeeoes.org)
Date of Signature: 5/16/2024