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A New Tool for Faster Construction of Marine Biotechnology Collaborative Networks

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The increasing and rapid development in technologies, infrastructures, computational power, data availability and information flow has enabled rapid scientific advances. These entail transdisciplinary collaborations that maximize sharing of data and knowledge and, consequently, results, and possible technology transfer. However, in emerging scientific fields it is sometimes difficult to provide all necessary expertise within existing collaborative circles. This is especially true for marine biotechnology that directly addresses global societal challenges. This article describes the creation of a platform dedicated to facilitating the formation of short or mid-term collaborative networks in marine biotechnology. This online platform (https://www.ocean4biotech.eu/map/) enables experts (researchers and members of the marine biotechnology community in general) to have the possibility to showcase their expertise with the aim of being integrated into new collaborations/consortia on the one hand, or to use it as a search tool to complement the expertise in planned/running collaborations, on the other. The platform was created within the Ocean4Biotech (European transdisciplinary networking platform for marine biotechnology) Action, funded under the framework of the European Cooperation in Science and Technology (COST). To build the platform, an inquiry was developed to identify experts in marine biotechnology and its adjunct fields, to define their expertise, to highlight their infrastructures and facilities and to pinpoint the main bottlenecks in this field. The inquiry was open to all experts in the broad field of marine biotechnology, including non-members of the consortium. The inquiry (https://ee.kobotoolbox.org/single/UKVsBNtD) remains open for insertion of additional expertise and the resulting interactive map can be used as a display and search tool for establishing new collaborations.

Keywords: marine biotechnology, collaboration, expertise, inquiry, tools and infrastructures

INTRODUCTION

The COST Action Ocean4Biotech (European transdisciplinary networking platform for marine biotechnology[1]) was officially launched in October 2019. The overall aim of Ocean4Biotech is to gather experts in the field of marine biotechnology, to provide a platform for sharing experience, knowledge, infrastructures and technologies and to design a roadmap for a more efficient and rapid development of marine biotechnology research in Europe and beyond (Rotter et al., 2020). This currently represents the largest, most diverse and geographically dispersed network of experts in the field of marine biotechnology. A little over a year from its beginning, the consortium of this EU-based Action already includes over 130 individual experts from 39 countries (European and beyond, including Tunisia, Israel, Algeria, South Africa, Ecuador, and Colombia). Since there are far more transdisciplinary experts internationally, which are not members of the Ocean4Biotech network, we conducted an inquiry to map these experts, their expertise, location, and their technologies, tools and infrastructures. Additionally, all the respondents were asked for valuable feedback on the challenges that the emerging field of marine biotechnology is facing. Such data are of high relevance, especially in European countries, where in 2021 the new Framework Programme – Horizon Europe was launched[2]. This is an ambitious research and innovation program with a budget of €95.5 billion and, for many research and innovation experts, it represents a unique opportunity to engage in larger international collaborations with substantial financial support, allowing the opportunity to address key societal challenges (e.g., climate change and well-being) and United Nations sustainable development goals[3] through collaborative networks. However, relevant experts may be excluded when addressing these societal challenges, as there is a lack of broadcast of individual expertise and capacity building of institutions.

COLLABORATIVE NETWORKS

Science is a social entity: conducted by groups, assessed by peer reviews and built upon collaborations (Levine and Moreland, 2004). Collaborative efforts usually yield the most productive, creative and innovative results. Experts at any career stage are often searching for new collaborative opportunities, either for pursuing their career with complementary expertise or for investigating novel scientific disciplines to address important societal challenges. Hence, experts organize themselves into collaborative networks, composed of autonomous, geographically distributed and transdisciplinary components, which are drivers of value creation (Camarinha-Matos and Afsarmanesh, 2004, 2005). Collaborative networks are dynamic structures governed by the emergence of the process and interpersonal relations by exchanging ideas, resources, trust and lead to innovation (Parker and Corte, 2017). They commonly have a limited duration, and the composition of their members evolves over time. A typical example of a collaborative network is a consortium formed for a specific research and innovation call. There are four approaches to construct a collaborative network. The two classical approaches use the existing (i) formal and (ii) informal collaborative networks. Formal collaborative networks involve past successful collaborations, while informal collaborative networks can arise from support lists (such as online tools, social media channels, or mailing lists). These networks can significantly accelerate the search for necessary and validated expertise. Their main advantage is that typically the expertise of individual network members is well known to the network coordinators. Thus, they capitalize on past successful interactions (professional and personal ones). (iii) The third approach involves *ad hoc* networking events, typically organized adjacent to a scientific conference or as standalone events (i.e., in the form of brokerage events or the so-called "project idea corners"). These events are targeted and organized when specific funding opportunities are open, allowing participants to seek collaborations that add specific expertise currently outside existing collaborative networks. (iv) Finally, the fourth approach for constructing collaborative networks allows a broader display of expertise, using online tools. These are typically top-down, where a vast array of transdisciplinary expertise can be displayed under specific funding call requirements. One example is the "Partner search" tool that was introduced during the former European Framework Programme, Horizon 2020 and is available under individual call information. These tools are typically available only after a call is launched.

In marine biotechnology, traditional networking opportunities include scientific conferences, trade fairs, national and international brokerage events, as well as access to research infrastructures (e.g., the MARINA platform[4], EMBRC European Research Infrastructure[5], the EBB – European Blue Biobank within EMBRC[6], and the ASSEMBLE + project[7]). It is, however, important to establish alternative and inclusive ways of showcasing individual expertise. The availability of such an expertise display, with the possibility for direct contact and interaction with the experts is also vital for human resource mobilization.

The Inquiry

The inquiry[8] was launched on April 14, 2020 using Ocean4Biotech's Twitter channel[9]. Action members were also asked to circulate the inquiry to their individual academic and industrial networks relevant to the field of marine biotechnology. Data were collected, processed, used and stored in compliance with the requirements of the General Data Protection Regulation (EU) 2016/679[10]. Taking into consideration that Ocean4Biotech

[1]https://www.ocean4biotech.eu/

[2]https://ec.europa.eu/info/horizon-europe_en

[3]https://sdgs.un.org/goals

[4]https://www.marina-platform.eu/

[5]https://www.embrc.eu/

[6]https://www.bluebiobank.eu/

[7]https://www.assembleplus.eu/

[8]https://ee.kobotoolbox.org/single/UKVsBNtD

[9]https://twitter.com/Ocean4Biotech

[10]https://www.ocean4biotech.eu/wp-content/uploads/2020/04/Ocean4Biotech-Inquiry-Privacy-Policy.pdf

is a relatively new network with its Twitter channel having 130 followers at the time, the Tweet was successful with almost 1,900 impressions on various Twitter feeds (i.e., the outreach potential is 10-times higher than the number of followers). When the second invitation to fill in the inquiry was forwarded on Twitter a month later (May 15, 2020), its outreach was close to 800 impressions on various Twitter feeds. Even though the inquiry is still open as the mapping of experts and their expertise is a long-term activity of Ocean4Biotech, we started the analysis of the answers after 3 months (July 14, 2020). Excluding double entries, non-EU respondents and respondents who did not allow their responses to be used for statistical purposes, the responses from the 131 first respondents were used for further analyses at a European level. The data used for constructing the interactive map was stored inside a MySQL database and connected to Wordpress via native Wordpress API functions for reading from database. An administrator can edit this data using a form made from Advanced Custom Fields inside the Wordpress installation. The interactive map uses Google maps Javascript API to display structured geodata from the database. It passes variables to the map layer and shows them when a user clicks on a marker. As the experts' information and the mapping results are displayed publicly and other relevant stakeholders have open access to these data, the audience and participation is expected to increase after the map's first release. The maintenance and updates will be done in two steps: (1) by new respondents filling in the questionnaire (see footnote 8) and (2) by periodically updating the information and increasing content in the interactive map[11]. After obtaining at least 50 new information from global respondents, the interactive map will also display the global contacts and expertise.

Most of our first respondents (71%) represent academic R&D experts and 9% come from non-academic R&D organizations. Marine biotechnology collaborative networks aim at the commercialization of new products for various applications, and for this reason, the participation of industrial organizations is necessary and of utmost importance. Small and medium enterprises and industrial partners represented 11% of our respondents, which will make them a valuable and sought partner type when establishing new collaborations. Other partner types with their specific know-how are also valuable collaborators, and 9% of our respondents come from governmental agencies, funding agencies or other types of organizations (such as professional networks). They have additional expertise, which is relevant when covering regulatory and market acceptance and commercialization of marine biotechnology products. Importantly, none of our inquiry's first respondents is an expert in intellectual property (IP) protection or legislation, and these fields might provide significant niches for new experts. As our inquiry and the online interactive map are new initiatives, these percentages of expertise representation might not mirror the actual state of affairs. However, as the number of respondents will keep increasing, we believe that the information on the map will be representative for the whole field. Ultimately, the coverage of expertise domains on our map will serve as a proxy for determining the most underrepresented categories in marine biotechnology.

[11]https://www.ocean4biotech.eu/map/

DIVERSITY AND INCLUSIVENESS AS A SUCCESS STRATEGY

Diverse teams that adhere to leader inclusiveness (i.e., encouraging diverse contributions and resources from all members) develop new ways of thinking, leading to more innovative solutions (Lasker et al., 2001; Mitchell et al., 2011, 2015). Hence, the inclusion of new experts with complementary skills to those in existing collaborative networks creates an added value compared to competing collaborations. Collaborative networks should therefore be inclusive in terms of field of expertise, type of institution, geopolitical location, gender and seniority level.

Transdisciplinarity

An important milestone in the formation of any collaborative network is the inclusion of complementary disciplines. By proactive engagement in transdisciplinary groups, individual experts benefit from mutual learning, can develop implementable solutions for practice, enjoy the benefits of science-practice cooperation and involve representatives from different stakeholder groups (Zscheischler et al., 2018). Therefore, especially in sciences that directly address societal challenges, transdisciplinary teams should be involved in increasing the diversity of fields of expertise, which stimulates innovation and productivity and can outperform competition (Saxena, 2014). For instance, the involvement of experts in chemistry with a solid background in natural products structure elucidation but also experts in taxonomy and in IP protection are imperative to increase the discovery rate of new biomolecules of well characterized origin.

The individual fields of expertise from our inquiry respondents and the fields subgroups representation are plotted in **Supplementary Figure 1** and available on the Ocean4Biotech website (see footnote 11). Biological fields characterize 52% of the respondents, and half of the biological expertise is in the fields of molecular biology, marine biology and marine microbiology. Chemical sciences are covered by 24% of the inquiry respondents, where over half of the respondents are experts in either (or both) analytical chemistry and marine natural products chemistry. Computational expertise characterizes 11% of the respondents, of which 60% are experts in computational biology, bioinformatics, transcriptomics and genomics. Engineering experts were represented by 6% of the respondents, of which around 70% are experts in bioengineering and downstream processing. Medical sciences are the field of expertise of 5% of the respondents, of which almost half are expert in general biomedicine. Finally, the expertise that is necessary at the final steps of the marine biotechnology development pipeline (Rotter et al., 2021) and that deals with product and business development, and life cycle assessment, was critically underrepresented, as it is covered by only 2% of the respondents, of which half are experts in business development.

There are two main approaches for filling the expertise and infrastructure gaps in the transdisciplinary fields, including marine biotechnology: (i) internal to external, where an already formed new collaborative network identifies a lack of expertise and corresponding infrastructures and (ii) external to internal, where individuals with specific expertise and infrastructures identify their niche in existing networks. As revealed by the answers to our inquiry (**Figure 1**), 76% of respondents have a clear idea of their primary field of application. Among them, 50% are focused on applications for pharmaceutical, food, aquaculture, nutraceutical, cosmeceutical, and biomaterials industries. Notably, 57% of our respondents already have facilities for biomass production and natural products isolation. This capacity is highly relevant when forming collaborative networks aiming to scale up the laboratory-validated prototypes. Around 50% of the respondents have sampling and harvesting equipment (**Figure 1**, middle). The most relevant empty niches have been identified as (i) the availability of biobanks and collections: only 29% of respondents have collections, mostly bacterial, and algal organisms. (ii) Similarly, expertise on toxicological assessment of marine biomolecules and (iii) innovation technology expertise (intellectual property, business development, ethics, and legal knowledge) is currently missing from the interactive map. Inputs of experts from these underrepresented fields would be welcome and their inclusion in novel collaborations will likely be essential for the completion of projects in marine biotechnology.

Geolocation Strategies

As marine biotechnology will keep evolving, diverse and transdisciplinary partners will be of strategic importance in collaborative networks. After fulfilling the imperative requirement of scientific excellence and field of expertise, the inclusion of new partners in collaborative networks can be prioritized based on geopolitical background. Indeed, smaller countries often have more opportunities to meet and engage with the most relevant stakeholders from a specific field, and they can represent a strategic partner in international collaborative efforts. In these countries, the degree of separation (distance) between the initial expert and the target stakeholder is usually smaller than in bigger countries, which can help in boosting innovation (Chen and Guan, 2010).

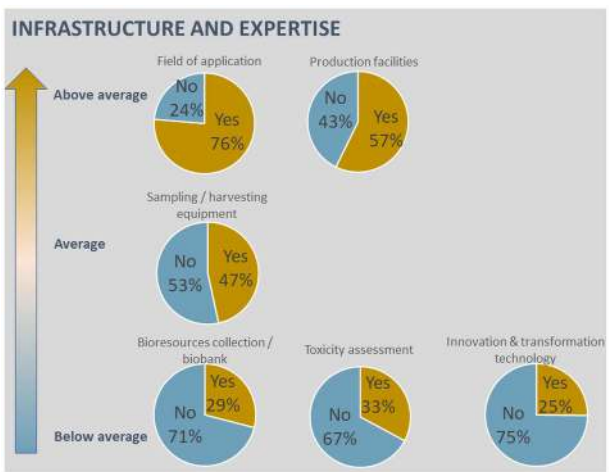

FIGURE 1 | Assessment of existing tools and infrastructures and expertise in the marine biotechnology inquiry. Based on the responses we categorized the existing expertise and infrastructures into: below average (where <50% of respondents have specific expertise), average (where around 50% of respondents have specific expertise), and above average (with >50% of respondents having specific expertise and infrastructures).

Gender and Seniority Level

Upon invitation to fill in our inquiry, the potential respondents were informed that their names and expertise would be showcased, thus giving them opportunities for engaging in new collaborations. With this incentive in mind, we assessed whether there was an overrepresentation of seniority level and gender in our respondents (**Figure 2**). Interestingly, females were overrepresented in their earlier career stages (up to 15 years after obtaining Ph.D., highlighted in yellow squares on **Figure 2**, $p < 0.002$, tested by the chi-squared test), while male respondents were overrepresented in the senior career stages (>25 years after Ph.D., brown square on **Figure 2**; $p < 0.002$, tested by the chi-squared test). This overrepresentation of male respondents in their later career stages in our inquiry could be a consequence of the leaky pipeline, a phenomenon describing a faster exit from science and academia for women than men at various stages of their careers (Blickenstaff, 2005; Gasser and Shaffer, 2014). The leaky pipeline effect is continuously observed in statistical reports (European Commission, 2019 as an example). Overall, new collaborations should be inclusive also in terms of seniority level. (i) On the one hand, collaboration benefits are more significant at the later career stages when research topics become wider and more complex (Hu et al., 2014). (ii) On the other hand, the association of prominent mature scientists with early career researchers positively impacts the career of the latter group (Li et al., 2019).

THE IMPORTANCE OF ONLINE PRESENCE

When establishing novel collaborations or building up research consortia, the search for new collaborators is quickly performed using online tools and social media. Therefore, online presence and/or social media accounts are important to gain or increase the individual's visibility. 97% of our respondents use at least one online tool, and 75% are active on more than one virtual channel. The vast majority (80%) of our respondents use ORCID[12], a unique identifier and database for storing individual information about publications, grants, current and past affiliations or more. The major three virtual channels used by our respondents are ORCID, Researchgate[13], an important database of publications and project information, and LinkedIn, which is often used in business and industrial networks. Since marine biotechnology

[12]https://orcid.org/

[13]https://www.researchgate.net/

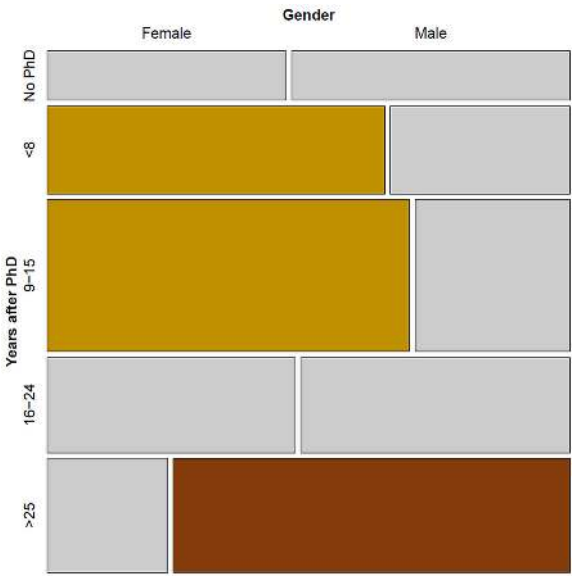

FIGURE 2 | Ocean4Biotech inquiry respondents' data. The plot represents the respondents' categories (gender and seniority level, in science typically denoted by years after obtaining Ph.D.). The area of the squares is proportional to the number of respondents from each of the categories. Colored areas represent overrepresented categories, with categories overrepresented by women colored in yellow, while categories overrepresented by men colored in brown.

aims at increasing the technology readiness level and entering the commercialization stage, many of our respondents (43%) are active on this social media channel. In comparison with the aforementioned channels, the respondents have a lower use of their professional webpages (24%). Unexpectedly, Twitter is not the most popular tool and is used by 27% of the respondents. When refreshing and updating individual Twitter feeds regularly, this media can be a powerful tool, especially for self-promotion and establishing individual brands.

Besides encouraging to publish good science with rigor, we also advise researchers and especially early career researchers to actively maintain at least two social media accounts mainly for the promotion of individual expertise. Moreover, when a collaborative network is launched or funded, the creation and maintenance of social media accounts is a direct channel for promotion of network's achievement, recruitment of new collaborators, increase of global visibility with the scientific, industrial and policy making stakeholders and a potential way for obtaining feedback from the followers.

NETWORKING TO ADVANCE IN MARINE BIOTECHNOLOGY

Similar to many other transdisciplinary scientific areas, marine biotechnology has still not reached its full potential (Rotter et al., 2020). Hence, the respondents were asked to identify the most important reasons behind the challenges that currently prevent a faster advancement of this field. The three main reasons include the funding opportunities, access to expertise and infrastructures and networking/collaboration opportunities. In general, funding opportunities and allocation of funds are the main bottlenecks that prevent advances in research and development, bioresources management, market entry, commercialization and the overall advancement of this field. To ensure more funding opportunities, it is necessary to address the governance levels. This could be done at a national level, regional (e.g., Mediterranean, Atlantic) or international level by establishing collaborations with the policy making sector. Easier access to expertise and infrastructures was also identified as an important obstacle. Hence, opening and sharing data and infrastructures are of high relevance in this field and it corroborates the efforts of the European Commission to promote open science and infrastructures. With enhanced networking opportunities (third most commonly identified bottleneck by the initial respondents), this approach should focus on existing and new collaborations. Our inquiry and the resulting interactive map addresses two out of the three mentioned challenges: by displaying individual expertise and infrastructures, the likelihood of being included in future collaborative networks can be increased.

DISCUSSION

There is a constant search for new collaborative opportunities in science. Ocean4Biotech is a collaborative networking platform that aims to increase the advancements in marine biotechnology, a rapidly developing field with limited networking opportunities. As part of our activities, we launched an inquiry to initiate, promote, and facilitate the dialogue among marine biotechnology actors, stakeholders, including researchers, industry and policy makers from complementary scientific fields, industries and markets. The inquiry was designed to map existing bioresource collections, expertise, equipment, facilities and identify major challenges in marine biotechnology. This first initiative will provide an overview of the current European scenario to give guidelines for sustainable, productive, and profitable marine bioprospecting in Europe. Nevertheless, by maintaining the inquiry (see footnote 8) open for new respondents, we will regularly refresh our inquiry dataset and interactive platform on the website, adding new experts and their expertise, also including countries outside Europe. This will improve the visibility of all marine biotechnology experts, regardless of their seniority level and geographical location and fill the gap of underrepresented disciplines. Hopefully, Ocean4Biotech open access map will become the one-stop-shop for engaging in future collaborations.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/**Supplementary Material**, further inquiries can be directed to the corresponding author/s.

AUTHOR CONTRIBUTIONS

AR participated in finetuning the inquiry, analyzed the data, and drafted the manuscript. SPG designed and organized the inquiry and analyzed the data. KK drafted and coordinated the development of the online interactive platform. J-NM, OPT, ID, CE, ZL, JR, and GCV participated in the inquiry design and its technical finalization. EG-B prepared draft of privacy policy notice. MIV created the online questionnaire and assisted in the preliminary data analysis. All authors contributed to writing, read, edited, and approved the final version of the manuscript.

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SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fmars.2021.685164/full#supplementary-material

Supplementary Figure 1 | Representation of expertise fields from the marine biotechnology experts that filled in the inquiry. The pie area represents the percentage of expertise covered. Note that the respondents could select more than one expertise to allow transdisciplinary experts to showcase their expertise (e.g., bioinformatics and molecular biology).

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Conflict of Interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Supplementary Figure 1. **Representation of expertise fields from the marine biotechnology experts that filled in the inquiry**. The pie area represents the percentage of expertise covered. Note that the respondents could select more than one expertise to allow interdisciplinary experts to showcase their expertise (e.g., bioinformatics and molecular biology).