

Contribution to the Symposium: ‘Marine Socio-ecological Systems Symposium’

Quo Vadimus

Shaping the future of marine socio-ecological systems research: when early-career researchers meet the seniors

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As the environmental issues facing our planet change, scientific efforts need to inform the sustainable management of marine resources by adopting a socio-ecological systems approach. Taking the symposium on “*Understanding marine socio-ecological systems: including the human dimension in Integrated Ecosystem Assessments (MSEAS)*” as an opportunity we organized a workshop to foster the dialogue between early and advanced-career researchers and explore the conceptual and methodological challenges marine socio-ecological systems research faces. The discussions focused on: a) interdisciplinary research teams versus interdisciplinary scientists; b) idealism versus pragmatism on dealing with data and conceptual gaps; c) publishing interdisciplinary research. Another major discussion point was the speed at which governance regimes and institutional structures are changing and the role of researchers in keeping up with it. Irrespective of generation, training or nationality, all participants agreed on the need for multi-method approaches that encompass different social, political, ecological and institutional settings, account for complexity and communicate uncertainties. A shift is needed in the questions the marine socio-ecological scientific community addresses, which could happen by drawing on lessons learnt and experiences gained. These require in turn a change in education and training, accompanied by a change in research and educational infrastructures.

Keywords: dialogue among research generations, future, governance, interdisciplinary science, marine socio-ecological systems, operational research.

Introduction

The way scientific research is structured and carried out in the marine environment and beyond has changed over the last decades (Edgar *et al.*, 2016) as theoretical scientific research increasingly blends with more applied and science-for-policy approaches. Globalization has brought a new economic framework that has led to a shift in scientific orientations to include industrial, commercial and political interests in the academic and research institutions. This shift is set to transform in part the social institution of science and research, making it more responsive to societal and policy needs (Mace, 2014). Potentially positive outcomes of this transformation include initiatives like the Future Earth (<http://futureearth.org/>) or Future Ocean (<http://www.futureocean.org/en/index.php>), which gather researchers

interested in the topic of sustainability and strive to produce science that is relevant to address the planetary requirements for sustainable futures. The current and future research community must confront such shifts and use them to advance research, while striving to make the science understood by all different parties involved. Integrative and interdisciplinary approaches within the science, policy and practice groups are commonly agreed means towards research that is able to achieve societal impact. While we believe this shift is under way, it should, however, not preclude the necessity of fundamental research that is and will remain the foundation of progress and applied research.

Overall, the need for integrated approaches that are based on collaborative scientific research to better inform decision-making is what the global scientific community is faced with (Sutherland

et al., 2012). More interdisciplinary approaches on the way we carry out scientific research are promoted through research calls that are built in inclusive, multi-actor, applied science, promoting also the need to involve early-career researchers. Interdisciplinary, policy-relevant research links theories, methods and skill sets across disciplines, which had previously been pursued independently, to create synthetic understandings (Pickett *et al.*, 1999). In our view, interdisciplinary scientists, or interdisciplinary research teams can be more efficient than disciplinary scientists when it comes to applying policy-relevant research that requires timely responses to policy demands. In the marine environment in particular, the influence of industrial, commercial and political stakeholders in marine scientific research is driven by different policy objectives, like marine spatial planning, fisheries and marine renewable energies regulation, often leading to conflicts between conservation and development of marine and coastal environments (Rice and Legacé, 2007; Hubert, 2011; Hilborn, 2016). To produce relevant science in this evolving context, the human dimension has to be considered in marine socio-ecological system (SES) assessments and knowledge has to be directly linked to action (e.g. Fox *et al.*, 2012), by providing information and guidance that can be used by decision-makers.

Linking epistemologies, theories, methods and skill sets across robust disciplines, to conduct a holistic research approach is not a concept any more, but a mandate for the current, and mostly the future generation of researchers. For instance, the United Nations' Sustainable Development Goal (SDG) number 17 explicitly refers to the need for multi-stakeholder partnership dialogue as a pre-requisite to achieve any of the SDGs (United Nations, 2016).

At the same time, this reference to “futures” also requires investing time and effort to ensure that the future generation of researchers will be able to tackle possible coming challenges. This requirement is now becoming part of policy agendas from a local to regional scales. In particular, in July 2016, the Competitiveness Council of the European Commission has released the Bratislava Declaration of Young Researchers (Competitiveness Council EU, 2016). This Declaration recognizes the role of the younger generation to transform people and society and calls on the senior generation to promote transparent and sustainable career trajectories, collaborative, interdisciplinary, open and ethical research environment. At the same time, a decline in funding and job opportunities along with the increase in early-career researchers' skills intensifies competition (Fang and Casadevall, 2015) and decreases productivity among scientists.

To explore and better understand the complex and interlinked challenges of carrying out interdisciplinary research and how these could be faced by early-career researchers, we set up a workshop aiming to open the dialogue among the different generations of researchers at the symposium on “Understanding marine socio-ecological systems: including the human dimension in Integrated Ecosystem Assessments (MSEAS)” (<http://www.ices.dk/news-and-events/symposia/MSEAS/Pages/Young-researchers-workshop.aspx>). Drawing inspiration from the discussions we had during the workshop we elaborate on the major topics addressed: (i) interdisciplinary research teams vs. interdisciplinary scientists; (ii) data and conceptual challenges among the early-career vs. “work with what you have” vision of the advanced-career researchers; and (iii) publishing interdisciplinary research. With this paper, we share our reflections on the way we see marine socio-ecological systems research being shaped and document

what we believe the future holds for the future generation of researchers.

The setting

We chose the setup of the MSEAS Symposium (30 May–3 June 2016, Brest, France) as a place where we could gather a global community of scientists and practitioners that deal with the assessment of marine SES across multiple ocean uses and sectors including fisheries, renewable energy, coastal development, transport and conservation. We organized a workshop that took place every afternoon, after the end of the main conference sessions, and went beyond the traditional conference format of presenting methods, results and research outcomes, but focused more on knowledge and information exchange among participants through an open dialogue.

During the workshop, 15 international early-career researchers had prepared in advance and presented general research inquiries, specific case studies or methodological or conceptual bottlenecks they encounter and interacted with a group of 47 international (from every continent) senior researchers. The researchers of all nationalities, career stages, were experts on marine socio-ecological systems, with a strong representation of fisheries scientists, economists and ecological modellers, and a smaller but strong representation of social scientists. The topics discussed during the workshop were (i) basic tools and methods for marine SES assessments: indicators, measures and data visualization; (ii) conceptual considerations of marine SES research: the role of Social in SES; and (iii) evidence from the field: research-practice integration.

The discussion

The three topics mentioned above, on tools and methods, concepts and case studies, shaped the discussion among the participants. The types of questions and topics, asked by the early-career researchers, varied from very specific to more conceptual. In Table 1, we provide a summary of the types of answers that were given by the workshop participants. We do not elaborate further on the questions asked *per se*, since for us they were a source of inspiration in order to further discuss the cross-cutting issues that emerged during the meeting.

Two crosscutting issues emerged from the discussions held during the workshop:

- I. *Interdisciplinarity*: Discussions ranged from how do we frame research questions within interdisciplinary science, how “much” of each discipline should we take into account in our research, and how do we actually achieve it?
- II. *Governance regimes and links with policy*: Discussions ranged from how do we account for the different governance regimes linked to the institutions that are relevant to our research questions and how could science inform decision makers towards achieving these objectives at the different spatial, administrative and temporal scales?

We further elaborate on those below, by highlighting the major points that were discussed with an emphasis on the converging and diverging opinions among generations.

Table 1. Questions that emerged during the workshop discussions during the young researchers' workshop (30 May–2 June 2016) and illustrative examples of answers given.

No.	Question	Answer
Q1	How do we value the deep sea?	Question is too broad you need to narrow it down Deep sea has a high existence value
Q2	Integrated coastal zone management: How can we choose efficient indicators? What type of actions can be taken at a state level?	Indicators exist but we miss indicators on human dimension There is no uniformly agreed-upon framework Link with policy if you want this to be more than a scientific exercise Take into account: scale of decision making; and policy relevance for indicator selection.
Q3	How can we take into account stakeholder perception, especially non-scientists? Would game theory be a good tool?	You need to consider complexity and uncertainty Test methods with a small group and then open it to people
Q4	How to improve the vulnerability of a fisheries SES when government doesn't support?	Do some stakeholder mapping Consider doing scenario analysis
Q5	What is the human dimension and how to include it in our analyses?	Narrow down these types of questions Try a bottom up approach rather than a high level top down view of the system Zoom in and out of the system, chose what you want to focus on We need to accept that government wants us to do something, but have no idea. We don't have an idea either
Q6	How can governments grow stewardship and make customary institutions disappear?	Ostrom already addressed this with her common pool resources dilemma
Q7	The hustle of doing interdisciplinary science: Really? This is how it goes?	Pick people you work with. Then, add benefit. If you made the wrong choice, go back. You need to pick the right people who want to engage, but you need to spend time to find them The cure for boredom is curiosity. There is no cure for curiosity. No cure for multi-disciplinarity. You have to learn to be flexible
Q8	Is there room for science in decision -making?	Work together with them and develop model and interdisciplinary approaches together Careers are long. Give time
Q9	How do you establish research priorities in complicated governance regimes?	It is not a 3 year PhD exercise to change an institution
Q10	Subsidies. Preserve biodiversity and maintain livelihoods. How do we combine SES aspects? Do we need to improve data systems?	Work with hidden initiatives is always a challenge
Q11	How can we integrate participatory methods to take action in the future?	Try to minimize externalities
Q12	How much do data and proxies need to account for fisheries sustainability? What are the social aspects of it?	Common problem. Need to involve markets and select species that have good historical records. People's perceptions change depending on who you ask. Link with ethnography/anthropology You need to build trust
Q13	Local ecological knowledge (99% of the fishermen said they don't know anything about). How much should we believe in data?	It's a common problem we've been struggling with for a long time now

I Interdisciplinarity

All topics discussed during the workshop, methodological, conceptual or referring to the links with stakeholders, had a strong interdisciplinary dimension. The topics focused on resources, practices, distribution of costs and benefits and thereby on natural sciences, economics and social sciences. The discussions addressed the challenges faced by the early and advanced career researchers to deal with different practices, paradigms and data. We extracted the main topics discussed where we considered that the perspectives among generations either differed more or converged more.

(a) Interdisciplinary scientists vs. interdisciplinary teams

We identified an apparent transition related to the concept of interdisciplinarity and how this is interpreted and applied by the different generations of researchers.

Our observation was that the more senior generation of researchers are trained to be experts at a single discipline. In their case, to carry out interdisciplinary research, this expertise is being enhanced by an ability to communicate, understand and collaborate with other disciplines. This becomes operational through the formulation of interdisciplinary teams that are able to integrate different information levels. Within the early-career generation of marine researchers, although single-discipline training is the most usual path one selects, more and more interdisciplinary education and training is happening (Ciannelli *et al.*, 2014), leading to scientists who are able to handle methods and concepts from social, economic or ecological disciplines without presenting oneself as being an expert in all these disciplines (e.g. Q7, Table 1). In that regard, the early-career researchers are educated to carry out applied marine science and give more space for dialogue among disciplines than before. In our view, this comes as a natural consequence of many years of research within disciplines

and efforts to carry out an open dialogue among them leading to various projects promoting interdisciplinarity and the inclusion of human dimension in marine sciences (e.g. IMBER[‡], CleanSea[\$], Tara expeditions[*], CLIVAR[††]). It also emerges from a raising recognition of the number of societal issues linked to the marine environment (e.g. economic development, fisheries overexploitation, climate change).

Still the transition to more interdisciplinary-oriented research comes with a recognition of nearly all participants at the workshop that “*life ain't simple; interdisciplinary research either*” as one of the participants mentioned. The above-mentioned transition requires recognition of complex social interactions, a selection of the level of detail in which someone wants to analyze the SES (Aboelela *et al.*, 2007), but also time available. In many cases, researchers need to produce outputs in a very short time, in order to respond to a research question, a policy maker's or practitioner's demand. For instance, one of the early-career participants expressed:

“This is how doing interdisciplinary research worked for me: I first had to find my stakeholders, then I had to meet them and convince them to trust me; then I asked for data and I had to wait for a year to get it; then I constructed/tested/run my models; then I had to understand the social norms that govern my system and interpret my results. Really? This is how it goes?”

Reflecting on that, we argue that to carry out interdisciplinary research, scientists need to be trained to acquire skills that relate to integrating disciplines, bringing people together or making feasibility checks of what is requested by a decision maker in a certain amount of time. Certain curricula of academic institutes already invest resources in making sure that the researchers are trained to interdisciplinarity (Jones and Merritt, 1999). It was really evident during our discussions that for the most senior researchers, these are skills acquired with time and experience.

(b) Idealism vs. pragmatism on data and conceptual gaps

Many early-career researchers presented very specific data and methodological inquiries, but also conceptual questions on how to manage those. Several expressed the need to reconcile ecological and socioeconomic data obtained on very different time scales, overcome some significant data gaps and to integrate, for instance, social with ecological indicators (e.g. Q2, Q3, Table 1).

In most cases, the senior generation of researchers does a synthesis of existing information that is as complete as possible, based on their knowledge and expertise. Then if researchers with complementary expertise could provide information on other aspects of the question right away, they are usually brought in and formulate a research team. If additional data were needed, then partial synthesis was done and other researchers were tasked to collect the missing information in future integrated assessments. The early-career researchers, as emerged from the discussions, seemed to mostly spend time and effort on trying to refine information or fill in data gaps, sometimes at the cost of the completion of the assessment. For instance, some of the workshop participants stated:

“I struggle with collecting enough ecological data to assess the ecological state of fisheries, or socio-economic data to explore issues of sustainable fisheries in my case study”

Similarly, for a socio-ecological assessment, several early-stage researchers seem to struggle a lot with identifying methods and ways to integrate the different types of data. A researcher stated for instance:

“How can I pursue a robust assessment with a mix of social and ecological indicators?”

In fact achieving interdisciplinarity requires also producing interdisciplinary outcomes that account for both the social and the ecological dimension of the marine system under investigation. This in turn requires the use of methods and tools that allow for such integration. However, such tools are not always easy to use and understand and require training. This might not always be feasible within the timeframe of a project or a thesis, which links back to the need to become pragmatic, fact very often highlighted during the workshop by the advanced-career researchers. This is a fact even within single-discipline research, but we argue that as research becomes interdisciplinary the amount of information that needs to be collected increases and also the time to assemble and synthesize it to research outputs, usually increases exponentially.

The conceptual gaps that were discussed were mostly linked to the way a scientist can achieve interdisciplinary research (e.g. Q5, Table 1). The early career researchers were raising issues like:

“What is human dimension for you?”

“Biodiversity, ecosystem services or natural resources: how could I deal with the ecological dimension of socio-ecological systems?”

The discussions mostly focused on improving communication within the research groups and between researchers and relevant stakeholders. It was almost unanimously agreed, irrespective of generation, that an open dialogue among those, is the first step for the integration of knowledge among disciplines. The overarching advice on how to overcome all types of above-mentioned conceptual, methodological and data gaps was the difference in the way interdisciplinary research is carried out by the different generations of researchers. In many cases, the younger generation is—and needs to be—more idealistic, wanting to apply everything they learned “by the book”, while the senior generation has an experience that allows them to evaluate a certain situation, do a reality check and decide what is feasible or not. We do not believe that there is a silver bullet between the two approaches. Still our perception is that we need a combination among the two in order to be able to move science forward while producing robust, useful and policy-relevant outputs.

(c) Publishing interdisciplinary research

Both early and advanced-career researchers recognized the need to target interdisciplinary journals to communicate their research results. The journal selection of course can influence the career of early-career researchers, who believe they have to be selective about where they publish. For instance, one of the early-career researchers raised concerns like:

“I would like to publish to journal X because it’s interdisciplinary, but since it is new, it has no impact factor yet. Therefore it doesn’t give me the credit I need for my doctoral studies.”

Still, more and more interdisciplinary journals are created, while many of the already established journals have adapted their editorial lines to take a more interdisciplinary direction. Indeed, with the decline of ocean resources and ecosystems (Halpern *et al.*, 2008), it became evident that research needs to look beyond the ecosystem and better consider the human–nature interactions. This leads marine science to experience a major turning point in terms of focal research topics, calling for more integrated and interdisciplinary approaches. We believe that pursuing and communicating this type of research requires also the existence of interdisciplinary journals that are able to host that. For instance, many advances in remote sensing technology facilitate data acquisition and mining that can benefit marine research (e.g. Fretwell *et al.*, 2014), but are rarely published in journals of marine science. Similarly, ways to include the human dimension in socio-ecological systems research have been explored since several years now, but are published in journals of broader interest without a dedicated focus on the marine realm (e.g. Klein *et al.*, 2008; Chan *et al.*, 2012; Nassl and Löffler, 2015). The drawback of this is that it might take a longer time for marine scientists to access this technological and scientific knowledge and benefit the way marine SES research is carried out.

II Governance regimes and links with policy

The second overarching topic that kept emerging during the workshop discussions was the way we link scientific research with policy objectives, how much and in what ways we could better involve decision-makers in the process, how we can produce science that is relevant to them and how we can communicate scientific outputs to them. Although this is directly linked with the way interdisciplinary science is carried out, we decided to deal with it separately due to the weight this topic got within our discussions.

(a) Scale and socio-political context

The main message that emerged during the discussions was that the practice of linking science to decision-making and policy requires explicit consideration of institutional, social, political and ecological dimensions of the issue under question. Above all, considering the specific governance regime of the topic under investigation is crucial, since in many cases, especially when dealing with issues like the exploitation of marine resources, such regimes might tackle sensitive political or societal issues (Klain *et al.*, 2014). For instance, several participants of the workshop phrased inquiries like:

“How could I help improve the state of vulnerability of my socio-ecological system, when my government doesn’t support such an action?”

Indeed the socio-political context needs to be taken into account when researchers want to investigate issues that might have practical, real-life applications. Still one needs to consider that marine socio-ecological systems are complex, dynamic, vulnerable and highly diverse (Jentoft *et al.*, 2007). Such systems are hard to measure and quantify and there is a lot of inherent uncertainty

within the models used to measure each of the ecosystem component. Such a level of uncertainty increases during the integration phase that combines, in that case, social, ecological components of the system. The level of uncertainty changes depending on the approach used, the available data and methods, but also the scale of assessment. Still, for research to be able to provide useful information to policy and decision-making, that uncertainty needs to be quantified and communicated to policy and decision-makers.

The discussion also leaped around effectively linking scientific research with policy objectives as something that is deeply dependent on the ecosystem and administrative scale researcher focuses on. This can facilitate the way SESs may represent complex networks of resource users linked across scales through multi-level governance arrangements (Janssen *et al.*, 2007; Apostolopoulou *et al.*, 2012). A very clear recommendation that emerged during the workshop was that defining the scale of focus can help research define the way questions are formed, methods are selected and data are collected.

(b) Multi-objective and changing governance regimes

Another topic linked to governance regime that emerged from the discussions was the misuse of scientific advice by decision-makers. In many cases, scientists are called to generate science that can end up being used to assess and evaluate multiple policy and management objectives, even if the initial intent was more targeted to a specific issue. This fact triggered the development of integrative frameworks like Integrated Coastal Management (ICM) or Ecosystem-Based Management (EBM) that require an interdisciplinary approach to design, evaluate and adapt such frameworks to specific locations (Ruckelshaus *et al.*, 2008; Christie, 2011). For instance, a type of question that was raised was:

“How can we sustainably integrate participatory methods to help us take immediate action in future institutional-political change?”

Such types of questions brought interesting reactions of the workshop participants. Interestingly enough, there seemed to be a nearly unanimous reaction to these issues irrespective of scientific background or experience in research and academia. Such a context puts the sustainability of research outputs under question since in many cases, the role of institutions and their priorities are changing. For instance, Marine Protected Areas (MPAs) are instruments whose role has been changing with time: from management instruments that promote long-term conservation of natural resources, they become flexible and adaptive to societal needs (Agardy *et al.*, 2003; Barr and Mourato, 2009). They have come to involve the human dimension in the way they are managed and prioritized, and their mandates are evolving to include the benefits humans receive from them directly, through fisheries for instance, or indirectly, through existence value of keystone species within their boundaries (Gruby *et al.*, 2015).

Overall, policies are transitioning from single objective to multiple objectives (Spangenberg and Settele, 2010; Wang *et al.*, 2012; Townsend *et al.*, 2014). This poses a major challenge since many existing governance structures were created in the past to deal with a single domain, like fisheries or water quality. The current needs to integrate multiple perspectives go beyond that and need coordination and open dialogue among the different institutions.

The workshop dialogue began to explore whether it is sufficient to have better coordination of existing governance structures or if new more inherently integrative structures are necessary as well as the degree to which the scientific community could influence those aspects of governance. However, the question was far larger than what the workshop could address.

The high-level conclusion on this topic was that science needs time to move forward and inform or influence decision-making (e.g. Q8, Table 1). At the same time, one needs to accept the limitations of research and the future generation is called to suggest paths for future research that will be focusing on addressing this type of research gaps and questions (e.g. Q9, Table 1).

Major conclusions and ways forward

Policy-relevant socio-ecological systems research is moving forward and becomes increasingly sophisticated as new frameworks emerge and new ideas are discussed (McGinnis and Ostrom, 2014). In the marine realm, progress is happening (Leenhardt *et al.*, 2015), substantially aided by open dialogue among scientists from different disciplines, but also among scientists, practitioners and decision-makers. Based on the discussions we had during the workshop and considering the major topics that emerged, we put together a framework that highlights the major elements that we need to consider in marine socio-ecological systems research, irrespective of generation (Figure 1). It ensures that the research outputs can relate to practice and are policy relevant. The framework identifies the areas where change needs to happen in order for the researchers to be able to address current and future research needs. In particular, it highlights the need for interdisciplinary training as a tool that allows researchers to reframe their research questions and adapt the research approaches to keep up with the ongoing transitions of marine SES. In particular, the framework shows the pathways that lead to operational, policy-relevant and interdisciplinary research in marine socio-ecological systems: ecological, economic and social knowledge together can inform interdisciplinary research. To do so, uncertainty and complexity of the system assessed ought to be considered (Langford *et al.*, 2009; Shi *et al.*, 2009). On the other side of things, policy mandates for research need to be interpreted to research needs that consider the governance regimes, the community structure and the different stakeholders involved. This framework reflects the process followed to carry out a SES research, by giving emphasis on “what it takes” to shift to a more interdisciplinary way of carrying out applied marine SES research.

Based on the discussions that emerged during the workshop, researchers need to change the way we approach policy-relevant marine SES research by (i) reframing the questions we ask in the current socio-political context and (ii) changing our approach by adapting existing tools and methods or by generating new ones. Overall, the major outputs of our discussion and the way we see the marine SES research future is summarized in the points below:

- We can achieve interdisciplinary research by ensuring that the emerging generation of researchers receives training that allows them to facilitate interdisciplinary dialogue.
- As new policy and societal needs emerge, researchers need to reframe the research questions they ask and adapt their methods and approaches.

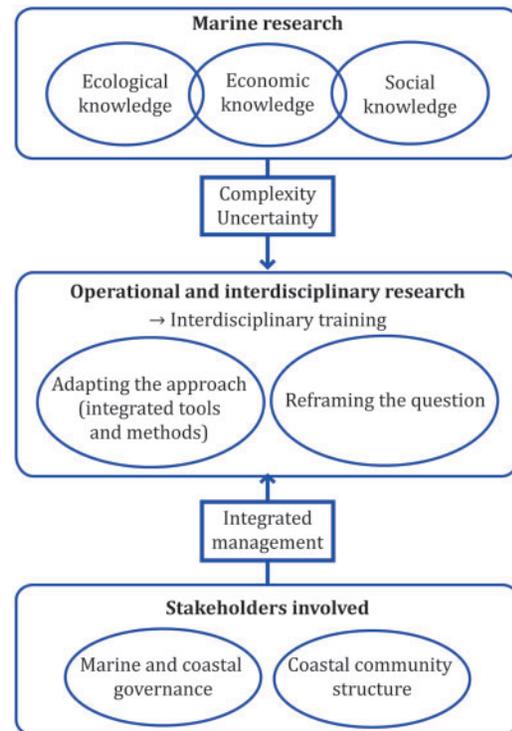


Figure 1. The conceptual framework inspired by the discussions held during the workshop. It shows the two pathways that lead to operational and interdisciplinary research in marine socio-ecological systems. On the top box, it shows that ecological, economic and social knowledge together can inform interdisciplinary research. To do so, accounting for uncertainty and complexity of the system assessed, is essential. On the bottom box, it shows that policy requirements need to consider the governance regimes, the community structure and the different stakeholders involved, in order to inform interdisciplinary research through integrated management. The ongoing changes in socio-political and environmental context require interdisciplinary training and also (i) reframing the questions we ask in the current socio-political context and (ii) changing our approach by adapting existing tools and methods or by generating new ones that could address the current and future research needs.

- To reframe those research questions, researchers need to build on the experience and knowledge available, be transparent and communicate uncertainties and gaps identified within existing research.
- Irrespective of expertise or generation, scientists also need to ensure that the language used that is tailored to the different target audiences or stakeholder groups, whether these are local decision makers or high level policy officers.
- To ensure that the research produced and communicated to decision-makers is operational, the degree of uncertainty of research findings needs to be communicated. That will allow for sound decision-making, but can also help trigger new research calls.
- The transition happening requires also a reform in the governance regimes. Whether this needs to happen through a better coordination of existing structures, or through the emergence of new ones, remains an open question.

- For all the above to be achieved, an open dialogue among research generations is required and initiatives that bring those together should be promoted by scientific associations. The workshop linked to this short opinion paper is an example of such an initiative, aiming at bringing together different types of researchers and practitioners, from a range of generations. Still, such initiatives are rarely encountered in scientific meetings, since they require significant amount of organization in advance, but also additional financial resources.

Such findings echo the key needs for marine scientists to be prepared for the unexpected, to increase collaboration across disciplinary boundaries and to understand our cognitive limitations (Österblom *et al.*, 2016). A quote by one of the senior researchers that attended the workshop summarizes well the major task of the next research generation:

The younger generation has to reframe the questions. The context has changed and you cannot be asking the same questions that our generation did. You should change your approach accordingly.

To conclude, we argue that to achieve all the above, researchers need to realize that there are no “super-human” scientists who can do everything. Teamwork—by team we refer to any research group that merges disciplines, creates space for dialogue, is open to ideas of early-career researchers—is essential to make science move forward. And to achieve this, education from the high-school level is required (Ciannelli *et al.*, 2014). That can happen through training activities, summer schools, scientific conferences or workshops like the one this opinion piece is inspired from. A major bottleneck is the high cost of such activities, which is restrictive for every generation, but particularly the younger one. Above all, interdisciplinary research is required to produce operational science that has an impact in real life. For this to be achieved, it takes an institutional reform, change in education and training and mindset, and also the creation of infrastructures (e.g. technological, scientific and educational) that are able to accommodate such a change. There is a pressing need to do this now and it is a responsibility of all generations to push towards this direction. We hope that initiatives like the one we took will keep happening with the aim to break institutional, generational and disciplinary boundaries, and in order to promote innovation in research and practice.

Our discussions during the workshop triggered lots of thoughts and raised many interesting questions on how marine SES research is moving forward, what it takes for a researcher to pursue robust research, what works well or not and what can future generations of researchers do to move things forward. Certainly, within this workshop and a short opinion paper, it is not possible to respond to all these questions. We see this opinion piece, as a conversation starter with multiple objectives and target audiences. In particular what we expect the readers to get out is (i) a call for more interaction among generations of researchers (e.g. within scientific meetings); (ii) an acknowledgement of the transformation that is happening on marine socio-ecological systems, which also requires a transition on the way research, training and education are pursued; and (iii) an awareness that this opinion piece and the workshop linked with it perhaps raised more questions than those that were actually answered, evidence of how productive and thought provoking such exchanges are.

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