frontiers | Frontiers in Marine Science

PERSPECTIVE
published: 18 April 2022
doi: 10.3389/fmars.2022.809284

Check for updates

Transdisciplinary Research: Can Citizen Science Support Effective Decision-Making for Coastal Infrastructure Management?

Sonya Agnew*, Kathrin Kopke, Orla-Peach Power, María Del Camino Troya and Amy Dozier

Centre for Marine and Renewable Energy, Environmental Research Institute, University College Cork, Cork, Ireland

OPEN ACCESS

Edited by:
Lyne Morissette,
M – Expertise Marine, Canada

Reviewed by:
Lucia Fanini,
Institute of Marine Biological Resources and Inland Waters, Hellenic Center for Marine Research, Greece
Robert Eliakim Katikiro,
University of Dar es Salaam, Tanzania
Benoît Pirenne,
University of Victoria, Canada

****Correspondence:***
Sonya Agnew
sagnew@ucc.ie

Specialty section:
This article was submitted to Marine Affairs and Policy, a section of the journal Frontiers in Marine Science

Received: *04 November 2021*
Accepted: *28 February 2022*
Published: *18 April 2022*

Citation:
Agnew S, Kopke K, Power O-P, Troya MDC and Dozier A (2022) Transdisciplinary Research: Can Citizen Science Support Effective Decision-Making for Coastal Infrastructure Management? Front. Mar. Sci. 9:809284. doi: 10.3389/fmars.2022.809284

Stakeholder engagement is increasingly recognised as imperative for developing effective climate change adaptation policy within the EU, particularly for delivering sustainable coastal infrastructure. This perspective discusses how current transdisciplinary research (TDR) approaches concerning ecoengineering solutions for artificial coastal structures are insufficient in ensuring adequate stakeholder engagement to facilitate coherent and enduring decision-making and policy development processes. Socio-cultural analysis focussing on how people view and feel about artificial coastal infrastructure within coastal infrastructure research has been recognised as a large knowledge gap. We suggest that citizen science (CS) methodologies as part of a cultural ecosystem services (CES) research approach can adequately inform and support the implementation of ecoengineering solutions for hard artificial coastal structures whilst addressing existing barriers associated with stakeholder engagement in current TDR approaches.

Keywords: transdisciplinary research, stakeholder engagement, citizen science (CS), cultural ecosystem services (CES), ecoengineering, coastal infrastructure

INTRODUCTION

Coastal ecosystems worldwide are impacted by a range of cumulating pressures including increasing urbanisation, industrial development, recreation, and tourism (Bulleri and Chapman, 2010; Firth et al., 2016; Strain et al., 2017) and are particularly vulnerable to the impacts of climate change, such as increased storminess, sea-level rise, and erosion (Cheong et al., 2013; Firth et al., 2016; Environmental Protection Agency, 2018). Consequently, artificial structures such as jetties, harbours, and marinas and defence mechanisms such as seawalls, groynes and riprap are necessary to support and protect coastal communities (Firth et al., 2013). The proliferation of this infrastructure has led to widespread coastal hardening contributing to changes in the coastal environment (Crowe and Frid, 2015; Firth et al., 2016; Bishop et al., 2017; Evans et al., 2019) such as resource depletion, habitat degradation, and species loss (Cigliano et al., 2015; Firth et al., 2016).

Academic focus has progressively sought to address the complexity of these issues through the development of nature-based solutions (Bulleri and Chapman, 2010; Firth et al., 2013). One recent approach considers the application of novel ecoengineering (also known as “ecological engineering”) mechanisms that aim to enhance biodiversity on hard coastal structures

(Evans et al., 2019; Natanzi et al., 2021). Ecoengineering involves the inclusion of enhancements that can be retrofitted to existing structures, or incorporated into planned structures to provide habitat for native species, enable habitat complexity, and address the negative impact of artificial structures along coastlines (Cheong et al., 2013; Firth et al., 2014, 2016; Daffron, 2017; Ware and Callaway, 2019; Airoldi et al., 2021; Natanzi et al., 2021).

Research into ecoengineering solutions for coastal artificial structures has predominantly focussed on the development of interventions and enhancements within an ecological and environmental context (Evans et al., 2015; Firth et al., 2016; Strain et al., 2017; Whelchel et al., 2018; O'Shaughnessy et al., 2020) and while nascent research has begun to emphasise the importance of stakeholder perspectives, perceptions and input (Evans et al., 2017; Gray et al., 2017; Kienker et al., 2018; Strain et al., 2019; Ware and Callaway, 2019), this remains limited.

Yet, stakeholder engagement embedded in eco-sociological research plays an important role in addressing complex socio-environmental issues in coastal and marine research, including: marine litter (Veiga et al., 2016; Black et al., 2019a); ocean literacy (Santoro et al., 2018); sustainable marine spatial planning and governance (Jentoft et al., 2012; Soma et al., 2014; Giakoumi et al., 2018; Twomey and O' Mahony, 2018; Mannan et al., 2020; O'Keeffe et al., 2020; Flynn et al., 2021). Engaging multi-perspective stakeholders can provide researchers with the opportunity to incorporate insight and knowledge from diverse groups (Waltham and Sheaves, 2015; Ryfield et al., 2019; Cabana et al., 2020) and presents a platform to communicate research beyond the limitations of the scientific world (O'Shaughnessy et al., 2020). For ecoengineered artificial coastal interventions to be successful, we argue that citizen science methods as part of a nested approach (see **Figure 1**) can facilitate dialogue across diverse stakeholder groups (Firth et al., 2016; Evans et al., 2017; Strain et al., 2019; O'Shaughnessy et al., 2020), and that the fundamental principles of transdisciplinary research (TDR) are best equipped to achieve this.

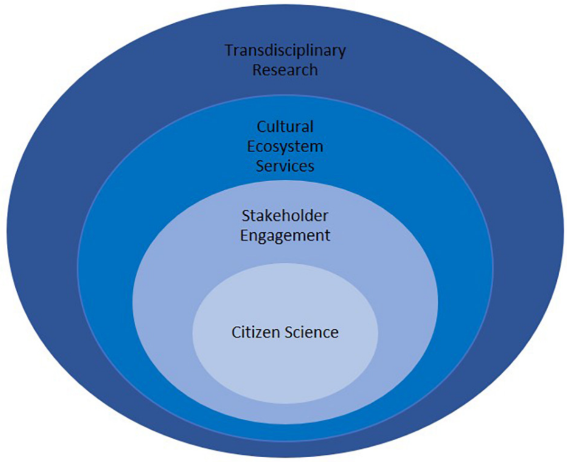

FIGURE 1 | Graphical representation of nested relationship between citizen science, stakeholder engagement, cultural ecosystem services, and transdisiplinary research.

TRANSDISCIPLINARY RESEARCH

Transdisciplinary Research (TDR) is "at once between the disciplines, across the different disciplines, and beyond all discipline" (Nicolescu, 2005, p. 4) and represents a significant paradigm shift in research emphasis, building on multi- and inter-disciplinary approaches, and facilitates a move beyond disjointed academic positioning to establish unified outlooks on specific issues (The United Nations Educational Scientific and Cultural Organization [UNESCO], 1998; von Wehrden et al., 2019). Although discourse on the need for synergies in research through TDR emerged in 1970, the concept was not fully embraced on an international platform for a further two decades. The Charter on TDR was established at the First World Congress on Transdisciplinarity (1994) in response to urgent calls from the UN Earth Summit in Rio de Janeiro 1992 for new research agendas to address global environmental crises and develop cohesive sustainability pathways (Bernstein, 2015). Alongside reaching beyond the boundaries of any one academic field or discipline (Klein et al., 2001; McGregor, 2004; Hirsch Hadorn et al., 2008; European Commission [EC], 2014b; Wickson and Carew, 2014; von Wehrden et al., 2019), TDR aims to integrate diverse societal perspectives (Hirsch Hadorn et al., 2008; Cundill et al., 2015; Pettibone et al., 2017; Rigolot, 2020), which can include governmental decision makers, commercial and industry stakeholders, civil-society stakeholders, community-based organisations, and NGOs, in addition to diverse academic disciplines (Bracken et al., 2015; United Nations [UN], 2017; Twomey and O' Mahony, 2018; Vienni Baptista et al., 2019; von Wehrden et al., 2019). Increasingly encouraged in academic research, particularly in relation to the natural environment (Bracken et al., 2015; von Wehrden et al., 2019), TDR seeks to address practical "real world" problems (Klein et al., 2001; McGregor, 2004; Robinson, 2008; Arnold, 2013; European Commission [EC], 2014b; Wickson and Carew, 2014) including the pressures of climate change (Godemann, 2008; Lang et al., 2012; Scholz, 2020).

Stakeholder engagement has been widely acknowledged within environmental EU legal and policy frameworks as a cornerstone in developing effective and coherent policymaking (Darvill and Lindo, 2016; Twomey and O' Mahony, 2018; Schneider et al., 2019; OECD, 2020). As a result of the Rio Declaration (1992; see Principle 10 and Agenda 21), a multilateral environmental agreement known as The Aarhus Convention (UNECE Convention on Access to Information, Public Participation in Decision-making and Access to Justice in Environmental Matters) (1998) was adopted in 1998. This agreement entered into force in 2001 and was subsequently ratified by the EU in 2005. More recently, the 2030 Agenda for Sustainable Development stressed the importance of public participation in achieving sustainability and environmental protection (United Nations [UN], 2015). Goal 16 calls for "responsive, inclusive, and participatory and representative decision-making at all levels" (United Nations [UN], 2017, p. 25). The environmental regulatory framework of the EU, as established within the EC's Better Regulation Guidelines SWD

(2017) 350, has embedded stakeholder engagement into the legal and policy making process, requiring a 12-week public consultation for major policy initiatives. Public consultation requirements for example are specified within the Environmental Impact Assessment Directive (85/337/EEC) as amended by 97/11/EC), the Water Framework Directive (2000/60/EC), the Marine Strategy Framework Directive (MSFD) (2008/56/EC), and the MSP Directive (2014/89/EU) (European Commission [EC], 1985, 1997, 2000, 2008, 2014a). Such processes require support across society to be successful (de Groot and Schuitema, 2012; Black et al., 2019b) and need to be underpinned by relevant environmental research that includes social dimensions.

Current approaches concerning the extent that civil society and stakeholders are included and engaged differ between EU environmental, legal, and policy frameworks (Black et al., 2019b). TDR presents an opportunity to enhance the science-policy interface, but to fully realise the potential of TDR and engage society in research-driven solutions, consideration of who contributes to scientific research, "what does and does not belong to scientific knowledge" (Regeer and Bunders, 2009, p. 54), and an unpacking of how diverse perspectives and values are considered and evaluated in decision making processes is required (Regeer and Bunders, 2009). Funding bodies seeking to address these shortfalls have therefore increasingly recommended that applied environmental research generate, facilitate, and incorporate diverse and equally legitimate knowledge beyond the academic sphere within the decision making process to establish effective and relevant policies (Pohl, 2008; Mobjörk, 2010; Bracken et al., 2015; IPBES, 2019; Vienni Baptista et al., 2019).

CULTURAL ECOSYSTEM SERVICES

Ecosystem services (ES), conceptualised by the Millennium Ecosystem Assessment [MEA] (2005), are the diverse values and services that ecosystems provide to humanity and are increasingly used in research to support decision-makers and develop policy Millennium Ecosystem Assessment [MEA], 2005; Darvill and Lindo, 2016; Irvine et al., 2016). Cultural ecosystem services (CES) are one focal point for the realisation of such aims. CES encompass societal factors and can be broadly conceived of, as the contributions by ecosystems in generating knowledge and supporting human experiences (Millennium Ecosystem Assessment [MEA], 2005; Satterfield et al., 2013; Ryfield et al., 2019). Moreover, a CES approach can provide a framework to advance the integration of different academic disciplines, and support both the inclusion of heterogenous and localised perspectives, and collaborative efforts with stakeholders to address complex environmental issues (Milcu et al., 2013; Ghorbanzadeh and Björkqvist, 2019; Ryfield et al., 2019; Gould et al., 2020).

However, CES does not provide a "magic wand" solution which guarantees the comprehensive inclusion of stakeholder values in decision-making processes. In fact, the effectiveness and applicability of the ES framework, specifically in relation to CES, has been the topic of much scholarly debate (Fish et al., 2016; Kirchhoff, 2019; Gould et al., 2020). Commentators have noted CES are less embedded in natural science studies than other ES categories, and despite the importance of community support for ecological interventions, a robust understanding of what people value, particularly where there is no clear indication of material benefit (Small et al., 2017), is often not effectively explored or relayed to decisionmakers (Chan et al., 2012; Canedoli et al., 2017). In exploring socio-cultural values held by stakeholders (Ryfield et al., 2019), CES data is characteristically subjective, context dependent and intangible, and captures values such as aesthetics, spiritual values, and sense of place (Daniel et al., 2012; Plieninger et al., 2013; Small et al., 2017; Chaudhary et al., 2019; Ryfield et al., 2019), and is commonly explored using qualitative methods which are primarily embedded within social science paradigms (Chan et al., 2012; Tengberg et al., 2012; Canedoli et al., 2017; Ryfield et al., 2019; Gould et al., 2020).

Academic literature has begun to unpack some of the barriers in CES driven research such as data collation and interpretation, as associated data has been reported as difficult to categorise or isolate (Milcu et al., 2013; Gould et al., 2019), is less quantifiable compared to natural sciences, frequently difficult to measure (often omitted from traditional valuation analysis processes) (Small et al., 2017), and present barriers to achieving the synergy required within TDR. Thus, there is an urgent need to address existing and entrenched disciplinary ontological differences to enable the transition from current "epistemological sovereignty" (Miller et al., 2008, p. 8) toward effective and robust pluralistic approaches.

Cultural ecosystem service provides opportunities to examine and understand the relationships, perceptions, cultural practices, and identities people have in relation to an ecosystem of interest (Daniel et al., 2012; Gould et al., 2019, 2020; QUB, 2020) and can ensure the necessary reflexivity, clarity, and rigour, to support effective stakeholder engagement in the research process (Milcu et al., 2013; Katz-Gerro and Orenstein, 2015; Gould et al., 2020). Previous CES studies have included discussions on cultural heritage values, identity, and the spatial and temporal dynamics of place to inform sustainable planning and decision-making (Tengberg et al., 2012; Ryfield et al., 2019; Cabana et al., 2020). These inquiries typically utilise tailored research approaches that may involve a mix of primary data collection methods (i.e., community level interviews, participatory events, GIS and remote mapping, focus groups with decision-makers, and community surveys), and secondary data (i.e., census data, geographical databases) that enable the inclusion of wider and more heterogenous populations, thus allowing for multi-criteria analysis (Ruskule et al., 2018; Chen et al., 2019; Santarém et al., 2020; Clarke et al., 2021). With this in mind, we present the role of citizen science (CS) mapping of artificial coastal structures through a CES lens to enhance stakeholder engagement in decision-making processes thus meeting a primary goal of transdisciplinary research.

CITIZEN SCIENCE

Citizen science is a dynamic and rapidly divergent field of research and is perceived as a tool that can support public engagement and interaction in policy and decision-making processes specifically concerning environmental concerns (Irwin, 1995; Purdam, 2014; ECSA, 2015; Vann-Sander et al., 2016; Garcia-Soto et al., 2017). Here, members of the public or non-professional scientists participate in data-gathering projects by recording observations, transcribing information, georeferencing datasets, or mapping (Purdam, 2014; ECSA, 2015; Ryfield et al., 2019; Tauginienė et al., 2020). Benefits of CS as a methodology are multifaceted and have been shown to expand the range of stakeholder inclusion in processes (Vann-Sander et al., 2016; Owen and Parker, 2018). Namely, CS can make specific issues like management or conservation of coastal heritage more accessible and relevant to the wider public, and can create a deeper understanding among participants of associated environmental challenges such as the impacts of climate change on coastal heritage (Dawson, 2014). Such actions have been demonstrated to drive community-based citizen initiatives, enabling direct discourse between citizens and local decision-makers (Owen and Parker, 2018), while facilitating new collaborative pathways between members of the public, NGOs, scientists, and decision-makers (Vann-Sander et al., 2016; Tauginienė et al., 2020). This has been used as an instrument to advance political agendas within the public sphere through both formal and informal avenues (Schade et al., 2021).

Citizen science is increasingly recognised as a pathway for enhancing stakeholder engagement in decision-making processes and the exchange of knowledge between academic and non-academic groups (ECSA, 2015; Tauginienė et al., 2020). This is evident, for example, through EU support for CS in both FP7 and Horizon 2020 funding programmes through for example the *Science for and with Society* programme (2018–2020), and more recently in the *Best Practices in Citizen Science for Environmental Monitoring programme* European Commission [EC], 2020a). Ongoing support for CS as a participatory tool is also signalled in the EU's recent document *Prepare Europe for climate disruptions and accelerate the transformation to a climate resilient and just Europe 2030,* which recommends cooperation between researchers, citizens, governments and industry to support the communication and education of climate risks and solutions whilst facilitating the reconciliation of different viewpoints and values where possible (European Commission [EC], 2020b). Notwithstanding the growing interest in applying CS approaches to stakeholder engagement, the application of CS within academic research frequently remains limited to singular disciplines and its potential within TDR remains underexplored (Hecker et al., 2018).

It can be argued that disciplinary entrenchment of CS, including the accessibility and publication of CS driven data, contributes to siloing in research design, epistemological stagnation, and science-centric emphasis. Indeed, while CS approaches are also applied within the arts, humanities, and social sciences (AHSS) (Dawson et al., 2014; Dobreva et al., 2015; Butkevičienė et al., 2021; Heinisch et al., 2021), they are less evident within scholarly literature when compared with scientific publications in the natural sciences (Vann-Sander et al., 2016; Tauginienė et al., 2020). Recent analysis within a European context revealed that 80% of CS research occurs within natural sciences and 11% within AHSS (Hecker et al., 2018). Moreover, both CS and CES are challenged by a prevailing methodology that favours natural science-based approaches to data collation and interpretation (Tengberg et al., 2012; Fish et al., 2016; Vann-Sander et al., 2016; Gould et al., 2019; Ryfield et al., 2019). However, there have been significant advances in the area of CES classification (Millennium Ecosystem Assessment [MEA], 2005; TEEB, 2010; Haines-Young and Potschin, 2013, 2018), which help provide in-depth understanding of local community perceptions and values, which can be applied to investigations around artificial structures and ecoengineered enhancements along coastlines. Concurrently, novel CS approaches are also emerging across disciplines and moving beyond a hitherto predominantly terrestrial arena, with increasing uptake of CS in coastal and marine research areas (Garcia-Soto et al., 2017; Fulton et al., 2019). Innovative methods of data collection mapping—enabled through new and evolving digital technologies—can improve reach, communication, and engagement with participant stakeholders, alongside facilitating broader participant heterogeneity (Urválková and Janoušková, 2019). CS methodologies have been applied in both the natural sciences, e.g., the Capturing Our Coasts project (Hyder et al., 2015; Vye et al., 2020), and AHSS disciplines areas such as the GIRT (Viduka, 2020), ShoreUPDATE (Dawson et al., 2014), and SeaSketch (Jarvis et al., 2015) projects. Similarly, digital mapping processes to gather data such as through geotagging of landscape aesthetics and recreational activities (Lee et al., 2019), crowdsourcing imagery to ascertain locations of recreational value (Gliozzo et al., 2016), identifying significant tourist sites to inform MSP policy (Ruskule et al., 2018), and co-authored mapping that examines cultural activities and participant perceptions of coastal ecological health (Ryfield et al., 2019). CS can be used to identify which CES are important to stakeholders, whilst fostering inclusive and transparent pathways in decision-making (Daily et al., 2009; Schröter et al., 2017) within a TDR approach. Such approaches can be utilised to examine and interpret how decisions—such as the introduction of hard artificial structures or enhancements thereon—are (potentially) received by local communities, providing researchers with indications of palatable solutions within coastal planning and policy development.

CONCLUDING THOUGHTS

While our understanding and knowledge of how ecological engineering approaches can enhance biodiversity on artificial coastal infrastructure has advanced in recent times (Firth et al., 2016; Evans et al., 2017), associated TDR research on effective stakeholder engagement to support the realisation of such interventions has not been utilised to its full potential, specifically in relation to engaging local coastal communities that inhabit the coastal areas of research interest. Furthermore, TDR can support greater reciprocity among decision-makers and through adequate planning and funding can facilitate resource provision at the institutional level for capacity building, e.g., between disciplines and between institution and external actors (Vienni Baptista et al., 2019). Yet, it is also challenged by concerns about the effectiveness of TDR methods in generating multifaceted stakeholder-based evidence to feed into decision-making and policy formulation processes (Vienni Baptista et al., 2019). In order to fully realise the potential of TDR, the academic community must re-evaluate current methods of knowledge production to and develop adequate integrative research models (Regeer and Bunders, 2009; Guimarães et al., 2019).

The concept of CES is well positioned to contribute to TDR approaches and can provide a framework in which to engage diverse stakeholders when addressing environmental problems (Milcu et al., 2013; Katz-Gerro and Orenstein, 2015). By integrating CS methodologies and applications stakeholder engagement can be facilitated within ecoengineering research in coastal areas e.g., allowing for participatory mapping of artificial coastal structures and habitats, while potentially opening decision-making processes to stakeholder input and interaction, thus meeting a primary goal of TDR. CS is an established and valuable methodological tool utilised across many academic fields and has the potential to provide a common ground for coherent and effective TDR in finding informed solutions to "real world problems." Thus, a CS application that is employed through a CES lens can provide a bridge between frequently juxtaposed academic disciplines as well as between academic and non-academic communities in supporting TDR aims.

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

SA and KK led the work on literature review and discussion and conclusion. O-PP, AD, and MT contributed significantly to discussion and conclusions. All authors conceived and explored the idea together.

FUNDING

This research was funded through the Ecostructure Project. The Ecostructure is part-funded by the European Regional Development Fund (ERDF) though the Ireland-Wales Cooperation programme 2014–2020.

ACKNOWLEDGMENTS

We would like to thank our Ecostructure colleagues at Aberystwyth University, Swansea University, Bangor University in Wales and University College Dublin and MaRei in Ireland.

REFERENCES

Airoldi, L., Beck, M. W., Firth, L. B., Bugnot, A. B., Steinberg, P. D., and Dafforn, K. A. (2021). Emerging solutions to return nature to the urban ocean. *Annu. Rev. Mar. Sci.* 13, 445–477. doi: 10.1146/annurev-marine-032020-020015

Arnold, M. (2013). "Transdisciplinary Research (Transdisciplinarity),"in *Encyclopedia of Creativity, Invention, Innovation and Entrepreneurship*, ed E. G. Carayannis, (New York, NY: Springer). doi: 10.1007/978-1-4614-3858-8_337

Bernstein, J. (2015). Transdisciplinarity: A review of its origins, development, and current issues. *J. Res. Prac.* 11:R1.

Bishop, M. J., Mayer-Pinto, M., Airoldi, L., Firth, L. B., Morris, R. L., Loke, L. H., et al. (2017). Effects of ocean sprawl on ecological connectivity: impacts and solutions. *J. Exp. Mar. Biol. Ecol.* 492, 7–30. doi: 10.1016/j.jembe.2017.01.021

Black, J. E., Kopke, K., and O' Mahony, C. (2019a). Towards a circular economy: using stakeholder subjectivity to identify priorities, consensus, and conflict in the Irish EPS/XPS market. *Sustainability* 11:6834. doi: 10.3390/su11236834

Black, J. E., Kopke, K., and O'Mahony, C. (2019b). A trip upstream to mitigate marine plastic pollution - A perspective focused on the MSFD and WFD. *Front. Mar. Sci.* 6:689. doi: 10.3389/fmars.2019.00689

Bracken, L. J., Bulkeley, H. A., and Whitman, G. (2015). Transdisciplinary research: understanding the stakeholder perspective. *J. Environ. Plann. Man.* 58, 1291–1308. doi: 10.1080/09640568.2014.921596

Bulleri, F., and Chapman, M. G. (2010). The introduction of coastal infrastructure as a driver of change in marine Environments. *J. App. Ecol.* 47, 26–35. doi: 10.1111/j.1365-2664.2009.01751.x

Butkevičienė, E., Skarlatidou, A., Balázs, B., Duží, B., Massetti, L., Tsampoulatidis, I., et al. (2021). "Citizen science case studies and their impacts on social innovation," in *The Science of Citizen Science*, eds K. Vohland, A. Land, L. Ceccaroni, R. Lemmens, J. Perelló, M. Pontiet, et al. (Switzerland: Springer), 309–329. doi: 10.1007/978-3-030-58278-4_16

Cabana, D., Ryfield, F., Crowe, T., and Brannigan, J. (2020). Evaluating and communicating cultural ecosystem services. *Ecosyst. Serv.* 42:101085.

Canedoli, C., Bullock, C., Collier, M. J., Joyce, D., and Padoa-Schioppa, E. (2017). Public participatory mapping of cultural ecosystem services: citizen perception and park management in the Parco Nord of Milan (Italy). *Sustainability* 9:891. doi: 10.3390/su9060891

Chan, K. M. A., Guerry, A. D., Balvanera, P., Klain, S., Satterfield, T., Basurto, X., et al. (2012). Where are cultural and social in ecosystem services? A framework for constructive engagement. *BioScience* 62, 744–756. doi: 10.1525/bio.2012.62.8.7

Chaudhary, S., McGregor, A., Houston, D., and Chettri, N. (2019). Spiritual enrichment or ecological protection? A multi-scale analysis of cultural ecosystem services at the Mai Pokhari, a Ramsar site of Nepal. *Ecosyst. Serv.* 39, 1–10. doi: 10.1016/j.ecoser.2019.100972

Chen, X., de Vries, S., Assmuth, T., Dick, J., Hermans, T., Hertel, O., et al. (2019). Research challenges for cultural ecosystem services and public health in (peri-)urban environments. *Sci. Total Environ.* 651, 2118–2129. doi: 10.1016/j.scitotenv.2018.09.030

Cheong, S. M., Silliman, B., Wong, P. P., van Wesenbach, B., Kim, C. K., and Guannal, G. (2013). Coastal adaptation with ecological engineering. *Nat. Clim. Chang.* 3, 787–791. doi: 10.1038/nclimate1854

Cigliano, J., Meyer, R., Ballard, H., Freitag, A., Phillips, T., and Wasser, A. (2015). Making marine and coastal citizen science matter. *Ocean Coast. Manage.* 77:115. doi: 10.1016/j.ocecoaman.2015.06.012

Clarke, B., Thet, A. K., Sandhu, H., and Dittmann, S. (2021). Integrating Cultural Ecosystem Services valuation into coastal wetlands restoration: A case study from South Australia. *Environ. Sci. Policy* 116, 220–229. doi: 10.1016/j.envsci.2020.11.014

Crowe, T. P., and Frid, C. (2015). *Marine Ecosystems: Human Impacts on Biodiversity, Functioning and Services*. Cambridge, UK: Cambridge University Press. doi: 10.1017/CBO9781139794763

Cundill, G., Roux, D. J., and Parker, J. N. (2015). Nurturing communities of practice for transdisciplinary research. *Ecol. Soc.* 20:22. doi: 10.5751/ES-07580-200222

Daffron, K. (2017). Eco-engineering and management strategies for marine infrastructure to reduce establishment and dispersal of non-indigenous species. *Manag. Biol. Inv.* 8, 153–161. doi: 10.3391/mbi.2017.8.2.03

Daily, G. C., Polasky, S., Goldstein, J., Kareiva, P. M., Mooney, H. A., Pejchar, L., et al. (2009). Ecosystem services in decision making: Time to deliver. *Front. Ecol. Environ.* 7:28. doi: 10.1890/080025

Daniel, T. C., Muhar, A., Arnberger, A., Aznar, O., Boyd, J. W., Chan, K., et al. (2012). Contributions of cultural services to the ecosystem services agenda. *Proc. Natl. Acad. Sci.U.A.* 109, 8812–8819. doi: 10.1073/pnas.1114773109

Darvill, R., and Lindo, Z. (2016). The inclusion of stakeholders and cultural ecosystem services in land management trade-off decisions using an ecosystem services approach. *Landsc. Ecol.* 31, 533–545. doi: 10.1007/s10980-015-0260-y

Dawson, T. (2014). A View from Scotland's coast. *Public. Hist.* 36, 31–49. doi: 10.1525/tph.2014.36.3.31

Dawson, T., Hambly, J., Kelley, A., Lees, W., and Miller, S. (2014). Coastal heritage, global climate change, public engagement, and citizen science. *Proc. Natl. Acad. Sci.U.A.* 117, 8280–8286. doi: 10.1073/pnas.1912246117

de Groot, J. I. M., and Schuitema, G. (2012). How to make the unpopular popular? Policy characteristics, social norms and the acceptability of environmental policies. *Environ. Sci. Policy* 19, 100–107. doi: 10.1016/j.envsci.2012.03.004

Dobreva, M., Jennings, E., and Devreni-Koutsouki, A. (2015). "*Citizen Science and Digital Cultural Heritage: Potential for Wider Engagement with the General Public," in *Paper Presented at the Conference: Workshop in Cultural Heritage Communities*, (Ireland: Limerick), doi: 10.13140/RG.2.1.2845.3843

ECSA (2015). *10 Principles of Citizen Science*. Available online at: https://ecsa.citizen-science.net/documents/ (accessed March 22, 2022).

Environmental Protection Agency (2018). *Reflecting on Adaptation to Climate Change: International Best Practice Review and National MRE and Indicator Development Requirements*. EPA Research Report No. 263, Available online at: https://www.epa.ie/researchandeducation/research/researchpublications/researchreports/Research_Report_263.pdf (accessed December 15, 2020).

European Commission [EC] (1985). *Council Directive 85/337/EEC COUNCIL DIRECTIVE of 27 June 1985 on the Assessment of the Effects of Certain Public and Private Projects on the Environment*. Available online at: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:31985L0337&from=EN (accessed November 20, 2020).

European Commission [EC] (1997). *Council Directive 97/11/EC of 3 March 1997 Amending Directive 85/337/EEC on the Assessment of the Effects of Certain Public and Private Projects on the Environment.* Available online at: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A31997L0011 (accessed November 20, 2020).

European Commission [EC] (2000). *Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 Establishing a Framework for Community Action in the Field of Water Policy.* Available online at: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32000L0060 (accessed November 20, 2020).

European Commission [EC] (2008). *Directive 2008/56/EC of the European Parliament and of the Council of 17 June 2008 Establishing a Framework for Community Action in the Field of Marine Environmental Policy (Marine Strategy Framework Directive).* Available online at: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32008L0056 (accessed November 21, 2021).

European Commission [EC] (2014a). Directive 2014/89/EU of the European Parliament and of the Council of 23 July 2014 Establishing a Framework for Maritime Spatial Planning. Available online at: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32014L0089 (accessed November 22, 2020).

European Commission [EC] (2014b). *How Should Trans-Disciplinarity be Addressed and Evaluated in Proposals?. Guidance for Evaluators of Horizon 2020 Proposals: 6 (version 1.0, 15.07.201).* Available online at: http://ec.europa.eu/research/participants/data/ref/h2020/grants_manual/pse/h2020-evaluation-faq_en.pdf (accessed January 21, 2021).

European Commission [EC] (2020a). *Commission Staff Working Document Best Practices in Citizen Science for Environmental Monitoring*. Available online at: https://ec.europa.eu/environment/legal/reporting/pdf/best_practices_citizen_science_environmental_monitoring.pdf (accessed January 3, 2021).

European Commission [EC] (2020b). *Proposed Mission: A Climate Resilient Europe: Prepare Europe for Climate Disruptions and Accelerate the Transformation to a Climate Resilient and Just Europe by 2030. Report of the Mission Board for Adaptation to Climate Change, Including Societal Transformation*. Available online at: https://op.europa.eu/en/web/eu-law-and-publications/publication-detail/-/publication/2bac8dae-fc85-11ea-b44f-01aa75ed71a1 (accessed January 3, 2021).

Evans, A. J., Firth, L. B., Hawkins, S. J., Hall, A. E., Ironside, J. E., Thompson, R. C., et al. (2019). From ocean sprawl to blue-green infrastructure a UK perspective on an issue of global significance. *Environ. Sci. Pol.* 91, 60–69. doi: 10.1016/j.envsci.2018.09.008

Evans, A., Firth, L., Hawkins, S., Morris-Webb, L., Goudge, H., and Moore, P. (2015). Drill-cored rock pools: An effective method of ecological enhancement on artificial structures. *Mar. Freshwater. Res.* 67, 123–130. doi: 10.1071/MF14244

Evans, A., Garrod, B., Firth, L., Hawkins, S., Morris-Webb, E., Goudge, H., et al. (2017). Stakeholder priorities for multi-functional coastal defence developments and steps to effective implementation. *Mar. Policy.* 75, 143–155. doi: 10.1016/j.marpol.2016.10.006

Firth, L. B., Thompson, R. C., Bohn, K., Abbiati, M., Airoldi, L., Bouma, T. J., et al. (2014). Between a rock and a hard place: Environmental and engineering considerations when designing coastal defence structures. *Coast. Eng.* 87, 122–135. doi: 10.1016/j.coastaleng.2013.10.015

Firth, L., Browne, K., Knights, A., Hawkins, S., and Nash, R. (2016). Eco-engineered rock pools: A concrete solution to biodiversity loss and urban sprawl in the marine environment. *Environ. Re. Lett.* 11:094015. doi: 10.1088/1748-9326/11/9/094015

Firth, L., Thompson, R. C., White, F. J., Schofield, M., Skov, M. W., Hoggart, S., et al. (2013). The importance of water-retaining features for biodiversity on artificial intertidal coastal defence structures. *Divers. Distrib.* 19, 1275–1283. doi: 10.1111/ddi.12079

Fish, R., Church, A., and Winter, M. (2016). Conceptualising cultural ecosystem services: A novel framework for research and critical engagement. *Ecosyst. Serv.* 21, 208–217.

Flynn, S., Meane, W., Leadbetter, A., Fisher, J. P., and Nic Aonghusa, C. (2021). Lessons from a Marine Spatial Planning data management process for Ireland. *Int. J. Digit. Earth* 14, 139–157. doi: 10.1080/17538947.2020.1808720

Fulton, S., López-Sagástegui, C., Weaver, A. H., Fitzmaurice-Cahluni, F., Galindo, C., Fernández-Rivera Melo, F., et al. (2019). Untapped Potential of Citizen Science in Mexican Small-Scale Fisheries. *Front. Mar. Sci.* 6:517. doi: 10.3389/fmars.2019.00517

Garcia-Soto, C., van der Meeren, G. I., Busch, J. A., Delany, J., Domegan, C., Dubsky, K., et al. (2017). "Advancing citizen science for coastal and ocean research," in *Position Paper 23 of the European Marine Board*, eds P. French, J. Kellett, Delany, and N. McDonough (Ostend: European Union).

Ghorbanzadeh, S., and Björkqvist, K. (2019). Different stakeholders perspectives on cultural ecosystem services: A case study of the Anzali Wetland. *Iran. Eur. J. Soc. Sci. Edu. Res.* 6, 75–82. doi: 10.26417/ejser.v6i1.p75-82

Giakoumi, S., McGowan, J., Mills, M., Beger, M., Bustamante, R. H., Charles, A., et al. (2018). Revisiting "success" and "failure" of Marine Protected Areas: A conservation scientist perspective. *Front. Mar. Sci.* 5:223. doi: 10.3389/fmars.2018.00223

Gliozzo, G., Pettorelli, N., and Haklay, M. (2016). Using crowdsourced imagery to detect cultural ecosystem services: a case study in South Wales, UK. *Ecol. Soc.* 6:21.

Godemann, J. (2008). Knowledge integration: a key challenge for transdisciplinary cooperation. *Environ. Educ. Res.* 14, 625–641. doi: 10.1080/13504620802469188

Gould, R., Adams, A., and Vivanco, L. (2020). Looking into the dragons of cultural ecosystem services. *Ecosyst. People* 16, 257–272. doi: 10.1080/26395916.2020.1815841

Gould, R., Morse, J., and Adams, A. (2019). Cultural ecosystem services and decision−making: How researchers describe the applications of their work. *People Nat.* 1, 457–475. doi: 10.1002/pan3.10044

Gray, J., O'Neill, K., and Zeyuan, Q. (2017). Coastal residents' perceptions of the function of and relationship between engineered and natural infrastructure for coastal hazard mitigation. *Ocean Coast. Manage.* 146, 144–156. doi: 10.1016/j.ocecoaman.2017.07.005

Guimarães, M. H., Pohl, C., Bina, O., and Varanda, M. (2019). Who is doing inter- and transdisciplinary research, and why? An empirical study of motivations, attitudes, skills, and behaviours. *Futures* 112:102441. doi: 10.1016/j.futures.2019.102441

Haines-Young, R., and Potschin, M. (2013). *Common International Classification of Ecosystem Services (CICES): Consultation on Version 4 August-December 2012. EEA Framework Contract No EEA/IEA/09/003*. Available online at: https://cices.eu/content/uploads/sites/8/2012/07/CICES-V43_Revised-Final_Report_29012013.pdf (accessed October 4, 2020).

Haines-Young, R., and Potschin, M. (2018). Revision of the Common International Classification for Ecosystem Services (CICES V5.1): A Policy Brief. *One Ecosyst.* 3:e27108.

Hecker, S., Bonney, R., Haklay, M., Hölker, F., Hofer, H., Goebel, C., et al. (2018). Innovation in citizen science – Perspectives on science-policy advances. *Citiz. Sci. Theory Pr.* 3:4. doi: 10.5334/cstp.114

Heinisch, B., Oswald, K., Weißpflug, M., Shuttleworth, S., and Belknap, G. (2021). "Citizen Humanities"," in *The Science of Citizen Science*, eds K. Vohland, A. Land-Zandstra, L. Ceccaroni, R. Lemmens, J. Perelló, M. Ponti, et al. (Cham: Springer), doi: 10.1007/978-3-030-58278-4_6

Hirsch Hadorn, G., Hoffmann-Riem, H., Biber-Klemm, S., Grossenbacher-Mansuy, W., Joye, D., Pohl, C., et al. (2008). *Handbook of Transdisciplinary Research*. Dordrecht: Springer.

Hyder, K., Townhill, B., Anderson, L., Delany, J., and Pinnegar, J. (2015). Can citizen science contribute to the evidence-base that underpins marine policy? *Mar. Policy* 59, 112–120. doi: 10.1016/j.marpol.2015.04.022

IPBES (2019). *The IPBES Global Assessment Report on Biodiversity and Ecosystem Services*. Bonn: Secretariat of the Intergovernmental Science-Policy.

Irvine, K., O'Brien, L., Ravenscroft, N., Cooper, N., Everard, M., Fazey, I., et al. (2016). Ecosystem services and the idea of shared values. *Ecosyst. Serv.* 21, 184–193. doi: 10.1016/j.ecoser.2016.07.001

Irwin, A. (1995). *Citizen Science: A study of People, Expertise and Sustainable Development*. London: Routledge.

Jarvis, R. M., Bollard Breen, B., Krägeloh, C., and Rex Billington, D. (2015). Citizen science and the power of public participation in marine spatial planning. *Mar. Policy* 57, 21–26. doi: 10.1016/j.marpol.2015.03.011

Jentoft, S., Pascual-Fernandez, J. J., De la Cruz Modino, R., Gonzalez-Ramall, M., and Chuenpagdee, R. (2012). What stakeholders think about marine protected areas: case studies from Spain. *Hum. Ecol.* 40, 185–197. doi: 10.1007/s10745-012-9459-6

Katz-Gerro, T., and Orenstein, D. E. (2015). Environmental tastes, opinions and behaviors: social sciences in the service of cultural ecosystem service assessment. *Ecol. Soc.* 20:28. doi: 10.5751/ES-07545-200328

Kienker, S. E., Coleman, R. A., Morris, R. L., Steinberg, P., Bollard, B., Jarvis, R., et al. (2018). Bringing harbours alive: assessing the importance of eco-engineered coastal infrastructure for different stakeholders and cities. *Mar. Policy* 94, 238–246. doi: 10.1016/j.marpol.2018.04.028

Kirchhoff, T. (2019). Abandoning the concept of cultural ecosystem services, or against natural–scientific imperialism. *BioScience* 69, 220–227. doi: 10.1093/biosci/biz007

Klein, J. T., Grossenbacher-Mansuy, W., Häberli, R., Alain, B., Scholz, R., and Welti, M. (2001). *Transdisciplinarity: Joint Problem Solving among Science, Technology, and Society An Effective Way for Managing Complexity*. Basel: Birkhäuser. doi: 10.1007/978-3-0348-8419-8_2

Lang, D. J., Wiek, A., Bergmann, M., Stauffacher, M., Martens, P., and Moll, P. (2012). Transdisciplinary research in sustainability science: Practice, principles, and challenges. *Sustain. Sci.* 7, 25–43. doi: 10.1007/s11625-011-0149

Lee, H., Seo, B., Koellner, T., and Lautenbach, S. (2019). Mapping cultural ecosystem services 2.0 – Potential and shortcomings from unlabeled crowd sourced images. *Ecol. Indic.* 96, 505–515. doi: 10.1016/j.ecolind.2018.08.035

Mannan, S., Nilsson, H., Johansson, T., and Schofield, C. (2020). Enabling stakeholder participation in marine spatial planning: the Bangladesh experience. *J. Indian. Ocean Reg.* 16, 268–291. doi: 10.1080/19480881.2020.1825200

McGregor, S. L. T. (2004). *Transdisciplinary Research and Practice. Kappa Omicron Nu Human Sciences Working Paper Series*. Available online at: https://www.kon.org/archives/forum/16-2/mcgregor.html (accessed March 22, 2022).

Milcu, A. I., Hanspach, J., Abson, D., and Fischer, J. (2013). Cultural ecosystem services: a literature review and prospects for future research. *Ecol. Soc.* 18:44. doi: 10.5751/ES-05790-180344

Millennium Ecosystem Assessment [MEA] (2005). *Ecosystems and Human Well-Being: Synthesis*. Washington, DC: Island Press.

Miller, T. R., Baird, T. D., Littlefield, C. M., Kofinas, G., Chapin, F. III, and Redman, C. L. (2008). Epistemological pluralism: reorganizing interdisciplinary research. *Ecol. Soc.* 13:46.

Mobjörk, M. (2010). Consulting versus participatory transdisciplinarity: A refined classification of transdisciplinary research. *Futures* 42, 866–873. doi: 10.1016/j.futures.2010.03.003

Natanzi, A., Thompson, B., Brooks, P., Crowe, T., and McNally, C. (2021). Influence of concrete properties on the initial biological colonisation of marine artificial structures. *Ecol. Eng.* 159:106104. doi: 10.1016/j.ecoleng.2020.106104

Nicolescu, B. (2005). *Transdisciplinarity - Past, Present and Future," Palestra apresentada no II Congresso Mundial de Transdisciplinaridade Vila Velha/Vitória – SC, Brasil 06 a 12 de setembro de 2005*. Available online at: https://www.tercercongresomundialtransdisciplinariedad.mx/wp-content/uploads/2019/08/Transdisciplinarity-past-present-and-future.pdf (accessed March 22, 2020).

O'Keeffe, J. M., Cummins, V., Devoy, R. J. N., Lyons, D., and Gault, J. (2020). Stakeholder awareness of climate adaptation in the commercial seaport sector: A case study from Ireland. *Mar. Polic.* 111:102404. doi: 10.1016/j.marpol.2016.04.044

OECD (2020). *Innovative Citizen Participation and New Democratic Institutions: Catching the Deliberative Wave*. Paris: OECD Publishing, doi: 10.1787/339306da-en

O'Shaughnessy, K., Hawkins, S., Evans, A., Hanley, M., Lunt, P., Thompson, R., et al. (2020). Design catalogue for eco-engineering of coastal artificial structures: A multifunctional approach for stakeholders and end-users. *Urban. Ecosyst.* 23, 1–13. doi: 10.1007/s11252-019-00924-z

Owen, R. P., and Parker, A. J. (2018). "Citizen science in environmental protection agencies," in *Citizen science Innovation in Open Science, Society and Policy*, eds S. Hecker, M. Haklay, A. Bowser, Z. Makuch, J. Vogel, and A. Bonn (London: UCL Press), 284–300. doi: 10.2307/j.ctv550cf2.27

Pettibone, L., Vohland, K., and Ziegler, D. (2017). Understanding the (inter)disciplinary and institutional diversity of citizen science: A survey of current practice in Germany and Austria. *PLoS One* 126:e0178778. doi: 10.1371/journal.pone.0178778

Plieninger, T., Bieling, C., Ohnesorge, B., Schaich, H., Schleyer, C., and Wolff, F. (2013). Exploring futures of ecosystem services in cultural landscapes through participatory scenario development in the Swabian Alb, Germany. *Ecol. Soc.* 18:39.

Pohl, C. (2008). From science to policy through transdisciplinary research. *Environ. Sci. Policy* 11, 46–53. doi: 10.1016/j.envsci.2007.06.001

Purdam, K. (2014). Citizen social science and citizen data? Methodological and ethical challenges for social research. *Curr. Sociol.* 62, 374–392. doi: 10.1177/0011392114527997

QUB (2020). *preserving and Sustainably Governing Cultural Heritage and Landscapes in European Coastal and Maritime Regions. Good Practices of Policy Integration of Cultural Heritage in Coastal and Maritime Policies. European Policy Brief*. Available online at: https://ec.europa.eu/research/participants/documents/downloadPublic?documentIds=080166e5c77301ea&appId=PPGMS. (accessed November 12, 2020).

Regeer, B. J., and Bunders, J. (2009). *Knowledge Co-Creation: Interaction Between Science and Society. A Transdisciplinary Approach to Complex Societal Issues*. The Hague: RMNO.

Rigolot, C. (2020). Transdisciplinarity as a discipline and a way of being: complementarities and creative tensions. *Hum. Soc. Sci. Commun.* 7:100. doi: 10.1057/s41599-020-00598-5

Robinson, J. (2008). Being undisciplined: Transgressions and intersections in academia and beyond. *Futures* 40, 7–86.

Ruskule, A., Klepers, A., and Veidemane, K. (2018). Mapping and assessment of cultural ecosystem services of Latvian coastal areas. *One Ecosyst.* 3:e25499.

Ryfield, F., Cabana, D., Brannigan, J., and Crowe, T. (2019). Conceptualizing 'sense of place' in cultural ecosystem services: A framework for interdisciplinary research. *Ecosyst. Serv.* 36:100907.

Santarém, F., Saarinen, J., and Brito, J. C. (2020). Mapping and analysing cultural ecosystem services in conflict areas. *Ecol. Indic.* 110:105943.

Santoro, F., Selvaggia, S., Gail, S., Géraldine, F., and Peter, T. (2018). *Ocean Literacy for All: A Toolkit. Paris: UNESCO*. Available Online at: https://ioc.unesco.org/publications/ocean-literacy-all-toolkit (accessed December 10, 2020).

Satterfield, T., Gregory, R., Klain, S., Roberts, M., and Chan, K. (2013). Culture, intangibles and metrics in environmental management. *J. Environ. Manage* 117, 103–114. doi: 10.1016/j.jenvman.2012.11.033

Schade, S., Pelacho, M., van Noordwijk, T., Vohland, K., Hecker, S., and Manzoni, M. (2021). "Citizen Science and Policy," in *The Science of Citizen Science*, eds K. Vohland, et al. (Cham: Springer), doi: 10.1007/978-3-030-58278-4_18

Schneider, F., Giger, M., Harari, N., Moser, S., Oberlack, C., Providoli, I., et al. (2019). Transdisciplinary co-production of knowledge and sustainability transformations: Three generic mechanisms of impact generation. *Environ. Sci. Policy* 102, 26–35. doi: 10.1016/j.envsci.2019.08.017

Scholz, R. W. (2020). Transdisciplinarity: science for and with society in light of the university's roles and functions. *Sustain. Sci.* 15, 1033–1049. doi: 10.1007/s11625-020-00794-x

Schröter, M., Kraemer, R., Mantel, M., Kabisch, N., Hecker, S., and Richter, A. (2017).). Citizen science for assessing ecosystem services: Status, challenges and opportunities. *Ecosyst. Serv.* 28, 80–94. doi: 10.1016/j.ecoser.2017.09.017

Small, N., Munday, M., and Durance, I. (2017). The challenge of valuing ecosystem services that have no material benefits. *Global Environ. Chang.* 44, 57–67. doi: 10.1016/j.gloenvcha.2017.03.005

Soma, K., Ramos, J., Bergh, O., Schulze, T., van Oostenbrugge, H., van Duijn, A. P., et al. (2014). The mapping out approach: effectiveness of marine spatial management options in European coastal waters. *ICES. J. Mar. Sci.* 71, 2630–2642. doi: 10.1093/icesjms/fst193

Strain, E. M. A., Alexander, K. A., Kienker, S., Morris, R., Jarvis, R., Coleman, R., et al. (2019). Urban blue: a global analysis of the factors shaping people's perceptions of the marine environment and ecological engineering in harbours. *Sci. Total Environ.* 658, 1293–1305. doi: 10.1016/j.scitotenv.2018.12.285

Strain, E. M., Olabarria, C., Mayer-Pinto, M., Cumbo, V., Morris, R. L., Bugnot, A. B., et al. (2017). Eco-engineering urban infrastructure for marine and coastal biodiversity: which interventions have the greatest ecological benefit? *J. Appl. Ecol.* 55, 426–441. doi: 10.1111/1365-2664.12961

Tauginienė, L., Butkevičienė, E., Vohland, K., Heinisch, B., Daskolia, M., Suškevičs, M., et al. (2020). Citizen science in the social sciences and humanities: the power of interdisciplinarity. *Palgrave Commun.* 6:89. doi: 10.1057/s41599-020-0471-y

TEEB (2010). *Mainstreaming the Economics of Nature: A Synthesis of the Approach, Conclusions and Recommendations of TEEB. The Economics of Ecosystems & Biodiversity*. Geneva: UNEP.

Tengberg, A., Fredholm, S., Eliasson, I., Knez, I., Saltzman, K., and Wetterberg, O. (2012). Cultural ecosystem services provided by landscapes: Assessment of heritage values and identity. *Ecosyst. Serv.* 2, 14–26. doi: 10.1016/j.ecoser.2012.07.006

The United Nations Educational Scientific and Cultural Organization [UNESCO] (1998). *Division of Philosophy and Ethics. Transdiciplinarity: Stimulating Synergies, Integrating Knowledge*. Available Online at: http://unesdoc.unesco.org/images/0011/001146/114694eo.pdf (accessed December 10, 2020).

Twomey, S., and O' Mahony, C. (2018). "Stakeholder Processes in marine spatial planning: Ambitions and realities from the European Atlantic experience," in *Maritime Spatial Planning. Palgrave Macmillan*, ed J. Zauchka, et al. (Switzerland: Springer), 295–325. doi: 10.1007/978-3-319-98696-8_13

United Nations [UN] (2017). *The UN Oceans Conference Fact Sheet*. Available online at: https://www.un.org/sustainabledevelopment/wp-content/uploads/2017/05/Ocean-fact-sheet-package.pdf. (accessed March 22, 2022).

United Nations [UN] (2015). *Transforming Our World: The 2030 Agenda for Sustainable Development*. New York: UN Publishing.

Urválková, E., and Janoušková, S. (2019). Citizen science and the professional-amateur divide: lessons from differing online practices. *Chem. Teach. Int.* 18:32.

Vann-Sander, S., Clifton, J., and Harvey, E. (2016). Can citizen science work? Perceptions of the role and utility of citizen science in a marine policy and management context. *Mar. Policy* 72, 82–93. doi: 10.1016/j.marpol.2016.06.026

Veiga, J. M., Vlachogianni, T., Pahl, S., Thompson, R., Kopke, K., Doyle, T., et al. (2016). Enhancing public awareness and promoting co-responsibility for marine litter in Europe: The challenge of MARLISCO. *Mar. Pollut. Bull.* 102, 309–315. doi: 10.1016/j.marpolbul.2016.01.031

Viduka, A. (2020). A maritime archaeological conservation citizen science programme for individual benefit and good public outcomes: GIRT Scientific Divers. *J. Community Archaeol. Herit.* 00, 1–19.

Vienni Baptista, B., Maryl, M., Wciślik, P., Fletcher, I., Buchner, A., Wallace, D., et al. (2019). *Deliverable 2.1: Preliminary Report of Literature Review on Understandings of Interdisciplinary and Transdisciplinary Research. SHAPE-ID project*. Availableonline at: https://zenodo.org/record/3760417#.YjodM-rP02w (accessed March 22, 2022).

von Wehrden, H., Guimarães, M. H., Bina, O., Lang, D. J., John, B., Gralla, F., et al. (2019). Interdisciplinary and transdisciplinary research: finding the common ground of multi-faceted concepts. *Sustain Sci.* 14, 875–888. doi: 10.1007/s11625-018-0594-x

Vye, S. R., Dickens, S., Adams, L., Bohn, K., Chenery, J., Dobson, N., et al. (2020). Patterns of abundance across geographical ranges as a predictor for responses to climate change: Evidence from UK rocky shores. *Divers. Distrib.* 26, 1357–1365. doi: 10.1111/ddi.13118

Waltham, N. J., and Sheaves, M. (2015). Expanding coastal urban and industrial seascape in the Great Barrier Reef World Heritage Area: Critical need for coordinated planning and policy. *Mar. Policy* 57, 78–84. doi: 10.1016/j.marpol.2015.03.030

Ware, J., and Callaway, R. (2019). Public perception of coastal habitat loss and habitat creation using artificial floating islands in the UK. *PLoS One.* 14:e224424. doi: 10.1371/journal.pone.0224424

Whelchel, A. W., Reguero, B. G., van Wesenbeeck, B., and Renaud, F. G. (2018). Advancing disaster risk reduction through the integration of science, design, and policy into eco-engineering and several global resource management processes. *Int. J. Disast. Risk. Re.* 32, 29–41. doi: 10.1016/j.ijdrr.2018.02.030

Wickson, F., and Carew, A. (2014). Quality Criteria and Indicators for Responsible Research and Innovation: Learning from Transdisciplinarity. *J. Responsible Innov.* 1, 254–273. doi: 10.1080/23299460.2014.963004

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.

Publisher's Note: All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.