# Power, knowledge and the transformative potential of marine community science

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**Power, knowledge and the transformative potential of marine community science**

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# Abstract

Community science has gained momentum as a participatory knowledge production approach that can transform governance into more transparent, socially relevant, and democratic endeavours. In the marine context, where the rationalisation of economic knowledge and the marginalisation of local communities are growing concerns, community science is advanced as a potential solution to environmental governance challenges. By increasing monitoring efforts and empowering members of the public to take political action to protect the oceans, community science has helped to transform marine management to address issues, such as, sea-level rise, overfishing, and ocean acidification. However, many community science projects do not realise their transformative potential and, instead, contribute toward reinforcing the status quo of governance, meaning that management challenges remain unsolved. To understand how the full potential of community science can be achieved, research must reframe what transformation is and assess why projects often fail to instigate change. Within community science research, there is an under-appreciation of how transformational change must involve actions that challenge prevailing power relations. We seek to address this gap by initiating a discussion on the political and power dimensions of community science. Drawing on the broader field of co-production, we argue that community science has been depoliticised to reinforce, as opposed to alleviate, unequal arrangements of power that inhibit societal transformation. To combat this, we suggest that community science must develop a more explicit comprehension of power and how it relates to the use and production of knowledge. Informed by the Foucauldian concept of power/knowledge, we argue for a politicised paradigm of community science that recognises how transformation requires pluralism, the contestation of knowledge, and learning amongst all community science actors. This review concludes by considering how transformative community science could introduce new ways of knowing to marine governance and facilitate more active community participation.

## 1. **Introduction**

The concept of community science[1], a participatory research approach wherein members of the public produce scientific knowledge in contributory, collaborative, or co-production processes, has produced promising opportunities in a marine context (Garcia-Soto et al., 2021). By enhancing the scope of monitoring efforts, and empowering local communities to engage with initiatives that seek to protect the oceans, community science provides an important source of scientific research on maritime challenges, including, rising sea levels, over-fishing, and ocean acidification (Kelly et al., 2020; Sandahl and Tøttrup, 2020). Community science has been advanced as a cost-effective means of producing knowledge to inform marine policy (Hyder et al., 2015; Schläppy et al., 2017), to broaden the engagement of communities with governance processes (Turrini et al., 2018) and to instil scientific and environmental learning amongst participants (Haywood, 2016). Due to this, community science is framed by academics and practitioners as a participatory approach that can, through the production of new knowledge, transform conservation management into more transparent, socially relevant, and democratic processes (Couvet and Prevot, 2015; Grossberndt et al., 2021; Loos et al., 2015; Peters and Besley, 2019). In marine governance, where decision-makers are often guided by hegemonic agendas (Tafon, 2018) and informed by the knowledge of dominant stakeholders (Said and Trouillet, 2020), community science has been suggested as a potentially transformative solution to unjust and undemocratic processes (Flannery et al., 2019). The way community science researchers and practitioners have conceptualised 'transformation' is, however, rather limited, and is often blind to power issues.

In this paper, we define 'transformation' as a fundamental form of change that is greater than progressive or incremental shifts. Transformation is described as a significant reordering, one that challenges existing structures to produce something fundamentally different (Blythe et al., 2018; Geels et al. 2017). Scholars have outlined how the realisation of ocean governance transformation is

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[1] As citizenship is not a criterion for inclusion in participatory research activities, we prefer to adopt the more inclusive label of "community science". We do feel, however, that our discussion is relevant to scholars and practitioners that make use of the term citizen science, as well as those in the broader field of co-production.

dependent upon paradigm shifts within existing structures of governance (Olsson et al., 2014). Discussing how to prepare for transformative change, Blythe et al. (2020: 261) state the importance of "the identification of a governance related challenge, growing social support for governance change and the communication of compelling narratives". We argue that community science can provide many of the required conditions for ocean governance transformation to be instigated, specifically because of the active participation that it supports and the diverse range of knowledge that it can produce.

The need for transformational change to how marine governance processes facilitate public participation (Bennett et al., 2019; Saunders et al., 2020; Fudge et al., 2021; Tafon et al., 2021) and incorporate different types of knowledge has become more evident in recent years (Said and Trouillet, 2020; Peters, 2020). Community science has been positioned by its champions as having the capacity to instigate change to how these challenges are managed in marine governance, yet literature illustrates an under-appreciation of how truly transformative change must involve actions that challenge dominant power relations. Turnhout et al. (2020) argue that 'depoliticisation' in the realm of co-production has led to participatory processes inadvertently reinforcing, as opposed to mitigating, unequal power relations. Community science that ineffectively challenges dominant power arrangements can, therefore, prevent the development of transformative practices and the instigation of meaningful change (Mach et al., 2020). Although some studies have begun to critically analyse the role of power in co-production processes, revealing crucial insights about transformation barriers that participatory interventions can encounter and how they can be prevented (see Lemos et al., 2018; Oliver et al., 2019), power remains an underexplored topic in the community science literature. While studies have revealed significant insight into transformative learning (see Bela et al., 2016; Ruiz-Mallén et al., 2016), a more explicit understanding of the relationship between power and knowledge must be developed by community science actors if the potential of community science is to be realised.

We argue that the transformative capacity of projects must be understood in terms of how community science knowledge is shaped by and produces power. Our argument is built upon the premise that power and knowledge are co-constitutive, hence the Foucauldian terminology of 'power/knowledge', meaning

that they are inextricably linked to each other and cannot exist independently (Foucault, 1980). Power/knowledge relations define what is important and what is possible in the realm of action, supporting particular developments while suppressing others (Sheridan, 1977).

We contend that if community science is to transform both how communities can participate in marine governance and how knowledge is integrated into decision-making processes, it must become politicised and acknowledge the array of power relations that define which knowledge is important and how it is used. As the concept of power/knowledge outlines, power is not a zero-sum game. Power can be challenged, resisted, and changed by developing other power/knowledge relations (Foucault, 1980). Power/knowledge arrangements can, therefore, both limit and enable action. We suggest that, by becoming conscious of the duality of power/knowledge, community science research and practice can develop a greater understanding of why attempts to instigate transformation fail, and how such barriers can be overcome. We posit that it is only by adopting more power-aware approaches that community science can realise its potential to transform marine governance into more democratic and transparent processes.

In the next section, we clarify the need to address the political and power dimensions of community science and discuss why this is important for both theory and practice. We begin by reviewing the current framings of community science and problematise how transformation has been conceptualised within the literature. The concept of power/knowledge is then outlined to demonstrate how it can inform an alternative community science paradigm that corrects for current limitations. This is followed by a discussion of how politicising community science can contribute to a better understanding of how and why projects often fail to instigate transformation and how persistent challenges can be prevented. To conclude, we consider how power-aware community science initiatives can practically work to transform the problems underpinning marine governance regimes and suggest how this topic could be examined further.

## 2. <u>Reframing transformation in community science</u>

Community science has quickly grown in popularity within marine conservation (Kelly at al., 2020), following a 'participatory trend' in scientific knowledge production (Chilvers and Kearnes, 2020). The increased support for participatory research and co-production has facilitated the creation of new relationships between civil society, science and government, wherein individuals can have a greater influence in decision-making processes (Albert et al., 2021). The origins of this participatory trend, and in particular the rise of community science, has been understood as a response to the urgent need for data on environmental challenges (Bennett, 2016; Chase and Levine, 2016) and the growing desire for community participation in environmental management (Pandya, 2012; Thompson, 2016). The limited scope of government monitoring programmes to efficiently deal with complex ecological challenges (Sharpe and Conrad, 2006), due to resource, time and cognitive constraints (Conrad and Daoust, 2008; Vercammen and Burgman, 2019), has led researchers to frame community science as a cost-effective means of broadening the scale of data collection processes (Jarvis et al., 2015) and improving the knowledge base that informs conservation management (Jambeck and Johnson, 2015; Steven et al., 2019). Developments in information technology (IT) have played a key role in facilitating the expansion of community science. IT tools and services are utilised by projects to support the collection, storage, management, and dissemination of data. Importantly, technology has strengthened the reliability, reusability and scientific trustworthiness of community science (Brenton et al., 2018; Thompson, 2016).

The participatory nature of community science has also encouraged scholars and practitioners to promote it as a means of instilling social and learning outcomes within volunteers. These can include enhanced environmental citizenship (McKinley et al., 2017), behavioural change and empowerment (Toomey and Domroese, 2013; Ruiz-Mallén et al., 2016), environmental stewardship (Merenlender et al., 2016), and increased environmental and scientific literacy (Haywood, 2016; Kelly et al., 2021 McAteer et al., 2021). The outcomes that volunteers obtain are dependent upon how they engage with community science. Engagement processes within community science projects can be divided into three categories – contributory, collaborative and co-produced – that involve various forms and degrees of

participation. Contributory projects refer to activities where participants contribute to the collection of data, in order to enhance datasets (Dickinson et al., 2012). An example of this is the Irish Whale and Dolphin Group's Ferry Survey, where volunteers record cetacean sightings onboard passenger ferries across the Irish Sea (McAteer et al., 2021). Collaborative and co-produced projects imply a deeper engagement of participants, whereby participation may also involve problem definition, data analysis and interpretation, and the dissemination of findings (Shirk et al., 2012). The Hudson River Estuary Eel Project is an example of a collaborative community science project. The project involves a catch and release monitoring programme that enables volunteers to take on data collection and analysis roles, whilst also facilitating participants with opportunity to co-design research objectives (Ballard et al., 2018). The Reclam the Bay scheme, where local volunteers worked to restore shellfish and maintain clean water in New Jersey's Barnegat Bay, is an example of a co-produced initiative. Following one year of coordination by scientists, volunteers took full ownership of the scheme and have helped to initiate similar projects in other parts of North America.

More so than contributory projects, collaborative and co-produced categories are interpreted as being capable of using knowledge to instigate change within environmental management processes (Eitzel et al., 2017). We suggest, however, that the three categories of community science should not be interpreted as mutually exclusive. Contributory, collaborative and co-produced projects can, and should, be interpreted as holding differing degrees of transformational potential. All community science projects operate within a unique arrangement of actors, each with differing degrees of power and influence over the evolvement and potential output of projects, and are faced with a range of different opportunities and barriers to instigating transformation (Bela et al., 2016). Thus, if we are to improve our understanding of the wider capacity of community science to instigate change in marine governance, it is crucial that research critically examines the factors that determine the transformative potential of all categories. By ignoring how community science can operate in a transformative manner, research risks rendering the unique potential of projects unfulfilled.

Whilst assertions continue to grow regarding the capacity of community science to catalyse societal and governance transformations, the realisation of transformative pathways is not supported by a substantial body of evidence (Bonney et al., 2020). Although research has, for example, revealed important insight on the transformative learning capacity of projects (Bela et al. 2016; Ruiz-Mallén et al. 2016), there is limited evidence of the degree to which community science knowledge can influence change within governance systems and instigate new approaches to participation and knowledge use. We argue that this limitation is the result of an inadequate interpretation of the concept of transformation and, subsequently, an inability to clarify how community science projects can overcome barriers to change. To clarify our argument, we break down this review of transformation into two segments. First, a brief assessment of the power dynamics of community science. Second, an examination of how the use and production of knowledge are considered in relation to the transformative potential of community science.

### Power dynamics

Transformational change within governance arenas must involve actions that engage with power relations and actively seek to instigate change to existent management approaches (Van Tatenhove and Toonen, 2020). Within the community science literature, we find limited evidence of how projects are actively mobilising knowledge to engage with existing power relations. Although some papers do provide recommendations on how to enhance the quality and impact of community science projects (Gallo and Waitt, 2011; Yadav and Darlington, 2016), there is a gap in the literature on the politics of transformation in community science and little clarification on how projects can engage with and influence change within decision-making structures. Current conceptualisations of transformation within the community science almost exclusively focus on volunteers and tend to ignore other, more powerful actors who interact with and shape these projects, including, practitioners (project coordinators and managers) and governance actors (end-users, funders). This approach narrows the transformative scope of community science and ignores how projects may effectively challenge the thinking and actions of those actors who have greater influence over the development of projects. At

the core of these limitations is an inadequate interpretation of the way power operates within community science.

Although community science is underpinned by suggestions of mutuality and equality amongst actors (Chilvers and Kearnes, 2020), the co-production literature has demonstrated how elite actors can use their resources and knowledge to shape participatory efforts to serve their interests and needs (Parkinson, 2012). This is reflected in the work of Akaateba et al. (2018), who, in their study on land reform processes in Ghana, found that co-production can be a conduit for private wealth accumulation within the broader context of weak institutional capacities and poor governance. In such a context, those with power and resources were able to take advantage of co-production processes and undermine efforts to promote more equitable governance. Similar challenges are found in the context of a narwhal co-management programme in Nunavut, Canada. Collaborative attempts sought to revise policy assumptions that did not consider indigenous knowledge, yet compartmentalised views of knowledge from managements actors were seen to constrain the influence of co-management efforts (Dale and Armitage, 2011). Management systems continued to privilege professionally collected, scientific knowledge, and proved to be resistant to change when certain types of knowledge were undermined. Thus, the co-management programme, initiated as a means of enhancing the role of indigenous knowledge in narwhal management, served to further exacerbate power imbalances between management actors and local communities (Dale and Armitage, 2011). The impact of power imbalances being reinforced also discouraged communities from participating in further co-management programmes. Evidence of bias towards elite actors within co-production processes is worrying, as they illustrate how participatory processes can reproduce existing inequalities (Parkinson, 2012). This form of critical analysis of power dynamics is often missing from the community science literature, rendering it difficult to accurately assess how the transformative potential of individual projects can be realised. Aligning with the argument of Turnhout et al. (2020), we assert that researchers have tended to assume that there is trust and symmetrical power relations within community science projects. Failing to recognise the role of power and how powerful actors can disproportionately shape the potential evolvement of projects can have detrimental consequences.

Of the literature that does consider power in community science, researchers tend to loosely consider power along two parallel lines of thought, both concerned with issues of power over[2]. First, power is framed as an attribute that some actors have, and others lack (Leach and Fairhead, 2002; Eitzel et al., 2017). This acknowledgement of uneven power relations between community science actors presents a simplistic notion of power, whereby elite actors can act unchallenged as they predetermine the problem framing or participatory scope of an initiative (Parkinson, 2012). This framing of power inequalities within community science is further compounded by the strong authority that is attributed to scientific expertise *vis-a-vis* other knowledge systems (Dale and Armitage, 2008). Second, within the existing literature, power is broadly understood as a constraining force that can limit the agency of projects or of weak actors (Ottinger, 2010). Power, in this sense, is a force that is exerted in a repressive and constraining manner. This includes the implementation of standardised practices within community science, whereby powerful actors set standards to dismiss knowledge that does not align with management assumptions or is interpreted as being irrelevant to the central project (Ottinger, 2010). More broadly, standards can disempower volunteers by dictating what they can and cannot do whilst participating in projects (Hampshire et al., 2005). This framing of how power operates in community science presents little recognition of the productive capacity of power, something that is central for transformative social change to occur (Foucault, 1982).

Despite some recognition of power within the community science literature, little attention has been paid to empirically assessing the workings of power. We argue that the prevailing perspectives of power within this literature are ontologically and epistemologically grounded in the natural sciences, wherein mere participation is viewed as a means of remedying power inequities. This has contributed to

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[2] VeneKlasen et al. (2002) describe four 'expressions of power'. These are power over (a force of repression and coercion, having power involves taking it from someone else and using it to control others), power with (building collective strength through collaboration often to reduce conflict and establish coalitions), power to (the potential of all human actors to act independently and to shape their own world) and power within (self-worth and self-knowledge, to have the capacity to imagine and have hope). Traditionally, scholars tended to exclusively discuss power only in negative terms and as a form of domination. However, the work of Foucault (1982) challenged this and illustrated how power can also be a positive force for individual and collective capacity to act for change.

community science's inability to identify the deeply embedded structural and societal barriers that can inhibit transformative change. When operating in this depoliticised and conservative manner, the space for community science to challenge prevailing governance logics is restricted, and participatory initiatives, often unconsciously, do little more than reinforce the *status quo* of governance frameworks (Gaventa and Cornwall, 2001). For instance, Hampshire et al. (2005) illustrate how shifts and re-negotiations of power relations are possible during participatory research projects but are commonly limited due to the desire of elite actors to define and maintain dominant agendas. In their study, power is revealed as being manifested in various forms at different stages of participatory research projects, with the overall effect of changing the priorities of volunteers to align with those of elite actors (Hampshire et al., 2005). Learning from this, we argue that a more explicit consideration of power, one that considers the opportunities and challenges to shifting imbalances, can inform an alternative community science paradigm and is vital if projects are to realise their transformative potential.

### The use and production of knowledge in community science

When discussing knowledge production in relation to transformation, much of the literature narrowly considers community science as a means of contributing to existent knowledge production and governance pathways (Brombal, 2020). This linear model of knowledge production frames community science as a unidirectional flow of information, wherein knowledge is generated by volunteers and then communicated to coordinating scientists and end-users (Devictor et al., 2010). We see this framing of the use and production of community science knowledge as being concerned with producing knowledge for *knowing*. Knowledge, in this sense, is produced to fill specific gaps of information in research or management frameworks (Jambeck and Johnsen, 2015), directly answering predefined questions that are set by practitioners or government actors (Steven et al., 2019). Thus, processes of community science knowledge production can be interpreted as a way of strengthening understanding of particular issues and adding valuable insight to existent datasets (Jarvis et al., 2015). Although valuable, if community science is framed solely in this manner it will to be limited to generating knowledge that fits within existent decision-making standards and supports the extension of current management processes.

Focusing on the attainment of knowledge in only a unidirectional manner neglects the broader transformative capacity of community science (Couvet and Prevot, 2015) and frames power as only accruing to existing powerholders (Leach and Fairhead, 2002). The knowledge for knowing approach reflects a limited appreciation of the potential transformative actions that can arise from knowledge production, both within and beyond projects. This framing ignores the way transformation often requires the production of alternative knowledge that reconfigures prevailing logics. Similar critiques of this conceptualisation of community science are also outlined by Bela et al. (2016), who emphasise that an accurate evaluation of community science's transformative capacity requires a more expansive analysis of the dynamic character of the knowledge that projects produce and the outcomes that projects generate. Whereas Bela et al. (2016) realise this objective by focusing on learning mechanisms within community science, we argue that there is a need to conduct more critical examinations of community science knowledge and the capacity it has to transform ways of thinking about and managing conservation matters. In essence, there is a need to examine the potential of community science to generate *knowledge for action* and to mobilise the potential for power to accrue in a multidirectional manner.

Knowledge that is actionable enables pluralism, the contestation of knowing, and is both politicised and capable of initiating change to governance (Mach et al., 2020). Our interpretation of knowledge for action builds upon this assumption. We contend that action is embedded, but not explicit, within knowledge. There is growing evidence within the literature to suggest that community science knowledge can be of relevance to marine policy and contribute to the evidence-base that underpins marine management (Hyder et al., 2015; Townhill and Hyder, 2017). Assessing the capacity of community science to inform marine policy in the United Kingdom, Hyder et al. (2017) illustrate how projects have documented valuable information on small-scale pollution events that have guided management decisions and have increased levels of understanding and engagement with science. However, there is less documentation of how initiatives are actively instigate policy change. Community science can instigate this type of change by challenging the knowledge that informs

problem framing. Thus, there is a need for research to plug this gap and to consider how future community science initiatives can become politicised and able to utilise their research findings to call for change. Cigliano et al. (2015) create a policy change toolkit that identifies modes through which marine community science may lead to positive outcomes related to policy change. This includes an assessment of how projects can support informed advocacy, whereby the collected and analysed data of projects can educate volunteers and help them argue effectively for their desired policy outcome. As an example, Cigliano et al. (2015) discuss how community science data regarding the prevalence of plastic bags in the marine environment could help to inform a campaign to establish a ban or implement a levy on plastic bags. In this framing, community science is mobilised as one piece of an argument made in a political venue where the fundamental impediment is often a values-based dispute. Community science volunteers, in turn, may become more active and effective advocates as a result of their participation (Cigliano et al., 2015). In this way, both the data and the learning outcomes of community science synergistically support advocacy (Toomey and Domroese, 2013)

Linking conservation science to action is an inherently challenging process. Government actors can be reluctant to accept contestations to current logic or knowledge claims (Kythreotis et al., 2019), with a lack of trust by government in the quality of community science knowledge a common challenge (Cigliano et al., 2015). In their assessment of the research program designed to support the management of the Ningaloo Marine Park in Australia, Cvitanovic et al. (2016) reveal the many barriers that can prevent knowledge from influencing conservation decision-making. Institutional barriers, such as organisational hierarchy and a lack of support from leaders for co-production activities, are significant challenges to overcome. Similarly, cultural differences in the interpretation of knowledge between participants and decision-makers have been a further barrier to action. To enhance the success of knowledge exchange strategies and to maximise the potential for knowledge to instigate action, Cvitanovic et al. (2016) emphasise the importance of co-developing research questions with as large of a portion of participants, practitioners and governance actors, as possible. Failing to engage relevant actors during the design phase of conservation research has the potential to marginalise individuals, bias results and jeopardise the long-term viability and support for the process (Reed et al., 2009).

Learning from these insights, it appears that the majority of barriers to instigating policy change are a result of unequal power that prevent participatory research from contesting governance logic and presenting alternative logics for environmental management matters. In an attempt to overcome these problems and to better understand how community science can truly instigate transformation, we argue for a reframed interpretation of how the knowledge that projects use and produce, relate to power. In the following section, we introduce the concept of power/knowledge as a means of achieving this objective.

### 3.  **Power/knowledge**

Foucault coined the concept of power/knowledge to demonstrate their co-constitutive nature. Foucault interpreted power and knowledge as inextricably linked entities, as "there is no power relation without the correlative constitution of the field of knowledge, nor any knowledge that does nor presuppose and constitute at the same time power relations" (Sheridan, 1977, pp. 22). Although representing only one of many resources in the power field, knowledge establishes what is perceived as important, possible, by and for whom. "Through access to knowledge, and participation in its production, use and dissemination, actors can affect the boundaries and indeed the conceptualization of the possible" (Gaventa and Cornwall, 2001, pp. 72). Power/knowledge arrangements are, therefore, omnipresent in all social relations. Any assessment of a social context that ignores or fails to identify the role of power, such as in much of the community science literature, can only be understood as an abstraction of the field under study (Foucault, 1980). The concept of power/knowledge does not view power as an instrument of coercion exercised by select individuals. Rather, it introduces the idea that power transcends politics and is everywhere, embodied in knowledge and regimes of truth (Sheridan, 1977).

To exemplify a practice of power/knowledge, Foucault, among other topics, examined systems for the administration and control of populations. This included studies on the promotion of social norms, whereby bodies of knowledge, including those on psychology, criminology and medicine, define norms of behaviour and deviance. Foucault's (1991) work documented how individuals are subjugated and

made to behave in specific manners, understood as a microcosm of social control, through what is termed 'bio-power'. To function effectively as a means of controlling populations, bio-power requires the collection and analysis of large sets of data on the actions of the populations in question. Production of such knowledge in the eighteenth century instigated the establishment of demography and statistics (Foucault, 1991).

Foucault's interpretation of the relationship between power and knowledge has developed into a central component of contemporary social theory, influencing research in a vast array of disciplines. The concept has informed an extensive body of literature that examines the co-evolution of knowledge production and governance practices. These include studies of the persistence of unsustainable governance regimes and explanations of how undemocratic conditions can be transformed through the development and mobilisation of alternative knowledge. For example, Van Assche et al. (2017) utilise the power/knowledge concept to demonstrate the paradox that characterises natural resource management (NRM). Despite a well-developed understanding and broad consensus on how to realise sustainable forms of NRM, there remains a significant gap between the promises and the actual realities of management (Van Assche et al., 2017). A power/knowledge framework reveals how certain types of knowledge, certain ways of constituting and understanding natural resources, can lead to specific ways of managing or governing them. In an assessment of when local communities are present and absent in decision-making in the Danube delta, Romania, Van Assche et al. (2011) demonstrate how NRM policies can co-create a 'local' that is scrutinised, subjugated and marginalised. Thus, the resources and power available to local residents can be directly influenced by how they are conceptualised at higher levels of policy-making, with management decisions veiled in specific rhetoric and supported by different forms of knowledge. Despite the difficulty of attempting to shift dominant agendas, the unravelling of power/knowledge configurations can help to illuminate how new connections between the thinking and organising of NRM can be produced to support more sustainable and just futures (Van Assche et al., 2017). Similarly, Jentoft (2017), in his assessment of how Marine Spatial Planning (MSP) may impact small-scale fisheries, illustrates how, once actors adopt positions of power and embed their agendas within institutions, incorporating different knowledge or facilitating challenges to the direction

of management can become extremely challenging. As Jentoft (2017, p. 270) explains: "given that power/knowledge interactions work both ways, power relations and their institutional materialization regulate, and are regulated by, how knowledge integration occurs". Thus, MSP institutions, and the participation processes that they establish, determine what and whose knowledge is integrated and how.

Power/knowledge arrangements can make the application of indigenous knowledge to local or international marine governance challenging. Von der Porten et al. (2020) demonstrate how power/knowledge configurations can establish path dependency within governance frameworks, rationalising the knowledge of elite stakeholders and limiting the autonomy of indigenous communities. The use of a power/knowledge framework helps to reveal the political nature of indigenous knowledge in the context of contested coastal lands and resources (Von der Porten et al., 2020). Despite the potential value of indigenous knowledge for the management of environmental challenges, such as climate change, ecosystem destruction and biodiversity loss, it commonly struggles to overpower the more established ways of knowing that inform marine governance (Schlüter et al., 2020). However, by being aware of the unequal power/knowledge arrangements at play, research suggests that alternative approaches to enhancing the power attached to indigenous actors and their knowledge can be realised.

The teaching of Foucault on power/knowledge does not frame power as a zero-sum game, and, instead, frames it as something that can be challenged, resisted, and changed (Rabinow, 1991). Foucault (1980) demonstrates how power can *both* limit and enable action. For instance, through the production of alternative knowledge and action, power can be altered, and new management structures or governance processes can be created. The production of uncomfortable knowledge is a useful example of how knowledge can be produced to actively challenge dominant power relations and instigate the creation of new, more just governance. In organisational theory, uncomfortable knowledge is knowledge that is disagreeable or intolerable to an organisation and is produced as a means of dismantling established norms (Rayner, 2012). This is the knowledge that is often excluded from decision-making processes, as it is contradictory to the way specific issues are framed or objectives are set (Marris et al., 2014). Uncomfortable knowledge can reveal illegitimacies, hypocrisy or evidence of inclusion or exclusion of

particular voices (Rayner, 2012). Crucially, the presentation of such information can instigate the reconfiguration of processes (Marris et al., 2014). Flyvbjerg (2013) examines the presentation of uncomfortable knowledge in the realm of land-use planning, illustrating how it has been used as an effective means of challenging malpractice. Focusing on the American Planning Association's (APA) handling of uncomfortable knowledge regarding overspending, 'bad planning' and negligence, it is revealed that denial and diversion strategies were used to suppress and undermine particular information that could harm organisational reputation. Flyvbjerg (2013, p. 163) concludes that "critique is historically a main driver of progress", demonstrating how it is in the interest of actors being challenged to have malpractice reduced, "and this best happens by exposing and addressing malpractice concerns, not by denying or diverting attention from them". Thus, the production of uncomfortable knowledge can act as a vital means of revealing unjust or undemocratic scenarios and acts as an important step in the process of creating new realities (Marris et al. 2014). It is this focus on the productive capacity of power that renders Foucauldian thinking particularly useful to community science research.

By acknowledging the productive capacity of power, community science can shift from ideas of power over, where projects are subjects of power, to notions of power to and power with, whereby participants are empowered to work collectively in the pursuit of positive change. Power/knowledge also teaches us that community science must encourage mobilisation and knowledge for action. Power/knowledge emphasis is not on the production of knowledge for its own sake, but on the production of knowledge that can revise outdated or ill-informed assumptions, leading to organisational improvement and the creation of solutions for practical problems (Gaventa and Cornwall, 2001).

Whilst becoming aware of power/knowledge can enable researchers to consider the broader transformative potential of community science, it must be underpinned by a critically reflective and politically conscious process. Not only must the production of community science knowledge be complemented by acting upon it, but participants engaged with the knowledge production process must also be facilitated with space for what Gaventa and Cornwall (2001) term 'self-critical investigation'. Critically reflecting upon one's reality is essential for more authentic knowledge to be generated as a

basis for action or representation to others. It is important to note how critical self-learning is important not only for the weak and powerless, as Freire (1996) discusses, but also for the more powerful actors who may themselves be trapped in received versions of their own situation (Keijser et al., 2020). Thus, learning and reflection through community science must extend beyond participants and impact practitioners and goverment actors as well. It is amongst these actors where any popular biases or unsupported assumptions that underpin marine governance processes can be reconfigured, leading to the initiation of new arrangements (Christens et al., 2016). From this perspective, what is empowering about community science is the extent to which it can create more democratic forms of knowledge, through action and mobilisation of communities to act on their affairs, in a way that also involves their critical reflection and learning.

## 4. Towards power-aware community science

Furthering calls for co-production processes to become '(re)politicized' (Turnhout et al., 2020), we argue that marine community science must become a process that embeds power analysis into its design structure. When blind to the avenues through which power/knowledge arrangements operate, community science risks reinforcing existing relations that have limited the ability of participatory research to successfully contribute to societal transformation and to enhance the influence that communities within governance processes (Lemos et al., 2018). We seek to instigate a shift in the conceptualisation of community science, and in particular the framing of its transformative potential, by introducing the concept of power/knowledge. Power/knowledge demonstrates how, to achieve transformative outcomes, community science must become conscious of what knowledge is, how it relates to arrangements of power and how it can be used to instigate change to marine governance. In addition to generating knowledge in a contributory manner, community science must produce knowledge that is explicit and capable of invoking critical reflection. This must involve acute analysis of knowledge systems and practices, to ensure that knowledge is truly reflective of current conditions and comprehends how they can be altered. Should community science be advanced solely as a means of contributing to the *status quo* of conservation management, projects will be forced to focus on what

is, rather than on what could be. In recent years, several ocean data portals have been created to support marine planning by establishing new knowledge infrastructures. Although portals can be diverse in content, contributors are largely limited to government actors, academics, and those working within Non-Governmental Organisations (Boucquey et al., 2019). We suggest that community science offers a more open and democratic approach to informing marine governance. Community science initiatives can facilitate the generation of a broader range of knowledge forms and, when made power-aware, have the capacity to change marine management. Community science projects should be imbued with a critical interpretation of the power/knowledge configurations that shape their development can. This will reveal pathways through which initiatives can better understand how and why transformative outcomes are often inhibited, and how such eventualities can be overcome.

We suggest that community science, particularly initiatives that have genuine aspirations of transforming conservation practice into more democratic and open processes, should be organised in a way that encourages reflections on the workings of power. Such projects should be designed with a recognition that unequal power relations cannot simply be 'managed away' but can be challenged through the production of what we have termed knowledge for action (Gaventa and Cornwall, 2001). The example of a co-production initiative in Caracas, Venezuela, that empowered poorer members of the public in technical water committees by way of engaging them with a broader political project set up to challenge unequal arrangements of power between the state and the population, is a useful case to reflect upon (McMillan et al., 2014). By way of engaging volunteers in a wider process of social change, the project was capable of promoting a 'rethink' of the concept of citizenship. This helped the initiative to avoid being captured or overwhelmed by the agendas of elite actors (McMillan et al., 2014). Instigating action-orientated participation that resists being shoehorned into predefined pathways of producing knowledge and attempts to foster critical reflection and learning amongst volunteers, practitioners and governance actors is central to realising this potential. Additionally, Rosen and Painter's (2019) assessment of the *Lift To Rise* initiative in the Coachella Valley, which researches poverty-related issues, represents an example of how co-production can effectively tackle imbalances of power through adaptive, flexible and long-term participatory processes. By engaging with

community change experts, the initiative created a dynamic participation process, rooted in continual and reflexive learning between both volunteers and land-use planners. Through this process, planners were challenged to rethink participation and to support community capacity building and resource sharing, to build and sustain community power (Rosen and Painter, 2019).

We suggest that power-aware and self-reflective community science projects can become well-placed to expose contradictions and inconsistencies within marine governance regimes. This is important, as there is growing evidence of marine governance being implemented through post-political processes (Tafon, 2018; Aschenbrenner and Winder, 2019; Clarke and Flannery, 2020). Post-political processes minimise engagement and meaningful debate, resist transforming the *status quo*, and replace contestation with elite and technocratic-managerialism (Flannery et al., 2018; Said and Trouillet, 2020). To challenge this, power-aware community science could involve revealing evidence of environmental injustice (Rosario-Ramos and Sawada, 2019), challenging inequality, exclusion or lack of democratic accountability (Shaw et al., 2020), and proposing alternative approaches or definitions based on collected knowledge (Thiollent, 2011). We have already seen examples of this in the broader field of co-production (see Lemos et al., 2018; Turnhout et al., 2020) and we believe that there is significant potential to experiment with such approaches within community science. We must better understand the mechanisms used by the co-production projects that do enable empowerment, transformative learning and knowledge for action, and examine how such mechanisms can become embedded within marine community science.

Operationalising a power-aware paradigm will require changes to both community science theory and practice. Informed by social theory, research can develop closer working relationships with projects and help to map out the field of power that they are operating within. We suggest that Foucault's theory of power/knowledge may be one option to inform future research, which we have presented as a useful means of understanding how power and knowledge relate to each other within the realm of community science. In particular, the power/knowledge framework can guide evaluative assessments of the power dynamics that operate between community science practitioners and other actors and reveal the degree

to which this balance influences the organisational design of projects. For instance, should cases of government actors suppressing the transformative capacity of community science be revealed, research can help to create alternative pathways for transformative community science. As one example, practitioners can learn from studies on how to broaden pathways to participation for marine community science volunteers, so that the specific motivations and desired outcomes of different volunteers can be responded to and supported (McAteer et al., 2021). This can help to maximise the potential contribution of volunteers and enhance their likelihood to sustain participation, both aspects that can benefit the potential transformative outputs of a project. Beyond this, future research could inform the creation of community science networks, whereby projects work collaboratively to share volunteers, create funding pots, and share advocacy skills and communication strategies. The notion of building collective strength through collaboration is aligned with the productive capacity of power that the power/knowledge concept promotes. Marine community science can learn from the creation of collaborative networks that have enhanced the power that activist groups can yield in their attempts to challenge injustice. This could enhance the capacity of projects to challenge persistent problems associated with marine governance, such as stakeholder marginalisation and the exclusion of local knowledge (Said and MacMillan, 2020). Uysal and Yang (2013), in their assessment of the impact of WikiLeaks on the stock value of Bank of America, illustrate how mass self-communication empowered a network of activists to promote and shape social change.

Power-aware community science practice should also support new models of learning, wherein critical reflection should be key. Although educational advancement and literacy-building are core outputs of many community science projects, we find that this is largely restricted to volunteers. The impact that community science has upon powerful figures, such as governance actors, is not comprehensively addressed by research and there are no apparent mechanisms in place to contribute to their transformation. By not engaging with, nor challenging the consciousness and actions of governance actors, the transformative capacity of community science is likely to be lessened. As a response, we suggest that research that evaluates learning within community science should extend its focus to actors beyond volunteers. This should involve surveying governance actors to understand how they interpret

community science and the degree to which their values and norms may be challenged by the knowledge that projects produce. Such evaluations could reveal valuable insight to learn from and to incorporate in future initiatives. This leads us to suggest that, to arrive at a more reliable and transparent measurement of the transformative potential of marine community science, evaluations of learning should be built into projects as an inherent step in the process. This is of particular relevance because learning in community science commonly occurs in unexpected ways and induces transformations at various levels, including changes in the values, beliefs, emotions, and actions of learners (Bela et al., 2016). Thus, volunteers, practitioners and governance actors should be equally involved in the process of learning evaluations through self-assessment and reflection.

## 5. **Conclusion**

We recognise that politicising the field of marine community science will bring challenges and may not result in actionable knowledge in an instrumental sense amongst all forms of projects. Also, we must not ignore the wider challenges that face community science. It is important to consider how power-aware community science may respond to these. Most notably, doubts regarding the ability of community science to consistently produce valid scientific knowledge, to avoid participant bias (Gonsamo and D'Odorico, 2014) and to fully engage with marginalised individuals (Walajahi, 2019). Such limitations have already been suggested as factors that make it difficult for community science to challenge social inequalities (Bela et al., 2016), and we must factor this into our thinking. It is also imperative to appreciate that some community science projects may prefer to function as contributory endeavours that distance themselves from critical approaches and, therefore, will see less benefit in becoming politicised. However, we present a politicised paradigm as a broader means of improving the understanding of transformation in community science and we hope that this can instigate critical reflection amongst all categories of projects. Community science has a strong potential to introduce new ways of knowing to marine governance, revise inaccurate assumptions that have misled management and facilitate more active community participation. This paper has highlighted how, for these transformative objectives to be fulfilled, it is vital to consider the field of power that projects operate within.

# References

Akaateba, M.A., Huang, H. and Adumpo, E.A., 2018. Between co-production and institutional hybridity in land delivery: Insights from local planning practice in peri-urban Tamale, Ghana. *Land Use Policy*, 72, pp.215-226.

Albert, A., Balázs, B., Butkevičienė, E., Mayer, K. and Perelló, J., 2021. Citizen social science: new and established approaches to participation in social research. In: Vohland, K. et al. (Eds.) *The Science of Citizen Science* (pp.119-138). Springer.

Aschenbrenner, M. and Winder, G.M., 2019. Planning for a sustainable marine future? Marine spatial planning in the German exclusive economic zone of the North Sea. *Applied Geography*, *110*, p.102050.

Ballard, H., Phillips, T. and Robinson, L., 2018. Conservation outcomes of citizen science. In: Hecker, S., Haklay, M. and Bowser, A. (Eds.) *Citizen Science - Innovation in Open Science, Society and Policy* (pp. 254-268). UCL Press: London.

Bela, G., Peltola, T., Young, J.C., Balázs, B., Arpin, I., Pataki, G., Hauck, J., Kelemen, E., Kopperoinen, L., Van Herzele, A. and Keune, H., 2016. Learning and the transformative potential of citizen science. *Conservation Biology*, 30(5), pp.990-999.

Bennett, N.J., 2016. Using perceptions as evidence to improve conservation and environmental management. *Conservation Biology*, 30(3), pp.582-592.

Bennett, N.J., Blythe, J., Cisneros-Montemayor, A.M., Singh, G.G. and Sumaila, U.R., 2019. Just transformations to sustainability. *Sustainability*, *11*(14), p.3881.

Blythe, J., Silver, J., Evans, L., Armitage, D., Bennett, N.J., Moore, M.L., Morrison, T.H. and Brown, K., 2018. The dark side of transformation: latent risks in contemporary sustainability discourse. *Antipode*, 50(5), pp.1206-1223.

Blythe, J., Armitage, D., Bennett, N., Silver, J.J., and Song, A.M., 2021. Conditions and Cautions for Transforming Ocean Governance. In: Baird, J. and Plummer, R. (Eds.) *Water Resilience: Management and Governance in Times of Change* (pp. 241–261). Cham: Springer International Publishing.

Bonney, R., Cooper, C.B., Dickinson, J., Kelling, S., Phillips, T., Rosenberg, K.V. and Shirk, J., 2009. Citizen science: a developing tool for expanding science knowledge and scientific literacy. *BioScience*, 59(11), pp.977-984.

Bonney, P., Murphy, A., Hansen, B. and Baldwin, C., 2020. Citizen science in Australia's waterways: investigating linkages with catchment decision-making. *Australasian Journal of Environmental Management*, 27(2), pp.200-223.

Boucquey, N., Martin, K.S., Fairbanks, L., Campbell, L.M. and Wise, S., 2019. Ocean data portals: Performing a new infrastructure for ocean governance. *Environment and Planning D: Society and Space*, 37(3), pp.484-503.

Brenton, P., von Gavel, S., Vogel, E. and Lecoq, M.E., 2018. Technology infrastructure for citizen science. In: Hecker, S., Haklay, M. and Bowser, A. (Eds.) *Citizen Science - Innovation in Open Science, Society and Policy* (pp. 63-80). UCL Press: London.

Brombal, D., 2020. Is fighting with data enough? Prospects for transformative citizen science in the Chinese Anthropocene. *Journal of Environmental Planning and Management*, 63(1), pp.32-48.

Chase, S.K. and Levine, A., 2016. A framework for evaluating and designing citizen science programs for natural resources monitoring. *Conservation Biology*, 30(3), pp.456-466.

Chilvers, J. and Kearnes, M., 2020. Remaking participation in science and democracy. *Science, Technology, & Human Values*, 45(3), pp.347-380.

Christens, B.D., Winn, L.T. and Duke, A.M., 2016. Empowerment and critical consciousness: A conceptual cross-fertilization. *Adolescent Research Review*, 1(1), pp.15-27.

Cigliano, J.A., Meyer, R., Ballard, H.L., Freitag, A., Phillips, T.B. and Wasser, A., 2015. Making marine and coastal citizen science matter. *Ocean & Coastal Management*, 115, pp.77-87.

Clarke, J. and Flannery, W., 2020. The post-political nature of marine spatial planning and modalities for its re-politicisation. *Journal of Environmental Policy & Planning*, 22(2), pp.170-183.

Conrad, C.T. and Daoust, T., 2008. Community-based monitoring frameworks: Increasing the effectiveness of environmental stewardship. *Environmental management*, 41(3), pp.358-366.

Couvet, D. and Prevot, A.C., 2015. Citizen-science programs: Towards transformative biodiversity governance. *Environmental Development*, 13, pp.39-45.

Cvitanovic, C., McDonald, J. and Hobday, A.J., 2016. From science to action: principles for undertaking environmental research that enables knowledge exchange and evidence-based decision-making. *Journal of environmental management*, 183, pp.864-874.

Dale, A. and Armitage, D., 2011. Marine mammal co-management in Canada's Arctic: Knowledge co-production for learning and adaptive capacity. *Marine Policy*, 35(4), pp.440-449.

Devictor, V., Whittaker, R.J. and Beltrame, C., 2010. Beyond scarcity: citizen science programmes as useful tools for conservation biogeography. *Diversity and distributions*, 16(3), pp.354-362.

Dickinson, J.L., Shirk, J., Bonter, D., Bonney, R., Crain, R.L., Martin, J., Phillips, T. and Purcell, K., 2012. The current state of citizen science as a tool for ecological research and public engagement. *Frontiers in Ecology and the Environment*, 10(6), pp.291-297.

Eitzel, M.V., Cappadonna, J.L., Santos-Lang, C., Duerr, R.E., Virapongse, A., West, S.E., Kyba, C.C.M., et al., 2017. Citizen Science Terminology Matters: Exploring Key Terms. *Citizen Science: Theory and Practice*, 2(1), pp.1–20.

Flannery, W., Healy, N. and Luna, M., 2018. Exclusion and non-participation in Marine Spatial Planning. *Marine Policy*, 88, pp.32-40.

Flannery, W., Clarke, J. and McAteer, B., 2019. Politics and power in marine spatial planning. In: Zaucha, J. and Gee, K. (Eds.) *Maritime spatial planning: Past, present and future* (pp. 201-217). Palgrave Macmillan, Cham.

Flyvbjerg, B., 2013. How planners deal with uncomfortable knowledge: The dubious ethics of the American Planning Association. *Cities*, 32, pp.157-163.

Foucault, M., 1980. Power/Knowledge: Selected Interviews and Other Writings, 1972-1977. Harvester, Brighton.

Foucault, M., 1982. The subject and power. *Critical Inquiry*, 8(4), pp.777-795.

Foucault, M., 1991. Discipline and Punish: the birth of a prison. London, Penguin.

Freire, P., 1996. Pedagogy of the oppressed (revised). New York, Continuum.

Fudge, M., Alexander, K., Ogier, E., Leith, P. and Haward, M., 2021. A critique of the participation norm in marine governance: Bringing legitimacy into the frame. *Environmental Science & Policy*, *126*, pp.31-38.

Gallo, T. and Waitt, D., 2011. Creating a successful citizen science model to detect and report invasive species. *BioScience*, 61(6), pp.459-465.

Garcia-Soto, C., Seys, J.J., Zielinski, O., Busch, J.A., Luna, S.I., Baez, J.C., Domegan, C., Dubsky, K., Kotynska-Zielinska, I., Loubat, P. and Malfatti, F., 2021. Marine Citizen Science: Current state in Europe and new technological developments. *Frontiers in Marine Science*, 8, p.241.

Gaventa, J. and Cornwall, A., 2001. Power and Knowledge. In: P. Reason, H. Bradbury (Eds.) *Handbook of Action Research: Participative Inquiry & Practice* (pp. 70-80). Sage Publications, London.

Geels, F.W., Sovacool, B.K., Schwanen, T. and Sorrell, S., 2017. Sociotechnical transitions for deep decarbonization. *Science*, 357(6357), pp.1242-1244.

Grossberndt, S., Passani, A., Di Lisio, G., Janssen, A. and Castell, N., 2021. Transformative Potential and Learning Outcomes of Air Quality Citizen Science Projects in High Schools Using Low-Cost Sensors. *Atmosphere*, 12(6), p.736.

Hampshire, K., Hills, E. and Iqbal, N., 2005. Power relations in participatory research and community development: a case study from northern England. *Human Organization*, 64(4), pp.340-349.

Haywood, B.K., 2016. Beyond data points and research contributions: the personal meaning and value associated with public participation in scientific research. *International Journal of Science Education, Part B*, 6(3), pp.239-262.

Hyder, K., Townhill, B., Anderson, L.G., Delany, J. and Pinnegar, J.K., 2015. Can citizen science contribute to the evidence-base that underpins marine policy?. *Marine Policy*, 59, pp.112-120.

Hyder, K., Wright, S., Kirby, M. and Brant, J., 2017. The role of citizen science in monitoring small-scale pollution events. *Marine Pollution Bulletin*, 120(1-2), pp.51-57.

Jambeck, J.R. and Johnsen, K., 2015. Citizen-based litter and marine debris data collection and mapping. *Computing in Science & Engineering*, 17(4), pp.20-26.

Jarvis, R.M., Breen, B.B., Krägeloh, C.U. and Billington, D.R., 2015. Citizen science and the power of public participation in marine spatial planning. *Marine Policy*, 57, pp.21-26.

Jentoft, S., 2017. Small-scale fisheries within maritime spatial planning: knowledge integration and power. *Journal of Environmental Policy & Planning*, 19(3), pp.266-278.

Kelly, R., Fleming, A., Pecl, G.T., von Gönner, J. and Bonn, A., 2020. Citizen science and marine conservation: a global review. *Philosophical Transactions of the Royal Society B*, *375*(1814), p.20190461.

Kelly, R., Evans, K., Alexander, K., Bettiol, S., Corney, S., Cullen-Knox, C., Cvitanovic, C., de Salas, K., Emad, G.R., Fullbrook, L. and Garcia, C., 2021. Connecting to the oceans: supporting ocean literacy and public engagement. *Reviews in fish biology and fisheries*, pp.1-21.

Keijser, X., Toonen, H. and van Tatenhove, J., 2020. A "learning paradox" in maritime spatial planning. *MAS T. Maritime Studies*, *19*(3), pp.333-346.

Kythreotis, A.P., Mantyka-Pringle, C., Mercer, T.G., Whitmarsh, L.E., Corner, A., Paavola, J., Chambers, C., Miller, B.A. and Castree, N., 2019. Citizen social science for more integrative and effective climate action: A science-policy perspective. *Frontiers in Environmental Science*, 7, p.10.

Leach, M. and Fairhead, J., 2002. Manners of contestation:"citizen science" and "indigenous knowledge" in West Africa and the Caribbean. *International Social Science Journal*, 54(173), pp.299-311.

Lemos, M.C., Arnott, J.C., Ardoin, N.M., Baja, K., Bednarek, A.T., Dewulf, A., Fieseler, C., Goodrich, K.A., Jagannathan, K., Klenk, N. and Mach, K.J., 2018. To co-produce or not to co-produce. *Nature Sustainability*, 1(12), pp.722-724.

Loos, J., Horcea-Milcu, A.I., Kirkland, P., Hartel, T., Osváth-Ferencz, M. and Fischer, J., 2015. Challenges for biodiversity monitoring using citizen science in transitioning social–ecological systems. *Journal for Nature conservation*, 26, pp.45-48.

Mach, K.J., Lemos, M.C., Meadow, A.M., Wyborn, C., Klenk, N., Arnott, J.C., Ardoin, N.M., Fieseler, C., Moss, R.H., Nichols, L. and Stults, M., 2020. Actionable knowledge and the art of engagement. *Current Opinion in Environmental Sustainability*, 42, pp.30-37.

Marris, C., Jefferson, C. and Lentzos, F., 2014. Negotiating the dynamics of uncomfortable knowledge: The case of dual use and synthetic biology. *BioSocieties*, 9(4), pp.393-420.

McAteer, B., Flannery, W. and Murtagh, B., 2021. Linking the motivations and outcomes of volunteers to understand participation in marine community science. *Marine Policy*, 124, p.104375.

McKinley, D.C., Miller-Rushing, A.J., Ballard, H.L., Bonney, R., Brown, H., Cook-Patton, S.C., Evans, D.M., French, R.A., Parrish, J.K., Phillips, T.B. and Ryan, S.F., 2017. Citizen science can improve conservation science, natural resource management, and environmental protection. *Biological Conservation*, 208, pp.15-28.

McMillan, R., Spronk, S. and Caswell, C., 2014. Popular participation, equity, and co-production of water and sanitation services in Caracas, Venezuela. *Water International*, 39(2), pp.201-215.

Merenlender, A.M., Crall, A.W., Drill, S., Prysby, M. and Ballard, H., 2016. Evaluating environmental education, citizen science, and stewardship through naturalist programs. *Conservation Biology*, 30(6), pp.1255-1265.

Oliver, K., Kothari, A. and Mays, N., 2019. The dark side of coproduction: do the costs outweigh the benefits for health research?. *Health research policy and systems*, 17(1), pp.1-10.

Olsson, P., Galaz, V. and Boonstra, W.J., 2014. Sustainability transformations: a resilience perspective. *Ecology and Society*, 19(4).

Ottinger, G., 2010. Buckets of resistance: Standards and the effectiveness of citizen science. *Science, Technology, & Human Values*, 35(2), pp.244-270.

Pandya, R.E., 2012. A framework for engaging diverse communities in citizen science in the US. *Frontiers in Ecology and the Environment*, 10(6), pp.314-317.

Parkinson, J., 2012. Democratizing deliberative systems. In: Parkinson, J. and Mansbridge, J. (Eds.) *Deliberative systems: Deliberative democracy at the large scale* (pp.151-172). Cambridge University Press, Cambridge.

Peters, K., 2020. The territories of governance: unpacking the ontologies and geophilosophies of fixed to flexible ocean management, and beyond. *Philosophical Transactions of the Royal Society B*, *375*(1814), p.20190458.

Peters, M.A. and Besley, T., 2019. Citizen science and post-normal science in a post-truth era: Democratising knowledge; socialising responsibility. In: Peters, M.A., Besley, T., Tesar, M., Jackson, L., Jandric, P., Arndt, S. and Sturm, S. (Eds.) *The Methodology and Philosophy of Collective Writing* (pp. 132-147). Routledge, London.

Rabinow, P., 1991. The Foucault Reader: An introduction to Foucault's thought. Penguin, London.

Rayner, S., 2012. Uncomfortable knowledge: the social construction of ignorance in science and environmental policy discourses. *Economy and Society*, 41(1), pp.107-125.

Reed, M.S., Graves, A., Dandy, N., Posthumus, H., Hubacek, K., Morris, J., Prell, C., Quinn, C.H. and Stringer, L.C., 2009. Who's in and why? A typology of stakeholder analysis methods for natural resource management. *Journal of environmental management*, 90(5), pp.1933-1949.

Rosario-Ramos, E. and Sawada, J., 2019. "They Think Detroit Is Just Litter": Youth Challenging Environmental Injustice Through Participatory Research and Civic Engagement. In: García-Sánchez, I.M. and Orellana, M.F. *Language and Cultural Practices in Communities and Schools* (pp.76-91). Routledge, London.

Rosen, J. and Painter, G., 2019. From citizen control to co-production: Moving beyond a linear conception of citizen participation. *Journal of the American planning association*, 85(3), pp.335-347.

Ruiz-Mallén, I., Riboli-Sasco, L., Ribrault, C., Heras, M., Laguna, D. and Perié, L., 2016. Citizen science: Toward transformative learning. *Science Communication*, 38(4), pp.523-534.

Said, A. and MacMillan, D., 2020. 'Re-grabbing' marine resources: a blue degrowth agenda for the resurgence of small-scale fisheries in Malta. *Sustainability Science*, 15(1), pp.91-102.

Said, A. and Trouillet, B., 2020. Bringing 'Deep knowledge' of fisheries into marine spatial planning. *Maritime Studies*, 19(3), pp.347-357.

Sandahl, A. and Tøttrup, A.P., 2020. Marine citizen science: recent developments and future recommendations. *Citizen Science: Theory and Practice*, 5(1).

Saunders, F., Gilek, M., Ikauniece, A., Tafon, R.V., Gee, K. and Zaucha, J., 2020. Theorizing social sustainability and justice in marine spatial planning: Democracy, diversity, and equity. *Sustainability*, *12*(6), p.2560.

Schläppy, M.L., Loder, J., Salmond, J., Lea, A., Dean, A.J. and Roelfsema, C.M., 2017. Making waves: marine citizen science for impact. *Frontiers in Marine Science*, 4, p.146.

Schlüter, A., Van Assche, K., Hornidge, A.K. and Văidianu, N., 2020. Land-sea interactions and coastal development: an evolutionary governance perspective. *Marine Policy*, 112, p.103801.

Sharpe, A. and Conrad, C., 2006. Community based ecological monitoring in Nova Scotia: challenges and opportunities. *Environmental monitoring and assessment*, 113(1), pp.395-409.

Shaw, J., Howard, J. and Franco, E.L., 2020. Building inclusive community activism and accountable relations through an intersecting inequalities approach. *Community Development Journal*, 55(1), pp.7-25.

Sheridan, A., 1977. Discipline and punish [Translation of Foucault]. Pantheon, New York.

Shirk, J.L., Ballard, H.L., Wilderman, C.C., Phillips, T., Wiggins, A., Jordan, R., McCallie, E., Minarchek, M., Lewenstein, B.V., Krasny, M.E. and Bonney, R., 2012. Public participation in scientific research: a framework for deliberate design. *Ecology and society*, 17(2).

Steven, R., Barnes, M., Garnett, S.T., Garrard, G., O'Connor, J., Oliver, J.L., Robinson, C., Tulloch, A. and Fuller, R.A., 2019. Aligning citizen science with best practice: Threatened species conservation in Australia. *Conservation Science and Practice*, 1(10), p.e100.

Tafon, R.V., 2018. Taking power to sea: Towards a post-structuralist discourse theoretical critique of marine spatial planning. *Environment and Planning C: Politics and Space*, 36(2), pp.258-273.

Tafon, R., Glavovic, B., Saunders, F. and Gilek, M., 2021. Oceans of Conflict: Pathways to an Ocean Sustainability PACT. *Planning Practice & Research*, pp.1-18.

Thiollent, M., 2011. Action research and participatory research: An overview. *International Journal of Action Research*, 7(2), pp.160-174.

Thompson, M.M., 2016. Upside-down GIS: The future of citizen science and community participation. *The Cartographic Journal*, 53(4), pp.326-334.

Toomey, A.H. and Domroese, M.C., 2013. Can citizen science lead to positive conservation attitudes and behaviors?. *Human Ecology Review*, pp.50-62.

Toonen, H.M. and van Tatenhove, J.P., 2020. Uncharted territories in tropical seas? Marine scaping and the interplay of reflexivity and information. *Maritime Studies*, 19, pp.359-374.

Townhill, B.L. and Hyder, K., 2017. Citizen science and marine policy. In: Cigliano, J.A. and Ballard, H.L. (Eds.) *Citizen Science for Coastal and Marine Conservation* (pp. 178-194). Routledge, London.

Turnhout, E., Metze, T., Wyborn, C., Klenk, N. and Louder, E., 2020. The politics of co-production: participation, power, and transformation. *Current Opinion in Environmental Sustainability*, 42, pp.15-21.

Turrini, T., Dörler, D., Richter, A., Heigl, F. and Bonn, A., 2018. The threefold potential of environmental citizen science-Generating knowledge, creating learning opportunities and enabling civic participation. *Biological Conservation*, 225, pp.176-186.

Uysal, N. and Yang, A., 2013. The power of activist networks in the mass self-communication era: A triangulation study of the impact of WikiLeaks on the stock value of Bank of America. *Public relations review*, 39(5), pp.459-469.

Van Assche, K., Duineveld, M., Beunen, R. and Teampau, P., 2011. Delineating locals: transformations of knowledge/power and the governance of the Danube Delta. *Journal of Environmental Policy & Planning*, 13(1), pp.1-21.

Van Assche, K., Beunen, R. and Duineveld, M., 2017. The will to knowledge: natural resource management and power/knowledge dynamics. *Journal of Environmental Policy and Planning*, 19(3), pp.245-250.

VeneKlasen, L. and Miller, V., 2002. Power and empowerment. *PLA notes*, 43, pp.39-41.

Vercammen, A. and Burgman, M., 2019. Untapped potential of collective intelligence in conservation and environmental decision making. *Conservation Biology*, 33(6), pp.1247-1255.

Von der Porten, S., Ota, Y. and Mucina, D., 2020. Indigenous Knowledge, knowledge-holders and marine environmental governance. In: Thornton, T.F. and Bhagwat, S.A. (Eds.) *The Routledge Handbook of Indigenous Environmental Knowledge* (pp. 356-365). Routledge.

Walajahi, H., 2019. Engaging the "Citizen" in Citizen Science: Who's Actually Included?. *The American Journal of Bioethics*, 19(8), pp.31-33.

Yadav, P. and Darlington, J., 2016. Design guidelines for the user-centred collaborative citizen science platforms. *Human Computation*, arXiv preprint arXiv:1605.00910.