frontiers in Marine Science

ORIGINAL RESEARCH
published: 27 September 2016
doi: 10.3389/fmars.2016.00174

The Kraken in the Aquarium: Questions that Urgently Need to be Addressed in Order to Advance Marine Conservation

John A. Cigliano[1, 2]*, *Amy Bauer*[3], *Megan M. Draheim*[4], *Melissa M. Foley*[5], *Carolyn J. Lundquist*[6, 7], *Julie-Beth McCarthy*[8], *Katheryn W. Patterson*[9], *Andrew J. Wright*[9] and *E. C. M. Parsons*[9]

[1] Environmental Conservation Program, Department of Biological Sciences, Cedar Crest College, Allentown, PA, USA, [2] Schoodic Institute, Winter Harbor, ME, USA, [3] Mangrove Roots, LLC, Sterling, VA, USA, [4] Center for Leadership in Global Sustainability, College of Natural Resources and Environment, Virginia Polytechnic Institute and State University, Arlington, VA, USA, [5] Center for Ocean Solutions, Stanford Woods Institute for the Environment, Stanford University, Stanford, CA, USA, [6] National Institute of Water and Atmospheric Research Ltd., Hamilton, New Zealand, [7] Institute of Marine Science, University of Auckland, Auckland, New Zealand, [8] Independent Researcher, Sparwood, BC, Canada, [9] Department of Environmental Science and Policy, George Mason University, Fairfax, VA, USA

OPEN ACCESS

Edited by:
Sara M. Maxwell,
Old Dominion University, USA

Reviewed by:
Summer Lynn Martin,
National Oceanic and Atmospheric Administration, USA
Cassandra Brooks,
Stanford University, USA
Tammy Davies,
University of Victoria, Canada

***Correspondence:**
John A. Cigliano
jaciglia@cedarcrest.edu

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

Received: 04 June 2016
Accepted: 31 August 2016
Published: 27 September 2016

Citation:
Cigliano JA, Bauer A, Draheim MM, Foley MM, Lundquist CJ, McCarthy J, Patterson KW, Wright AJ and Parsons ECM (2016) The Kraken in the Aquarium: Questions that Urgently Need to be Addressed in Order to Advance Marine Conservation. Front. Mar. Sci. 3:174. doi: 10.3389/fmars.2016.00174

Despite advances in marine conservation research, policy, and management, human activities continue to negatively affect marine species, habitats, and ecosystems, and the people who rely on them for needed resources. This begs the question: What is preventing us from being more effective in conserving marine species, habitats, and ecosystems? Answering this requires us to identify gaps in marine conservation efforts and develop a consensus on how best to target our efforts. One way to do this is to conduct research prioritization exercises. The questions discussed here were identified during a series of workshops designed to establish a list of important questions that need to be answered to advance marine conservation. We deemed these particular questions to be in a separate class than those considered in the associated paper "Seventy-One Important Questions for the Conservation of Marine Biodiversity" (Parsons et al., 2014b). These questions were put into a separate category because they were identified as areas of ecological, social, and economic research that include external drivers or required sizable paradigm shifts to address. Here we describe and discuss these "Kraken in the aquarium" questions—the marine equivalent of "the elephant in the room" questions—in four sections: human nature, meeting our responsibilities, entrenched interests, and corporate driven policy. Within each section, we address multiple questions by identifying the issues and offering examples of ways forward where possible. This paper is intended to start a dialog about these difficult questions that loom over marine conservation research and management. It is becoming increasingly important that the conservation practitioner community engages in these discussions and develops solutions in order for our work to be fully effective.

Keywords: marine conservation, horizon scanning, marine biodiversity, policy, priority setting, research agenda, research questions

INTRODUCTION

It is overwhelmingly apparent that human activities have significantly affected marine species, habitats, and ecosystems. From acidification (Harvey et al., 2013; Gaylord et al., 2015) to zoonotic pathogens (Baily et al., 2015), the integrity and resilience of marine ecosystems are being threatened (Duarte, 1995; Neubauer et al., 2013). People who rely on the oceans for ecosystem services such as carbon sequestration, food, and cultural security are also being affected (Millennium Ecosystem Assessment, 2005; Worm et al., 2009).

Much good work in research, policy, and management is being done to conserve marine species and ecosystems. In particular, there has been a significant rise in interdisciplinary conservation biology research that tackles persistently difficult management issues, such as fisheries (Dayton et al., 1995; Essington et al., 2006; Worm et al., 2009), biodiversity (Roberts et al., 2002; Sala and Knowlton, 2006), climate change (Harley et al., 2006; Guinotte and Fabry, 2008), marine protected areas (Allison et al., 1998; Halpern, 2003; Palumbi, 2003), cumulative effects (Halpern et al., 2008), ecological tipping points (Selkoe et al., 2015), resilience (Hughes et al., 2005), ecosystem services (Palumbi et al., 2009; White et al., 2012), ecosystem-based management (Arkema et al., 2006; Mcleod and Leslie, 2009) and marine planning (Crowder et al., 2006; Naidoo et al., 2006). In spite of this wealth of research, the health of marine ecosystems is continuing to decline in many areas (Jackson et al., 2001; Worm et al., 2009; Howarth et al., 2014). What are we missing? What else can be done to be more effective in conserving marine species, habitats, and ecosystems? Perhaps the most pertinent question is: how does one identify gaps in marine conservation efforts and develop consensus on how best to target our efforts? One technique that has been used successfully to create consensus on direction, priority, and gaps in conservation are research prioritization exercises (Sutherland and Woodroof, 2009; Rudd, 2011, 2014; Rees et al., 2013).

We conducted one such exercise (Parsons et al., 2014a) and identified 71 important questions that need to be answered in order to advance marine conservation. During the exercise, we also identified "Kraken in the aquarium" questions, i.e., the marine equivalent of "the elephant in the room." These are questions that need to be addressed but are not, either because they conflict with the interests of scientists, managers, or funders; question dogma; or are thought to be outside the realm of "proper" conservation science. However, we believe that marine conservation research and management cannot be fully effective until we start a dialog with the broader ocean community and identify opportunities to address these issues.

METHODS

Our methodology is fully described in Parsons et al. (2014a). Briefly, we conducted a pair of two-day workshops where we identified the 71 most important questions that needed to be answered to advance marine conservation. The first workshop was held at the 2nd International Marine Conservation Congress (IMCC) in 2011. At this meeting, 17 participants with expertise in a variety of disciplines reviewed an initial list of 631 questions, which were solicited from participants at the IMCC, professional peer groups, and by the Society for Conservation Biology. The number of questions was then reduced during a second workshop in 2012. During the process we also identified a number of "Kraken in the aquarium" questions that were urgent but not being addressed because of the reasons noted above. Similar questions were combined and the resulting questions were grouped into four categories: human nature, meeting our responsibilities, entrenched interests, and corporate-driven policy. It should be noted that these categories were not prioritized. Likewise, the questions in these categories were not ranked, nor do the number of questions in each section reflect their relative importance.

We discuss some of these "Kraken in the aquarium" questions below within their respective categories. In the discussion we identify why these questions are important to ask and answer and provide evidence from peer-reviewed publications to illustrate opportunities for addressing these issues.

KRAKEN TOPICS

Human Nature

Academic, political, and research funding cycles tend to be much shorter than ecological cycles. How can these cycles acknowledge and incorporate the temporal scales of biological and ecological change and conservation success evaluation?

Funding cycles for marine conservation actions and research are often determined by election and/or academic cycles; in other words, these projects usually last one to four years (Lundquist et al., 2016). Interest in conservation actions among policy makers might also hinge on these cycles. For example, a survey in Scotland noted that 40% of the public would be more likely to vote for a politician if they showed strong support for nature conservation (Scott and Parsons, 2005). Following the release of the survey results, all political parties started mentioning cetacean conservation in their manifestos for the first—and last—time in anticipation of an upcoming national election. Thus, this issue had a lifespan of merely one election cycle.

In many cases, however, conservation action and research span longer time periods than funding cycles. The marine environment is large, three-dimensional, dynamic in nature and visually impenetrable, all of which leads to difficulties in gathering data (Norse and Crowder, 2005). The physical and highly dynamic nature of the oceans means that data collected across broad scales of time and space are often necessary before we are able to detect patterns and understand processes. For example, it can take a decade or more to detect a significant decline in a small population of dolphins (Wilson et al., 1999; Thompson et al., 2000; Bejder et al., 2006) or fish stocks (Maxwell and Jennings, 2005), particularly if there is a lot of natural variability in population size (Scheffer et al., 2009). This makes marine conservation time-consuming, expensive, and often leaves us with scientific uncertainty; marine science is difficult and "messy" (Norse and Crowder, 2005). These are all factors that funding bodies, policy makers, and even academic institutions tend to dislike, preferring short-term actions with definitive and guaranteed results. Ultimately, fewer resources and less support are available for long-term marine conservation research at a time when it is vital (Kochin and Levin, 2003, 2004). Incidentally, a focus on short-term funding could exacerbate the problem of shifting baselines, an acknowledged issue in marine conservation (Pauly, 1995; Papworth et al., 2009). A paradigm shift in scientific evaluation is needed so that the benefits of long-term research can be assessed incrementally, whether during political, academic, or funding cycles, so that the evaluation of success is more in line with the realities of research in the marine environment (Lundquist et al., 2016).

Does compromising as part of the marine planning process fail marine conservation?

There is the old adage that true compromise leaves both sides unsatisfied. Compromise has become a standard part of marine conservation planning, whether by governments, local stakeholders, or corporations. But should it be? Are we doing a disservice to marine conservation in doing so, and will it ultimately lead to bigger problems down the line? For example, compromise can result in scaled back conservation objectives and actions that may have loopholes, delayed timelines, or promote ineffective measures that could worsen ecological conditions (Hutchings, 2000; Hutchings and Reynolds, 2004).

All stakeholders should understand the tradeoffs associated with different management scenarios before decisions are made (White et al., 2012). While incorporating the value of an area of important dolphin habitat or a sacred natural site into decision making can be difficult, tools and techniques are being developed to address these challenges (Nelson and Vucetich, 2009; Maes et al., 2012; Ruckelshaus et al., 2015). Power dynamics must also be recognized; i.e., artisanal fishers and conservationists typically have less power to dictate equal terms than government agencies, branches of the military, and/or large multinational corporations (Le Heron et al., 2016; Lundquist et al., 2016).

Finally, does compromise contribute to increasing cumulative effects? The number of human stressors in the ocean is increasing (Halpern et al., 2008), but our ability to account for and manage the cumulative effects of these activities is still inadequate in most locations (Duinker et al., 2013). While marine planning is likely to reduce the rate of new stressors being added to the marine environment, compromises in the process may not completely reduce the addition of new stressors. This behooves us to think strategically about what compromises allow us to reduce overall cumulative effects while still attaining the conservation goals of the process (Halpern and Fujita, 2013).

MEETING OUR RESPONSIBILITIES

To what degree should marine scientists serve as advocates for nature?

Traditionally, scientists have had one main responsibility: to carry out high-quality science that advances human knowledge. Today, the term "scientist" carries different meaning and weight, as there are many disciplines, applications, and discourses that can be applied to the discipline of science. It can be argued that scientists were not previously required to fulfill the additional obligations and responsibilities that today's scientists are expected to meet (Evers, 2001). Some still believe in the knowledge-deficit model, where scientists should dispassionately conduct research and enable their science to "speak for itself" (Wynne, 2006). However, this viewpoint is rapidly changing, especially for conservation scientists. Conservation scientists are now expected to play an expanded role in outreach and engagement with the general public and drive evidence-based policy (Kassen, 2011).

However, whether conservation scientists should advocate for their science is still debated (Shrader-Frechette, 1996; Lackey, 2007; Noss, 2007; Chan, 2008; Nelson and Vucetich, 2009; Parsons, 2013; Parsons et al., 2015). For many marine conservation scientists, advocacy is viewed as a loss of objectivity, being emotive or radical, and somehow unprofessional; i.e., there is no difference between an "advocate" (someone who defends a particular cause) and an emotive "activist" (someone who highlights a cause). However, there is an important distinction between the two. An advocate needs information on an issue to be able to argue their case; thus scientists can be effective advocates because they are often trained to logically argue the facts of a case, whereas you do not need to be a scientist to be an activist (Parsons, 2013). Being an advocate for marine conservation science allows scientists to ensure the appropriate information gets into the right hands in the right format at the right time (Parsons, 2013; Parsons et al., 2015; Rose and Parsons, 2015).

Even if advocacy is accepted as appropriate, many scientists argue that we often do not have enough information about an issue to act or that there too much uncertainty where marine science is concerned. However, the "precautionary principle" is accepted and well established in international law, so a lack of "enough" scientific evidence should no longer be used as an excuse for an absence of conservation action. Even very basic marine questions are never understood completely. If scientists fall back on the "we do not have enough information" or "more research is needed" argument, action for a conservation issue may not happen until it is too late. Marine scientists have expert knowledge on marine issues; if a significant number of scientists acknowledge there is a conservation threat, this should be enough to warrant a conservation intervention. A well-structured conservation intervention identifies the drivers of change that can be managed, weighs the tradeoffs of different management options, and understands the range of potential ecological, social, and economical outcomes of taking action (Halpern et al., 2013).

Soulé (1985) argued in his seminal work, "What is Conservation Biology," that conservation biology is a mission-driven, valued-laden discipline with normative postulates—value statements that are shared by most conservationists and provide standards for measuring conservation success. Furthermore, the Society for Conservation Biology states at the beginning of its most recent strategic plan that the Society holds the following values (Society for Conservation Biology, 2011):

1. There is intrinsic value in the natural diversity of organisms, the complexity of ecological systems, and the resilience created by evolutionary processes.

2. Human-caused extinctions and the destruction and loss of function of natural ecosystems are unacceptable.
3. Maintaining and restoring biological diversity are individual and collective responsibilities of humans.
4. Science is critical for understanding how the natural world operates and how human actions affect nature.
5. Collaboration among scientists, managers, and policy-makers is vital to incorporate high-quality science into policies and management decisions affecting biological diversity.

Thus, a professional society that represents conservation science, scientists, professionals, and practitioners (including those who are marine-oriented) is effectively advocating for pro-conservation values and for conservation scientists to advocate for science-based conservation in management and policy-making.

The aversion to advocacy shown by marine scientists is not universal in the scientific community. In the public health arena, for example, few object when scientists advocate for policies that protect human health. It is critical that conservationists recognize that poor scientific decisions commonly result from the failure of scientists to communicate their message effectively (Kassen, 2011). The continued decline of marine ecosystems behooves us to use marine science to advocate for management and policy solutions, and arguably it should become the standard practice for the modern conservation biologist (Chan, 2008).

How can aquariums and zoos be best used and supported to forward marine conservation? What is their role?

Aquariums and zoos are well positioned to advocate for marine conservation through public outreach and education. However, not all zoos and aquariums are effective in these endeavors (Curtin and Wilkes, 2007; Marino et al., 2010). Jiang et al. (2007) found that people who had visited a captive cetacean facility had significantly less conservation concern and knowledge than in the control group who had never visited a marine park. Additionally, scientific information presented at facilities is often incorrect or distorted in order to avoid negative publicity, such as lower life expectancies of captive cetaceans in comparison to wild cetaceans (Rose et al., 2009; Jett and Ventre, 2015). However, there is evidence that zoos and aquariums may improve the overall pro-conservation attitudes, knowledge, intentions, and behaviors of visitors, at least in the short-term (Wyles et al., 2013). Skibins et al. (2013) suggested that the most effective way to cultivate pro-conservation behaviors among visitors is to stimulate levels of "conservation caring" (how individuals think, feel, and act toward a species), for example, through affective messaging and persuasive communication.

Aquariums and zoos also have a unique opportunity to take the lead on marine conservation research. While some institutions have made significant contributions to conservation research and advocacy, for example, the Monterey Bay Aquarium and its associated Monterey Bay Aquarium Research Institute (Yalowitz, 2004), other institutions fall short. Less than ten percent of zoos and aquariums (including dolphinariums) are involved in conservation programs in the natural world or in captive settings (Rose et al., 2009). Minteer and Collins (2013) argue that as the negative effects of anthropogenic stressors on biodiversity increase, the conservation role of aquariums and zoos must expand, especially in research related to the effects of climate change on animal health, pathogens, and emergent diseases, and the introduction of animals into novel environments, and that this research must be part of what they refer to as a *pan situ* conservation strategy that integrates *ex situ* and *in situ* conservation.

ENTRENCHED INTERESTS

Why are we still using Maximum Sustainable Yield (MSY)?

Stock assessments have been the preferred fisheries forecasting tool of fishery managers since the early 1900s. These assessments are used at multiple scales—from local to international—to develop a set of metrics that are used to set single species fishery targets, including maximum sustainable yield (MSY), or the maximum sustainable catch of a fishery (Panayotou, 1982). MSY underpins most fishery management programs around the world (Worm et al., 2009). The development of MSY began in the 1930s (Punt and Smith, 2001) and is based on four assumptions: (1) the existing stock level of a fishery can be accurately estimated; (2) the maximum sustainable fishing effort can be estimated; (3) fishing can be reduced quickly once this level is reached; and (4) recovery rates of fished stocks can be accurately determined. Over time it has become clear that these assumptions are not valid (Larkin, 1977; McClanahan et al., 2007; Finley and Oreskes, 2012), most often owing to a lack of data and uncertainty in models (Punt and Smith, 2001). MSY also fails to take into account ecological uncertainty that could reduce MSY, such as multispecies interactions, spatial, and genetic structure, depensation (i.e., the "Allee effect"), demographic stochasticity, and climate forcing (Larkin, 1977; Panayotou, 1982; Punt and Smith, 2001). MSY is also susceptible to the shifting baselines phenomenon (Pauly, 1995) because historical perspectives are often not incorporated into MSY determinations (Alexander et al., 2011). MSY was not meant to become as institutionalized as it has become in fisheries management (Punt and Smith, 2001) and calls from the scientific community to abandon the use of MSY in favor of more advanced assessments have been made for decades (Berkes, 2003; Pauly, 2009; Khalilian et al., 2010). Almost 40 years ago Larkin (1977) wrote the following epitaph for MSY:

> M.S.Y.
> 1930s-1970s
> Here lies the concept, MSY
> It advocates yields too high,
> And it didn't spell out how to slice the pie,
> We bury it with the best of wishes,
> Especially on behalf of fishes,
> We don't know what will take its place,
> But hope it's good for the human race.
> R.I.P

However, the use of MSY is still widely used in the fisheries management community (e.g., UN, 2002; FAO, 2010; UNEP, 2012). Unwillingness or inability to move beyond MSY and stock assessments is often complicated by a lack of funding, expertise, and capacity that hinders the management community's ability to incorporate complex interactions and uncertainty into fishery management practices. In addition, complexity of ecological interactions and cumulative stressors challenge our interpretation of drivers causing declines in fish stocks. The result of inaction, however, is an ever-increasing list of overexploited fish stocks around the world (e.g., Myers and Worm, 2003; but also see Worm et al., 2009 for a different analysis) and altered marine ecosystems (e.g., Howarth et al., 2014). If we are to continue utilizing MSY as a management tool, at the very least, a precautionary approach in setting MSY and fishery targets (e.g., Punt and Smith, 2001; Worm et al., 2009) should be exercised along with the incorporation of the best available science into decision-making. Ideally, MSY would be part of a broader approach to fisheries management, including ecosystem-based fisheries management, marine reserves, increased gear selectivity, and dedicated access privileges (Hilborn, 2011; Salomon et al., 2011; Howarth et al., 2014), such as being implemented by some fisheries management agencies. Ultimately, what is needed to move beyond MSY and to develop more effective fishery management (and conservation) strategies is increased dialog and cooperation between marine conservation and fisheries scientists (Salomon et al., 2011) and better partnerships between scientists and resource managers (Bremer and Glavovic, 2013; Lundquist et al., 2016).

Are we overselling the fisheries benefits of MPAs?

The area covered by marine protected areas (MPAs) has increased over the last two decades, but only 2.1% of the ocean is protected in implemented and actively managed MPAs and only 1% is strongly protected as no-take (Marine Conservation Institute, 2016). Most MPAs are established with two main objectives: (1) protect biodiversity (Norse and Crowder, 2005) by functioning as climate refuges (Chollett et al., 2014) and/or promoting ecological resilience; and (2) manage fisheries through the protection of target species and the corresponding spillover of individuals into fished areas (Roberts et al., 2001). However, it is unclear whether our current system of MPAs actually achieves these goals (Gaines et al., 2010). Spillover (i.e., movement of recovered fish stocks out from the MPA as eggs, larvae, juveniles, or adults to enrich fishery stocks outside the reserve; Halpern et al., 2010), while often used to justify benefits to stakeholders from the establishment of no-take MPAs, is not universal. Studies have shown that whether spillover occurs is dependent on several factors, including the oceanographic characteristics of the system (e.g., Puckett et al., 2014), life history (Gerber et al., 2005; Kaplan, 2009) and larval dispersal and movement patterns of the target species (Le Quesne and Codling, 2009; Green et al., 2015), the size and location of the reserve (Gaines et al., 2010), and the level of reserve enforcement (Byers and Noonburg, 2007). Many empirical studies suggest that benefits to the fishery often only occur within hundreds of meters of the reserve boundary (e.g., Russ et al., 2003; Halpern et al., 2010) and can be variable and localized across the reserve boundary or network (Cudney-Bueno et al., 2009) and over time (Green et al., 2015). It has also become evident that fisheries benefits are more likely if reserves are networked in a way that maximizes the net effect of spillover to fished areas between the reserves and allows population persistence of target species (Kellner et al., 2007; Moffitt et al., 2011). However, most reserves are too small to allow population persistence and are un-networked (Gaines et al., 2010; Edgar et al., 2014).

While there is evidence that spillover from MPAs can sustain fisheries outside the reserve (Cudney-Bueno et al., 2009; Halpern et al., 2010; Harrison et al., 2012), the above-mentioned caveats must be made clear to stakeholders (see Gleason et al., 2013 and Saarman et al., 2013 for an example of such a process). It must also be made clear that if fisheries management is a goal of the reserve, then adaptive management (including size and location) will be required. Additionally, given the potential localized effects of spillover, it is critical that reserves and reserve networks be designed so that the fisheries that are enhanced by spillover benefit the communities that are affected by the closure of traditional fishing areas (Cudney-Bueno et al., 2009). If these points are not communicated clearly, the benefits of MPAs for fisheries management have the potential to be exaggerated for a particular location and system, which can lead to dissatisfied stakeholders.

MPAs are one part of the ecosystem-based management strategy necessary to increase diversity, health, and resources in the world's ocean. Additional management strategies such as marine spatial planning (Foley et al., 2010), integrated ecosystem assessments (Levin et al., 2009), and cumulative effects assessment (Clarke Murray et al., 2014) need to be part of the conservation toolbox too.

CORPORATE DRIVEN POLICY

How can we break through the overwhelming media superiority of large corporations and facilitate the spread of accurate conservation science?

One of the greatest challenges to advancing conservation action is the heavy resistance often displayed by corporations. Compared with scientific institutions and global environmental organizations, corporations (and more generally, well-funded religious institutions, industry representative groups, and unions) possess disproportionate financial resources and public relations expertise, which can be used to lobby and finance politicians, influence public opinion through advertising campaigns and in some cases, fund "research" to advance corporate goals (e.g., efforts to prove smoking was harmless) (e.g., Schroeder et al., 2012). Similarly, many corporations in the U.S. have sponsored "grass-roots" campaigns to deliberately mislead public opinion (e.g., infer the existence of major "disagreement" over climate change science), with scientifically based information struggling to combat inaccurate concepts previously released into the public realm (Boykoff and Rajan, 2007; Boykoff, 2008).

There is no real answer to this problem at present. Corporations simply have more resources at their disposal. With fewer resources, conservationists will need to be increasingly strategic about outreach efforts, especially given evidence demonstrating that delivery of messages by those perceived to be activists may actually undermine the cause of the message

(Bashir et al., 2013). Conservation messaging would fare better if we continued to increase our use of the same marketing tools that corporations have successfully incorporated into their marketing campaigns (Wright et al., 2015). Specifically, it may be necessary to employ advertising techniques that strike a chord with public sentiment (see discussion above on media superiority of large corporations). Fortunately, pristine environments are inherently attractive, and the use of flagship species (such as dolphins and polar bears) to drive public concern for conservation issues has proven successful in some cases (e.g., Smith and Sutton, 2008). Additionally, increasing engagement by marine conservation scientists, potentially through the use of social media, could also be effective at countering the media superiority of large corporations.

The burden of proof to identify potentially significant economic, ecological, or cultural impacts for activities that may have negative environmental impacts is usually on those that provide the mitigation and management strategies to combat the negative impacts, instead of on those that proposed the potentially harmful activities. How do we switch the burden of proof to those who propose the activities?

Despite proposers often being required legally to demonstrate that there are no significant environmental or cultural impacts to a project, the burden of proof is often placed on those that oppose the project to instead demonstrate that an impact is likely. This can be difficult in situations when uncertainty persists in available data which is why, from an environmental perspective, the burden of proof should be on the project proponents (Agardy, 2000; Brulle and Pellow, 2006; Fitzpatrick et al., 2011). However, the question remains as to how that can be achieved. One example of new legislation that promotes a precautionary approach for ocean management is New Zealand's Exclusive Economic Zone and Continental Shelf (Environmental Effects) Act 2012, where uncertainty in the ability to estimate environmental impacts of resource extraction has resulted in many resource consent applications being denied (Lundquist et al., 2016). Even here it must be noted that seismic surveys used to find oil and gas deposits are designated as a "permitted activity," effectively setting the default management decision to "approval" for all such operations.

It is hard to demonstrate a lack of impact if there is no information on, for example, the distribution of potentially impacted species. Corporations often resist requests to wait years (or decades) for such information to be collected and rarely fund the necessary research to inform risk assessments. Political pressure is thus brought to bear and decisions are made, despite various laws in place around the world that already incorporate appropriate decision-making thresholds. Addressing this issue is likely going to require legal action, particularly in areas where legal precedence has enforced this model (e.g., Prahler et al., 2014). For example, following a legal challenge, the United States District Court for the District of Hawaii (USDCDH) found that the U.S. National Marine Fisheries Service (NMFS) had made an arbitrary and capricious decision that U.S. Navy activities would only have a "negligible impact" on several marine mammal stocks as information was lacking on which to base such a conclusion (USDCDH, 2015). This finding was made while acknowledging that NMFS has no duty to create such data. Unfortunately, not all environmental legislation allows third-party suits.

How do we deal with countries that are actively using the resources of other countries but are not paying the true value of the resource they obtain or paying in ways that do not benefit most people in the exploited countries?

Corporate economic power can allow for circumvention of conservation measures in other ways. For example, resource-extraction or manufacturing operations can move to countries with fewer environmental restrictions, lower costs, or lower tax burdens. Marine-based industries can also move into waters where access is prohibited but under-policed (e.g., in many developing nations). The situation is more complex when trans-boundary stocks are considered. Even within Europe, the Common Fisheries Policy does little to address such problems, and potentially exacerbates them by taking precedence over the EU Habitats Directive (e.g., Khalilian et al., 2010). Well-written international agreements may help to address illegal activities, especially when backed up by systematic and effective law enforcement (Sander et al., 2014).

In addition to fisheries, the emerging industry of deep sea mining (DSM) is another area where corporations could take advantage of developing countries by paying sub-values for access for mineral or oil and gas extraction (e.g., Kingan, 1998). Resolving these challenges requires more creative solutions to prevent legal or political agreements that grant sub-value access to resources. This is likely to require structured and comprehensive outreach to educate the affected public about the issue and then solicit an environmentally responsible response (see Wright et al., 2015).

How expensive should resources be if all externalities were considered?

Profit-driven projects typically focus on immediate economic needs and do not account for all the externalities. For example, extractive industries tend to pay for the costs of resource removal and access to the resource's location, but rarely for the resource itself. For non-renewable resources, extraction results in a loss of future natural resource capital, including a reduction in ecosystem services that should be accounted for in the total cost of production and in the calculation of a country's wealth (e.g., Torras, 2000). Similarly, habitat degradation through modification (e.g., aquaculture), pollution, extraction of biological components (e.g., fishing), or climate change also reduces natural resource capital for the future, although in some cases long-term recovery might be possible.

These "costs," known collectively as externalities, are not currently incorporated into prices paid by consumers. This is one of the reasons that it is often cheaper to simply replace many products shipped from around the world, rather than have them repaired locally. One option for incorporating some of these externalities is to levy environmental taxes, similar to the carbon tax implemented by British Columbia (Canada) in 2008 (Duff, 2009). Although the perception is that such taxes are ultimately passed along to consumers, in reality, this will depend on demand elasticity (Scorse, 2010). A related option would be to introduce futures trading for resources that have yet to be extracted (not their sale price), which would supplement licensing access fees. In this way, companies might be required to "buy" the resource (e.g., iron ore) *in situ* from the government. In other words, the company is paying the government now for the national loss of natural capital in the future, rather than simply buying or leasing the land at a price that is a fraction of the value of the natural capital. As the remaining resource dwindles, future potential value of the resource increases, as would purchase prices. Companies could then buy and trade these resources *in situ* in a subtly different version of today's futures that would essentially represent a trade in, for example, "potential" oil, rather than future oil sales. This would generate a new commercial use of non-extracted resources and offer one way to reconcile the corporate/financial requirement of perpetual growth with the limited capacity of ecosystems to provide resources. Governments could use the revenue from these initial sales and taxes to support environmentally sustainable industry development and carbon reduction or offsetting schemes. Additionally, it becomes possible to buy the resource to ensure that it is not extracted. Product demand may also be reduced if higher prices result.

How can we reconcile the corporate/financial requirement of perpetual economic growth with the limited capacity of ecosystems to provide resources?

All of the above issues discussed in this section are merely symptoms of the drive of corporations to produce the widest profit margin possible. However, the finite amount of resources available on the planet is simply unable to support unlimited economic and population growth (e.g., Turner, 2014). Addressing this issue will require a fundamental shift in the way we function economically. For example, nations might benefit if they moved away from our current single-aspect indicator of market economic activity, the Gross Domestic Product (GDP), to a more inclusive indicator of economic welfare. One such indicator, which includes the value of community and environmental capital (among other things), is the Genuine Progress Indicator (GPI; for details see Kubiszewski et al., 2013). Other possibly complementary options include a move to a steady state economy (e.g., Czech and Daly, 2004) or push to ensure reinvestment in natural and human capital to support future industry and consumption (e.g., Arrow et al., 2004).

Regardless, governments will need to enact laws and enter into treaties to reduce waste, reduce the export of environmental damage through foreign manufacturing, curb direct interference in politics by corporations, and increase financial transparency of grass-roots organizations, among other measures. Ample support should also be provided for research with the potential to eliminate or substantially reduce demand for some of the resources that are associated with the highest risk to the marine environment. For example, by funding development of alternative energies and fuel-cell technology, governments could promote a low-oil economy and reduce threats of oil spills and other environmental damage associated with oil and gas extraction and exploration. Unfortunately, conservation practitioners will still need to overcome likely corporate resistance to these initiatives, as discussed above.

CONCLUSION

There have been significant advances in marine conservation but we still have a long way to go. To advance marine conservation further, we need to continue to ask the hard questions, the "Kraken in the aquarium" questions, and think creatively about how to tackle them. Some of the questions we have raised have the potential to be addressed sooner rather than later. The science around MSY and MPAs, for example, is starting to point us in new directions. Other issues—particularly those with high financial stakes—are likely to move more slowly. Regardless, these questions highlight the importance of dialog, transparency, and tackling problems from multiple angles—education, advocacy, funding, legislation, economics, social well-being—and multiple sectors—industry, government, religion, and research. In many ways, all of these issues are interrelated and stem from the resource needs of a growing human population coupled with a desire for continuous economic growth, with many confounding factors. Indeed, the complexity and controversy they stir up was apparent even within our small, similarly tasked group. However, unless we do begin to discuss these questions meaningfully and openly, our efforts to protect marine biodiversity and the people that rely on the benefits it provides will not be effective in the long-term. It's time we start collectively thinking outside the confines of the Aquarium so we can "release the Kraken."

AUTHOR CONTRIBUTIONS

All authors listed, have made substantial, direct and intellectual contribution to the work, and approved it for publication.

FUNDING

The Society for Conservation Biology Marine Section provided funding for the workshops that that produced the "Kraken" questions.

ACKNOWLEDGMENTS

The authors would like to thank all individuals who submitted the questions and who participated in the workshops. We would also like to thank Jason Scorse for his helpful comments on the Corporate Driven Policy section. The authors also wish to thank the Society for Conservation Biology Marine Section for funding open access charges for this paper.

REFERENCES

Agardy, T. (2000). Effects of fisheries on marine ecosystems: a conservationist's perspective. *ICES J. Mar. Sci.* 57, 761–765. doi: 10.1006/jmsc.2000.0721

Alexander, K., Leavenworth, W. B., Claesson, S., and Bolster, W. J. (2011). Catch density: a new approach to shifting baselines, stock assessment, and ecosystem-based management. *Bull. Mar. Sci.* 87, 213–234. doi: 10.5343/bms.2010.1063

Allison, G. W., Lubchenco, J., and Carr, M. H. (1998). Marine reserves are necessary but not sufficient for marine conservation. *Ecol. Appl.* 8, S79–S92. doi: 10.2307/2641365

Arkema, K. K., Abramson, S. C., and Dewsbury, B. M. (2006). Marine ecosystem-based management: from characterization to implementation. *Front. Ecol. Environ.* 4:525–532. doi: 10.1890/1540-9295(2006)4[525:MEMFCT]2.0.CO;2

Arrow, K., Dasgupta, P., Goulder, L., Daily, G., Ehrlich, P., Heal, G., et al. (2004). Are we consuming too much? *J. Econ. Perspect. 18,* 147–172. doi: 10.1257/0895330042162377

Baily, J. L., Méric, G., Bayliss, S., Foster, G., Moss, S. E., Watson, E., et al. (2015). Evidence of land-sea transfer of the zoonotic pathogen Campylobacter to a wildlife marine sentinel species. *Mol. Ecol.* 24, 208–221. doi: 10.1111/mec.13001

Bashir, N. Y., Lockwood, P., Chasteen, A. L., Nadolny, D., and Noyes, I. (2013). The ironic impact of activists: negative stereotypes reduce social change influence. *Eur. J. Soc. Psychol.* 43, 614–626. doi: 10.1002/ejsp.1983

Bejder, L., Samuels, A., Whitehead, H., Gales, N., Mann, J., Connor, R., et al. (2006). Decline in relative abundance of bottlenose dolphins exposed to long-term disturbance. *Conserv. Biol.* 20, 1791–1798. doi: 10.1111/j.1523-1739.2006.00540.x

Berkes, F. (2003). Alternatives to conventional management: lessons from small-scale fisheries. *Environments* 31, 5–20.

Boykoff, M. (2008). The real swindle. *Nat. Rep. Clim. Change* 2, 31–32. doi: 10.1038/climate.2008.14

Boykoff, M. T., and Rajan, S. R. (2007). Signals and noise: mass-media coverage of climate change in the USA and the UK. *Eur. Mol. Biol. Organ.* 8, 207–211. doi: 10.1038/sj.embor.7400924

Bremer, S., and Glavovic, B. (2013). Exploring the science–policy interface for integrated Coastal Management in New Zealand. *Ocean Coast. Manage.* 84,107–118. doi: 10.1016/j.ocecoaman.2013.08.008

Brulle, R. J., and Pellow, D. N. (2006). Environmental justice: human health and environmental inequalities. *Ann. Rev. Public Health* 27, 103–124. doi: 10.1146/annurev.publhealth.27.021405.102124

Byers, J. E., and Noonburg, E. G. (2007). Poaching, enforcement, and the efficacy of marine reserves. *Ecol. Appl.* 17, 1851–1856. doi: 10.1890/07-0067.1

Chan, K. M. (2008). Value and advocacy in conservation biology: crisis discipline or discipline in crisis? *Conserv. Biol.* 22, 1–3. doi: 10.1111/j.1523-1739.2007.00869.x

Chollett, I., Enríquez, S., and Mumby, P. J. (2014). Redefining thermal regimes to design reserves for coral reefs in the face of climate change. *PLoS ONE* 9:e110634. doi: 10.1371/journal.pone.0110634

Clarke Murray, C., Mach, M. E., and Martone, R. G. (2014). *Cumulative Effects in Marine Ecosystems: Scientific Perspectives on its Challenges and Solutions*. Monterey, CA: World Wildlife Federation Canada, Vancouver and Center for Ocean Solutions.

Crowder, L. B., Osherenko, G., Young, O. R., Airame, S., Norse, E. A., Baron, N., et al. (2006). Sustainability - Resolving mismatches in US ocean governance. *Science* 313, 617–618. doi: 10.1126/science.1129706

Cudney-Bueno, R., Lavín, M. F., Marinone, S. G., Raimondi, P. T., and Shaw, W. W. (2009). Rapid effects of marine reserves via larval dispersal. *PLoS ONE* 4:e4140. doi: 10.1371/journal.pone.0004140

Curtin, S., and Wilkes, K. (2007). Swimming with captive dolphins: current debates and post-experience dissonance. *Int. J. Tour. Res.* 9, 131–146. doi: 10.1002/jtr.599

Czech, B., and Daly, H. E. (2004). The steady state economy – what it is, entails, and connotes. *Wildl. Soc. Bull.* 32, 598–605 doi: 10.2193/0091-7648(2004)32[598:IMOTSS]2.0.CO;2

Dayton, P. K., Thrush, S. F., Agardy, M. T., and Hofman, R. J. (1995). Environmental effects of marine fishing. *Aquat. Conserv. Mar. Freshw. Ecosyst.* 5, 205–232. doi: 10.1002/aqc.3270050305

Duarte, C. M. (1995). Submerged aquatic vegetation in relation to different nutrient regimes. *Ophelia* 41, 87–112. doi: 10.1080/00785236.1995.10422039

Duff, D. G. (2009). Carbon taxation in British Columbia. *Vt. J. Env. Law* 10, 87–107. doi: 10.2307/vermjenvilaw.10.1.87

Duinker, P. N., Burbidge, E. L., Boardley, S. R., and Greig, L. A. (2013). Scientific dimensions of cumulative effects assessment: toward improvements in guidance for practice. *Environ. Rev.* 21, 40–52. doi: 10.1139/er-2012-0035

Edgar, G. J., Stuart-Smith, R. D., Willis, T. J., Kininmonth, S., Baker, S. C., Banks, S., et al. (2014). Global conservation outcomes depend on marine protected areas with five key features. *Nature* 506, 216–220. doi: 10.1038/nature13022

Essington, T. E., Beaudreau, A. H., and Wiedenmann, J. (2006). Fishing through marine food webs. *Proc. Natl. Acad. Sci. U.S.A.* 103, 3171–3175. doi: 10.1073/pnas.0510964103

Evers, K. (2001). *Standards for Ethics and Responsibility in Science: An Analysis and Evaluation of their Content, Background and Function*. The International Council for Science. The Standing Committee on Responsibility and Ethics in Science (SCRES).

FAO (Food and Agriculture Organization of the United Nations) (2010). *The State of World Fisheries and Aquaculture*. Available online at: http://www.fao.org/docrep/013/i1820e/i1820e.pdf

Finley, C., and Oreskes, N. (2012). Maximum sustained yield: a policy disguised as science. *ICES J. Mar. Sci.* 70, 245–250. doi: 10.1093/icesjms/fss192

Fitzpatrick, M., Graham, N., Rihan, D. J., and Reid, D. G. (2011). The burden of proof in co-management and results-based management: the elephant on the deck! *ICES J. Mar. Sci.* 68, 1656–1662. doi: 10.1093/icesjms/fsr098

Foley, M. M., Halpern, B. S., Micheli, F., Armsby, M. H., Caldwell, M. R., Crain, C. M., et al. (2010). Guiding ecological principles for marine spatial planning. *Mar. Pol.* 34, 955–966. doi: 10.1016/j.marpol.2010.02.001

Gaines, S. D., White, C., Carr, M. H., and Palumbi, S. R. (2010). Designing marine reserve networks for both conservation and fisheries management. *Proc. Natl. Acad. Sci. U.S.A.* 107, 18286–18293. doi: 10.1073/pnas.0906473107

Gaylord, B., Kroeker, K. J., Sunday, J. M., Anderson, K. M., Barry, J. P., Brown, N. E., et al. (2015). Ocean acidification through the lens of ecological theory. *Ecology* 96, 3–15. doi: 10.1890/14-0802.1

Gerber, L. R., Heppell, S. S., Ballantyne, F., and Sala, E. (2005). The role of dispersal and demography in determining the efficacy of marine reserves. *Can. J. Fish. Aquat. Sci.* 62, 863–871. doi: 10.1139/f05-046

Gleason, M., Fox, E., Ashcraft, S., Vasques, J., Whiteman, E., Serpa, P., et al. (2013). Designing a network of marine protected areas in California: achievements, costs, lessons learned, and challenges ahead. *Ocean Coast. Manage.* 74, 90–101. doi: 10.1016/j.ocecoaman.2012.08.013

Green, A. L., Maypa, A. P., Almany, G. R., Rhodes, K. L., Weeks, R., Abesamis, R. A., et al. (2015). Larval dispersal and movement patterns of coral reef fishes, and implications for marine reserve network design. *Biol. Rev.* 90, 1215–1247. doi: 10.1111/brv.12155

Guinotte, J. M., and Fabry, V. J. (2008). Ocean acidification and its potential effects on marine ecosystems. *Ann. N.Y. Acad. Sci.* 1134, 320–342. doi: 10.1196/annals.1439.013

Halpern, B. S. (2003). The impact of marine reserves: do reserves work and does reserve size matter? *Ecol. Appl.* 13, S117–S137. doi: 10.1890/1051-0761(2003)013[0117:tiomrd]2.0.co;2

Halpern, B. S., and Fujita, R. (2013). Assumptions, challenges, and future directions in cumulative impact analysis. *Ecosphere* 4, 1–11. doi: 10.1890/ES13-00181.1

Halpern, B. S., Klein, C. J., Brown, C. J., Beger, M., Grantham, H. S., Mangubhai, S., et al. (2013). Achieving the triple bottom line in the face of inherent trade-offs among social equity, economic return, and conservation. *Proc. Natl. Acad. Sci. U.S.A.* 110, 6229–6234. doi: 10.1073/pnas.1217689110

Halpern, B. S., Lester, S. E., and Kellner, J. B. (2010). Spillover from marine reserves and the replenishment of fished stocks. *Environ. Conserv.* 36, 268–276. doi: 10.1017/S0376892910000032

Halpern, B. S., Walbridge, S., Selkoe, K. A., Kappel, C. V., Micheli, F., D'Agrosa, C., et al. (2008). A global map of human impact on marine ecosystems. *Science* 319, 948–952. doi: 10.1126/science.1149345

Harley, C. D., Randall Hughes, A., Hultgren, K. M., Miner, B. G., Sorte, C. J., Thornber, C. S., et al. (2006). The impacts of climate change in coastal marine systems. *Ecol. Lett.* 9, 228–241. doi: 10.1111/j.1461-0248.2005.00871.x

Harrison, H. B., Williamson, D. H., Evans, R. D., Almany, G. R., Thorrold, S. R., Russ, G. R., et al. (2012). Larval export from marine reserves and the recruitment benefit for fish and fisheries. *Curr. Biol.* 22, 1023–1028. doi: 10.1016/j.cub.2012.04.008

Harvey, B. P., Gwynn-Jones, D., and Moore, P. J. (2013). Meta-analysis reveals complex marine biological responses to the interactive effects of ocean acidification and warming. *Ecol. Evol.* 3, 1016–1030. doi: 10.1002/ece3.516

Hilborn, R. (2011). Future directions in ecosystem based fisheries management: a personal perspective. *Fish. Res.* 108, 235–239. doi: 10.1016/j.fishres.2010.12.030

Howarth, L. M., Roberts, C. M., Thurstan, R. H., and Stewart, B. D. (2014). The unintended consequences of simplifying the sea: making the case for complexity. *Fish Fish.* 15, 690–711. doi: 10.1111/faf.12041

Hughes, T. P., Bellwood, D. R., Folke, C., Steneck, R. S., and Wilson, J. (2005). New paradigms for supporting the resilience of marine ecosystems. *Trends Ecol. Ecol.* 20, 380–386. doi: 10.1016/j.tree.2005.03.022

Hutchings, J. A. (2000). Collapse and recovery of marine fishes. *Nature* 406, 882–885. doi: 10.1038/35022565

Hutchings, J. A., and Reynolds, J. D. (2004). Marine fish population collapses: consequences for recovery and extinction risk. *Bioscience* 5, 297–309. doi: 10.1641/0006-3568(2004)054[0297:MFPCCF]2.0.CO;2

Jackson, J. B., Kirby, M. X., Berger, W. H., Bjorndal, K. A., Botsford, L. W., Bourque, B. J., et al. (2001). Historical overfishing and the recent collapse of coastal ecosystems. *Science* 293, 629–637. doi: 10.1126/science.1059199

Jett, J., and Ventre, J. (2015). Captive killer whale (*Orcinus orca*) survival. *Mar. Mamm. Sci.* 31, 1362–1377. doi: 10.1111/mms.12225

Jiang, Y., Lück, M., and Parsons, E. C. M. (2007). Public awareness, education, and marine mammals in captivity. *Tour. Rev. Int.* 11, 237–250. doi: 10.3727/154427207783948829

Kaplan, D. M. (2009). Fish life histories and marine protected areas: an odd couple? *Mar. Ecol. Prog. Ser.* 377, 213–225. doi: 10.3354/meps07825

Kassen, R. (2011). If you want to win the game, you must join in. *Nature* 480, 153. doi: 10.1038/480153a

Kellner, J. B., Tetreault, I., Gaines, S. D., and Nisbet, R. M. (2007). Fishing the line near marine reserves in single and multispecies fisheries. *Ecol. Appl.* 17, 1039–1054. doi: 10.1890/05-1845

Khalilian, S., Froese, R., Proelss, A., and Requate, T. (2010). Designed for failure: a critique of the Common Fisheries Policy of the European Union. *Mar. Policy* 34, 1178–1182. doi: 10.1016/j.marpol.2010.04.001

Kingan, S. G. (1998). *Manganese Nodules of the Cook Islands.* SOPAC Miscellaneous Report 295. SOPAC Secretariat. Available online at: http://ict.sopac.org/VirLib/MR0295.pdf

Kochin, B. F., and Levin, P. S. (2003). Lack of concern deepens the ocean's problems. *Nature* 424, 723. doi: 10.1038/424723a

Kochin, B. F., and Levin, P. S. (2004). Publication of marine conservation papers: is conservation biology too dry? *Conserv. Biol.* 18, 1160–1162. doi: 10.1111/j.1523-1739.2004.00452.x

Kubiszewski, I., Costanza, R., Franco, C., Lawn, P., Talberth, J., Jackson, T., et al. (2013). Beyond GDP: measuring and achieving global genuine progress. *Ecol. Econ.* 93, 57–68. doi: 10.1016/j.ecolecon.2013.04.019

Lackey, R. T. (2007). Science, scientists, and policy advocacy. *Conserv. Biol.* 21, 12–17. doi: 10.1111/j.1523-1739.2006.00639.x

Larkin, P. A. (1977). An epitaph for the concept maximum sustainable yield. *Trans. Am. Fish. Soc.* 106, 1–11. doi: 10.1577/1548-8659(1977)106<1:AEFTCO>2.0.CO;2

Le Heron, R., Lewis, N., Fisher, K., Thrush, S., Lundquist, C., Hewitt, J., et al. (2016). Non-sectarian scenario experiments in socio-ecological knowledge building for multi-use marine environments: Insights from New Zealand's Marine Futures project. *Mar. Policy* 67, 10–21. doi: 10.1016/j.marpol.2016.01.022

Le Quesne, W. J. F., and Codling, E. A. (2009). Managing mobile species with MPAs: the effects of mobility, larval dispersal, and fishing mortality on closure size. *ICES J. Mar. Sci.* 66, 122–131. doi: 10.1093/icesjms/fsn202

Levin, P. S., Fogarty, M. J., Murawski, S. A., and Fluharty, D. (2009). Integrated ecosystem assessments: developing the scientific basis for ecosystem-based management of the ocean. *PLoS Biol.* 7:e1000014. doi: 10.1371/journal.pbio.1000014

Lundquist, C. J., Fisher, K. T., Le Heron, R., Lewis, N. I., Ellis, J. I., Hewitt, J. E., et al. (2016). Science and societal partnerships to address cumulative impacts. *Front. Mar. Sci.* 3:2. doi: 10.3389/fmars.2016.00002

Maes, J., Egoh, B., Willemen, L., Liquete, C., Vihervaara, P., Schägner, J. P., et al. (2012). Mapping ecosystem services for policy support and decision making in the European Union. *Eco. Serv.* 1, 31–39. doi: 10.1016/j.ecoser.2012.06.004

Marine Conservation Institute (2016). *MPAtlas [On-line]*. Seattle, WA. Available online at: www.mpatlas.org (Accessed April 21, 2016).

Marino, L., Lilenfeld, S. O., Malamud, R., Nobis, N., and Broglio, R. (2010). Do zoos and aquariums promote attitude change in visitors? A critical evaluation of the American zoo and aquarium study. *Soc. Anim.* 18, 126–138. doi: 10.1163/156853010X491980

Maxwell, D., and Jennings, S. (2005). Power of monitoring programmes to detect decline and recovery of rare and vulnerable fish. *J. Appl. Ecol.* 42, 25–37. doi: 10.1111/j.1365-2664.2005.01000.x

McClanahan, T. R., Graham, N. A. J., Calnan, J. M., and MacNeil, M. A. (2007). Toward pristine biomass: reef fish recovery in coral reef marine protected areas in Kenya. *Ecol. Appl.* 17, 1055–1067. doi: 10.1890/06-1450

Mcleod, K.L., and Leslie, H. (eds.). (2009). *Ecosystem-Based Management for the Oceans*. Washington, DC: Island Press.

Millennium Ecosystem Assessment (2005). *Ecosystems and Human Well-being: Synthesis*, 137.

Minteer, B. A., and Collins, J. P. (2013). Ecological ethics in captivity: balancing values and responsibilities in zoo and aquarium research under rapid global change. *ILAR* 54, 41–51. doi: 10.1093/ilar/ilt009

Moffitt, E. A., White, J. W., and Botsford, L. W. (2011). The utility and limitations of size and spacing guidelines for designing marine protected area (MPA) networks. *Biol. Conserv.* 144, 306–318. doi: 10.1016/j.biocon.2010.09.008

Myers, R. A., and Worm, B. (2003). Rapid worldwide depletion of predatory fish communities. *Nature* 423, 280–283. doi: 10.1038/nature01610

Naidoo, R., Balmford, A., Ferraro, P. J., Polasky, S., Ricketts, T. H., and Rouget, M. (2006). Integrating economic costs into conservation planning. *Trends Ecol. Evol.* 21, 681–687. doi: 10.1016/j.tree.2006.10.003

Nelson, M. P., and Vucetich, J. A. (2009). On advocacy by environmental scientists: what, whether, why, and how. *Conserv. Biol.* 23, 1091–1101. doi: 10.1111/j.1523-1739.2009.01250.x

Neubauer, P., Jensen, O. P., Hutchings, J. A., and Baum, J. K. (2013). Resilience and recovery of overexploited marine populations. *Science* 340, 347–349. doi: 10.1126/science.1230441

Norse, E., and Crowder, L. B. (2005). "Why marine conservation biology?," in *Marine Conservation Biology*, ed. E. Norse and L. B. Crowder (Washington, DC: Island Press), 1–18.

Noss, R. (2007). Values are a good thing in conservation biology. *Conserv. Biol.* 21, 18–20. doi: 10.1111/j.1523-1739.2006.00637.x

Palumbi, S. R. (2003). Population genetics, demographic connectivity, and the design of marine reserves. *Ecol. Appl.* 13, S146–S158. doi: 10.1890/1051-0761(2003)013[0146:pgdcat]2.0.co;2

Palumbi, S. R., Sandifer, P. A., Allan, J. D., Beck, M. W., Fautin, D. G., Fogarty, M. J., et al. (2009). Managing for ocean biodiversity to sustain marine ecosystem services. *Front. Ecol. Environ.* 7:204–211. doi: 10.1890/070135

Panayotou, P., (1982). "Management concepts for small-scale fisheries: economic and social aspects," in *FAO Fisheries Technical Paper* (Rome), 228.

Papworth, S. K., Rist, J., Coad, L., and Milner-Gulland, E. J. (2009). Evidence for shifting baseline syndrome in conservation. *Conserv. Lett.* 2, 93–100. doi: 10.1111/j.1755-263x.2009.00049.x

Parsons, E. C. M. (2013). So you want to be a Jedi? *Advice for conservation researchers wanting to advocate for their findings. J. Environ. Stud. Sci.* 3, 340–342. doi: 10.1007/s13412-013-0133-0

Parsons, E. C. M., DellaSala, D. A., and Wright, A. J. (2015). Is marine conservation science becoming irrelevant to policy makers? *Front. Mar. Sci.* 2:102. doi: 10.3389/fmars.2015.00102

Parsons, E. C. M., Favaro, B., Draheim, M., McCarthy, J. B., Aguirre, A. A., Bauer, A. L., et al. (2014a). Seventy-one important questions for the conservation of marine biodiversity. *Conserv. Biol.* 28, 1206–1214. doi: 10.1111/cobi.12303

Parsons, E. C. M., Shiffman, D. S., Darling, E. S., Spillman, N., and Wright, A. J. (2014b). How twitter literacy can benefit conservation scientists. *Conserv. Biol.* 28, 299–301. doi: 10.1111/cobi.12226

Pauly, D. (1995). Anecdotes and the shifting baselines syndrome of fisheries. *Trends Ecol. Evol.* 10, 430. doi: 10.1016/S0169-5347(00)89171-5

Pauly, D. (2009). Beyond duplicity and ignorance in global fisheries. *Sci. Mar.* 73, 215–224. doi: 10.3989/scimar.2009.73n2215

Prahler, E. E., Reiter, S. M., Bennett, M., Erickson, A. L., Melius, M. L., and Caldwell, M. R. (2014). It all adds up: enhancing ocean health by improving cumulative impacts analyses in environmental review documents. *Stanford Environ. Law J.* 33, 351–417.

Puckett, B. J., Eggleston, D. B., Kerr, P. C., and Luettich, R. A. (2014). Larval dispersal and population connectivity among a network of marine reserves. *Fish. Oceanog.* 23, 342–361. doi: 10.1111/fog.12067

Punt, A. E., and Smith, A. D. M. (2001). "The gospel of maximum sustainable yield in fisheries management: birth, crucifixion and reincarnation," in *Conservation* *of Exploited Species*, ed J. D. Reynolds, G. M. Mace, K. H. Redford, and J. G. Robinson (Cambridge: Cambridge University Press), 41–66.

Rees, S., Fletcher, S., Glegg, G., Marshall, C., Rodwell, L., Jefferson, R., et al. (2013). Priority questions to shape the marine and coastal policy research agenda in the United Kingdom. *Mar. Policy* 38, 531–537. doi: 10.1016/j.marpol.2012.09.002

Roberts, C. M., Bohnsack, J. A., Gell, F., Hawkins, J. P., and Goodridge, R. (2001). Effects of marine reserves on adjacent fisheries. *Science* 294, 1920–1923. doi: 10.1126/science.294.5548.1920

Roberts, C. M., Mcclean, C. J., Veron, J. E., Hawkins, J. P., Allen, G. R., Mcallister, D. E., et al., (2002). Marine biodiversity hotspots and conservation priorities for tropical reefs. *Science* 295, 1280–1284. doi: 10.1126/science.1067728

Rose, N. A., and Parsons, E. C. M. (2015). "Back off, man, I'm a scientist!" When marine conservation science meets policy. *Ocean Coast. Manage.* 115, 71–76. doi: 10.1016/j.ocecoaman.2015.04.016

Rose, N. A., Parsons, E. C. M., and Farinato, R. (2009). *The Case against Marine Mammals in Captivity, 4th Edn*. Washington, DC: The Humane Society of the United Stares and the World Society for the Protection of Animals.

Ruckelshaus, M., McKenzie, E., Tallis, H., Guerry, A., Daily, G., Kareiva, P., et al. (2015). Notes from the field: lessons learned from using ecosystem service approaches to inform real-world decisions. *Ecol. Econ.* 115, 11–21. doi: 10.1016/j.ecolecon.2013.07.009

Rudd, M. A. (2011). How research-prioritization exercises affect conservation policy. *Conserv. Biol.* 25, 860–866. doi: 10.1111/j.1523-1739.2011.01712.x

Rudd, M. A. (2014). Scientists' perspectives on global ocean research priorities. *Front. Mar. Sci.* 1:36. doi: 10.3389/fmars.2014.00036

Russ, G. R., Alcala, A. C., and Maypa, A. P. (2003). Spillover from marine reserves: the case of Naso vlamingii at Apo Island, the Philippines. *Mar. Ecol. Prog. Ser.* 264, 15–20. doi: 10.3354/meps264015

Saarman, E., Gleason, M., Ugoretz, J., Airame, S., Carr, M., Fox, E., et al. (2013). The role of science in supporting marine protected area network planning and design in California. *Ocean Coast. Manage.* 74, 45–56. doi: 10.1016/j.ocecoaman.2012.08.021

Sala, E., and Knowlton, N. (2006). Global marine biodiversity trends. *Annu. Rev. Environ. Resour.* 31, 93–122. doi: 10.1146/annurev.energy.31.020105.100235

Salomon, A. K., Gaichas, S., Jensen, O., Agostini, V. N., Sloan, N. A., Rice, J., et al. (2011). Bridging the divide between fisheries and marine conservation science. *Ocean Coast. Manage.* 87, 251–274. doi: 10.5343/bms.2010.1089

Sander, K., Lee, J., Hickey, V., Bundi Mosoti, V., Virdin, J., and Magrath, W. B. (2014). Conceptualizing maritime environmental and natural resources law enforcement – the case of illegal fishing. *Environ. Dev.* 11, 112–122. doi: 10.1016/j.envdev.2013.08.002

Scheffer, M., Bascompte, J., Brock, W. A., Brovkin, V., Carpenter, S. R., Dakos, V., et al. (2009). Early-warning signals for critical transitions. *Nature* 461, 53–59. doi: 10.1038/nature08227

Schroeder, H., Boykoff, M. T., and Spiers, L. (2012). Equity and state representations in climate negotiations. *Nat. Clim. Change* 2, 834–836. doi: 10.1038/nclimate1742

Scorse, J. (2010). *What Environmentalists Need to Know about Economics*. New York, NY: Palgrave MacMillan.

Scott, N. J., and Parsons, E. C. M. (2005). A survey of public opinions in Southwest Scotland on cetacean conservation issues. *Aquat. Conserv.* 15, 299–312. doi: 10.1002/aqc.662

Selkoe, K. A., Blenckner, T., Caldwell, M. R., Crowder, L. B., Erickson, A. L., Essington, T. E., et al. (2015). Principles for managing marine ecosystems prone to tipping points. *Ecosyst. Health Sustain.* 1, 1–18. doi: 10.1890/ehs14-0024.1

Shrader-Frechette, K. (1996). Throwing out the bathwater of positivism, keeping the baby of objectivity: relativism and advocacy in conservation biology. *Conserv. Biol.* 10, 912–914. doi: 10.1046/j.1523-1739.1996.10030904-3.x

Skibins, J. C., Powell, R. B., and Hallo, J. C. (2013). Charisma and conservation: charismatic megafauna's influence on safari and zoo tourists' pro-conservation behaviors. *Biodivers. Conserv.* 22, 959–982. doi: 10.1007/s10531-013-0462-z

Smith, A. M., and Sutton, S. G. (2008). The role of flagship species in the formation of conservation intentions. *Hum. Dim. Wildl.* 13, 127–140. doi: 10.1080/10871200701883408

Society for Conservation Biology (2011). *2011-2015 SCB Strategic Plan*. Washington, D.C. Available online at: http://conbio.org/about-scb/strategic-plan/

Soulé, M. E. (1985). What is conservation biology? *BioScience* 35, 727–734. doi: 10.2307/1310054

Sutherland, W. J., and Woodroof, H. J. (2009). The need for environmental horizon scanning. *Trends Ecol. Evol.* 24, 523–527. doi: 10.1016/j.tree.2009.04.008

Thompson, P. M., Wilson, B., Grellier, K., and Hammond, P. S. (2000). Combining power analysis and population viability analysis to compare traditional and precautionary approaches to conservation of coastal cetaceans. *Conserv. Biol.* 14, 1253–1263. doi: 10.1046/j.1523-1739.2000.00099-410.x

Torras, M. (2000). The total economic value of Amazonian deforestation, 1978-1993. *Ecol. Econ.* 33, 283–297. doi: 10.1016/S0921-8009(99)00149-4

Turner, G. (2014). *Is Global Collapse Imminent?* MSSI Research Paper No. 4, Melbourne Sustainable Society Institute, University of Melbourne.

UN (United Nations) (2002). *World Summit on Sustainable Development, Johannesburg, South Africa 26 August–4 September 2002*. New York, NY: United Nations.

UNEP (United Nations Environmental Program) (2012). *Input to the Report of the High-Level Panel on Global Assessment of Resources for Implementing the Strategic Plan for Biodiversity 2011-2020*. New York, NY: United Nations.

USDCDH (United States District Court for the District of Hawaii) (2015). *Amended Order Granting Conservation Council's Motion for Summary Judgment, Granting NRDC's Motion for Summary Judgment, Denying NRDC's Motion for Leave to Submit Extra-Record Evidence, and Granting in Part and Denying in Part Defendants' Motion to Strike*. Available online at: https://awionline.org/sites/default/files/uploads/documents/AWI-ML-HSTT-AmendedOrder-03312015.pdf

White, C., Halpern, B. S., and Kappel, C. V. (2012). Ecosystem service tradeoff analysis reveals the value of marine spatial planning for multiple ocean uses. *Proc. Natl. Acad. Sci. U.S.A.* 109, 4696–4701. doi: 10.1073/pnas.1114215109

Wilson, B., Hammond, P. S., and Thompson, P. M. (1999). Estimating size and assessing trends in a coastal bottlenose dolphin population. *Ecol. Appl.* 9, 288–300. doi: 10.1890/1051-0761(1999)009[0288:esaati]2.0.co;2

Worm, B., Hilborn, R., Baum, J. K., Branch, T. A., Collie, J. S., Costello, C., et al. (2009). Rebuilding global fisheries. *Science* 325, 578–585. doi: 10.1126/science.1173146

Wright, A. J., Veríssimo, D., Pilfold, K., Parsons, E. C. M., Ventre, K., Cousins, J., et al. (2015). Competitive outreach in the 21st Century: why we need conservation marketing. *Ocean Coast. Manage.* 115, 41–48. doi: 10.1016/j.ocecoaman.2015.06.029

Wyles, K. J., Pahl, S., White, M., Morris, S., Cracknell, D., and Thompson, D. J. (2013). Enhancing the "marine mindset": the effects of an aquarium visit and information booklet on attitudes and intentions about fish sustainability and marine pollution. *Visit. Stud.* 16, 95–110. doi: 10.1080/10645578.2013.768077

Wynne, B. (2006). Public engagement as a means of restoring public trust in science – hitting the notes, but missing the music? *Community. Genet.* 9, 211–220. doi: 10.1159/000092659

Yalowitz, S. S. (2004). Evaluating visitor conservation research at the Monterey Bay Aquarium. *Cur. Mus. J.* 47, 283–298. doi: 10.1111/j.2151-6952.2004.tb00126.x

Conflict of Interest Statement: 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.

The reviewer CB declared a past co-authorship with one of the authors MF to the handling Editor, who ensured that the process met the standards of a fair and objective review.