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Is there a need for a '100 questions exercise' to enhance fisheries and aquatic conservation, policy, management and research? Lessons from a global 100 questions exercise on conservation of biodiversity

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Recent global and regional exercises have been undertaken to identify 100 questions of relevance to policy makers that, if answered, would improve decision making and conservation actions. These were intentionally broad, but all included themes and questions of relevance to aquatic and fisheries professionals (*e.g.* exploitation, habitat alteration, effectiveness of protected areas, migratory connectivity and environmental effects of aquaculture). Here, the content of the global 100 question exercise relevant to aquatic and fisheries issues is summarized and a critical analysis is provided. Many of the questions addressed in apparently unrelated themes and topics (*e.g.* terrestrial, agriculture and energy policy) have potential relevance to fisheries and aquatic habitats, which underlines the connectivity between terrestrial and aquatic realms. Given the intimate link between aquatic environmental problems and human activities (including culture and economics), greater understanding of the human dimension is required to inform decision making. Stakeholder perspectives need to be included as a core component of the fisheries management triangle (*i.e.* managing fish, habitat and people). The benefits and risks of conducting a global 100 questions exercise with an exclusive focus on questions of relevance to fisheries and aquatic practitioners are also considered. There is no question that evidence-based approaches to conservation are essential for addressing the many threats that face aquatic ecosystems and reverse the imperilment trends among ichthyofauna. It is still unclear, however, as to the extent to which 100 questions exercises will help to achieve conservation and management targets for aquatic resources. A global 100 questions exercise that focused on fisheries and aquatic issues would certainly help to generate interest and awareness sufficient to justify such an exercise.

Key words: biodiversity; conservation effectiveness; fisheries management; global fisheries; research priorities.

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INTRODUCTION

In recent years, there has been a growing recognition that management and policy decisions related to natural resource conservation need to be based on credible scientific evidence (Sutherland *et al*., 2004), similar to the approach adopted in the medical field (Pullin & Knight, 2001). Although the approach is intuitive, there is evidence to suggest that conservation practitioners fail to incorporate contemporary scientific evidence into decision making for natural-resource management (Pullin *et al*., 2004). One of the perceived barriers limiting the implementation and adoption of evidence-based conservation is the notion that scientific research activities are not focused on issues of relevance to decision makers and natural-resource policy (Pullin *et al*., 2004; Pullin & Knight, 2005). To help overcome this barrier, there have been a number of recent initiatives focused on identifying questions that are of high priority and relevance to decision makers charged with the task of conservation of natural resources. Commonly referred to as '100 question exercises', the typical model involves soliciting questions from a large sample of stakeholders and then using a group of expert thought leaders to condense, coalesce and prioritize the questions submitted, to yield a list of 100 questions. To date, in the ecological field, there have been three such exercises completed: one in the U.K. (Sutherland *et al*., 2006), one in Australia (just 22 questions; Morton *et al*., 2009) and one with a global focus (Sutherland *et al*., 2009). In addition, two more exercises are underway with a focus on conservation, one in Canada (M. Rudd, pers. comm.) and the other in the U.S.A. (E. Fleishman, pers. comm.), and another in the U.K. with a focus on plant biology (http://www.100plantsciencequestions.org.uk/index.php). The exercises conducted to date have had a rather broad focus and have included themes such as exploitation, forestry, fisheries, agriculture, urban development and ecosystem services.

Globally, freshwater and marine ecosystems and their associated ichthyofauna represent some of the most threatened systems and imperilled organisms (Warren & Burr, 1994; Vincent & Hall, 1996; Ricciardi & Rasmussen, 1999; Powles *et al*., 2000). Many of the management and conservation issues facing aquatic ecosystems and fisheries demand evidence-based approaches to reduce uncertainty and facilitate consensus formation (Groves *et al*., 2002). For example, there is much debate regarding the effectiveness of aquatic protected areas (Agardy, 2000). Given the many threats facing aquatic ecosystems (Gray, 1997; Richter *et al*., 1997) and the global decline of fisheries (Pauly *et al*., 1998; Myers & Worm, 2003), it seems intuitive that a more focused 100 questions exercise for aquatic ecosystems would prove insightful in terms of prioritizing the focus of future research to address policy and management needs.

The objective of this article is to inform aquatic and fisheries professionals about the 100 questions exercises. A secondary objective is to provide a summary and critical analysis of the existing global 100 questions exercise (Sutherland *et al*., 2009) to identify the questions of relevance to aquatic and fisheries professionals. The need for a global 100 questions exercise with a specific focus on aquatic and fisheries issues is also considered along with a possible framework for implementing such an exercise. The article is approached from an open perspective that considers both the benefits and risks of such exercises.

OVERVIEW OF GLOBAL 100 QUESTIONS EXERCISE

The objective of the global 100 questions exercise (Sutherland *et al.*, 2009) was to identify 100 scientific questions that, if answered, would have the greatest beneficial effect on conservation practice and policy. The intended audience of Sutherland *et al.* (2009) was researchers wishing to make their work more applicable to conservation organizations (including governments and intergovernmental bodies) and direct their conservation research programmes and financial support. To achieve their objective, 2291 questions were gathered from 761 individuals through workshops, email requests and discussions. Email voting followed by a workshop with invitees from international organizations, regional sections and working groups of the Society for Conservation Biology, and academia was used to refine the list of questions. The questions were not ranked (*i.e.* the first question is not necessarily of higher priority than the 100th question) and were divided into 12 sections, each of which is addressed below with the objective of identifying questions and content that are of relevance to aquatic and fisheries professionals.

ECOSYSTEM FUNCTION AND SERVICES

Fishes are integral components of aquatic ecosystems (both freshwater and marine), structuring communities and influencing a range of ecosystem processes and services (*e.g.* food chain dynamics, nutrient cycling and ecosystem resilience; Holmlund & Hammer, 1999; Worm *et al.*, 2006). In some cases, these benefits extend beyond the aqueous realm such as Pacific salmon *Oncorhynchus* sp. delivering marine-derived nutrients to riparian ecosystems (Naiman *et al.*, 2002). Fishes are a major source of protein and generate income for regional and national economies through commercial and recreational fisheries. In a review of the ecosystem services provided by fishes, Holmlund & Hammer (1999) conclude that fishes are embedded in ecosystems and that management approaches that utilize substitutions for declining populations and habitat losses, such as stock enhancement programmes and the use of protected areas, rarely replace losses of all services. Holmlund & Hammer (1999) also suggest that the loss of fish populations will directly influence human welfare.

The 100 questions exercise identified eight questions dealing with ecosystem services and function. Not surprisingly, these questions are rather broad in focus, dealing with large-scale phenomena that are not taxon or habitat specific. Only one question (question 8) is not directly relevant to aquatic conservation (*i.e.* it was focused on soil productivity); however, the other questions are applicable to the conservation of aquatic systems and fisheries. For example, the question asking whether thresholds exist at which the loss of species diversity, or the loss of a particular species, disrupts ecosystem functions and services, and how can these thresholds be predicted (question 1) is highly relevant to fishes, given the threatened status and extinctions facing much of the world's ichthyofauna. Just recently, the implications of losing species or functional groups in aquatic ecosystems (*e.g.* apex predators; Myers & Worm, 2003) have been considered. Predictive tools would be highly useful for identifying species or systems for which thresholds are particularly important and thus for which conservation actions are needed. In addition, question 5 (how, where and when has biodiversity loss affected human welfare?) is particularly relevant to fisheries as global exploitation of both marine and freshwater fisheries is conducted primarily to provide protein for human consumption, particularly in developing countries. Documenting such effects on human welfare would certainly help to prioritize the rebuilding of fish stocks and the implementation of sustainable management (Meadows *et al*., 1992).

CLIMATE CHANGE

There is little doubt that climate change will have profound effects on aquatic ecosystems and fish populations (Roessig *et al*., 2004; Graham & Harrod, 2009). Fishes are ectotherms and therefore water temperature regulates nearly all their biological functions such as enzymatic function, metabolic rate, swimming performance, growth, digestion and key events such as the timing of reproduction and migration (Fry, 1971). In fact, the influence of temperature on fishes is so manifold that it is regarded as the 'master' environmental factor (Brett, 1956). Temperature also influences the distribution of fishes in space and time and can exclude or kill fishes when water temperatures exceed their critical thermal thresholds (Beitinger *et al*., 2000). As such, many of the 100 questions focused on climate change (14 questions in total) are highly relevant to aquatic conservation and fishes.

Question 9 (What impact will the melting of the polar ice . . . have on the human use of high-latitude ecosystems, and how will these changes in human use affect biodiversity?) is particularly relevant for aquatic fauna. Changes in polar ice will increase shipping traffic and increase opportunities for expanded harvest of fishes in these systems. Current harvest of fishes in polar regions is largely restricted to small-scale aboriginal fisheries, and thus a shift in the scale of fishing practices could have a severe effect on these ecosystems (Reist *et al*., 2006). Moreover, the limited understanding of fisheries productivity and life history can increase complexities associated with the sustainable management of high-latitude fisheries in the face of climate change. Question 11 (How is the resilience of ecosystems to climate change affected by human activities and interventions?) is particularly relevant to freshwater ecosystems and drought (Lake, 2003). Question 13 (How will climate change, together with other environmental stressors, alter the distribution and prevalence of diseases of wild species?) is also highly relevant to fishes, given that most stressors do not act alone (also see questions 48 and 52 for examples of multiple stressors influencing coral reefs and marine ecosystems in general, respectively). For example, climate change can be combined with other stressors such as fishing, habitat alteration and changes in water quality, which collectively can increase parasite and pathogen infections (Marcogliese, 2001). At present, it is difficult to predict and manage the collective effects of climate change on fisheries and develop effective adaptation strategies.

TECHNOLOGICAL CHANGE

Technological innovations arising from human ingenuity and economic development can present emerging risks to biodiversity. The five 100 questions addressing this topic were focused on nanotechnology (question 23), renewable energies (question 24), genetically modified organisms (question 25) and the emerging bioeconomy (*e.g.* pharmaceuticals, plastics and adhesives; question 26). All of these technological innovations represent threats that have the potential to alter aquatic ecosystems and fish populations, albeit most of these potential threats have been poorly studied. Nanotechnology development can lead to exposure of aquatic animals to nanoparticles, which may have the potential to interfere with sub-cellular level processes (Moore, 2006; Handy *et al.*, 2008). In addition, there are possible ecological risks and human health risks associated with nanoparticles entering the food chain (Klaine *et al.*, 2008). Currently there are far more questions than answers for this emerging technology, making it difficult for regulators to protect aquatic ecosystems. Renewable energy also presents possible risks to aquatic ecosystems. Wind farms have been studied only recently in the context of interactions with fishes, and there is evidence of behavioural alterations from noise and electromagnetic fields (Wilhelmsson *et al.*, 2006; Öhman *et al.*, 2007). Tidal power is another source of renewable energy, which has been poorly studied with respect to fishes (Davies, 1988), but for which the risks were sufficient to justify the development of an American Fisheries Society Policy Statement in 1986 (Rulifson *et al.*, 1986; AFS, 2004). In fact, impacts and mitigation of even established renewable energy sources such as hydropower still suffer from much uncertainty regarding biological effects on fishes leading to regulatory uncertainty despite substantial investment in research (Rosenberg *et al.*, 1997; Stoneman, 2005; Arthington *et al.*, 2010).

Issues related to genetically modified organisms are particularly relevant to fisheries science, given that the reproductive biology of fishes facilitates genetic manipulation. Transgenic fishes are being developed primarily for use in fish culture to maximize production; however, the potential for captive fishes to escape and interact with wild ichthyofauna has generated a number of concerns (Hedrick, 2001; Aerni, 2004). In addition, the public have expressed concern over the nutrition and health implications of consuming transgenic aquatic organisms (Maclean, 2003). There is also potential to culture aquatic organisms to provide pharmaceuticals (Silva *et al.*, 2008) and other products in support of a growing bioeconomy. The maintenance of biodiversity (aquatic and otherwise) means that there is potential to concomitantly protect important unknown pharmaceuticals and other products that could be of benefit to humans. Collectively, these technological innovations represent great uncertainty with respect to their potential and actual threats to aquatic ecosystems and fisheries resources making them legitimate and timely topics for research and debate.

PROTECTED AREAS

Protecting habitats as a management tool for the conservation of terrestrial biodiversity has been practised for well over a century (Leopold *et al.*, 1963; Chape *et al.*, 2005). In many cases, the boundaries of terrestrial protected areas have included aquatic habitats and fisheries resources (*e.g.* Yellowstone Lake within Yellowstone National Park, U.S.A.); however, only recently has the design of terrestrial protected areas involved adopting a landscape-level approach which includes the conservation needs of aquatic resources (Chape *et al.*, 2005). What is also relatively recent is the use of protected areas specifically for the conservation of aquatic biodiversity, fisheries and other aquatic resources (Murray *et al.*, 1999). Although protected areas are predominantly regarded as conservation tools in marine environments (*i.e.* marine protected areas, MPA), they have a long history of use in the conservation of threatened freshwater aquatic resources as well (Saunders *et al.*, 2002; Suski & Cooke, 2007).

Many design and management principles used for aquatic protected areas have been inherited from their terrestrial analogues, primarily because of common goals to protect not only species but also the structure and function of habitats within area boundaries (Lubchenco *et al.*, 2003). As such, the four questions in the 100 questions exercise addressing issues with terrestrial protected areas are all applicable when examining the conservation value of protected areas in aquatic systems. Specifically, there are a number of types of aquatic protected areas each with different management objectives (Boersma & Parrish, 1999; Agardy *et al.*, 2003; Sobel & Dahlgren, 2004); thus, quantifying the effectiveness of each type (question 27) will help determine whether specific conservation objectives are attainable. For instance, although the underlying goals of marine parks and marine reserves might be similar (*i.e.* to protect habitats and species), marine parks are often areas with relatively high levels of human activities that often present challenges for protecting habitats. In contrast, additional restrictions to human use imposed by no-take marine reserves can present social challenges when attempting to gain support for conservation efforts from local resource user groups (Boersma & Parrish, 1999; Jameson *et al.*, 2002). Similarly, understanding the management costs necessary for the effective operation of a range of aquatic protected area types (question 28) is important; otherwise necessary tasks that may help maximize the likelihood of attaining conservation goals could fall victim of funding shortfalls (Balmford *et al.*, 2004). This is especially important since the use of aquatic protected areas has been widely advocated as a low cost and often simple solution to resources management and conservation; thus, adequately defining planning and management costs may help avoid the establishment of 'paper parks' (Agardy *et al.*, 2003).

These challenges are reflected in question 29, which addressed the human well-being costs and benefits of protected areas. The short-term consequences of restrictions on human activities, such as subsistence fishing, must be balanced by positive outcomes of the conservation effort related to tangible gains in ecosystem goods and services (Agardy *et al.*, 2003; Mascia, 2003). Addressing question 30 related to how protected areas can affect conservation beyond boundaries is also highly relevant to aquatic systems. From a fisheries perspective, aquatic protected reserves can help conserve essential habitat and promote the accumulation of biomass, which, in turn, may result in the spillover of adults into adjacent fishing grounds and the downstream export of larvae to more distant fished areas (Roberts & Polunin, 1993; Roberts, 1997; Murray *et al.*, 1999). As such, a greater emphasis needs to be paid to evaluating the effectiveness of aquatic protected areas.

ECOSYSTEM MANAGEMENT AND RESTORATION

As the majority of the world's natural systems lie beyond protected areas, maintenance of ecological integrity within these unprotected areas is paramount if they are to continue to supply ecosystem goods and services. This topic has been a core theme of fisheries management in all aquatic environments for several decades (Link, 2002; Naiman *et al.*, 2002; Pikitch *et al.*, 2004). Freshwater and salmonid biologists were the first to have considered management to include landscape scale processes (*e.g.* the link between terrestrial processes and rivers within a catchment). Accordingly, freshwater biologists are more advanced in their ability to understand the ecosystem-level effects of different types of stressors or management interventions. The eight questions under this theme focused on: understanding the pros and cons of intensive cultivation systems *v.* wild capture fisheries with respect to its effects on biodiversity (question 31); understanding the structure of systems before significant disruption occurred so as to provide a baseline against which to measure the current situation (question 32); what, and where are the significant opportunities for ecosystem restoration (question 33); can ecosystem management mimic better natural processes and perhaps improve the effectiveness of conservation (question 34); should ecosystem management transcend terrestrial, freshwater and marine realms and would this lead to more effective outcomes (question 35); what pattern of human settlement has the least impact on biodiversity (question 36); what is the contribution of areas that are intensively managed for cultivation (harvesting) to conservation at a landscape scale (question 37); how will consumer choices in respect of climate change influence resource use and hence affect biodiversity (question 38)?

Aquaculture in freshwater and marine systems (question 31) is playing an increasingly important role in the production of food, and its importance will continue to increase into the future. Although the overall spatial occupancy of global aquaculture has yet to be estimated, it is undoubtedly far lower than the area of the natural environment affected directly by fisheries activities (Halpern *et al*., 2008). The direct effects on biodiversity of the cultivation sites themselves are relatively small compared with the wider ecosystem disturbance created by wild capture fisheries (Jennings & Kaiser, 1998). The latter, however, continues to provide an important component of the feed required for the aquaculture of carnivorous species of fishes, and hence cannot be divorced from the negative effects associated with these wild capture fisheries (Naylor *et al*., 2000). Furthermore, the cultivation of non-indigenous species has been an important vector of exotic species that can undermine the biodiversity in the recipient systems. A future focus on the cultivation of herbivorous and native species could greatly reduce many of the negative effects associated with aquaculture.

The issue of shifting 'baselines' (Pauly *et al*., 1998; Jackson *et al*., 2001) is a well-known theme in the context of marine fisheries, and given the known effects of the serial depletion of large-bodied fishes across a range of oceans (Myers & Worm, 2003), it is likely that large trophic changes have occurred in marine ecosystems that affect the flow of energy through those systems (question 32). The ability to predict the structure of marine ecosystems in the absence of human intervention, however, is limited to insights from historical accounts (Jackson *et al*., 2001) and extrapolations based on macroecological theory (Jennings & Blanchard, 2004). This last question is directly related to the issue of restoration (question 33) as the effectiveness of restoration can only be assessed if there is a good understanding of the previous state of the system. While it is possible to re-engineer some habitat features (*e.g.* river morphology and wood debris), most marine systems do not lend themselves to such direct forms of intervention. In some instances, millions of pounds have been spent on fish habitat restoration programmes with little effective outcome (Lenihan *et al*., 2001).

The issue of management regimes attempting to mimic natural disturbance (question 34) is not well considered in the aquatic field with some notable exceptions. Such an exception is the replacement of naturally occurring *Oncorhynchus* sp. carcasses in western North American river systems with carcasses of cultivated *Oncorhynchus* sp. (Bartz & Naiman, 2005). It seems clear, however, that conservation efforts to restore populations of 'ecosystem engineers' would be a key focus of any such research, as these organisms are primarily responsible for major disturbances to ecosystems that have significant consequences for many other components of the same system (Pace *et al.*, 1999). Another example is the use of environmental flows in regulated rivers to emulate the typical flood-pulse regime that has been moderated by hydropower operations (Arthington *et al.*, 2010).

The integration of management regimes that transcend multiple ecosystems is a relatively new and emerging field (question 35). Typically scientists have tended to confine themselves to a single realm (*e.g.* terrestrial *v.* marine); however, there is a growing awareness of the need to consider the intimate linkage between neighbouring systems. For example, near-shore coastal systems are directly influenced by the quality and frequency of discharges that arise from catchments that feed into estuaries. Water quality is likely to be affected by increased loadings of dissolved organic carbon and nutrients in runoff, while regions of freshwater influence (ROFI) may intensify along-shore density-driven current flow. The latter will influence fish habitat quality and transport processes relevant for the dispersal of fish larvae and eggs (see also question 51).

The pattern of human settlement affects fish habitat quality through direct use (abstraction) of water, inputs of chemicals and organic pollutants and direct use of fish as a resource. As such, a negative relationship between (native) fish diversity and human population density might be expected. In a situation with dispersed high-density aggregations of humans, patches of highly degraded habitat and fish population structure could fragment fish populations with consequences similar to habitat fragmentation in terrestrial systems (question 36).

Areas of intensive cultivation, or harvesting, could contribute to wider biodiversity at a landscape scale through energy subsidies (Polis & Strong, 1996) (question 37). In aquaculture systems, this might relate to the provision of organic material or unconsumed food pellets to the surrounding system. Organisms such as seals, cormorants and herons could potentially derive an energy subsidy from fish aquaculture, while there is strong evidence that shellfish cultivation maintains abnormally high numbers of wading birds (Caldow *et al.*, 2004). Similarly, wild capture fisheries are known to subsidize wild populations of scavenging seabirds, some of which are critically endangered (Furness, 1996).

TERRESTRIAL ECOSYSTEMS

There is a long history of how groundwater, streams, rivers, lakes and coastlines have been influenced by human activities occurring on adjacent landscapes (Foster *et al.*, 2003; Allan, 2004). With a high proportion of the world's growing population living within close proximity to water (Small & Nicholls, 2003), transformations of landscapes because of human enterprises (*e.g.* agriculture, industry, recreation and inhabitation) are posing very real threats to aquatic ecosystems and biodiversity (Vitousek *et al.*, 1997; Vörösmarty *et al.*, 2000). As new land use practices emerge and historical land uses evolve, it is critical to evaluate how human activities in terrestrial systems will influence fisheries and aquatic conservation (Foster *et al.*, 2003). One of the 100 questions directly addresses the potential effects of a new technology, specifically biofuel production (question 39), on biodiversity and ecosystem services. Although biofuel production can be viewed as a beneficial alternative for non-renewable fossil fuels used in transportation, there are potential risks to aquatic ecosystems associated with the intensive agricultural production of feed-stocks such as the grain of maize, soyabeans and oil palm (Hill, 2007; Danielsen *et al.*, 2009). In addition, limited research has been done on the direct and indirect effects of biofuel as an acute contaminant when it enters aquatic systems through accidental spills.

Intensive agriculture is a particular land-use practice that can have considerable implications for aquatic systems primarily because of the conversion of wild lands, freshwater usage for irrigation and nutrient loading (Lemly *et al.*, 2000; Heaney *et al.*, 2001), and simply a lack of land. As such, question 40 addressing whether the continued intensification of agriculture can contribute to conserving biodiversity by reducing pressure to convert natural ecosystems is of particular relevance to aquatic conservation. Specifically, although the intensification of agriculture could result in less wild land being converted, including native wetlands, the resulting effects on aquatic systems through greater localized freshwater needs and increased nutrient loading could be considerable (Lemly *et al.*, 2000). Questioning the friendliness of organic farms to conserving biodiversity (question 41) is also applicable for aquatic ecosystems because of the potential effects of nutrient runoff (Hansen *et al.*, 2001).

Practices that remove and add trees to terrestrial landscapes could also influence aquatic ecosystems and biodiversity at a range of spatial scale (questions 42 and 43). Deforestation can have numerous effects on lakes, streams and their inhabitants, through factors such as increased loading of nutrients (Devito *et al.*, 2000), metals (Porvari *et al.*, 2003) and sediment (Jones *et al.*, 1999). Afforestation has also been shown to influence the hydrology and chemistry in streams (Hornung & Newson, 1986). Thus, a better understanding of the role of regenerative forestry practices in the conservation of fishes and aquatic systems should be a priority.

Question 45 in the 100 questions exercise is of particular interest since it addresses how urban nature reserves and green amenity spaces, such as golf courses, can contribute or even enhance biodiversity conservation. Although preserving and creating urban green spaces may provide habitat for terrestrial species and contribute to conservation, such land uses tend to have rather negative effects on aquatic ecosystems. Golf courses have been shown to have considerable effects on aquatic systems through nutrient and pesticide runoff (Wheeler & Nauright, 2006). In addition, even though other green spaces such as urban nature reserves could provide localized protection for aquatic systems, the cumulative effects of urban land use (Meador & Goldstein, 2003) could potentially marginalize their value for the conservation of aquatic biodiversity.

MARINE ECOSYSTEMS

Approximately 2·2 billion people live within 100 km of the coastline and many in developing countries depend upon marine fishes as their primary source of dietary protein (Pauly *et al.*, 2002). Marine wild capture fisheries yield *c*. 82 million t per annum, but this is a slight decline on the previously accepted asymptote of 90 million t up until the 1990s. Nearly 75% of world fisheries are fully (50%) or overexploited

(25%). Coastal pollution continues to cause disruption to large areas with an increasing intensity of phenomena such as dead zones that arise from eutrophication. These and other anthropogenic activities (*e.g.* shipping, hydrocarbon exploitation, aggregate extraction and coral mining) act against a background of global climate change that is changing ocean temperature and acidity. As such, there is a pressing need to understand ecosystem responses to these activities and background changes and the synergies between them. Such knowledge would inform the management of human activities and how to best employ adaptive strategies to survive within these newly defined boundaries. This topic generated eight questions from the 100 questions exercise. The first of these asked, how will ocean acidification affect marine biodiversity and how could its effects be mitigated (question 46)? Calcareous organisms such as bivalves, corals and coralline algae are just some of the biota likely to succumb to the increasing acidity of the world's oceans (Hall-Spencer *et al.*, 2008). This will have significant ecosystem effects at a local scale. Bivalves are important organisms in the capture of carbon from the water column and many are prey for fish species (Hinz *et al.*, 2006). Bivalves also form biogenic reef structures that are important habitats for different life-history stages of fishes. Similarly, there is considerable endemism of coral reef-associated fish species (Roberts *et al.*, 2002).

What are the ecological, economic and social consequences of the expanding marine aquaculture sector (and freshwater sector) (question 47)? The ecological effects of these activities were discussed under question 31; however, in terms of economic and social effects it is certain that the demand for fish products will continue to increase with world population growth. The controlled conditions whereby aquaculture is undertaken could divorce the supply of fishes from the uncertainties of wild stock availability. This would have a positive social outcome on the well-being of nations that are largely dependent upon fishes as their primary source of protein. Continued uncontrolled exploitation of wild stocks, and in particular industrial fisheries that provide the bulk of protein for fish feeds, however, will limit the potential of aquaculture to deliver its potential positive social outcomes.

Which management actions are most effective to ensure the long-term survival of coral reefs to the combined effects of climate change and other stressors? (question 48). The use of marine protected areas has been successful in maintaining coral-reef fish population status within the area of protection (Gell & Roberts, 2003). Thus, the exclusion of an appropriate amount of human activities that are detrimental to the coral-reef system and its associated species would seem the most appropriate and effective approach. The ability of these management actions to deliver their intended outcome is largely dependent upon much larger-scale processes linked to current climate change. The inertia of change in the ocean environment means that the detrimental effects of climate change on coral-reef systems (and hence the fishes associated with them) may be too late to avert.

Which management approaches to fisheries are most effective at mitigating the effects of fish extraction and fishing gear on non-target species and habitats (question 49)? Complex management frameworks such as an ecosystem-based approach to fishery management (EBFM) have largely arisen due to the need to effectively regulate the key stressor: the amount of fishing activity. Reducing fishing activity to a level that allowed stock and ecosystem recovery would achieve many of the goals of EBFM. This, together with spatial restrictions to protect the most vulnerable fish habitats and biodiversity attributes, would achieve the basis to sustainable use of marine ecosystems (Hall, 1999; Kaiser, 2005).

How does the effectiveness of marine protected areas vary with ecological, physical and social factors and with connectivity to other protected areas (question 50)? This is a complex and compound question. Marine protected areas are instigated to achieve either biodiversity conservation or fisheries enhancement and sustainability objectives. To date, many MPA have been designed without clear objectives in mind and hence the factors outlined in this question have not been considered. Accordingly, some of the variability in the outcome of implementing MPA is related to ill-considered or lacking *a priori* objectives. Effective MPA will be those that are connected to other subunits of a population at a local and regional level. Isolated MPA are far less likely to contribute wider population resilience and may be vulnerable to population collapse without a source of recruits. For fish species with larval dispersal, physical dispersal processes related to currents will be key. A consideration of the critical life-history bottlenecks for the species of concern is highly relevant (*e.g.* the requirement for structured habitat during a juvenile stage). Future changes in physical processes may undermine the ability of MPA to deliver their stated objectives (*e.g.* changes in currents or carrying capacity).

What will be the impacts of climate change on phytoplankton and ocean productivity, and what will be the feedbacks of these impacts on climate (question 51)? Climate change will alter physical processes to differing extents across the globe with increasing levels of rainfall in some areas, no change in others and decreasing rainfall in others (IPCC, 2007). Wind forcing will change similarly. Thus, at regional scales, some areas will see large changes in the physical environment, whereas others will be less severely affected (IPCC, 2007). Increasing storminess and increases in sea level will heighten mixing processes in shallow shelf seas and increase productivity in these areas. Intensification of stratification in other areas, however, will reduce primary production. For fisheries that are driven by bottom-up processes, this will directly affect the trophic levels higher up in the system with consequent increases in fish production in some areas and decreases in others. Management practices will need to take these factors into account when setting quotas and assessing the reason for fluctuations in populations size (*e.g.* declines may be climate driven, not fisheries driven, while increases in fish population size may be climate driven and not as a result of good governance).

How will multiple stressors, especially fishing, pollution, sea temperature fluctuations, acidification and diseases, interact to affect marine ecosystems (question 52)? The synergistic interaction between different stressors is a major cause for concern, particularly in situations where stressors have sublethal effects on an organism's integrity. For example, a fish that is already challenged due to increased oxygen demand in warmer water may not be able to sustain the assault of a number of chemical contaminants at the same time. The endless range of combinations of stressors mean that it is unfeasible to ever ascertain which blend of stressors is responsible for mortality, or the threshold beyond which an organism may succumb to additive sublethal effects.

Which mechanisms are most effective at conserving biodiversity in ocean areas occurring outside the legal jurisdiction of any single country (question 53)? The answers to this question are combination of the responses to questions 49 and 50. In addition to these measures, the global implementation of vessel-tracking systems with an automated means of administering fines together with measures to eliminate the supply of illegal and unreported catches of fishes would eliminate many of the problems encountered in international waters in relation to fisheries.

FRESHWATER ECOSYSTEMS

Similar to marine ecosystems, freshwater ecosystems are in crisis. Although marine systems tend to receive more attention (Abell, 2002), the challenges facing freshwater systems may in fact be more complex because of the multiple competing demands for freshwater resources (*e.g.* drinking water, fisheries resources and energy) and the variety of threats (*e.g.* hydropower, water extraction and pollution; Richter *et al.*, 1997; Dudgeon *et al.*, 2006). Such alterations are expected to continue and expand.

In recognition of the threats facing the aquatic realm, freshwater ecosystems was treated as a separate thematic area in the 100 questions exercise. There were five questions identified in this theme and all are obviously relevant to aquatic and fisheries conservation. Question 54 (How can freshwater biodiversity and ecosystem service values best be incorporated in the design of water-provisioning schemes for direct human use and food production?) recognizes the fact that clean fresh water is essential for drinking and demand is surely to increase. Irrigation for agriculture in arid regions such as California has generated conflict among stakeholders and placed fishes at risk (Moyle & Williams, 1990). Water for use in industry and human consumption can also be quite high in urban environments (FitzHugh & Richter, 2004). There is growing recognition of the importance of river-flow regimes as natural drivers of the habitat structure, recruitment and ecosystem function that maintain fish diversity and fisheries and the need to identify 'environmental flows' (Arthington *et al.*, 2010; Poff *et al.*, 2010; note, this is also relevant to hydroelectric operations). Clearly, there is need for more research on mitigating water withdrawal, identifying environmental flows and on balancing competing demands for limited water (Baron *et al.*, 2002; Arthington *et al.*, 2010). Question 55 (Which aquatic species and communities are most vulnerable to human impacts, and how would their degradation affect the provision of ecosystem services?) is important as it would enable resources (time and money) to be appropriately dedicated to high priority problems. Similar prioritization approaches have been advocated for conservation science in general (Master, 1991), and in a fisheries context, identify *Oncorhynchus* sp. stocks in need of restoration (Allendorf *et al.*, 1997). Question 56 (Where will the impacts of global climate change on hydrology be most extreme, and how might they affect freshwater species and the ability of wetlands and inland waters to deliver ecosystem services?) recognizes the potential influence of climate change on hydrology (Gleick, 1989) and the resultant implications for freshwater diversity (Xenopoulous *et al.*, 2005).

The last two questions specific to fresh water deal with institutional arrangements, governance, cost benefits and decision making. Question 57 (Which multinational governance, cross-sector cooperation agreements and finance mechanisms will make freshwater ecosystem management more effective and reduce international conflicts over water?) recognizes the inherent management challenges associated with institutional governance overlap and conflict. The final question (*i.e.* Question 58, How does investment in restoration ... compare with construction of dams and flood defences in providing cost-effective improvements in flood management and the storage and retention of water for domestic, industrial, and agricultural use?) if answered could help to justify large-scale protection of wetlands and riparia and associated ichthyofauna. The question is largely one for ecological economics to tackle and is related to several other questions discussed in the section 'impacts of conservation interventions'.

SPECIES MANAGEMENT

Early fisheries management used a single-species approach; nonetheless, in the 1970s the stock concept was developed that recognized the intraspecific variation in biotic characters (*e.g.* life history, genetics and morphology) among populations of the same species that are of interest to managers (Begg *et al.*, 1999; Brooke, 1999). More recently, there has also been growing interest in adopting an ecosystem approach to fisheries management (Link, 2002). Despite the fact that there are number of units and levels at which organisms can be managed, the reality is that today the species still tends to be the primary management unit for many taxa, although with fishes it is arguably the stock that is the most common and appropriate unit for management (Begg *et al.*, 1999; Mace, 2001). The stock concept (note that the term stock tends to be specific to fishes, population is typically used for other taxa) is not as widely embraced by those that manage other taxa (*e.g.* birds and mammals), although this is changing rapidly (Palsbøll *et al.*, 2007).

The 100 questions exercise identified eight questions that were primarily directed towards the species level of which several are relevant to the fisheries profession. For example, question 60 deals with determining what information is required to decide when and how to manage non-native species. Such questions are becoming increasingly common, particularly with respect to taxa that have been introduced intentionally to generate recreational fishing opportunities [*e.g.* rainbow trout *Oncorhynchus mykiss* (Walbaum) and largemouth bass *Micropterus salmoides* (Lacépède); Cambray, 2003] or those that were inadvertently introduced but now represent significant components of ecological systems [*e.g.* round goby *Neogobius melanostomus* (Pallas) in the Laurentian Great Lakes and Nile perch *Lates niloticus* (L.) in the East African rift lakes]. Question 62 is important to fisheries professionals as it deals with how resources should be directed towards different contributions to species-level programmes such as education, captive breeding and habitat management. Such questions arise frequently as practitioners must decide how limited money should best be allocated to maximize benefit. An example in the fisheries realm includes efforts to restore American eel *Anguilla rostrata* (LeSueur), populations in the St Lawrence River catchment and the challenges in determining whether efforts should be devoted to developing hatchery programmes, addressing hydropower effects, or other strategies (Haro *et al.*, 2000). Clearly, providing measures of cost effectiveness would be an important tool for decision makers. Question 65 is also relevant in that it deals with evaluating approaches for reversing range and population collapse in top predators and other species that exert disproportionate control on ecosystems. In fisheries, there is some evidence of 'fishing down the food chain' (Pauly *et al.*, 1998) as apex predators are in decline or collapse (Myers & Worm, 2003). Hence, there is interest in developing conservation strategies to allow such populations to rebuild. In the fisheries world, most of the species that fill this role are themselves quite large, and in some cases possess life-history characteristics that make recovery using direct management interventions (*e.g.* stock enhancement) challenging or even futile

(Mace, 2001). Any efforts to develop conservation and management strategies aside from simply prohibiting all fishing-induced mortality (harvest and incidental) would certainly be welcomed by managers and fishers (Arthington *et al*., 2004; Birkeland & Dayton, 2005).

ORGANIZATIONAL SYSTEMS AND PROCESSES

Six questions relating specifically to the scope, capacity and evaluation of conservation organizational systems and processes were identified. These questions focused on issues such as how organizational structure and funding influenced the effectiveness of conservation efforts (question 67), how societal needs and preferences shape conservation policy (question 68) and how the effectiveness and efficiency of various conservation interventions can be evaluated and communicated. These types of questions are typically addressed in other fields by researchers in public administration, policy science, management and economics. Because of the central role that human organizations play in influencing markets, policies and governance costs (Simon, 1991; Williamson, 1999), all six of the questions identified by Sutherland *et al*. (2009) in this section have relevance for the conservation of fishes and aquatic habitats.

One key question (question 68) asks how human needs and preferences are considered in policy design and implementation. The emphasis in the conservation field is often on the cost-effectiveness of achieving specific conservation targets or on the economic efficiency (*i.e.* costs *v*. benefits) of conservation programme alternatives. Economic performance is, however, only one criterion upon which public policy choices can be made. Other possibilities include equity (both in terms that people who benefit from interventions bear the cost of paying for them and in terms of the redistribution of equity that protects vulnerable groups of society), accountability, conformance to general morality (*i.e.* ethics and social norms) and adaptability (Ostrom & Ostrom, 2004). Because conservation outcomes can vary greatly even with seemingly minor changes in organizational structure and rules governing behaviour (Ostrom, 1990), the issue of how criteria for decision making are derived will have major implications for aquatic conservation. A second major area of inquiry examines the relevance of organizational structure and function on the effectiveness of conservation outcomes (questions 67 and 69 to 72). An important factor here is the influence of natural and social science advice (and other information such as traditional ecological knowledge) in the policy process (Sutherland *et al*., 2004). That is, how is knowledge both generated and communicated in such a way that aquatic conservation legislation, policy and guidelines are based on the best available evidence? This will clearly be a central issue for fishes and aquatic conservation at multiple scales.

SOCIETAL CONTEXT AND CHANGE

Sutherland *et al*. (2009) identified 13 questions that focus on the influence of societal structures and processes on biodiversity. Important themes included: the influence of demographic, technological and political change (questions 73 and 84), the relationship between biological diversity and the economy (questions 74, 76, 78 and 79), the influence of property rights on conservation outcomes (question 77) and the role of human values and education on biodiversity conservation (questions 81 to 83). Questions relating to human–wildlife conflict and the effects of armed conflict on biodiversity are less salient for aquatic conservation relative to the terrestrial environment. This group can also be divided into questions relating to the macro-level drivers (*e.g.* migration, technological change, economic activity, conflict and commodity prices) of biodiversity depletion, the human values influencing organizational and societal development choices, and the property right and policy challenges (*e.g.* tenure systems, trade agreements, subsidies and corruption) associated with countering adverse environmental change. Again, virtually all of the questions in this section have substantial relevance for the conservation of fishes and aquatic ecosystems.

Issues relating to macro-scale changes in patterns of human consumption, trade and technology over time are particularly relevant to the conservation of many marine fishes, given the lack of property rights in international waters and for migratory species targeted by commercial fisheries or landed as by-catch, advanced harvesting technologies and substantial technical overcapacity, and extensive fleet subsidization (Munro & Sumaila, 2002; Pauly *et al*., 2005; Berkes *et al*., 2006). For many freshwater and estuarine species, issues of human values and economic development may be much more salient, given the great effects that invasive species, water diversions and terrestrial development (*e.g.* agriculture and urbanization) have on freshwater and coastal ecosystems in many parts of the world (Vörösmarty & Sahagian, 2000; Malmqvist & Rundle, 2002; Brauman *et al*., 2007; Martínez *et al*., 2007; Murchie *et al*., 2008; Williams & Grosholz, 2008). Given the probable changes in coastal cities and lands due to future sea-level rise, societal attitudes and values relating to coastal protection, management or abandonment strategies will also have a potentially important effect on coastal fishes and aquatic environments (Turner *et al*., 2007; Poulter *et al*., 2009).

EFFECTS OF CONSERVATION INTERVENTIONS

This final section of the 100 question exercise includes what are perhaps to most eclectic group of questions, many of which have some level of redundancy with questions addressed in other sections. In addition, some questions are at a very high level (*e.g.* question 86, asking about convention on biological diversity targets) and are relevant to many taxa. One of the more interesting questions (question 89) relates to whether efforts are best devoted towards improving knowledge (*e.g.* status, nature of threat and effectiveness of interventions) or direct conservation actions. Given the long tradition of a science-based approach to fisheries management, it might be assumed that generating knowledge is an obvious first step to addressing pressing fisheries and aquatic conservation issues. When issues are time-sensitive, however, action may be needed (*i.e.* the precautionary approach) before the complete body of evidence exists. In fisheries there are a number of examples of where science was not heeded even when it did exist (*e.g.* Atlantic cod *Gadus morhua* L. collapse off eastern Canada; Hutchings & Myers, 1994), making the likelihood of action in the absence of science even more unlikely when actions involve limiting fishing effort or harvest. This section also includes a number of questions that address human welfare (question 91) and the potential for engaging stakeholders to improve the effectiveness of conservation programmes (question 92). Given the immense amount of time and effort spent engaging stakeholders in fisheries science, knowing whether this work actually improves the effectiveness of a programme would be useful, particularly when dealing with controversial topics such as aquatic protected areas.

FISHERIES PERSPECTIVE ON WHAT IS MISSING FROM EXISTING 100 QUESTION EXERCISES

A useful exercise is to determine what is missing from the existing 100 questions exercise that would be particularly useful for fisheries professionals. As opposed to focusing on very specific questions, it is most instructive to address larger themes. The first concern is related to the fact that the majority of the expertise specific to fisheries was from developed regions, North America in particular. The team of leaders that were involved with assembling the final list of 100 questions included several individuals with specific expertise in fisheries science and aquatic ecology. What was evident from this team was that for the aquatic expertise, the leaders were based in North America, although some of them do conduct research or address issues in other regions. With perspectives associated with North America, it could easily be seen how issues and questions specific to developing countries could be under represented. It is worth noting, however, that the leaders were responsible for synthesizing information that was obtained from a broader constituency of managers and policy makers from around the world. In other words, the 100 questions exercise was not about researchers defining the research agenda, it was about conservation practitioners defining the research agenda. Another theme evident in the exercise was the notion that fisheries exploitation issues were restricted to marine waters. Indeed, this theme seems to also persist in the fisheries literature where the inland fisheries crisis is overshadowed by that in the marine environment. Issues such as fisheries exploitation and by-catch are also relevant in fresh water, even if there has been considerably less research on the topic (Allan *et al*., 2005). In addition, when exploitation is discussed, it is almost always in the context of large-scale commercial fisheries rather than considering the role of the other fisheries sectors (*e.g.* recreational and subsistence; Cooke & Cowx, 2006). The 100 questions exercise also includes substantial content of relevance to understanding the human dimension and institutional framework for conservation problems. For fisheries in particular, understanding the human dimension is critical when resolving conflict. It is not as much that this was missing from the global 100 questions exercise as it was that the biological and human dimensions questions were not fully integrated. For example, many of the questions regarding protected areas need to be considered in terms of zonation, which requires an explicit integration of natural science and human dimension understanding (Day, 2002).

Although not the focus of the current analysis, the previous exercise from the U.K. (Sutherland *et al*., 2006) also included some content of relevance to fisheries although it was more specific to the U.K. In fact, the U.K. exercise included a topical subheading of 'Fisheries, Aquaculture and Marine Conservation'; however, the topics covered here were specific to marine waters. Freshwater issues were covered in several sections, although rarely were the questions specific to fishes (*e.g.* What is the most appropriate and ecologically sustainable way of dealing with excess nutrients during terrestrial and freshwater habitat restoration?). Some of the questions in the document were quite specific. For example, one question was addressing the implications of species introductions that were intended to generate recreational (fishing) opportunities. It is also worth noting that most of the questions are hopelessly interconnected (*e.g.* renewable energy and climate change); hence, there is inherent complexity and risk when approaching research one question at a time.

Of note is the fact that the paper by Sutherland *et al.* (2006) represents one of the most downloaded (in the top 10) of all papers in the entire Wiley-Blackwell family of journals, emphasizing its interest among the scientific community. The 22 questions exercise from Australia (Morton *et al.*, 2009) also contained significant content relevant to fisheries, particularly given that 40% of their coastline is lined by coral reefs that are important for fisheries and tourism. The questions from the Australian exercise appeared to be much broader (*e.g.* dealing with ocean acidification and multiple stressors in coastal and inland systems) than those outlined in the global 100 questions exercise. Nonetheless, there were more questions in the Australian exercise that could be immediately recognized as relevant to fishes and aquatic ecosystems. Both the U.K. and Australian models have a slightly different focus than the global exercise, primarily because of the regional scope. Indeed, because those two exercises were inherently more focused, they may yield more immediate benefit than the more general global exercise.

IS THERE A NEED FOR A 100 QUESTIONS EXERCISE FOCUSED ON FISHERIES AND AQUATIC RESOURCES?

There is no doubt that conducting a 100 questions exercise with a focus on fishes would be an interesting exercise in its own right simply to elucidate the collected consensus on issues relevant to fishes. Such an exercise, if conducted, must also generate information that is of practical benefit to the community of fisheries professionals or to the resource itself. The existing 100 questions exercises have not been without criticism. Indeed, it could even be suggested that question 101 should be whether 100 questions exercises serve any real purpose in advancing the conservation of biodiversity. The primary criticisms often revolve around what is included and excluded from the list (*i.e.* Is my favourite topic included?) and how that decision could influence the potential funding for such research in the future. The global 100 questions exercise goes so far as to suggest that the questions generated could be used to identify funding priorities. Papers, studies and grant applications could be seen as using the fact that a question is included in the list as a justification for the work. Is this necessarily a bad thing? It really comes down to scale (Stevens *et al.*, 2007) since not all issues are global in scale or scope. In some cases, a local issue is extremely relevant to a local group of stakeholders. Having stakeholders and researchers think beyond their specific issue or problem and place it in a global context may be challenging, although the global 100 question exercises would act as anchor point for much more specific considerations.

Perhaps, the greatest benefit of completing a 100 questions exercise with a fish focus would be that it would help to generate awareness regarding the plight of marine, estuarine and freshwater ichthyofauna and the need for scientific research to support policy and management decisions. Clearly, aquatic systems are facing many threats, and any efforts to increase awareness among the general public and other stakeholders through transfer of scientific knowledge would be beneficial (Loftus, 1987; Mikalsen & Jentoft, 2001). Indeed, there are many examples both globally (Cambray & Pister, 2002; Jacquet & Pauly, 2007) and locally (Shunula, 2002; Tran, 2006) where fisheries conservation and management actions have benefited from an aware and engaged group of stakeholders. Given that 100 questions papers are often fairly general, the content is quite accessible to a range of stakeholders including politicians and voters. Also of relevance is the fact that such an exercise may help to increase the immediacy with which emerging issues receive appropriate recognition and attention (Moser & Dilling, 2004). Failure to generate immediate awareness of emerging problems by society can have significant ecological costs and consequences (Scheffer *et al*., 2003).

A CALL FOR A 100 QUESTIONS EXERCISE FOCUSED ON FISHES AND AQUATIC ECOSYSTEMS

The use of 100 questions exercises to identify questions that, if answered, would help to address longstanding conservation and management questions, is gaining in popularity. As outlined above, the existing global exercise (Sutherland *et al*., 2009) included many topics that were of broad relevance to fisheries professionals; however, there were also some notable omissions. Would such an exercise focused on fisheries and aquatic professionals be a worthwhile endeavour? Although there is some risk in attempting to identify $n = \mathrm{X}$ questions for an entire field, such an exercise can be useful for generating awareness. Considering the plight of ichthyofauna and the continued range of threats facing marine, estuarine and freshwater systems (Gray, 1997; Richter *et al*., 1997), such awareness would certainly be welcomed. In addition, given that the exercises are focused on identifying questions of relevance to practitioners (*e.g.* managers and policy makers), there is also the potential for such an exercise to help direct researchers towards practical needs that can yield an immediate tangible benefit. Such an exercise must rely on significant input from the policy makers and management community or otherwise the activity will be self-serving for researchers and will be unlikely to address key management issues. Provided that it is acknowledged that any list of questions is unlikely to be truly exhaustive or inclusive, then such an exercise does appear to have merit. As such, it is proposed that a 100 questions exercise be initiated with a goal of identifying questions of relevance to fishes and aquatic ecosystems that if answered would improve the ability to manage and conserve fishes, fisheries and aquatic systems for both human benefit (food, wealth, recreation and culture) and their inherent ecological value.

So what is the way forward? Such an exercise would be best addressed through the joint efforts of all major professional societies, perhaps under the leadership of the World Council of Fisheries Societies. There are several items, however, that are important and should be used to help scope the approach and content. First off, the exercise needs to be inherently global with participants from a range of countries including those that are considered ‘developing’. In fact, to encourage submission of questions from around the globe, there may be merit in soliciting questions in several languages such as Spanish, French, German, Japanese, Mandarin and Portuguese. Use of professional societies [including the Fisheries Society of the British Isles, American Fisheries Society (in particular the International Section, the Canadian Aquatic Resources Section and the Fisheries Management Section), Australian Society for Fish Biology, Indian Society of Fisheries Professionals, Asian Fisheries Society, Japanese Society of Fisheries Science, the Zoological Society of Pakistan, Mexican Fisheries Society] could assist with ensuring broad participation. Also important will be the need to include a significant focus on human dimensions, with a particular interest in developing questions that integrate human dimensions and natural science. The exercise must also target fisheries practitioners, those that deal with fisheries management and policy on a day-to-day basis. Such a focus would help to identify knowledge gaps that constrain fisheries management, restoration and aquatic ecosystem conservation. Finally, such an exercise must provide equal emphasis on freshwater and marine systems, as well as transitional habitats (*e.g.* estuaries) and cover all fisheries sectors (commercial, recreational and artisanal and subsistence, as well as aquaculture). Provided that the proposed 100 questions exercise is of appropriate scope and regarded as a means of generating awareness and helping to clarify applied research needs, this idea should be pursued immediately in order to reap the greatest immediate benefit with the ideal outcome being the more effective conservation and sustainable management of global fish populations and aquatic ecosystems.

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