Chapter 7
Ecosystem Health in the Context of Fisheries and Aquaculture – A Governability Challenge

José J. Pascual-Fernández and Ratana Chuenpagdee

Abstract The importance of marine and ocean ecosystems to the livelihoods and wellbeing of fishing and coastal communities around the world is well recognized. Global efforts have been made to prevent these ecosystems from deteriorating, but the challenges are huge, with ongoing pressures and stresses driven largely by a wide range of human activities. In this chapter, we first employ the governability concept to examine these stressors in terms of their diversity, complexity, dynamics and scales in relation to the natural and social systems-to-be-governed, the governing systems and the governing interactions. Recognizing that the health of the ecosystem is an outcome of governing efforts and interactions between governing institutions and social actors, we apply the governability perspective to assess factors affecting the ability of the social system-to-be-governed and the governing system to cope with the present state of the marine and ocean ecosystems, and draw policy implications based on that analysis.

Keywords Human ecosystems • Ecosystem health • Fisheries • Coastal zone • Aquaculture • Global warming • Governability

J.J. Pascual-Fernández (✉)
Institute of Social and Political Sciences, University of La Laguna, Tenerife, Spain
e-mail: jpascual@ull.es

R. Chuenpagdee
Department of Geography, Memorial University of Newfoundland, St. John's, NL, Canada
e-mail: ratanac@mun.ca

M. Bavinck et al. (eds.), *Governability of Fisheries and Aquaculture: Theory and Applications*, MARE Publication Series 7, DOI 10.1007/978-94-007-6107-0_7,
© Springer Science+Business Media Dordrecht 2013

Stresses and Challenges to Ecosystem Health[1]

Humans have been related to and dependent on coastal areas and oceanic ecosystems since hunter and gatherers' societies. This dependency has increased in the last centuries with the growing and changing demographics in coastal areas around the world. The diversity of human uses in these areas has also increased with expansions in the exploitation of underwater mineral resources, such as petroleum and gas, and renewable resources like fisheries, as well as ongoing development of harbor and related infrastructure for maritime transport. Human pressures on the oceans are much higher today than in any other moment in history. Increased attention must therefore be paid to questions regarding the means by which we govern the ecosystems we depend on, and how to mediate the relationship between human societies and nature.

The continuous modification of coastal and marine ecosystems by human societies means their survival is at stake. They are vulnerable to changes that may end up transforming their functions to the point that they are no longer able to provide ecosystem services and goods. Past lessons show that some of these changes are not reversible and that their effects can be drastic. Cod fisheries collapse in Newfoundland is a good example of how anthropogenic changes may strike back on coastal populations (Finlayson and McCay 1998). Human-nature interactions are frequently inscribed in co-evolution processes that, for instance, allowed humans to develop seeds (for agriculture) that slowly changed with and because of human behavior. This consequently made the transformation from hunter and gatherer societies into agricultural adaptations possible (Rindos 1984). In other circumstances, human-nature interactions may be conducive to abrupt changes and unforeseeable consequences, such as when pressures on the ecosystems or human populations compromise their integrity and resilience. As described, the relationship between human societies and ecosystems creates increasing concerns about the health of coastal and marine ecosystems.

Several integrated management frameworks and ecosystem-based approaches have been employed to address these concerns. Some of them, such as the one promoted by Resilience Alliance (Berkes and Folke 2000; Armitage et al. 2007), emphasize linkages between social and ecological systems. While the interactive governance approach has a similar focus, it is explicit in the examination of all related systems, i.e., those that are being governed, the governing system and the interactions between the two, throughout the entire 'fish chain' (Kooiman et al. 2005). These systems receive even attention because it is understood that factors fostering or inhibiting governance can be found in any of them. In addition, looking at ecosystem health from the governability perspective, as suggested here, is a

[1] The research summarized in this chapter is related to the project *Governability analysis applied to the creation process of Marine Protected Areas* (GOBAMP, CSO2009-09802), supported by the Spanish Ministry of Economy and Competitiveness. We also acknowledge the support from the Social Sciences and Humanities Research Council of Canada.

systematic way of analyzing what makes the system more or less governable, and what governing interventions may therefore be required.

Before delving in any further, we would like to first acknowledge that the word ‘ecosystem’ evokes multiple connotations, even within the scientific community. It generally refers to a complex system that relates living organisms and physical factors in an environment. One of the most widely accepted definitions of the term is provided by Convention on Biological Diversity. Accordingly, ‘ecosystem’ means a dynamic complex of plant, animal and micro-organism communities and their non-living environment interacting as a functional unit (CBD 1993 [1992]).[2] However, some elements of the concept may be understood from different perspectives. For instance, where or how the limits of an environment can be located may constitute a controversial issue, because natural systems are globally interrelated. Another relevant issue, perhaps the most important for our aims, is how the role of human societies in ecosystems can be conceptualized. For some authors it is evident that humans have a clear, dominating role in the recent evolution of ecosystems in our planet (Vitousek et al. 1997). Others even argue for the use of a ‘human ecosystems’ concept for those ecosystems where humans constitute a central agent (Stepp et al. 2003). As posited by Vitousek et al., “It is clear that we control much of Earth, and that our activities affect the rest. In a very real sense, the world is in our hands - and how we handle it will determine its composition and dynamics, and our fate” (1997, 498–499). This position looks increasingly clear after considering all of the accumulated evidence on how humans induce ecosystem transformations in the world, as is the case with climate change.

Next, defining what a healthy ecosystem is may be subject to debate. System evaluators may have different opinions about the baseline, because ecosystems are continuously changing. Moreover, based on their experiences, each generation may have a very different perspective of the state of a healthy ecosystem. Finding pristine ecosystems without clear human impact, whether it is at sea or on land, is no longer possible. Even remote areas are being exploited directly by humans or indirectly by other activities (Kulbicki 2005), including through processes like climatic change.

Well-functioning ecosystems are crucial not only for fisheries productivity (Chuenpagdee et al. 2005), but also for other functions. The capacity of the sea to absorb CO_2, for instance, is a key factor in assimilating climate change. Ocean currents are also essential for climate stability in many areas of the world. The extent to which human societies depend on ecosystem services, specifically on marine ecosystems, may not be completely known. Yet, humans may very well be the only species on earth to have unprecedentedly impacted ecosystem health far beyond recovery. This is perhaps due to confidence in our ability to develop technologies to control the natural realms. However, such ability is increasingly contested by

[2] The relevance of this concept even conduces to detailed legal definitions, for instance as “a dynamic complex of plant, animal and micro-organism communities and their non-living environment interacting as a functional unit” (Commonwealth of Australian Law 1999, 466).

obstinate facts. Climate change is a good example of this global challenge, with major technological or political efforts providing meager results.

Maintaining marine ecosystem health and its functions is a governability issue that requires the involvement and commitment from actors across the board and at all levels of governance. Most programs and initiatives related to ecosystem health have both local and global dimensions. Marine protected areas (MPAs), for instance, are one of the most popular ecosystem management tools promoted around the world, but they are also a classic example of a wicked problem that needs to be examined through the governability lens. Because MPA proposals involve large areas, achieving agreements on what needs to be done, as well as on who and how to do them, raises significant challenges. Globally, nations struggle to meet the various targets set and adopted to increase the level and extent of marine protection, including the latest recommendation at the 2003 World Parks Congress to establish networks of MPAs (including strictly protected areas) covering at least 20–30% of each habitat by 2012.[3] Debates are ongoing about how the targets were set, whether they are realistic and whether these MPAs would indeed contribute to improving ecosystem health. At the local level, MPAs are often ridden with conflicts among user groups with incompatible practices and competing interests, making their creation problematic (Jentoft et al. 2011). Without local support, MPAs are unlikely to be successful or sustained. Considering all the challenges described above, serious consideration about our governing capacity and the understanding of the characteristics and qualities of the ecosystems that need to be governed is essential.

Following a governability perspective, we characterize challenges affecting fisheries and coastal ecosystem health in terms of the system-to-be-governed, the governing-system and the government interactions, taking into account their diversity, complexity, dynamics and scale/vulnerability (Table 7.1). The detailed analysis of these challenges is presented around three relevant global issues related to ecosystem health: coastal zones; fisheries and aquaculture; and climate change.

Coastal Zones: Diversity, Complexity and Dynamics on the Rise

Coastal Transformations

Coastal zones constitute a key element in many ecosystems. They are crucial for the growth, reproduction and vitality of many species, including humans. These areas play essential roles in the development and evolution of societies and cultures across

[3] WPC Recommendation 5.22, see http://www.internationalwildlifelaw.org/MPARecs.pdf

Table 7.1 Challenges related to fisheries and coastal development affecting ecosystem health

Characteristics	System-to-be-governed	Governing system	Governing interactions
Diversity	New economic opportunities like tourism, transportation, commerce, recreation, etc. conducive to coastal development; increasing number of ethnic communities due to coastal migration; increasing use of fishing gear types; new entrants into the fishery	Increasing actors in fisheries and coastal areas requiring a higher number – or broader scope – of responsible government agencies; new rules and regulations established to address the multiple demands and interests	Greater level, and variation in types, of interactions between government agencies and fisheries-coastal actors required to manage growth and to prevent negative consequences for fisheries resources and the coastal ecosystem
Complexity	Fishers of different gear types, coastal communities of different ethnic groups and multiple coastal stakeholders relying on the sharing of limited resources and space	Various governing agencies with different responsibilities requiring increasing coordination to achieve their individual mandates	Not all interactions are mutually supportive. For instance, two-way information sharing between stakeholders can generate trust, while one-way information flow can be seen as exploitative
Dynamics	User conflicts and social tension arising from resource and space competition – gear conflict may surge because risks associated to specific gears; cultural differences leading to an intensification of effort in fishing and coastal development and deterioration of social capital	Mandates and goals of the various agencies may not be compatible causing confusion and uncertainty among stakeholders	Interactions can result in positive outcomes such as compliance and partnership building, or negative outcomes such as conflict and disagreement among stakeholders
Scale	Impacts of fishing and coastal development are not contained within the areas where the activities take place; they also do not happen immediately but can be accumulated over time. Other general processes may deeply affect coastal areas (climate change)	Most governing agencies are restricted in their spatial jurisdiction, having thus difficulty coping with the different magnitude of the impacts and the consequences of phenomena like climate change, sea level rise and tsunamis	Interactions are difficult to coordinate when space is widened and when time sensitivity may be an issue, as in the case of adaptive management where learning and feedback are required. Also, contradictory interests, like those related to climatic change between powerful countries, may pose enormous challenges to reach agreements

the globe. As shown by archeological evidence, early complex cultures and civilizations emerged along the coasts. In addition, communication and commerce have depended on sea pathways at least since the appearance of pristine natural states. At present, these coastal areas are probably more important than ever, as population and economic growth have converged in the last decades, seen in particular in the "Pacific Rim" countries (Lundin and Linden 1993). In densely populated coastal areas, pollution due to waste disposal is one of the main concerns. Organic waste disposal may increase the relevance of certain algae, transforming the ecosystem with undue consequences. The increasing incidence of red tides exemplifies this. Shellfish gathering in the affected areas becomes extremely dangerous for human health. Other target fish species may suffer from the same problems. In areas where industrial development is prominent, chemical pollution may threaten the entire ecosystem, hindering many human uses of the coasts. In many tropical countries, coastal development involves conversion and clear-cutting of mangrove forests. An estimated 35% of the global mangrove area has been lost since 1980. Mangrove forests consequently constitute the most threatened coastal habitat in the world (Valiela 2006). Previously, mangroves had generally been considered 'wasteland,' with low ecosystem values except for their harvestable products such as wood for charcoal and the construction of houses and fishing gear. The conversion of mangrove areas for other uses was therefore deemed suitable. Loss of mangrove forests, however, has major negative consequences due to their important ecosystem functions and services, for example, as habitats and nursery grounds for juvenile fish and other living marine organisms. Mangroves also provide shoreline stabilization and help waste assimilation, thereby mitigating coastal pollution problems. Despite its vast destruction, the Indian Ocean tsunami in December 2004 has led to renewed appreciation for the values of mangroves. Coastal communities in the tsunami affected areas avowed the importance of mangrove forests in mitigating the devastation.

Coastal Processes Accelerating Changes

In the last decades, coastal areas have been modified by human activities to the point that the future of humankind may be threatened. Coastal erosion and displacement, water and air pollution, disappearance of living marine resources, and degradation of coastal habitats are all signs of harmful coastal changes brought about by anthropogenic and natural causes. These various coastal processes create tensions and compromise the previous social arrangement and relative ecosystem homeostasis. An increase in diversity and complexity are likely consequences of these changes, because the new system elements contain more actors who may not fit perfectly with each other. For example, new entrants into the coasts may mean more fishers with different gear types, coastal communities with different ethnic groups, and a host of other coastal stakeholders all relying on the sharing of limited resources and space. Depending on the relationship, conflicts among traditional users and new entrants may arise. Resource and space competition is going to be permanent source of rivalry among different coastal activities. Such is already the case when tourism development enter an area previously linked to fishing activities. The same human and economic capital, as well as political resources, is diverted from one to the other.

Population Growth and Displacement

More than half of the human population lives within 100 km from coasts, and a large percentage also inhabit regions that are less than 3 m above sea level (Ojeda Zújar et al. 2001). Economic forces and industrial development patterns have shaped these processes. For example, sea trade is still a cheap and efficient mode of transportation for industrial production. Industries tend to establish their factories in coastal areas for this reason. In some cases they also need the vicinity of the sea or large masses of water for refrigeration or waste disposal. Many of the largest cities in the world, including several 'megacities' with more than ten million inhabitants, are also located in coastal areas. The number of coastal megacities is expected to grow more than fourfold from 1975 to 2015 (Ojeda Zújar et al. 2001). One activity that perhaps has grown the most in the twentieth and twenty-first centuries, transforming what was a privilege of upper classes at the beginning of twentieth century into a mass activity, is tourism. The tourism industry has shaped coastal landscapes, transforming mostly uncultivated or unpopulated lands into densely inhabited resorts in only a few decades. This is certainly the case in many areas of the Mediterranean or Caribbean coasts, as well as Southeast Asia (Boissevain and Selwyn 2004). In many cases, coastal tourism has clearly contributed to the displacement of populations to the shore, increasing the complexity in the system because of the new mix of stakeholders and the power that some of these new entrants may exercise in policy-making.

Capture Fisheries and Aquaculture: Dynamics and Scale Issues

One of the most important activities directly impacting ecosystem health is fishing. Around the world, there is a long history of modernization of capture fisheries. Traditional small, wooden, non-mechanized boats are being replaced by motorized boats, equipped with mechanized and powerful gear and modern technology (such as radar and sonar for fish finding). Such modernization, along with the improvement in storage and onboard processing facilities, has enabled fishing to take place further offshore, in deeper areas and with longer duration. Post-harvesting technology has also been developed to accommodate the increasing amount of fish removed from the sea, changes in consumers' taste and preferences for seafood products, and globalization. These transformations affect the dynamics of the system, reinforcing user conflicts because not all the stakeholder groups have the same opportunities to access the new technology or means of production. This may even lead to expelling user groups from their traditional activities due to changes in the market or the overexploitation of resources. This happened to artisanal fishers in many coastal areas or inland waters in Africa after the entrance of more powerful industrial fleets. Two processes in this area deserve special attention. The introduction of trawling and the generalization of aquaculture have introduced systemic changes in the fish chain, as well as in the dynamics and scale of the ecosystem.

The Development of Trawling and Gear Conflicts

From a technological perspective, one of the most prominent changes in fisheries in the last century came with the progressive development of trawlers. This technology has a long history in the West, first appearing in the form of sailing trawlers in the latter Middle Ages, but its evolution during nineteenth and twentieth centuries is closely linked to the adoption of onboard steam and diesel engines. These advances increased trawler capacity to not only extract resources, but also to alter the ocean floor (Roberts 2007). Later in the twentieth century, this technology was extended all over the world. In Southeast Asia, for example, trawls were first used in Manila Bay at the end of the Second World War, before spreading throughout the whole region in the early 1960s (Butcher 2004). Trawling, a non-selective fishing method that results in a mixture of target and non-target species, including juveniles and young fish, is an intensive operation that cannot be sustained. In the Gulf of Thailand, for instance, catches from trawling started to decline from 300 kg of catch per hour in 1961 to only about 50 kg/h in the 1980s, and eventually to 20–30 kg/h in the 1990s (Eiamsa-Ard and Amornchairojkul 1997). The decline in catch per effort was accompanied by changes in catch composition (e.g., more small and short-lived species, including ‘trash fish’), after which the ‘fishing down the food web’ phenomena followed (Pauly and Chuenpagdee 2003). In addition to causing ecosystem effects, including habitat destruction and bycatches, trawling competes directly (in terms of space and target species) with other small-scale and stationary fishing gear, such as pots and traps, creating conflicts among fishers. While many countries have regulations that prevent trawling from operating close to shore, gear conflicts between fishing sectors remain one of the key governability issues related to both ecosystem health and social justice. It is important to remember that the governments of many countries heavily subsidized the development of trawling fleets. Bearing in mind their significant contribution to the world’s fisheries production, more support at international and national levels needs to be given to small-scale fisheries, (Chuenpagdee et al. 2006; Chuenpagdee 2011). While it is true that some small-scale fishing practices also damage the ecosystem, namely those that involve the use of cyanide and bomb blasting, the overall impact from this sector is still relatively low in comparison to the large-scale fisheries. Importantly, the contribution of small-scale fisheries to the society, in terms of jobs, income and livelihoods, is a lot greater than that of industrial fisheries (Pauly 2006).

Aquaculture Increasing Diversity, Complexity and Impacts on Ecosystem Health

Another major coastal transformation is induced by aquaculture. Enterprises of different types, sizes and technology have spread around the globe, generating impacts on ecosystem health. Aquaculture development increases system complexity with its presence in areas previously devoted to fishing or other activities. It brings new stakeholders with different images of reality and visions for the future of the coastal area, marginalizing traditional users who have little capital or may not be eager to join (Pascual 2004), and thus increasing the diversity of the system-to-be-governed and the governability challenges.

From an ecosystem perspective, great diversity and complexity can also be found in the aquaculture system, with huge differences between herbivorous, carnivorous and omnivorous species. The latter two depend, to some extent, on compound feed, made up of fishmeal and fish oil, among other ingredients. Carp and shrimp, for instance, consume more than 40 and 18% of the total world production of this aquafeed, respectively (FAO 2009). Problems with this are related to the fact that raw materials used in the production of fishmeal are comprised of small and juvenile fish, some of which may have little to no value but are often important sources of protein for the poor (Tacon and Hasan 2007). Furthermore, they are mostly caught with destructive gear such as bottom trawling and push net. Another concern resulting from aquaculture development is environmental health. For instance, the early development of intensive shrimp culture, mainly tiger prawn (*Penaeus monodon*) in Southeast Asia in the late 1980s involved clear-cutting of large areas of mangrove forests. Large amount of feed is input into ponds that are densely stocked with larvae from hatcheries. The high density culture system and the intensive feeding, coupled with use of fertilizers, biocides and antibiotics for disease control, has compromised their long term viability and created side effects such as high concentrations of nitrogen and organic wastes. Euthrophication due to the excess nutrients may also constitute a risk, because some algae species can be toxic to humans or marine organisms.

Another side effect of aquaculture is the introduction of alien species; typically those that have sufficient market value ensure the culture is profitable. However, all ecosystems are subject to the arrival of alien species, and recent increases in water temperature have fostered this process in the oceans. Ballast water in cargo ships also contributes to such introductions. No less relevant are the intentional or accidental releases from different sources, as in the case of a tropical green alga (*Caulerpa taxifolia*), which was released from the Monaco Oceanographic Museum before 1984 and colonized large areas of the Mediterranean Sea (Meinesz et al. 2001; Valiela 2006). Some of these introductions are controversial. For instance, zebra mussels (*Dreissena polymorpha*) brought to the Great Lakes by ballast water was considered by some to have helped clean up the water. This, however, means that they have filtered out most of the phytoplankton and small zooplankton in the waters, leaving larval and juvenile fish without any food. Debate about the benefits and risks of non-native oysters (*Crassostrea ariakensis*) to the Chesapeake Bay has been on-going since their introduction in the 1990s, as suggested for example by Graczyk et al. (2006).

According to the FAO (2010), aquaculture development since 2000 has mostly followed an ecosystem approach to management principles, and is in accord with the Code of Conduct for Responsible Fisheries. While such trends are not consistent in all regions of the world, it is certainly a step in the right direction that should lead to better overall environmental performance of the aquaculture sector. Such improvement can be attributed to various factors, including technological innovations, lead to improved feed conversion and reduction of fishmeal, and appropriate legislation and governance.

Sea Level Rise and Global Warming: Widening the Scale

Human impacts on ecosystem may be local, but increasingly scientific evidence suggests that they generate problems at a global scale. For instance, when humans transform coastal areas by developing tourist resorts and associated infrastructures, the local impact is coastal alteration, while at a distance they contribute to increasing CO_2 emissions. This results in global warming, which is an increasing challenge to coastal and ocean ecosystems, and may alter large areas in a process that is still largely uncertain. A high rate of ecosystem change is one of the effects of global warming, driving, for instance, the extinction of some species. Corals are among the most affected species, as the rise in temperature results in an incident referred to as 'coral bleaching,' threatening their survival (Hoegh-Guldberg et al. 2007).

Sea level rise, due to, among other factors, global warming and the melting of polar ice (Warrick et al. 1993), may increase the challenges for coastal populations, especially in some island states. Scientific evidence has clearly shown the capacity of humankind in altering natural cycles and accelerating changes that have previously occurred at lower rates, surpassing even the ability of science to predict the consequences. In fact, according to Church et al. (2001) several ice sheets (like the Antarctic and the Greenland) and other hundred thousand non-polar glaciers contain water sufficient to raise significant sea level if they were melted. In addition to islands like the Maldives, many highly populated estuaries may be inundated by these changes, although the rate of these processes is the subject of scientific debate.[4] Other effects of global warming include variations in the acidity of the ocean, wind patterns and hurricanes, all of which pose high risks for many coastal territories. In general, aquatic ecosystems may buffer climatic changes and reduce shocks, but not when the magnitude of change is high. The growing risks and scales of these processes increase governability challenges.

[4] For instance (Mörner 2007), criticizes the assumptions about the current process of sea level rise and their impacts in Maldives or Sri-Lanka.

The level of scale is perhaps the most problematic, especially when actions to alleviate some of the problems imply changes that many countries are not ready to bear. The struggle with the Kyoto protocol is a good illustration of the global governability challenges.

Governability Analyses

Pressure on coastal ecosystems has grown in developed and less developed countries. While it is frequently assumed that the developed world is better equipped with the technology and resources needed to care for the environment and minimize ecological degradation, such assumptions may be questioned. Even with the best available science, a complete understanding of these processes is still lacking. Disasters such as the collapse of the Northern cod stocks in Canada, despite large sums of funding and effort invested on research and fisheries management, can be attributed to insufficient knowledge of the fish species and their life history (Finlayson 1994; Hannesson 1996; Finlayson and McCay 1998). Restoring ecosystems may constitute a huge challenge in many cases, as the decades of attempts in oyster restoration in the Chesapeake Bay illustrate. In the Newfoundland cod fisheries, the ecosystem changes occurring after the collapse have driven some scientists to conclude that recovery would be impossible, and that current fishing practices may also hinder the possibility of this recovery (Davies and Rangeley 2010). It is very difficult and extremely costly, if not altogether impossible, to go back to the previous stages of ecosystems that have been hugely transformed by human activities. Precautionary approaches have been proposed since the 1990s as a general principle in order to avoid risks and irreversible processes (FAO 1996). Yet, practical applications of this principle are still rare (Punt 2006). The challenges are greater for developing and less developed countries coping with these environmental issues because of the scarcity of human and financial resources. Often, short-term goals to secure subsistence and livelihoods of coastal communities overcome long-term considerations for the ecosystem effects of human activities.

Ecosystem health can be considered an outcome of the governing interactions between governing actors and institutions and the social system-to-be-governed in the process of dealing with multiple stressors. It can also be treated as the existing ecosystem conditions, posing conditions and limitation for governability that the governance system needs to deal with. In the latter case, governability is related mainly to the ability of the social system-to-be-governed and the governing system to adapt to the present ecosystem state. The analysis of multiple stressors, particularly fisheries, aquaculture or coastal development, in terms of how they affect the system's governability has already been demonstrated by Chuenpagdee et al. (2008), and is therefore only presented in summary below. The discussion instead focuses on how to improve governability when faced with ecosystem health under stress.

Table 7.2 Characteristics of the fisheries, aquaculture and coastal ecosystems, and their relative governability

	Capture fisheries			Aquaculture			Coastal zones		
	SG	GS	GI	SG	GS	GI	SG	GS	GI
Diversity	M	M	M	M	L	L	H	H	H
Complexity	M	M	M	M	L	L	H	H	H
Dynamics	M	L	L	M	L	L	H	H	H
Scale	M	L	L	L	L	L	H	H	H
Governability	Moderate			High			Low		

Source: Adapted from Chuenpagdee et al. (2008)
SG system-to-be-governed, *GS* governing system, *GI* governing interactions

Governability of Multiple Stressors Affecting Ecosystem Health

In the examination of diversity, complexity, dynamics and scale in relation to capture fisheries, aquaculture and coastal zones, Chuenpagdee et al. (2008) assert that, relatively speaking, these properties are featured most prominently in coastal zones, followed by capture fisheries and aquaculture. In other words, the governability of the aquaculture industry is considered to be highest when compared to capture fisheries and coastal zones (Table 7.2).

As described above, diversity and complexity in capture fisheries arise in both natural and social systems, and more so in tropical areas than in temperate waters. Habitats such as mangroves and coral reefs are rich in biodiversity and high in productivity, and therefore support multi-species fisheries. In terms of trophic interaction, the relationships of these species, in addition to their dependency on the habitats, are generally complex and dynamic. When the balance is upset, the natural fisheries system generally shows signs of degenerating health. On the social side, fisheries stakeholders are numerous and diverse, each with their own complexity and dynamics. They also interact among themselves and with governing institutions in ways that are not easy to understand or predict. Regarding scale, the range and representation of the natural and social boundaries in capture fisheries give rise to governance challenges. In terms of the governing system, institutions dealing with capture fisheries, aquaculture and coastal areas need to acknowledge the intricate properties of the natural and social systems. Frequently, increasing the diversity of actors requires a higher number, or a broader scope, of responsible government agencies. New rules and regulations may be needed to cope with an increased diversity of demands and interests. Principles such as precaution for the natural system and social justice for the human system are the operational foundations for the governing system that lead to improvements in ecosystem health.

Diversity and complexity in coastal zones is generally higher than that found in fisheries. There are more actors involved in multiple livelihood opportunities, and there is a vast array of investment in development for urban and industrial purposes. Depending on the activities, changes in coastal areas take place on a daily basis and at varying scales. The thermodynamics of the ocean may result in long-term change observed through sea level rise. Temperature fluctuation is associated with seasonal variation or with phenomena such as El Niño and La Niña. Coastal development for tourism, and as part of coastal sprawl and urban development, often happens quickly and not necessarily with proper planning. Coastal infrastructure is primarily developed on an ad-hoc basis to support rising demands. They rarely account for possible changes brought about by coastal hazards or global warming. Conflicts among various user groups in coastal zones are largely due to direct competition for space, resources and economic gains. These can, however, also be accelerated by many causes, for example, when the various governing institutions dealing with coastal zone issues lack clarity in their vision and goals. The various governing agencies that deal with overlapping issues need increased coordination, potentially posing challenges to their traditional operations. The recent hype in stakeholder participation in fisheries and coastal management adds another complication to the governance of coastal areas. In addition, the incompatibility of the mandates, goals and concrete policies of the various agencies causes uncertainty and confusion among stakeholders, and reduces the governability of the coastal zone. Improving ecosystem health requires efforts from the governing system to foster interactions among coastal stakeholders through transparent and accountable processes. It also requires a rethinking of the governing institutions. They must reconsider, for instance, the scale issues affecting governability.

Compared to capture fisheries and coastal zones, the overall level of governability of aquaculture is the highest. Aquaculture can be diverse, complex, dynamic and of varying scales. The extent of each of these properties depends on species culture, types of operation and areas where farming takes place. The number of actors and their multiplicity is generally smaller in comparison to the other two systems. While coastal aquaculture is highly governable, there are some concerns about aquaculture and ecosystem health that qualify them as wicked problems requiring interventions at global and national levels. For example, the 'Good Aquaculture Practices' (or GAP) program promoted by the FAO aims to regulate and standardize farming operations worldwide for food safety and environmental sustainability. Ethical considerations are needed when discussing the contributions and threats to food security associated with farming issue, such as the use of low value fish as raw materials in fishmeal, the conversion of mangrove forests and other land areas, and the space competition between fishing and aquaculture that takes place in coastal areas. Finally, similar to large-scale capture fisheries, aquaculture operations often receive high levels of subsidies in comparison to the small-scale fishing sector, adding yet another layer of conflicts and justice issues among fisheries stakeholders.

Improving Governability of Ecosystem Under Stress

The focus on the 'poor' state of the ecosystem, in which way it is defined, does not suggest that governability of an ecosystem that is in good health can be neglected. Rather, it reflects two observations: that the majority of the world's marine ecosystem is under stress, and that governability of such systems is truly a wicked problem. Using the framework suggested by Jentoft and Chuenpagdee (2009), we begin by looking at the natural ecosystem under stress for ways to improve its governability. It has, however, been recognized that improving ecosystem health requires long-term planning and the commitment of human and financial resources. The examination of what can be done at the social system-to-be-governed is therefore critical. As has previously been mentioned, social, cultural and economic diversity is great among people whose livelihoods depend on healthy fisheries and coastal ecosystems (Pascual Fernández 1991; Pascual-Fernández et al. 2005). The level of complexity and dynamism in these social systems constitute both challenges and opportunities for governance. Communities that have strong social capital and a traditional network of support tend to cope well in stressful situations and would therefore likely be able to find adaptive mechanisms to deal with challenges. Communities with complex and multiple livelihood strategies that draw from a wide range of resources can rotate to using other resources or can acquire food and income by other means while waiting for resource recovery. The role of government agencies is then to develop policies that encourage livelihood diversification. These could include appropriate incentive schemes and capacity building and training programs. However, such policy developments have to be based on a thorough understanding of the dynamics of the social systems and the intra- and inter-sectoral relationships. The latter is particularly important as the tendency for conflicts among numerous fisheries and coastal stakeholders is high. The governing system needs to become familiar with the analysis of stakeholders, in terms of their resource dependency and power relationships, to devise suitable interventions. The increased diversity in the coastal zone begs for a greater level of interaction between stakeholders and governing institutions, as well as a variation in types of interactions between government agencies and fisheries-coastal actors.

Alternative livelihoods for small-scale fishing communities are among the most popular interventions, but are difficult to accomplish without an understanding of the diversity and complexity of fishers' socio-economic conditions and the cultural and traditional importance of fishing activities to their way of life. As many fishers would profess, fishing is not just a livelihood but a preferred lifestyle (Onyango 2011). Fishers have their reasons to be reluctant about leaving the fishing occupation or to contemplate doing other things when fishing is not profitable. Some argue, for example, that fishing is the family tradition, while others may prefer it for the freedom it offers. In these instances, non-fishing activities outside the fishing season or during area or seasonal closures should be promoted to enable food and income supplement. Those owning lands are likely to already be doing this by engaging in, for example, vegetable growing or small-scale animal farming. Some support should then be given to help these fishers maintain their ability to derive income and food sources from non-fishing activities. Examples of these efforts are securing market access or controlling prices for the sale of their crops, offering training in the making of value-added fisheries and non-fisheries products, and providing low interest loans to help them start small businesses.

Demands for the governing system to cope with the diversity, complexity, dynamics and scale issues affecting ecosystem health are high. For instance, adapting to the continuously evolving situation in the marine ecosystem and coastal zones requires the governing system to be capable of re-designing institutional arrangements appropriate for new circumstances. Increasing actors and stakeholders in the coastal areas means a higher number or a broader scope of government agencies to adjust existing rules or create new ones. The capacity of the agencies to cope with the new conditions may be compromised, however, by a mismatch in the scale of the problems they confront and their competencies. The nature, level and variation of interactions of fisheries and coastal actors with the governing institutions would be expected to expand as a consequence of the increased diversity. Similarly, the multiplicity of stakeholders and the increased complexity in the social system-to-be-governed requires reconsideration of the types of information and the methods of sharing and dissemination. Information sharing, for instance, can enhance trust when considered adequate. It can also induce suspicion if it is interpreted as exploitative. There are no recipes for perfect interactions, but some emphasis should be placed on partnership building as a way to enhance compliance and avoid conflict and disagreement among stakeholders. The way in which effective partnerships are built depends on the characteristics of the system, especially the scale extent. It may be difficult to encourage positive and direct interaction between groups that are spatially widespread. Time issues may also have an impact on the interactions, as the period required to address the challenges may discourage collective action or increase difficulties for effective learning and feedback processes.

Conclusion

Challenges posed by the current health of the marine and ocean ecosystems around the world are overwhelming. The human capacity to alter these systems through direct physical modification, as happened in coastal urbanization or bottom trawling is enormous. The consequences of these processes are immediate and long-term, both begging for effective policy measures and appropriate governing interventions.

Many of the ecosystem health concerns discussed in this chapter follow the wicked problem definition. They are difficult to define and delineate from other concerns. Their specificities are difficult to grasp, and there is no simple solution. This is due in large part to the fact that any intervention implies major changes in the social system-to-be-governed and the governing system. Responses to these problems need collective efforts that may be beyond our present capacity to interact adequately in reaching agreements and finding solutions. Nevertheless, the heightened awareness of the poor state of the world's marine and ocean ecosystems at global, national, and local levels, and the ongoing attempts to address it are encouraging signs. The analytical lens offered by the interactive governance and the governability approach, contribute to enhancing our understanding of the factors that affect ecosystem health, as well as the areas and types of interventions that may help address the problem. Our analysis shows that the diversity, complexity, dynamics and scale of the key challenges affecting ecosystem health, such as those generated from coastal zone development, intensifying fisheries and aquaculture, and climate change, can be found in the system-to-be-governed, the governing system and the governing interactions. Likewise, the ways to improve governability can also be found in all three systems.

References

Armitage, D. R., Berkes, F., Doubleday, N. (2007). Adaptive co-management: Collaboration, learning, and multi-level governance (Sustainability and the environment). Vancouver: UBC Press.

Berkes, F., & Folke, C. (Eds.). (2000). Linking social and ecological systems: management practices and social mechanisms for building resilience (1st paperback ed.). Cambridge: Cambridge University Press.

Boissevain, J., & Selwyn, T. (Eds.). (2004). Contesting the foreshore: Tourism, society and politics on the coast (MARE series). Amsterdam: Amsterdam University Press.

Butcher, J. G. (2004). The closing of the frontier: A history of the marine fisheries of Southeast Asia c. 1850–2000. Singapore: Institute of Southeast Asian Studies.

CBD. (1993 [1992]). Convention on biological diversity. United Nations — Treaty Series. Rio de Janeiro-New York: United Nations.

Chuenpagdee, R. (Ed.). (2011). World small-scale fisheries: Contemporary visions. Delft: Eburon.

Chuenpagdee, R., Degnbol, P., Bavinck, M., Jentoft, S., Johnson, D., Pullin, R. et al. (2005). Challenges and concerns in capture fisheries and aquaculture. In J. Kooiman, M. Bavinck, S. Jentoft, R. Pullin (Eds.), Fish for life: Interactive governance for fisheries (pp. 25–37). Amsterdam: Amsterdam University Press.

Chuenpagdee, R., Liguori, L., Palomares, M.L.D., Pauly, D. (2006). Bottom-up, global estimates of small-scale marine fisheries catches. Fisheries Centre Research Reports, 14(8), 1–94.

Chuenpagdee, R., Kooiman, J., Pullin, R.S.V. (2008). Assessing Governability in Capture Fisheries, Aquaculture and Coastal Zones. The Journal of Transdisciplinary Environmental Studies, 7(1), 1–20.

Church, J.A., Gregory, J.M., John, H.S., Karl, K.T., Steve, A.T. (2001). Sea level change. In J.H. Steele, S.A. Thorpe, K.K. Turekian (Eds.), Encyclopedia of ocean sciences (pp. 2599–2604). Oxford: Academic Press.

Commonwealth of Australian Law. (1999). Environment Protection and Biodiversity Conservation Act 1999. Act Compilation (current) – C2010C00505. Vol. 2. Australia: Australian Government, Attorney-General's Department. Retrieved from http://www.comlaw.gov.au/ComLaw/Legislation/ActCompilation1.nsf/0/93CECCC69FFF754BCA25776600173C09?OpenDocument

Davies, R.W.D., & Rangeley, R. (2010). Banking on cod: Exploring economic incentives for recovering Grand Banks and North Sea cod fisheries. Marine Policy, 34(1), 92–98.

Eiamsa-Ard, M., & Amornchairojkul, S. (1997). The marine fisheries of Thailand, with emphasis on the Gulf of Thailand trawl fishery. In G. Silvestre, & D. Pauly (Eds.), Status and management of tropical coastal fisheries in Asia (pp. 85–95). Philippines: Asian Development Bank & International Center for Living Aquatic Resources Management (ICLARM).

FAO. (1996). Precautionary approach to capture fisheries and species introductions. FAO Technical Guidelines for Responsible Fisheries 2. Rome: FAO.

FAO. (2009). The state of world fisheries and aquaculture 2008. Rome: FAO.

FAO. (2010). The state of world fisheries and aquaculture 2010. Rome: FAO.

Finlayson, A.C. (1994). Fishing for truth: A sociological analysis of Northern Cod stock assessments from 1977 to 1990. St. John's: Institute of Social and Economic Research, University of Newfoundland.

Finlayson, A.C., & McCay, B.J. (1998). Crossing the threshold of ecosystem resilience: The commercial extinction of northern cod. In F. Berkes, & C. Folke (Eds.), Linking social and ecological systems: Management practices and social mechanisms for building resilience (pp. 311–337). Cambridge: Cambridge University Press.

Graczyk, T.K., Girouard, A.S., Tamang, L., Napier, S.P., Schwab, K.J. (2006). Recovery, bioaccumulation, and inactivation of human waterborne pathogens by the Chesapeake Bay nonnative oyster, Crassostrea ariakensis. Applied and Environmental Microbiology, 72(5), 3390–3395.

Hannesson, R. (1996). Fisheries mismanagement: The case of North Atlantic Cod. Oxford: Fishing News Books.

Hoegh-Guldberg, O., Mumby, P.J., Hooten, A.J., Steneck, R.S., Greenfield, P., Gomez, E. et al. (2007). Coral reefs under rapid climate change and ocean acidification. Science, 318(5857), 1737–1742.

Jentoft, S., & Chuenpagdee, R. (2009). Fisheries and coastal governance as a wicked problem. Marine Policy, 33(4), 553–560.

Jentoft, S., Chuenpagdee, R., Pascual-Fernandez, J.J. (2011). What are MPAs for: On goal formation and displacement. Ocean & Coastal Management, 54, 75–83.

Kooiman, J., Bavinck, M., Jentoft, S., Pullin, R. (Eds.). (2005). Fish for life: Interactive governance for fisheries. Amsterdam: Amsterdam University Press.

Kulbicki, M. (2005). Aquatic ecologies. In J. Kooiman, M. Bavinck, S. Jentoft, R. Pullin (Eds.), Fish for life: Interactive governance for fisheries (pp. 45–69). Amsterdam: Amsterdam University Press.

Lundin, C.G., & Linden, O. (1993). Coastal ecosystems – Attempts to manage a threatened resource. Ambio, 22(7), 468–473.

Meinesz, A., Belsher, T., Thibaut, T., Antolic, B., Mustapha, K.B., Boudouresque, C.F. et al. (2001). The introduced green alga Caulerpa taxifolia continues to spread in the Mediterranean. Biological Invasions, 3(2), 201–210.

Mörner, N.A. (2007). Sea Level changes and tsunamis, environmental stress and migration overseas: The case of the Maldives and Sri Lanka. Internationales Asienforum, 38(3–4), 353–374.

Ojeda Zújar, J., Vallejo Villalta, I., González Romero, G. (2001). El acceso de los estados al mar: Áreas costeras y cuencas marinas. In J.L. Suárez de Vivero (Ed.), Los océanos: medio ambiente, recursos y políticas marinas (1ª ed., pp. 41–67, Vol. 25). Barcelona: Ediciones del Serbal.

Onyango, P.O. (2011). Occupation of last resort? Small-scale fishing in Lake Victoria, Tanzania. In S. Jentoft, & A.H. Eide (Eds.), Poverty mosaics: realities and prospects in small-scale fisheries (pp. 97–124). Dordrecht: Springer.

Pascual, J.J. (2004). Littoral fishermen, aquaculture and tourism in the Canary Islands: Attitudes and economic strategies. In J. Boissevain, & T. Selwyn (Eds.), Contesting the foreshore: Tourism, society and politics on the coast (pp. 61–82). Amsterdam: Amsterdam University Press.

Pascual Fernández, J. (1991). Antropología marítima: Historia, ecología, organización social y cambio económico entre los pescadores. Madrid: Ministerio de Agricultura, Pesca y Alimentación.

Pascual-Fernández, J.J., Frangoudes, K., Williams, S.B. (2005). Local institutions. In J. Kooiman, M. Bavinck, S. Jentoft, R. Pullin (Eds.), Fish for life: interactive governance for fisheries (pp. 153–172). Amsterdam: Amsterdam University Press.

Pauly, D. (2006). Major trends in small-scale marine fisheries, with emphasis on developing countries, and some implications for the social sciences. Maritime Studies (MAST), 4(2), 7–22.

Pauly, D., & Chuenpagdee, R. (2003). Development of fisheries in the Gulf of Thailand Large Marine Ecosystem: Analysis of an unplanned experiment. In G. Hempel, & K. Sherman (Eds.), Large marine ecosystems of the world: Trends in exploitation, protection, and research (pp. 337–354). Amsterdam: Elsevier.

Punt, A.E. (2006). The FAO precautionary approach after almost 10 years: Have we progressed towards implementing simulation-tested feedback-control management systems for fisheries management? Natural Resource Modeling, 19(4), 441–464.

Rindos, D. (1984). The origins of agriculture: An evolutionary perspective. Orlando: Academic Press.

Roberts, C. (2007). The unnatural history of the sea. Washington, DC: Island Press/Shearwater Books.

Stepp, J.R., Jones, E.C., Pavao-Zuckerman, M., Casagrande, D., Zarger, R.K. (2003). Remarkable properties of human ecosystems. Conservation Ecology, 7(3), 11.

Tacon, A.G.J., & Hasan, M.R. (2007). Global synthesis of feeds and nutrients for sustainable aquaculture development. In M.R. Hasan, T. Hecht, S.S. De Silva & A.G.J. Tacon (Eds.), Study and analysis of feeds and fertilizers for sustainable aquaculture development (pp. 3–17). Rome: FAO.

Valiela, I. (2006). Global coastal change. Malden/Oxford: Blackwell Publications.

Vitousek, P.M., Mooney, H.A., Lubchenco, J., Melillo, J.M. (1997). Human domination of Earth's ecosystems. Science, 277(5325), 494–499.

Warrick, R.A., Barrow, E.M. & Wigley, T.M.L. (Eds.). (1993). Climate sea level change: Observations, projections and implications. Cambridge: Cambridge University.