Analysis of Social-Ecological Systems for Community Conservation

Community Conservation
Research Network

Community Conservation Research Network (CCRN)

The CCRN is an international initiative to understand and support the links between communities, conservation and livelihoods, and to seek out best governance practices to support the combination of community-based conservation and sustainable livelihoods.

The CCRN is a partnership of indigenous, community, university, governmental and nongovernmental organizations, with a base at Saint Mary's University in Halifax, Canada. The CCRN undertakes local-level community-based research and capacity building activities at our sites around the world, and works globally to provide a focal point on the crucial themes of Communities, Conservation and Livelihoods.

The CCRN's research, which applies a consistent social-ecological systems lens, is producing a range of insights – on such themes as regional and community environmental governance, indigenous self-governance, local networking and the success of conservation initiatives – that will yield important lessons for communities, policy makers and decision makers at all levels, from local to global.

As a global network we are able to bring together a wide range of community experiences in conservation for the benefit and well-being of local residents. The results being produced will enable researchers, governments and communities to make changes that will empower communities and enhance their natural environments and local economies for decades to come.

For more information regarding the work conducted by the CCRN please visit our website at http://www.communityconservation.net/ or email us at ccrn@smu.ca.

Analysis of Social-Ecological Systems for Community Conservation

Fikret Berkes, Minerva Arce-Ibarra, Derek Armitage, Anthony Charles, Laura Loucks, Mitsutaku Makino, Arif Satria, Cristiana Seixas, John Abraham and Samantha Berdej

Working Group on Social-Ecological Systems and Community Resilience, Community Conservation Research Network

Revised July 2016

Community Conservation
Research Network

Recommended citation for this publication:
Berkes F., Arce-Ibarra M., Armitage D., Charles A., Loucks L., Makino M., Satria A., Seixas C., Abraham J., Berdej S. 2016. *Analysis of Social-Ecological Systems for Community Conservation*. Community Conservation Research Network, Halifax Canada. Available online at:
http://www.communityconservation.net/resources/social-ecological-systems.

Published by the Community Conservation Research Network
Halifax, Nova Scotia, Canada

The Community Conservation Research Network and its participants are pleased to acknowledge funding support from the Social Sciences and Humanities Research Council of Canada (SSHRC).

Contents

Introduction to Social-Ecological Systems

Social-ecological systems are integrated complex systems that include social (human) and ecological (biophysical) subsystems in a two-way feedback relationship (Berkes 2011). The system outputs are returned to the system as an input, either to oppose the initial input (negative feedback), or to enhance it (positive feedback). This relationship occurs whenever people interact with their environment. The forms of interactions can vary from community-based small-scale fishing to country-wide eco-tourism. Thus, the interactions within a social-ecological system have implications regarding social systems (i.e. jobs) and ecological systems (i.e. biodiversity loss).

For example, in a study of how forest degradation was replaced by net forest increase, Sendzimir and colleagues (2011) found that tree density started to increase in the 1980s when the influence of government forestry officers declined and farmers started to experiment with locally devised techniques, reversing the direction of change. This change reinforced the sense of tree ownership and stewardship, resulting in a further increase in forest density.

Integrated studies of coupled human and natural systems reveal new and complex patterns and processes that are simply not evident when studied by social or natural scientists separately. Liu et al. (2007) studied six well documented cases of social-ecological systems from around the world. They found that the cases showed complex patterns and processes: non-linear dynamics with surprises, feedback loops, time lags, and other complex behaviour. Many of these patterns and processes became apparent only when the full social-ecological system was taken as the unit of analysis.

When looking at social-ecological systems, researchers need to be explicit in linking together the human system (communities, society, economy) and the natural system (ecosystems). This integration of humans in nature is important because in any conservation effort, there are interactions and feedback between ecological and social subsystems. This includes essential links related to people's knowledge (local or traditional knowledge), and management institutions, as well as rules and norms that mediate how humans interact with the environment. For these reasons, a social-ecological systems lens is crucial.

Key Concepts for Understanding Social-Ecological Systems

The social-ecological systems lens draws on many concepts and approaches, however the form described here includes three key concepts: multiple scales, multiple levels, and resilience.

Multiple scales

Scale usually refers to time (temporal) and space (spatial), specifically whether an event (like a fishery opening) occurs over a short or long temporal scale, or whether an activity (like fishing) takes place over a small or a large spatial scale. For example, a herring roe fishery in British Columbia, Canada, may happen over just a few minutes in a very local area (thus, a short temporal scale and a small spatial scale), whereas a tuna fishery may involve boats roaming over an ocean for a matter of months (thus a longer temporal scale and a larger spatial scale). Another common use of the scale concept is comparing large scale and small scale fisheries. This is an example of an analytical dimension. The concept of a small scale fishery allows us to focus on the different aspects particular to a small scale fishery when compared to large scale fishery.

Given our focus on the interplay of local and large scale environmental initiatives, it is crucial to address variations across scales. How conservation challenges are perceived and addressed in a local setting (e.g., Annapolis Basin, Nova Scotia, Canada) may differ greatly from that of a broader scale (e.g., Eastern Canada or the country as a whole). Governance is similarly challenged by multiple scales, indicating a need for cross-scale and cross-boundary approaches. Environment Canada, for example, notes the need for suitable regional governance responsive to both local initiatives and national policy initiatives. Monitoring outcomes also requires attention to scale. Observing multiple scales may allow conservation outcomes to be tracked across scales.

An illustration of the implications of considering different scales when analyzing resource management comes from the south coast of Rio de Janeiro State, Brazil. Studies of small-scale fisheries management took place at three different scales in that region:

1. ***The geographical scale:*** related to resource use (local/community level, the Paraty municipality area, and the Ilha Grande Bay area which encompasses other municipalities).
2. ***The temporal scale:*** regarding the development of new initiatives related to small scale fisheries management.
3. ***The social-political scale:*** related to those initiatives involving different stakeholders (community-based organizations; regional forum of traditional people; municipal, state and federal government; universities; NGOs; and the private sector encompassing community based enterprises to national level enterprises).

Multiple levels

Parallel to the idea of scale is that of level; a specific point along a scale, or a unit of analysis within a scale. For example, if we are interested in a spatial scale, a community marine protected area (MPA) would be at a small spatial scale when compared to a large high-sea MPA. These two MPAs represent two different levels on the spatial scale.

The idea of level is most often used when referring to levels of governance. For example, it is often noted that high-level governmental policy should enable innovation and conservation success at a community scale, while low-level mobilization of a community, and horizontal networks, can drive change at higher levels.

A multi-level approach is important in allowing us to examine different levels at which conservation interventions can be made. Analyzing a community through a social-ecological systems lens means examining cross-scale linkages and environmental governance. This leads to an understanding of the interplay between high-level enabling policies and approaches and local-level environmental initiatives.

To continue the example from Brazil, the region has a complex and fragmented management system which has resulted in strong consequences for the small-scale fisheries system. The creation of this fragmented management system was due to:

- Conflicting interests at different levels of the social-political scale.
- Power asymmetry among stakeholders at different levels of the social-political scale.
- Discontinuity of small scale fishery management initiatives at different levels of the geographic scale.

Resilience

In systems containing social and ecological subsystems, the ability of this system to maintain overall function and structure, despite unexpected shocks to that system, is called resilience. The term social-ecological resilience specifically focuses thinking on how resilience, or its absence, affects all aspects of a social-ecological system.

A key aspect to analysing resilience involves looking at how communities react to environmental and community shocks, such as those arising from global climate change and economic change. The interrelationships of these changes, combined with community conservation initiatives, should be examined across multiple scales. For example, at a local scale how do communities perceive resilience, how does this perception vary internally and what are the governance implications to this perception? At a larger scale, questions may arise concerning how government policy impacts local and regional environmental resilience and social cohesion. When researching social-ecological systems, we need to look at how local environmental stewardship initiatives and livelihood activities interact with higher-level policy, and how all of these affect social-ecological resilience.

Additional Concepts Regarding Social-Ecological Systems

In addition to the three key social-ecological system concepts of scale, level and resilience, there are other important concepts that often arise in social-ecological system research. Some of these, transformation, thresholds, emergent properties, drivers, collective action, worldviews, and power and agency are discussed below.

Transformation

Transformation involves a fundamental or systemic shift in a social-ecological system when existing social, economic, political and ecological conditions are untenable. A good example comes from the transformation of the Kristianstad wetland landscape in Sweden which experienced significant degradation (Olsson et al. 2004). This case highlights the social processes that resulted in the transformation toward ecosystem management. The transformation involved three phases: 1) preparing the system for change, 2) seizing a window of opportunity, and 3) building social-ecological resilience of the new desired state. The methods used to transform the Kristianstad wetland are described below (Olsson et al. 2004):

- Initiated trust-building dialogue and mobilized social networks with actors across scales.
- Started processes for coordinating people, information flows and ongoing activities.

- Started processes for compiling and generating knowledge, understanding, and management practices of ecosystem dynamics.
- This process involved understanding, collaborative learning, and creating public awareness.

Thresholds

Thresholds are the critical boundary (e.g., spatial, temporal) or break point between two alternate system configurations. When crossed, thresholds can involve (but not always) sudden and dramatic changes. There are many classic examples of thresholds in social-ecological systems. A well-studied example is the shift from intact coral-dominated reef to an algae-dominated reef. In this case, fish herbivory, sediments, nutrient run-off and climate (warming, acidification) have coalesced to cross thresholds. Where thresholds have been crossed in coral reef systems (as seen in much of the Caribbean), there are significant implications for fisheries, tourism, hazard protection, etc. Thresholds may be determined through ecological models, but they also have a social component. For example, different groups may differ in their definition of thresholds and the implications of threshold changes may be felt differently by these different groups.

Emergent Properties

Resource management decision-making has often focused on setting objectives that address a specific problem (Cundill et al. 2012). However, Checkland (2000) argues that in complex social-ecological systems, the nature of the problem is difficult to understand and the associated solutions are equally challenging to clarify. In most cases, the goals and objectives proposed result in a series of side effects or unintended, and usually unforeseen, consequences. In contrast to conventional goal setting, the identification of purposeful action is an important emergent property that arises from sharing multiple perspectives (worldviews) on the nature of the system and the situation (Wals 2007). Research on Canadian prairie farmer learning strategies for adapting to climate change highlights the importance of multiple sources of information and social learning feedback processes to facilitate the emergent properties of new behavioural norms for sustainable farming practices (Tarnoczi 2010).

Drivers

Drivers describe the broad range of factors that lead to changes in social-ecological systems. The Millennium Ecosystem Assessment defines drivers as any natural or human-induced factor that directly or indirectly causes a change in a social-ecological system. A direct driver (i.e. changes in local resource use) is one that can be identified

and measured. Indirect drivers (i.e. demographic change) operate more diffusely, often by altering one or more direct drivers, and their influence is established by understanding their effects on direct drivers. The Millennium Ecosystem Assessment emphasized that there are almost always multiple factors of change, and their effects are multiplicative rather than additive (MEA 2003).

Collective Action

The theory of collective action suggests that people will only be motivated to cooperate under conditions in which the benefits from cooperating exceed the individual costs and the problem of free-riding is resolved (Olson, 1965). Research on agricultural fertilization practices in Sweden revealed that once farmers were aware that their actions were contributing to water eutrophication in the adjacent catchment area, they did not view the problem as being theirs alone to resolve, nor did they perceive that they would benefit individually from changing their practices. They also perceived that even if farmers did agree to cooperate to engage in new practices, not every farmer was equally trustworthy in their behaviour. Hence, "the 200 farmers saw themselves as stuck with a disproportionate share of the burden for providing clean water quality, while a large share of the benefits would go to the thousands of 'non-paying others' in the catchment area" (Lundqvist 2001). Ostrom (1990) argues that when "individuals repeatedly communicate and interact with one another in a localised physical setting ... it is possible that they learn whom to trust ... and how to organize themselves to gain benefits and avoid harm". However, in the same way a barrier to collective action can arise when social capital is eroded, people can develop a sense that not everyone can be trusted to behave consistently for collective benefit.

Worldviews

Every culture has its own way of thinking about the world, the cosmos, as well as the origin and functioning of the universe. Usually, each worldview entails a different and complex set of knowledge, practices and beliefs, which is mediated by social institutions and management systems (Berkes 2013). When working with social-ecological systems, understanding worldviews (in which local and traditional management systems are embedded) are of paramount importance. In this respect, in order to understand the local stewardships in place, researchers need to study the worldview as a key concept held by any community or group of users (see Reichel-Dolmatoff 1976). Understanding worldviews becomes especially relevant to the CCRN because it works on meanings of conservation, motivations for conservation, and conservation outcomes.

Power and Agency

Understanding power and agency is relevant to the research conducted by the CCRN

because these concepts describe how conservation is shaped and who will benefit from it. Conservation is not only about natural resources, but rather the relationship between the ecosystem and the socio-political-economical system, wherein power is an important factor. Politics and the environment are interconnected, and political ecology tries to analyze such connections. There is a need to focus on the interests, characteristics and actions of different types of actors. Conservation is an arena wherein interests invested with power are contested; resulting conflicts can produce distinctive patterns of resource management. An examination of how this reality arises in a marine setting, concerning the interaction of fisheries and biodiversity governance, is given by Garcia et al. (2014). This conflict issue in marine conservation is also shown by Satria et.al. (2006). Moreover, conservation is associated with the control of resources that has been wrested from the local people through the implementation of state and global interests to preserve the environment at the expense of local livelihoods, production and socio-political organisation (Robbins 2004). The outcome of conservation depends on the situation of power relation among actors.

Governance and Social-Ecological Systems

Governance can be seen as a system of rules, institutions, organizations and networks set up "to steer societies towards preventing, mitigating, and adapting to global and local environmental change" (Biermann et al. 2009). A social-ecological systems lens highlights the importance of conservation-focused institutions and governance arrangements that:

- Match complex social-ecological systems.
- Adapt as these systems change over time.
- Help steer these systems towards sustainability.

When applying an ecological systems lens to governance, some of the key ingredients for success include:

- Presence of multi-level institutions.
- Partnerships among state and non-state actors.
- Appreciation of diverse perspectives and knowledge.
- Shared learning and social processes that provide opportunities for adaptability.

Several critical insights for conservation can be drawn from the emerging literature linking social-ecological systems and governance:

- Two social ecological interactions are not well understood.
    - Social-ecological change and uncertainty.
    - Implications for community conservation in a tightly-connected world.
- Community conservation, stewardship and related governance arrangements cannot be fixed to an ideal spatial or temporal level, a multi-level perspective is essential.
- The attributes that lead to effective community conservation in complex social-ecological systems is only now emerging. These attributes include meanings, governance and motivations.

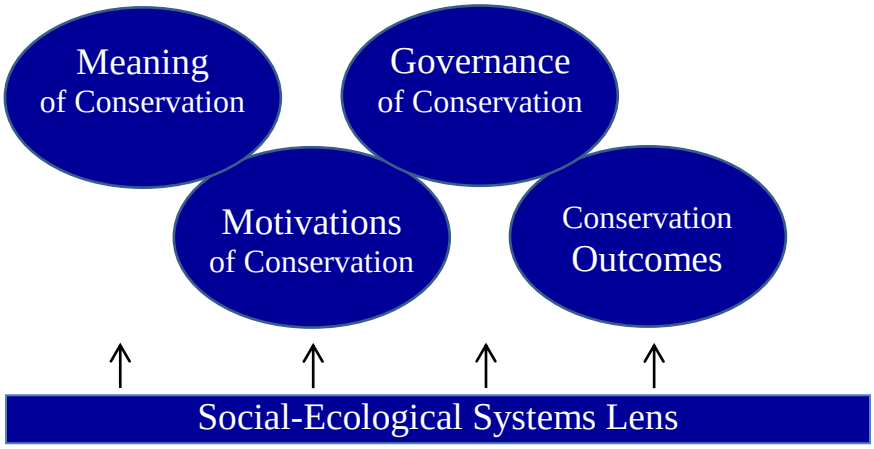

Figure 1. Four main themes for analysing social ecological systems.

Meaning

Conservation and stewardship are actions (including community initiatives, governance arrangements and policy measures) that ensure the long-term sustainability of resources and associated livelihoods. But what does conservation and stewardship mean to local communities, governments and NGOs? Communication concerning this question, between these different groups, may improve a community's environmental initiative by establishing a conservation policy that fits with local realities and needs.

Does the meaning attached to ideas of conservation and stewardship vary between different social-ecological systems? For example, in considering the natural resources and ecosystems on which the livelihood of a typical place-based rural community depends (i.e. fisheries, forests, wildlife, land for farming), does the meaning of conservation and stewardship vary between different resource systems? How do environmental aspirations interact with ideas of economy and livelihoods, and how does this vary across scales in the social-ecological system?

Motivations

- In order to understand the structure and interaction between the social and ecological system, the motivations for conservation need to be understood.
- What are the motivations (or lack thereof) for environmental conservation and stewardship?
- Who is or is not motivated to be involved in stewardship, both locally and within high-level governments?

- How closely linked are conservation motivations to concerns about sustainability of livelihoods and economies?

Governance

In applying a social ecological system lens to issues of governance, it is crucial to understand how various governance arrangements can promote conservation that sustains human well-being and the ecosystem services upon which we depend. While governance arrangements will vary from place to place, our interest is to determine which components of these arrangements work to promote conservation and are broadly acceptable to local communities. The main goal is to achieve a fundamental balance between food and livelihood needs, while ensuring that the ecosystem continues to provide goods and services. A social ecological system lens ensures a broad enough perspective to address these goals by:

- Evaluating effectiveness from all angles of the social ecological system.
- Determining effective community conservation initiatives and practices operating inside or outside the formal state governance system.
- Determine how these initiatives become integrated into a higher-level network of conservation efforts.
- Evaluating to what extent the governance processes that emerge in complex conservation situations adapt to change and uncertainty.

Outcomes

Outcomes of conservation initiatives, whether community-led or government-driven, will be multi-dimensional in nature. Therefore, researchers need to consider environmental outcomes, social-economic outcomes, livelihood outcomes, social-cultural factors, equity factors, and governance processes. It is important to examine the impact human use and conservation can have across the entire social ecological system, with a focus on the outcomes that are viewed as the most relevant and important. When monitoring outcomes, systematic indicator frameworks can be key tools to ensure that we cover the breadth of a social-ecological system.

Frameworks for Analysing Social-Ecological Systems

The following is a collection of useful frameworks concerning social-ecological systems and community resilience.

Resource Systems Approach

Societies, economies and communities dependent on environmental services and natural resources always have ecosystem, human and management/governance components to them. One cannot properly understand a coupled human-nature system without taking an integrated approach that incorporates these multiple considerations. Therein lies the basis for what is in fact a long tradition of viewing natural resource sectors (i.e. such as fisheries, forestry and mining) as systems. The figure below, adapted from Charles (2001), indicates three sub-systems, the interactions among them, and some of the external drivers affecting the system.

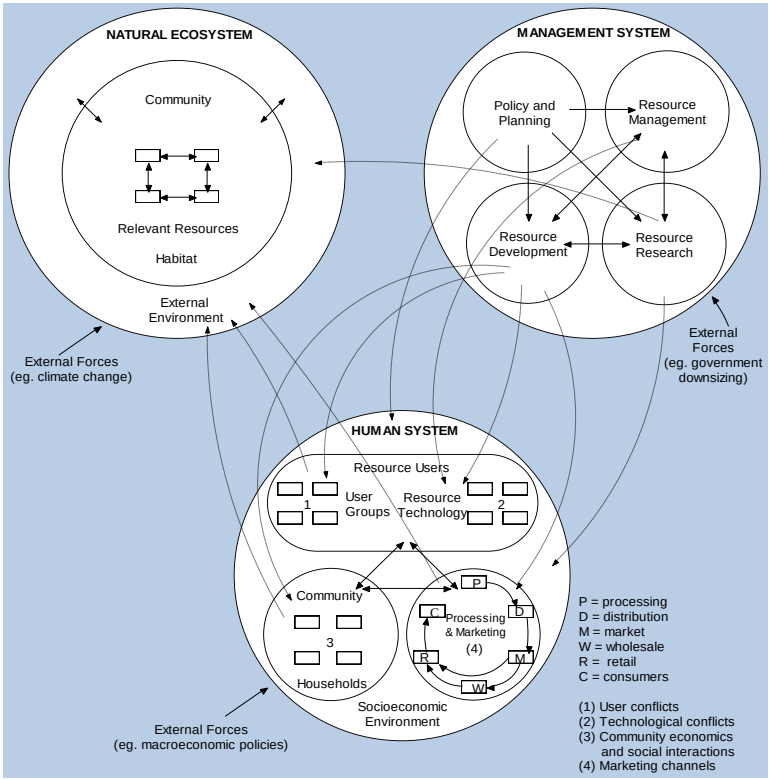

Figure 2. The resource systems approach **(**Charles 2001).

Framework for Analysing Sustainability of Social-Ecological Systems

Ostrom's (2009) framework for analysing social-ecological systems involves four core systems and a large number of variables falling under the core systems (see Table 1 of Ostrom 2009).

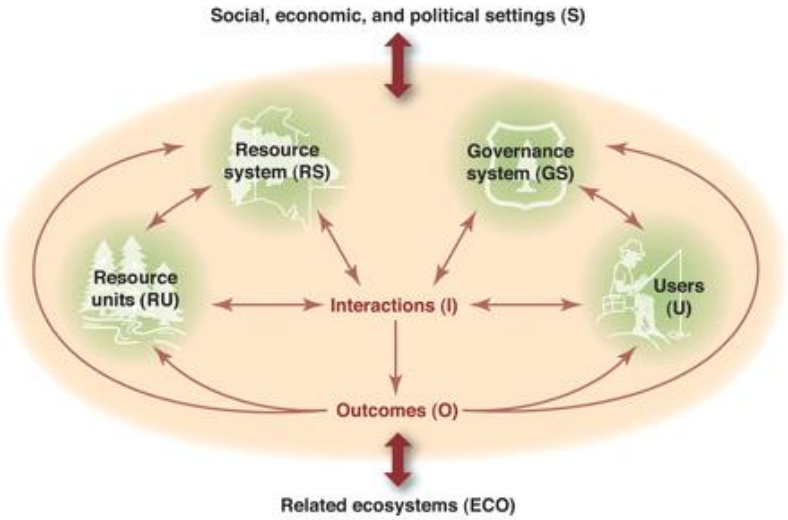

Figure 3. Framework for Analysing Sustainability of Social-Ecological Systems (Ostrom 2009).

Interactive Governance Framework

Interactive governance theory holds that governance is broader than management in that, in addition to goals and policies, it includes the deliberation and determination of these goals, and the values and principles on which decision-making should be based (Kooiman et al. 2005; Jentoft and Chuenpagdee 2009). According to this theory, fisheries and coastal governance consist of three systems: a governing system, a system-to-be-governed (natural and social-economic), and a system of governing interactions, linking the first two (Kooiman et al. 2005).

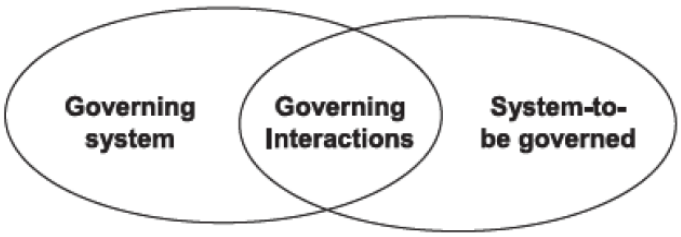

Figure 4. Interactive Governance Framework (Kooiman et al. 2005).

Millennium Assessment Framework

The large international project, Millennium Ecosystem Assessment focused on the relationships between ecosystem services and well-being (MEA 2005).

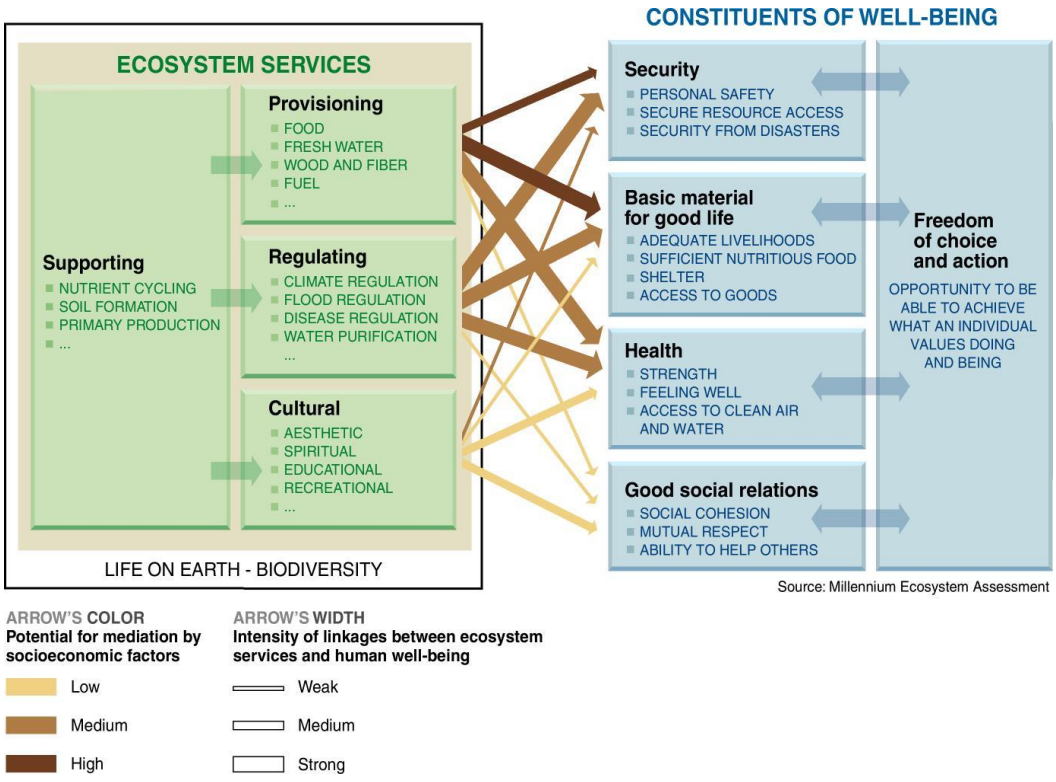

Figure 5. Millennium Assessment Framework (MEA 2005).

Sustainable Livelihoods Approach

The Sustainable Livelihoods Approach was one of the first efforts in addressing variables from a system which included rural people and their natural resource base (or a human-in-nature system). The approach is centered on people and is aimed at alleviating poverty through the enhancement of people's livelihoods. It includes assessing key components of the livelihood system (referred to as assets or capitals) including: human capital, social capital, natural capital, physical capital and financial capital. These components are all represented graphically on the axes of a pentagon. The approach also includes a description of the vulnerability context for the addressed system as well as local people's livelihoods strategies, and desired changes to achieve specific livelihoods outcomes (Chambers and Conway 1992; Scoones 1998; DFID 1999; Carney et al. 1999).

Resilience Assessment Workbook for Practitioners (Resilience Alliance 2010)

The workbook uses a framework to conceptualize case studies as integrated social-

ecological systems, and to evaluate the resilience of particular components of the system to shocks or stresses (abrupt or gradual change). Assessments typically involve participatory workshops with stakeholders and experts to:

- Address questions concerning resilience, drivers of change, disturbances and potential thresholds.
- Develop a conceptual model of system dynamics, with a focus on thresholds, feedbacks and alternate states.
- Identify sources of resilience and the capacity of the social-ecological system to adapt or transform.

Community Resilience Characteristics

Much of the literature on community resilience comes from the area of the psychology of development, specifically extending to community development. This literature emphasizes identifying and developing community strengths, and building resilience through agency and self-organization. Nine characteristics have been identified as important, leading to agency and self-organization in communities of place: people-place connections, values and beliefs, knowledge and learning, social networks, collaborative governance, economic diversification, infrastructure, leadership, and positive outlook. These factors do not apply to all cases. But they do provide a guide for resilience building at the community level; leading to discussions on how adaptive capacity, self-organization and agency can be supported and fostered through processes such as community development and community based planning. Adaptive capacity and agency can be facilitated by community members themselves through social learning, or by external change agents (such as NGOs), using well known approaches in community development for building community strengths and relationships (Berkes and Ross 2013).

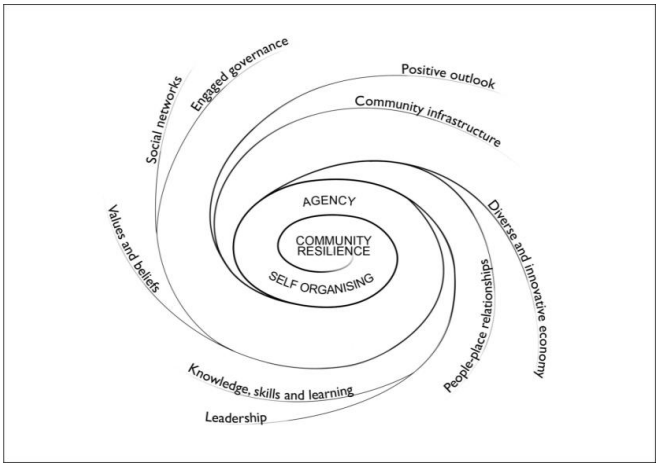

Figure 6. Community Resilience Characteristics framework (Berkes and Ross 2013).

Vulnerability framework

There are four core components in this framework. The researchers first document past and current exposure sensitivities in order to identify the conditions that are of particular relevance to the community. They also identify and document adaptation strategies and processes to describe the ways in which communities have managed the conditions to which they are exposed and sensitive to. Together, these characterize current vulnerability. They also provide the basis for estimating future vulnerability (both future exposure-sensitivity and future adaptive capacity). This involves assessing the likelihood of changes in the conditions pertinent to the community. This is done by drawing on scientific predictions of change in natural and social systems and characterizing the scope and limits to adaptive capacity. The assessment of future risks, and prospects for adapting, provides the basis for collaboratively identifying policy needs and options and the initiatives that could enhance the capacity of the community to adapt (Smit et al. 2008).

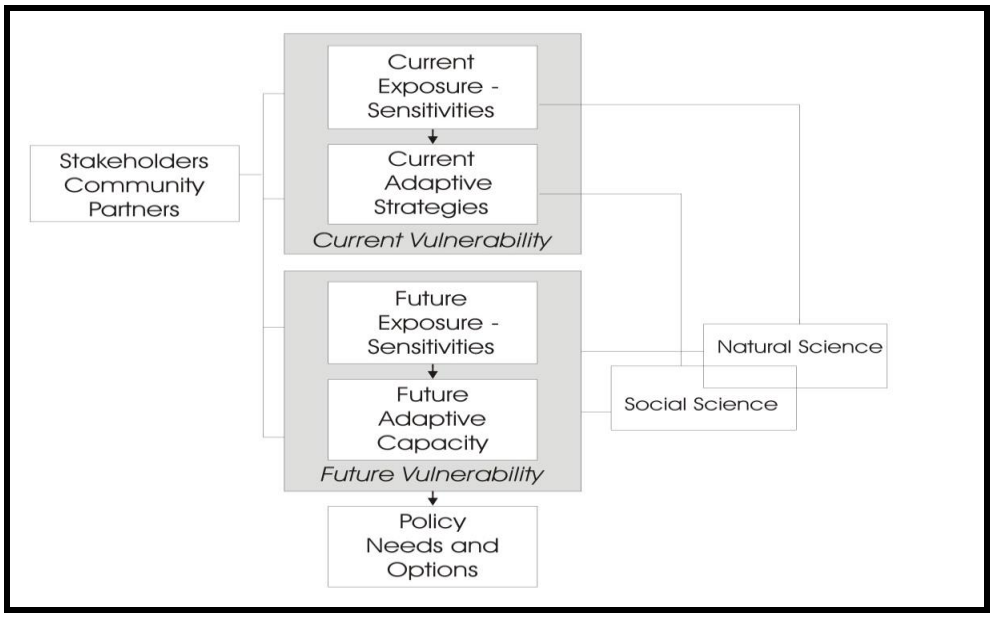

Figure 7. Vulnerability framework (Smit et al. 2008).

Social Wellbeing

Well-being is often framed as a desired target or an outcome (MEA 2005). However, a social conception of well-being has been developed by the Research Group on Well-being in Developing Countries (Gough and McGregor 2007). A social conception of well-being nests the individualistic and basic needs aspects of well-being within a broader understanding of the psychological and cultural needs required to live well

(Deneulin and McGregor 2010). In this view, social well-being is an outcome and a process that considers three related dimensions of a life well lived: a material dimension, a relational dimension, and a subjective dimension. Under this approach, well-being is not perceived just as a targeted or desired state of being; it can also serve as a framework for the analysis of human thriving. Importantly, the concept can be used to help unpack some of the main elements that drive people's choices and behaviour, or their meanings and motivations.

Examples of Social-Ecological Systems

In this section, we seek to describe how to go about doing a social-ecological systems analysis, whether as original research or as a means to express existing knowledge in a social-ecological systems context. First, it is important to realize that there is no unique way to do a social-ecological systems analysis, but rather there are some common ingredients:

1. A fundamental focus on the integrated nature of social-ecological systems, with natural, human and governance sub-systems.
2. Attention to the multiple scales, multiple levels and resilience attributes of the system.

In achieving the first of these common ingredients, there are many possible ways to describe the integrated nature of a social-ecological system. For example, one can think of three interacting sub-systems of the overall social-ecological system, the natural system, the social system and the management (or governance) system. This is referred to as the Resource System Approach (Charles 2001). Alternatively, one can consolidate these three components into two sub-systems, the ecological and social, with governance included in the latter. Another approach involves separating the social-ecological system into a resource system and a governance system (Ostrom 2009).

The social-ecological systems model used by the CCRN builds on the Ostrom (2009) approach described above, and consists of three sub-systems: a resource system (that provides ecosystem services), the human component of the social-ecological system (notably resource users/communities) and a governance system. The CCRN approach envisions meanings, motivations and outcomes as key aspects that connect the resource system, the human system and the governance system, and in particular, connect ecosystem services to resource users and communities.

The following section describes three examples of how to apply integrated social-ecological systems thinking to three real world case studies.

Re-planting of Seagrass Beds in Tokyo Bay, Japan

by Mitsutaku Makino, Fisheries Research Agency, Japan

Introduction

Since the 17th century, Tokyo Bay has been famous as a production area that supplies high quality fish for sushi, such as conger eel, mantis shrimp, sea bass, smelt-whiting, dotted gizzard shad, oval squid, etc. According to late nineteenth century maps, the majority of this regions coastal area were tidal lands with shallow bottoms covered by seagrass.

Since then, Tokyo Bay has been developed and reclaimed. Starting in the 1960s, the national government promoted the development of heavy industry in Tokyo Bay. Indeed, this was the main driver of Japanese economic growth between the 1960s and 1970s. Now, Tokyo Bay is one of the most urbanized bays in the world. In Yokohama City, which faces the west coast of Tokyo Bay and is Japan's second largest city, the 140 km coastline has only 0.5 km of natural coastline left. As a result, seagrass beds, whose existence is crucial for the egg and juvenile stages of fish and shellfish, have almost entirely disappeared around urban areas.

In 1981, a group of scuba divers started an activity to clean the ocean bottom, and local researchers started experimental re-planting of sea grasses. Then, local fishers established a No-Take zone in this area. Now, local residents, schools, environmental NGOs, private companies, etc. have all joined the re-planting activities.

Interaction with High-Level Policy

A formal alliance among the groups previously mentioned was established, and since 2003, government bodies (City, Fisheries Agency, Cabinet office, etc.) are financially supporting this alliance.

Meaning of Conservation

The pictures below are famous woodblock prints (called *Ukiyoein* in Japanese) of Tokyo Bay, printed in the early 19th century (Figure 9). Note that people are living along the coast line, harvesting sea food, and enjoying boat cruises. This longstanding use of the coast indicates that local people's lives on the coast are not something to be

eliminated from the ecosystem, but an indispensable component of that ecosystem (unless the objective of MPAs or ecosystem conservation is to return to the original wilderness present hundreds of years ago).

Figure 9. Woodblock prints (called Ukiyoein in Japanese) of Tokyo Bay, printed in the early 19th century.

Outcomes

These conservation activities have successfully expanded the areas covered by seagrasses. As a measure of success, spawning of oval squid was observed in 2004 for the first time in 30 years.

The Marine Protected Area Network in Bali, Indonesia

By Samantha M. Berdej, University of Waterloo

Introduction

The Indonesian province of Bali is located just east of the island of Java, covering the main island of Bali and a handful of smaller satellite islands. It is home to close to 4 million inhabitants (BPS 2011) divided across eight administrative districts and one city. The majority of the population adheres to Balinese Hinduism. Bali is situated in the southeast corner of the Coral Triangle, a region containing the richest marine ecosystems on the planet. The province boasts 406 species of coral and 977 species of reef fish (Mustika et al. 2012) and is home to an array of mega fauna including multiple species of sea turtles, dolphins, whales, dugongs, manta rays, mola mola, and shark. Important coastal habitats include coral reefs, mangroves, and seagrass

beds. Bali's rich marine resources have long been an important economic asset – both as a source of food security for local communities and as a focus for marine-based tourism. The province is the largest tourist destinations in Indonesia and one of the country's wealthiest regions (although there remains a wide wealth disparity between districts). Other important marine-based activities in the area include fisheries, ornamental fisheries and mariculture.

A combination of rapid and uncoordinated coastal development, poor sewage and garbage disposal, dredging/reef channel development, overfishing and destructive fishing practices have led to significant deterioration of many of Bali's marine environments (Mustika et al. 2012). Recognition of widespread anthropogenic threats has prompted greater interest in long-term coastal development planning and conservation efforts, including the establishment of a comprehensive Bali Marine Protected Area Network. In this section we describe the social-ecological system for two of the nine areas prioritized for this network, Nusa Penida and East Buleleng (Tejakula).

Nusa Penida

Users and Community

Nusa Penida is an island chain southeast of the Balinese coast under the Klungkung District comprised of three major islands: Nusa Lembongan, Nusa Ceningan, and Nusa Penida island. It has 45,000 inhabitants in 16 villages (CTC 2012). Livelihood activities are based on fisheries, seaweed production, and marine tourism. Nusa Penida supports an estimated 850 fishermen and includes gill-net, hand-line, and rod fishers. There are 308 hectares of coastal seaweed farms (Welly et al. 2011). The islands attract some 200,000 tourists per year (Welly et al. 2011) associated with activities such as scuba diving, snorkeling, pontoon cruising and local mangrove tours. Alongside other local organizations, the Coral Triangle Center (an international NGO) is positioned to engage users and communities.

Governance System

Nusa Penida is officially only under Klungkung District Law and, subsequently, village administrative law (*dinas*); but, unofficial regulations (*awig-awig*) are also implemented by customary village-level bodies (*Adat*) and a joint Tribes Council (*Majelis Adat)*. Other unofficial bodies include the Lembongan Marine Association, a consortium of diving businesses that self-regulate through agreed practices and codes of conduct, as well as both seaweed, fishermen and mangrove tourism associations. Nusa Penida was declared a marine protected area (MPA) in 2010 (although not yet finalized), which will result in the formation of a Joint Management Body comprised

of government and non-government representatives (e.g., local community, fishermen, seaweed farmers, etc.).

Resource System

Nusa Penida has highly diverse coral ecosystems (296 species of coral and 576 species of fish) (Allen and Erdman 2008) and is home to large charismatic species such as the mola mola, manta rays, sharks and turtles. Other important coastal habitats include mangrove forests and seagrass beds. Habitats are threatened by poor waste disposal practices, non-environmental friendly tourism practices, overfishing and destructive fishing practices such as potassium, cyanide, and bomb fishing (Dharma et al. 2010).

Ecosystem Services

The main provisioning services in Nusa Penida for fishermen include tuna, snapper, grouper, mackerel and shark. Commercial seaweed farming is likewise considered a provisioning service. Marine tourism operators and community groups derive recreation and cultural services in the form of tourism experiences and opportunities (snorkeling, scuba diving, watersports, marine viewing) and spiritual ties/associations (ceremonies).

Interactions

This research is ongoing and aims to identify and characterize key organizations that are involved in 'bridging' different local to regional-scale conservation practices (and their respective knowledge/belief systems) in support of effective multi-level ocean governance. This research seeks to understand the role of these entities both as a means to organize and integrate varied perspectives and actors, and as a platform on which to articulate and navigate trade-offs (social, economic, ecological) associated with conservation efforts/actions.

East Buleleng (Tejakula Subdistrict)

Users and Community

The Tejakula coast is located in northern Bali under the Buleleng District. In 2012, the sub-district housed 54,700 inhabitants in ten villages (PKB 2013), of which four villages are of interest for their achievement of local marine management areas and practices (Desa Bondalem, Desa Tejakula, Desa Les, Desa Penuktukan). This area is one of the poorest regions in Bali. Marine-based livelihoods include fishing, mariculture industries, the marine aquarium trade and marine tourism (swimming, snorkeling, scuba diving, dolphin viewing). The Buleleng district in general is one of the world's leading exporters of ornamental fish. The area has been identified as a future location for the development of marine tourism. Two NGOs – Reef Check

Indonesia and Yayasan Alam Indonesia Lestari (LINI) – have been particularly active in the region.

Governance System

The area is officially only under Buleleng Regency Law and, subsequently, village administrative law (*dinas*); but unofficial regulations (*awig-awig*) are also implemented by customary village-level bodies (*Adat*). Other entities include ornamental fishers' and fishers' associations, and planning and regulatory bodies for each marine management area. The waters in front of the Tejakula subdistrict as a whole have been declared an MPA, but remains in the very early stages of planning and zoning.

Resource System

Coral reefs in Tejakula stretch for 25 kilometers and are home to some 276 species of reef fish (Reef Check Indonesia 2013), and include large charismatic species such as turtles, whale sharks and dolphins. The area as a whole has been threatened by widespread overfishing, destructive fishing practices (e.g., blast or cyanide fishing), coral extractions, climate events (bleaching) and pollution. In the last five years, rehabilitation of reef ecosystems has undergone rapid progress using fish shelters, low level currents to induce reef-building, coral breeding programs, etc.

Ecosystem Services

The main provisioning services in Nusa Penida for fishermen include oil sardinella, skipjack tuna, flying fish and lemadang. Grouper and pearl farming industries are likewise considered provisioning services. The ornamental fisheries trade includes a range of tropical reef fishes. Marine tourism operators and community groups derive recreation and cultural services in the form of tourism experiences and opportunities (swimming, snorkeling, scuba diving, dolphin viewing) and spiritual ties/associations (ceremonies).

Interactions

This research aims to identify and characterize key organizations that are involved in 'bridging' different local to regional-scale conservation practices (and their respective knowledge/belief systems) in support of effective multi-level ocean governance. It seeks to understand the role of these entities both as a means to organize and integrate varied perspectives and actors, and as a platform on which to articulate and navigate trade-offs (social, economic, ecological) associated with conservation efforts/actions.

A Case of Community Conservation and Livelihood Action in Port Mouton Bay, Canada

By Laura Loucks, PhD, Royal Roads University[1]

Introduction

Port Mouton Bay, an important marine harbour located in Queens County Nova Scotia, is home to several generations of families whose ancestors settled in small fishing villages along this shoreline hundreds of years ago. For the smaller communities situated along the shores of Port Mouton Bay, such as White Point, Hunts Point, Port Mouton and Summerville, lobster fishing and tourism related livelihoods are their economic backbone. In 1994, two events rocked the basis of these livelihoods, causing both short and long-term impacts. The first event was the collapse of the Northern Atlantic cod fishery and the second was the introduction of open net pen salmon aquaculture. This aquaculture facility led to a growing accumulation of nuisance algae progressively spreading in the waters beyond the fish farm site. This accumulation led to a decline in shellfish such as mussels, clams, scallops and periwinkles adjacent to the fish farm (Gilbert 2007). The algae had the effect of blocking the lobster trap entryways and resulted in a significant drop in the catch rate of lobsters in the inner and outer harbours of the Bay (Gilbert 2007).

The Resource System

The coastal habitats that interface the marine and terrestrial ecosystems in this area contribute to a limited source of nutrients, a high level of biodiversity and a wide range of refuge sites for migratory waterfowl and shorebirds, marine plants, invertebrates and fish. The ocean bathymetry of Port Mouton Bay reveals a pattern of relatively shallow ocean sills separating deeper basins on the ocean bottom in which fine grain sediments are deposited, particularly around the islands (Hargrave 2009). Fishermen believe these mud/sand bottom ocean basins also act as refuge areas for a number of species and provide critical breeding, moulting and spawning habitat for lobsters.

[1] I would like to thank the Friends of Port Mouton Bay for generously sharing their information for this case study. I also thank those members of the Community Conservation Research Network's Social Ecological Systems Working Group who co-created an outline for this case study: Dr. Derek Armitage, Dr. Fikret Berkes, Dr. Tony Charles and Jennifer Graham.

Loss of Ecosystem Services

In Port Mouton Bay, the loss of benefits from ecosystem services associated with the negative impacts from aquaculture, are related to both the loss of access to productive marine habitat and the degradation of the marine ecology. These two sources of ecological and social stress could potentially lead to diminishing ecological, social, and economic benefits derived from ocean ecosystem services.

The Governance System

In 1996 the Nova Scotia Fisheries and Coastal Resources Act was passed for the purpose of developing, sustaining and increasing production of the fishing and aquaculture industry. While the Minister of Fisheries and Aquaculture is responsible for promoting aquaculture projects, there is nothing specific in the Act to suggest that the role of the Minister is to balance the benefits from ecosystem services for the broader public with the interests of fisheries and aquaculture industries (ECEL 2013). Similarly, there is no statement within the Act to suggest that the role of the Minister is to balance existing fishing industry interests with new aquaculture industry interests. However, the increase in loan funds for aquaculture development over the last 18 years would suggest that this particular sector is of priority interest to the province. The regulatory role in protecting ocean ecosystem services from the potentially negative environmental impacts of finfish aquaculture remains unclear at the Provincial level of governance.

The Federal roles and responsibilities for aquaculture are equally fuzzy in their lack of distinction between regulator and promoter of the industry. The significant investment made in the promotion and production of aquaculture presents a potential conflict of interest between the benefits to the aquaculture industry and the benefits to the Canadian public. For example, the Federal government Sustainable Aquaculture Program is a $70 million program designed to promote the industry, increase its productive capacity and subsidize its market competitiveness (Cohen, 2012).

At the Municipal level of governance, the views on aquaculture are distinctly different in Queens County than the positions reflected in Federal and Provincial government policy. In March 2012, the Municipal Council unanimously passed the resolution that the Provincial Minister of Fisheries and Aquaculture designate Port Mouton Bay as a closed area unsuitable for aquaculture and "before any decision is made to renew, alter or grant new aquaculture licenses in Port Mouton Bay, that full and open public hearings be held in the area affected, including presentations by provincial scientists to address community concerns…" (RQMC 2012).

Users and Community

Most fishermen in Port Mouton Bay are descendants from generations of people who have made their living from the sea for over 200 years. The lobster fleet in Port Mouton Bay consists of 40 Class "A" licensed fishermen who generate over $4 million in total annual revenues and have an asset value exceeding $16.5 million invested in fishing vessels and gear. However, the fish farm off Spectacle Island has had a negative impact on the lobster migration routes. Fishermen with historical access to the inner and outer harbour, previously lucrative lobster fishing regions, now have to move outside the harbour in search of new fishing areas.

When asked specifically about the changes in Port Mouton Bay over the past few years, Clyde Fisher, a fisherman with over 50 years of experience said:

"You can't even compare. The bottom of the harbour has changed so much. Around the fish farm, an area…now I call it the 'dead zone', there's sludge…in some places 3 or 4 feet deep. There's very little life. No scallop beds. Eight or nine lobster where there used to be hundreds. And the sludge is moving closer and closer to the beaches. I first noticed the Algae in Spectacle Bay (adjacent to the current fish farm) then I started to see patches in the Bay. Now it's on the beaches. It's spreading and it's not good. It smothers life. Things are dying. The beaches are turning brown. They used to be white. And there was a shine. The muck that is washing up on shore is awful. Tourists don't want to see that" (Ediger, 2007).

It was in this context of crisis that the community of Port Mouton Bay mobilized their collective social and human capital to resist the second proposed aquaculture site on the inside of Port Mouton Island. In the process of this resistance, numerous properties of the collective community emerged that would otherwise never have been realized.

In an effort to document the negative impacts of the first fish farm, a groundswell of interest in citizen science emerged that engaged local fishermen and residents in an unprecedented effort to evaluate, document and steward their local marine ecosystem services. Local oceanographers, with strong family ties to the community, worked with fishermen to document ocean currents and tidal action that showed the low flushing rate of the second proposed aquaculture site was unsuitable for aquaculture requirements (FPMB 2008; Ford 2008). In a similar way, local residents and fishermen with advice and technical support from National Parks staff, recorded and measured eel grass habitat loss adjacent to the existing aquaculture site. Numerous acts of care and stewardship for Port Mouton Bay have been catalyzed over the last 8 years as the community rallies around the place they love (Loucks et al. 2012). Yet even so, there is a growing sense of despair and frustration as Port Mouton Bay citizens grow weary

from not being listened to and respected (Pottie, 2013). For example, the Nova Scotia Ministry of Fisheries and Aquaculture has not responded to the FPMB (Friends of Port Mouton Bay)request to meet with them except to say that they could meet but not discuss any science, despite the significant capacity the community has created for scientific monitoring over six years at that time.

Interactions

In 2009, a moratorium on new aquaculture expansion in Port Mouton Bay was announced. Following this, the collective community stewardship initiatives (and likely other factors) were successful enough to motivate Cook Aquaculture to let the Spectacle Island site lie fallow for almost 3 years. During the later fallow years local fishermen and community members were thrilled to find early evidence of ecosystem recovery in the previously degraded habitat. Lobster fishermen and mossers noticed that the lobsters and Irish moss were beginning to return to the outer harbour and to the periphery of the inner harbour. Consequently, harvests increased, though not near the Spectacle Island fallow site. Similarly, eelgrass beds were noticeably recovering and the level of nuisance algae decreased throughout the large areas of the harbour (FPMB 2012).

Yet, despite these successes, there was neither any change in the provincial aquaculture siting criteria nor was there any legal guarantee that aquaculture would be prevented from expanding in Port Mouton Bay at any time in the future. This 'governance gap' in Federal and Provincial regulatory requirements for aquaculture siting criteria has proven to be highly problematic for protecting the ecosystem service benefits on which coastal communities depend. In 2012, Ocean Trout Farms took over the aquaculture lease from Cooke Aquaculture for the Spectacle Island site and re-stocked the net pens with rainbow trout, without notice to the community. Since that time, the negative impacts previously documented by the Friends of port Mouton Bay are returning one by one in the same sequence as observed in 1995 and 1996 when the site was initially leased for aquaculture purposes.

Conclusions

Looking at the community's experience of finfish aquaculture in Port Mouton Bay through the lens of social-ecological systems, reveals a significant governance gap and lack of protection of ocean ecosystem services in Canada. Certainly, there is a recognized need for aquaculture regulatory reform in Nova Scotia. Yet, for the citizens of Port Mouton Bay, the development and implementation of any new aquaculture siting criteria needs to also consider the complex evolution of local institutions and livelihood patterns dependent on marine ecosystem services. More specifically, the importance of traditional lobster fishing practices must be considered

in association with the protection of the migratory pathways of lobsters, the location of lobster nursery areas and spawning habitat and their associated ecosystem variables such as water quality and trophic food web relationships.

Glossary

Adaptive Capacity: The ability of social actors or systems to cope with change or disturbance and/or learn through uncertainty.

Adaptive Co-Management: A flexible system of collaborative resource management, tailored to specific places and situations, supported by, and working in conjunction with, various organizations at different levels. This concept merges the principles and practices of co-management and adaptive management (Armitage et al. 2009).

Adaptive Management: Systematic learning-by-doing.

Agency: The ability of individuals or groups to undertake actions despite constraints imposed by larger social or material structures (Giddens 1984; Bourdieu 1977).

Bridging Organizations: Serving as catalysts and facilitators, these organizations provide an arena for knowledge co-production, trust-building, sense-making, learning, vertical and horizontal collaboration, and conflict resolution (Berkes 2009).

Clumsy Solutions: Exploratory solutions that include inputs from a range of stakeholders along the fish chain and require information-sharing, knowledge synthesis and trust-building, where approximations are needed to move forward (Khan and Neis 2010).

Co-Management: A resource management partnership in which local users and other stakeholders share power and responsibility with government agencies (Armitage et al. 2007).

Community Conservation: The practice of conservation initiated and developed by local people. However, in some cases, community conservation may be the result of devolution of the government to the local people. Satria and Matsuda (2004) identified types of *awiq-awiq*as models of community conservation based on source of initiation.

Community of Practice: A social group or learning network that develops around shared interests or activities.

Community Resilience: The existence, development and engagement of community resources by community members to thrive in an environment characterized by change, uncertainty, unpredictability and surprise (Magis 2010).

Community Vulnerability: Refers to the degree a community is sensitive to and exposed to particular conditions and shocks, while considering the community's adaptive capacity to deal with these conditions and shocks. If a community is too sensitive to natural hazards and has a low adaptive capacity, the community is vulnerable.

Complex System: A number of non-linear interactions among its interdependent parts. One cannot understand the system behavior by just considering each of the parts and combining them. Instead one must consider how the relationships between the parts affect the behavior of the whole. Feedback among interdependent parts allows for the self-organization of complex systems.

Co-Production of Knowledge: The collaborative process of bringing a plurality of knowledge sources and types together to address a defined problem, and build an integrated or systems-oriented understanding of that problem (Armitage et al. 2011).

Culture: The customs, art, social institutions, etc. of a particular sector, society or nation (CBD Ecosystem Approach). Different sectors, societies or nations view ecosystems in terms of their own cultural and economic needs. Therefore, culture considerably influences how the ecosystems and their services are valued by a specific sector, society or nation.

Driver: A natural or human induced factor that causes a change in a system.

Ecosystem Services: The benefits to human society from ecosystems.

Emergence: A characteristic of a complex adaptive system that cannot be predicted or understood simply by examining the components of the system.

Feedback Loops: The process by which system outputs are returned to the system as an input, either to oppose the initial input (negative feedback), or to enhance it (positive feedback).

Governance: The public and private interactions undertaken to address challenges and to create opportunities within society. Governance thus includes the development and application of the principles, rules, norms and enabling institutions that guide public and private interactions (Armitage et al. 2009).

Incentives (regarding resource conservation and stewardship): Building of institutional systems that provide incentives to individual fishers and enterprises that lead to behaviour consistent with conservation (Hilborn et al. 2005).

Institutions: The formal (rules, laws, constitutions, organizational entities) and informal (norms of behaviour, conventions, codes of conduct) practices that structure human interaction (Armitage et al. 2009).

Institutional Interplay and Linkages: Relationships among organizations and institutions, both vertically across levels and horizontally within the same level, have been identified as critical factors in building resilient social-ecological systems (Gunderson et al. 2006).

Integrative science: Methods and processes to support suitable institutional responses, a broader planning perspective, and development of suitable resilience-building strategies (Miller et al. 2010).

Level: see scale.

Memory: Accumulated experience and history of the system (both social and ecological) which provide the basis for self-organization (Armitage et al. 2009).

Multi-Level Governance: Governance involving links that may be horizontal (across geographic space) or vertical (across levels of organization), with the recognition that there often is no single spatial or temporal level of analysis for governing social-ecological systems (Brondizio et al. 2009).

Networks: The interconnections among people and organizations within a social-ecological system. Networks may structure themselves around resource use, administrative responsibility and/or other functions and may be connected to other networks (Armitage et al. 2009).

Polycentric Systems: Institutions which are nested, quasi-autonomous decision-making units operating at multiple scales, balancing between centralized and decentralized control (Folke et al. 2005).

Regime Shift: A regime shift (or "flip") is said to occur when a critical threshold has been crossed and a system shifts into an alternate configuration controlled by different feedbacks.

Resilience: the capacity of a system to absorb disturbance and reorganize while undergoing change so as to still retain essentially the same function, structure, identity and feedbacks (Walker et al. 2004).

Scale: The spatial, temporal, quantitative, or analytical dimensions used to measure and study any phenomenon; levels are the units of analysis that are located at different positions on a scale (Cash et al. 2006).

Self-Organization: In adaptive co-management, self-organization involves the emergence of formal and informal networks, working in a collaborative and creative process, often drawing on a range of knowledge sources and ideas (Armitage et al. 2009).

Social Capital: The social norms, networks of reciprocity and exchange, and relationships of trust that enable people to act collectively (Armitage et al. 2009).

Social-Ecological Systems: integrated complex systems that include social (human) and ecological (biophysical) subsystems in a two-way feedback relationship (Berkes 2011).

Social Learning: The collaborative or mutual development and sharing of knowledge by multiple stakeholders through learning-by-doing. Learning may involve the identification of strategies or actions (e.g., harvesting techniques) to resolve specific problems and improve outcomes (e.g., improved incomes, higher yields). Alternatively, learning may involve fundamental changes in underlying values or worldviews, sometimes referred to as transformative learning.

Stewardship (ecosystem stewardship): A strategy to respond to and shape social-ecological systems under conditions of uncertainty and change, to sustain the supply and opportunities for use of ecosystem services to support human well-being (Chapin et al. 2010).

Surprise: Unexpected findings about the natural environment or social-ecological system that do not conform to formal hypotheses or working conceptions of what is deemed likely (Lindenmayer et al. 2010).

Threshold: An abrupt breaking point between alternate states of a system, where a small change in the controlling variable produces a large change in the characteristic structure, function and feedbacks of the system (Arctic Council 2013).

Tipping Point: A kind of threshold characterized by bifurcation in a system (Arctic Council 2013).

Wicked Problems: Problems that have no definitive formulation, no stopping rule, and no test for a solution.

References

Allen G.R., and Erdman M.V. 2008. *Reef Fish of Nusa Penida, Indonesia*. Final Report to Conservation International. Pp. 22.

Arctic Council. 2013. *Arctic Resilience Interim Report*. Stockholm Environment Institute and Stockholm Resilience Centre, Stockholm.

Armitage D., Berkes F., Dale A., Kocho-Schellenberg E., and Patton E. 2011. Co-management and the co-production of knowledge: learning to adapt in Canada's Arctic. *Global Environmental Change,* 21: 995-1004.

Armitage D., Plummer R., Berkes F., Arthur R.I., Charles A., Davidson-Hunt I.J., Diduck A.P., Doubleday N.C., Johnson D., Marschke M., McConney P., Pinkerton E.W., and Wollenberg E.K. 2009. Adaptive co-management for social-ecological complexity. *Frontiers in Ecology and the Environment*, 7: 95-102.

Armitage D., Berkes F., and Doubleday N., eds. 2007. *Adaptive Co-Management: Collaboration, Learning, and Multi-Level Governance.* University of British Columbia Press, Vancouver.

Berkes F. 2009. Evolution of co-management: role of knowledge generation, bridging organizations and social learning. *Journal of Environmental Management,* 90: 1692-1702.

Berkes F. 2011. Restoring unity: the concept of social-ecological systems. In: *World Fisheries: A Social-Ecological Analysis* (R.E. Ommer, R.I. Perry, K. Cochrane and P. Cury, eds.). Wiley-Blackwell, Oxford, pp. 9-28.

Berkes F. 2012. *Sacred ecology*. Routledge, New York.

Berkes F., and Ross H. 2013. Community resilience: Toward an integrated approach. *Society and Natural Resources,* 26: 5-20.

Biermann F, Betsill MM, Gupta J, Kanie N, Lebel L, Liverman D, Schroeder H, and Siebenhüner B. 2009. Earth System Governance Project Report No. 1. Available at: http://www.ihdp.unu.edu/docs/Publications/ESG/IHDP_ReportNo20_ESG_ReportNo1.pdf

Bourdieu P. 1977. *Outline of a Theory of Practice*. Cambridge University Press, London.

BPS (Bandan Pusat Statistik Provinsi Bali). 2011. Available online at: http://bali.bps.go.id/index.php

Brondizio E.S., Ostrom E., and Young O.R. 2009. Connectivity and the governance of multilevel social-ecological systems: the role of social capital. *Annual Review of Environment and Resources,* 34: 253-278.

Cash D.W., Adger W., Berkes F., Garden P., Lebel L., Olsson P., Pritchard L., and Young O. 2006. Scale and cross-scale dynamics: governance and information in a multilevel world. *Ecology and Society,* 11:8. Available online at: www.ecologyandsociety.org/vol11/iss2/art8/

Carney D., Drinkwater M., Rusinow T., Neefjes K., Wanmali S., and Singh N. 1999. Livelihoods approaches compared. Department for International Development. Available online at: www.start.org/Program/advanced_institute3_web/p3_documents_folder/Carney_etal.pdf

Chambers R., and Conway G. 1992. Sustainable rural livelihoods: practical concepts for the 21st century', Institute for Development Studies (IDS) Discussion Paper 296, Brighton: IDS. Available online at: http://opendocs.ids.ac.uk/opendocs/handle/123456789/775#.UgBaQZI98aA

Chapin F.S. III, Carpenter S.R., Kofinas G.P., Folke C., Abel N., Clark W.C., Olsson P., Smith D.M.S., Walker B., Young O.R., Berkes F., Biggs R., Grove J.M., Naylor R.L., Pinkerton E., Steffen W., and Swanson F.J. 2010. Ecosystem stewardship: sustainability strategies for a rapidly changing planet. *Trends in Ecology and Evolution,* 25: 241-249.

Charles A. 2001. *Sustainable Fishery Systems*. Wiley-Blackwell, Oxford UK, 384p.

Checkland P. 2000. Soft systems methodology: a thirty year retrospective. *Systems Research and Behavioural Science,* 17:11–58.

Cohen B. 2012. *Commission of Inquiry in to the Decline of the Sockeye Salmon in the Fraser River, The Uncertain Future of Fraser River Sockeye*. Volume 3, Recommendations, Summary, Process.

CTC (Coral Triangle Center). 2012. Nusa Penida: establishing an MPA learning site. Available online at: http://www.coraltrianglecenter.org/wp-content/infosheet/pdf/infosheet-np-bps-march26.pdf

Cundill G., Cumming G.S., Biggs D., Fabricius C.F. 2012. Soft Systems and Social Learning for Adaptive Management, *Conservation Biology,* 26(1): 13-20.

Darma N., Basuki R., and Welly M. 2010. *Profil Kawasan Konservasi Perairan (KKP) Nusa Penida, Kabupaten Klungkung, Propinsin Bali*. Pemda Klungkung, Kementrian Kelautan dan Perikanan. The Nature Conservancy - Indonesia Marine Program, Denpasar.

Deneulin S., and McGregor J.A. 2010. The capability approach and the politics of a social conception of wellbeing. *European Journal of Social Theory,* 13(4):501–519. Available online at: http://dx.doi.org/10.1177/1368431010382762

DFID (Department for International Development). 1999. Sustainable livelihoods framework sheets. Available online at: http://www.eldis.org/vfile/upload/1/document/0901/section2.pdf

ECEL (East Coast Environmental Law). 2013. Aquaculture Regulation in Nova Scotia: Overview of the Regulatory Framework and Considerations for Regulatory Reform. p. 15. Available online at: http://www.ecelaw.ca/aquaculture-regulation-in-nova-scotia-overview-of-the-regulatory-framework-and-considerations-for-regulatory-reform.html

Ediger M. 2007. Fishermen Interviews in Port Mouton Bay. Friends of Port Mouton Bay. Unpublished document.

Folke C., Hahn T., Olsson P., and Norberg J. 2005. Adaptive governance of social-ecological systems. *Annual Review of Environment and Resources,* 30: 441-473.

Ford J. 2008. The Fight for Port Mouton Bay. *Rural Delivery*. Available online at: http://www.friendsofportmoutonbay.ca/docs/RuralDelivery-Fight-PortMoutonBay-June2008.pdf

FPMB (Friends of Port Mouton Bay). 2008. The Proposed Port Mouton Island Site - Unsuitable for Aquaculture. Available online at: http://www.friendsofportmoutonbay.ca/docs/PMB_OverviewReport.pdf

FPMB (Friends of Port Mouton Bay). 2012. Lobster Trap Survey - 2007-2012. Available online at: http://www.friendsofportmoutonbay.ca/docs/Lobster-Trap-Survey-2012-Port-Mouton-Bay.pdf

Garcia, S.M., Rice, J., Charles, A. 2014. *Governance of Marine Fisheries and Biodiversity Conservation: Interaction and Co-evolution*. Wiley-Blackwell. Oxford, U.K.

Giddens A. 1984. *The Constitution of Society: Outline of the Theory of Structuration*. University of California Press.

Gilbert G. 2007. Traditional Ecological Knowledge; Port Mouton Bay. Available online at: http://www.friendsofportmoutonbay.ca/docs/TraditionalKnowledgePMB.pdf

Gough I., McGregor J.A., and Camfield L. 2007. Theorising wellbeing in international development. *Wellbeing in developing countries: from theory to research*. (Gough and J. A. McGregor, editors). Cambridge University Press, Cambridge, UK. Pages 3–44

Gunderson L.H., Carpenter S.R., Folke C., Olsson P., Peterson G.D. 2006. Water RATs (resilience, adaptability, and transformability) in lake and wetland social-ecological systems. *Ecology and Society,* 11: 16. Available online at: http://www.ecologyandsociety.org/vol11/iss1/art16/

Hargrave B.T. 2009. Application of a Traffic Light Decision System for Marine Finfish Aquaculture Siting Assessment in Port Mouton, Nova Scotia. *Report for Friends of Port Mouton Bay*. Available online at: http://www.friendsofportmoutonbay.ca/docs/Summary-MFADSS-application-Port-Mouton-20090423-HargraveBT.pdf

Hilborn R., Orensanz J.M., and Parma A.M. 2005. Institutions, incentives and the future of fisheries. *Philosophical Transactions of the Royal Society, B*360:47–57.

Jentoft S., and Chuenpagdee R. 2009. Fisheries and coastal governance as a wicked problem. *Marine Policy,* 33: 553-560.

Khan A.S., and Neis B. 2010. The rebuilding imperative in fisheries: clumsy solution for a wicked problem? *Progress in Oceanography,* 87: 347-356.

Kooiman J., Bavinck M., Jentoft S., and Pullin R., eds. 2005. *Fish for Life: Interactive Governance for Fisheries*. Amsterdam University Press, Amsterdam.

Lindenmayer D.B., Likens G.E., Krebs C.J., and Hobbs R.J.2010. Improved probability of detection of ecological "surprises". *Proceedings of the National Academy of Sciences,* 107: 21957-21962.

Liu J., Dietz T., Carpenter S.R., et al. 2007.Complexity of human and natural systems. *Science,* 317: 1513-1516.

Loucks R., Smith R., Fisher C., and Fisher B. 2012. Copper in the sediment and sea surface microlayer near a fallowed open-net fish farm. *Marine Pollution Bulletin,* 64(9): 1970-1973.

Lundqvist L. 2001. Games real farmers play: knowledge, memory and the fate of collective action to prevent eutrophication of water catchments. *Local Environment,* 6(4): 407–419.

Magis K. 2010. Community resilience: an indicator of social sustainability. *Society and Natural Resources,* 23: 401-416.

MEA (Millennium Ecosystem Assessment). 2003. *Ecosystems and human well-being: A framework for assessment*. Island Press, Washington, D.C.

MEA (Millennium Ecosystem Assessment). 2005. *Ecosystems and human well-being: synthesis*. Island Press, Washington, D.C.

Miller K., Charles A., Barange M., et al. 2010. Climate change, uncertainty, and resilient fisheries: institutional responses through integrative science. *Progress in Oceanography,* 87: 338-346.

Mustika P.L., Ratha I.M.J., and Purwanto S. (eds.). 2012. The 2011 Bali Marine Rapid Assessment (Second English edition August 2012). RAP Bulletin of

Biological Assessment 64. Bali Marine and Fisheries Affairs, South East Asia Center for Ocean Research and Monitoring, Warmadewa University, Conservation International Indonesia, Denpasar. Pp. 137.

Olson M. 1965. *The Logic of Collective Action.* Cambridge, MA, Harvard University Press.

Olsson P., Folkeand C., and Hahn T. 2004. Social-ecological transformation for ecosystem management: the development of adaptive co-management of a wetland landscape in southern Sweden. *Ecology and Society*, 9(4): 2. Available online at: http://www.ecologyandsociety.org/vol9/iss4/art2

Ostrom E. 1990. *Governing the Commons. The Evolution of Institutions for Collective Action,* Cambridge, UK, Cambridge University Press.

Ostrom E. 2009. A general framework for analysing sustainability of social-ecological systems. *Science,* 325: 419-422.

Pottie J. 2013. (pers. comm. August 13, 2013)

PKB (Permerintah Kabupaten Buleleung: Kecamatan Tejakula). 2013. *Profil*. http://tejakula.bulelengkab.go.id/ Accessed 28 December 2013.

Reef Check Indonesia. 2013. *Conservation efforts led by Buleleng villages*. http://reefcheck.or.id/conservation-efforts-led-by-buleleng-villages/. Accessed 28 December 2013.

Resilience Alliance. 2010. Assessing resilience in social-ecological systems: Workbook for practitioners. Version 2.0. Available from: http://www.resalliance.org/files/ResilienceAssessmentV2_2.pdf

Reichel-Dolmatoff G. 1976. Cosmology as ecological analysis: A view from the rainforest. *Man*, 307-318. Available online at: http://www.jstor.org/stable/2800273?seq=1#page_scan_tab_contents

Robbins P. 2004. *Political Ecology: A Critical Introduction, critical introductions to geography.* Wiley-Blackwell, Oxford.

RQMC (Region of Queens Municipal Council). 2012. Letter to Minister of Fisheries and Aquaculture. Available online at:

http://www.friendsofportmoutonbay.ca/docs/Region-of-Queens-Letter-Belliveau-PMB-Closed-for-Aquaculture-Mar-19-2012.pdf

Satria A., Sano M., and Shima H. 2006. Politics of marine conservation area in Indonesia: From a centralised to a decentralised system. *International Journal of Environment and Sustainable Development,* 5(3): 240-261.

Satria A., and Matsuda Y. 2004. Decentralizatin of fisheries management in Indonesia. *Marine Policy,* 28(5): 437-450.

Scoones I. 1998. Sustainable rural livelihoods: a framework for analysis. Institute for Development Studies (IDS) Working Paper 72. Brighton: IDS. Available online at:
https://www.staff.ncl.ac.uk/david.harvey/AEF806/Sconnes1998.pdf

Sendzimir J., Reijand C.P., and Magnuszewski P. 2011. Rebuilding resilience in the Sahel: regreening in the Maradi and Zinder regions of Niger. *Ecology and Society,* 16(3):1. Available online at: http://dx.doi.org/10.5751/ES-04198-160301

Smit B., Hovelsrud G., and Wandel J. 2008. CAVIAR Community adaptation and vulnerability in Arctic regions. University of Guelph, Dept. of Geography Occasional Paper No. 28. Available online at:
http://www.uoguelph.ca/gecg/images/userimages/CAVIAR%20FRAMEWORK%20-%20APR%202008.pdf

Walker B, Holling CS, Carpenter SR, Kinzig A. 2004. Resilience, adaptability and transformability in social–ecological systems. *Ecology and Society,* 9(2): 5.
http://www.ecologyandsociety.org/vol9/iss2/art5/

Wals A.E.J. 2007. Learning in a changing world and changing in a learning world: reflexively fumbling towards sustainability. *Southern African Journal of Environmental Education,* 24:35–45.

Welly M., Sanjaya W., Trimudya D., Yanto W.G. 2011. Profil Perikanan Nusa Penida, Kabupaten Klungkung, Propinsi Bali. Pp. 28.

Community Conservation Research Network
Saint Marys University
Halifax, Nova Scotia, Canada
B3H 3C3
Phone: 1-902-420-5003
Email: ccrn@smu.ca
Website: http://www.communityconservation.net

Community Conservation
Research Network