CHAPTER 17
A COMPARATIVE ANALYSIS OF THREE MODES OF COLLABORATIVE LEARNING IN FISHERIES GOVERNANCE: HIERARCHY, NETWORKS AND COMMUNITY

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Abstract

This chapter discusses three different ways of using collaborative learning in fisheries governance, all of which have been applied in the Coasts Under Stress (CUS) project in Canada. The three modes are: hierarchy; networks; and community. The hierarchical mode entails top-down computer modelling techniques, in which the experiential knowledge that is gathered from fishers' haul data is integrated with scientists' survey data into management plans. The networks mode entails developing an understanding of complex marine ecosystems by sharing knowledge between individuals and groups interacting in discussions about ecosystem structures and recovery strategies. The community mode entails the involvement of local communities in knowledge sharing. Our finding is that, in whatever mode it occurs, collaborative learning is of inestimable value in improving fisheries governance, especially by removing mutual misunderstandings. But techniques of collaborative learning cost time and money, and governments must be willing to devote the necessary resources to make them work.

17.1 Introduction

This chapter begins with an assumption that we have a duty to govern our interactions with social-ecological systems in a responsible fashion, but that we have failed to carry out this duty in recent years, partly because we have been using inadequate modes of governance. In particular, we have not fully recognised the complexity of the marine ecosystem, or the vital contribution to our understanding of this complexity that can be made by experiential knowledge. Indeed, the complexity of the ecosystem requires a correspondingly complex governance response. Governance of social-ecological systems today involves networks of interdependent public, private and non-government interests planning and making decisions at scales ranging from the local to the global in an "emerging multi-level governance regime" (Environment Canada 1999; Phillips and Orsini 2002).

Such improved governance for sustainable development requires improved systems for **managing knowledge** in the face of complexity, uncertainty and serious knowledge gaps that exist even in the midst of our 'information age' (Bouder 2002). Gaps and challenges in knowledge management are particularly apparent in the marine and coastal environment (Wolfe 2000). The Coasts Under Stress (CUS) project drew together over seventy investigators to generate knowledge of coastal social-ecological systems. Specifically, the research was designed to identify the complex non-linear interactions

T. S. Gray (ed.), Participation in Fisheries Governance, 291–306.

between social and environmental restructuring, as that operated across scales to affect the health and resilience of social-ecological systems (Murray *et al* this volume). CUS, itself an experiment in knowledge governance, was organised not around a central hypothesis with Cartesian partitioning into discrete subcomponents, but around one meta-concern (healthy social-ecological systems) in which various aspects of system well-being were first examined relatively distinctly and then integrated as the pathways between them were identified. Using the logo of a seastar, which mirrors the approach, one ‘arm’, for example, sought to understand how different kinds of **knowledge** (local and formally scientific) about ecosystem dynamics help to influence decision-making, which in turn affects human and environmental health. In this chapter, we discuss the creation and dissemination of knowledge relative to the dimensions of space and time using three CUS case study examples, one conceptual and two applied, to understand how cross-scale knowledge movements contribute to evolving forms of collaborative, adaptive multi-scale governance, necessary to the creation and maintenance of resilient socio-ecological systems.

17.2 The importance of scale

An important feature of improved fisheries governance lies in the scale of what we might call our ‘home place’ or ‘community’, to which we feel a sense of belonging and relatedness. In CUS we have found through the examination of wetlands stewardship programmes, for example, that there are very different interpretations of the notion of ‘stewardship’ across interests and scales (McLaren *et al* forthcoming). Stewardship ties in with the geographer’s concept of *genre de vie* or **lifeworld**. Environmental aspects of the lifeworld include “sense of place, social space, time-space rhythms, and the lived dialectic between home and horizon” (Buttimer in Seamon 2004:1), and the term **landscape** used by cultural geographers when referring to relations between the natural environment and human society (Rose 1993). Much more complex than a space that can be indicated by a boundary on a map, landscape is both a home and a site of struggle, both “embedded in place and constructed and reconstructed by forces larger than itself”, a complex, unstable material, and at the same time an ideological entity (Mitchell 2001:271; cf Lippard 1997). Thus the notion of clearly defining boundaries of ‘community’ in either time or space for purposes of governance is problematic. This is particularly true for First Nations, where the concept of boundary gives way to that of a functioning interlinked social-ecological cultural-spatial system whose limits cannot therefore easily translate to a boundary line drawn on a map.

Mitchell (2001) speaks of the **politics** of scale, using the example of how relation to place is packaged and sold to meet the needs of industries, such as tourism, which compete for access to space and resources with traditional activities (such as logging or fishing) that are very much a part of this original sense of identity. We found many of these ideological and material struggles over locality in our CUS research areas on both the east and west coasts of Canada. Other struggles over scale included debates about whether fisheries decision-making should take place at the local or regional, provincial, national or even international scale. For example, should cod fisheries be managed by individual bay, province, nation and/or internationally? Mitchell (2001) argues that any space is at once both local and global. CUS research (Vodden 2004; Ommer *et al* forthcoming), as well as that of resilience researchers such as Yorque *et al* (2002) suggest that while governance must increasingly involve multiple nested scales, regional scales, such as watersheds or catchment areas, warrant special attention, being an appropriate level at which to consider issues of sustainability since, at that scale, people and ecosystems maintain a close connection. This suggestion moves governance thinking closer to that of First Nations and their traditional territories, since ecology and society are clearly interdependent in such a view.

How, then, can we transfer knowledge of social-ecological systems across various scales? Since we need to work across physical and temporal scales if we are to grasp the complex relationships involved between people (individual, household, community…), their location (village, coastline, region…) and their environment (land, sea, fauna, biota and atmosphere), considered over time, multi-scale analysis is obviously required, as is cross-disciplinary work. One needs a range of space, time, organisational and conceptual levels of analysis to understand the structure and dynamics of social-ecological systems. In doing so, many different tools can be employed. The challenge is to investigate the utility of these tools in cross-scale analysis and knowledge transfer involving participants outside of the realm or discipline from which they evolved. The three case discussed below focus on three different modes of fisheries governance: 1) hierarchical space-time modelling; 2) network ecological modelling; and 3) community research activity.

17.3 Case studies

17.3.1 HIERARCHICAL SPACE-TIME MODELLING

This mode of fisheries governance is a top-down approach, making use of computer modelling to integrate the information gathered by fishers with the statistical data generated by scientific surveys. It is an example of interdisciplinary collaboration between fishers and scientists, though neither participated directly in management decisions. Figure 17.1 shows how this knowledge gathering activity is carried out.

Figure 17.1 shows one of the principal information gathering activities in fisheries science: the stratified random survey to estimate stock size. The unit of information is the biomass of fish in a single haul of the net (fixed duration of 10 minutes). A single survey of a large area (such as NAFO zones 2J and 3KL east of Newfoundland) might consist of 900 single hauls placed randomly in a larger area, the frame (F) of all possible hauls in 2J3KL. The area measured is $\sum H$, which takes about a month. The number of fish in the entire area (the frame) is then inferred from the sample ($\sum H \rightarrow F$). This measurement at one point in time is then used to represent the status of the stock for the year. The length of the horizontal arrow shows the burden placed on statistical inference from a sample to the frame of all possible sample locations.

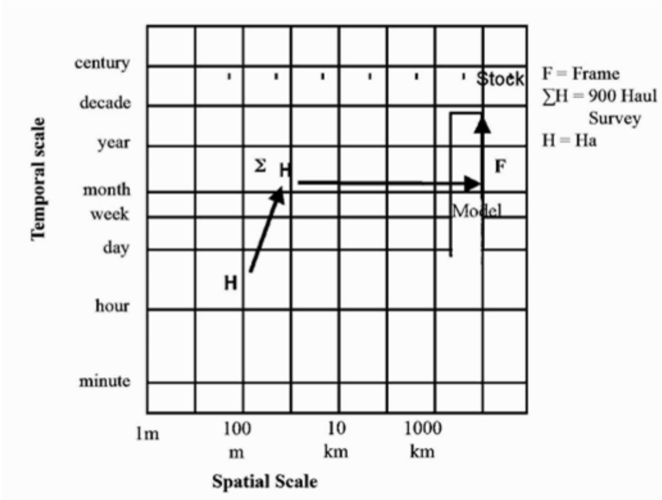

Fig. 17.1. The space and time scales of knowledge assembly by stratified random survey and computational model in fisheries research

Figure 17.2 contrasts the information gathering activity in fishery science with the information gained through the experience of an individual fisher and a fishing community. The information gathered during the course of a single trip occurs over a small area. Experience from each trip accumulates during the course of a career (and even multiple generations and careers), usually over a restricted area. The experience of the individuals in a community will cover a larger area.

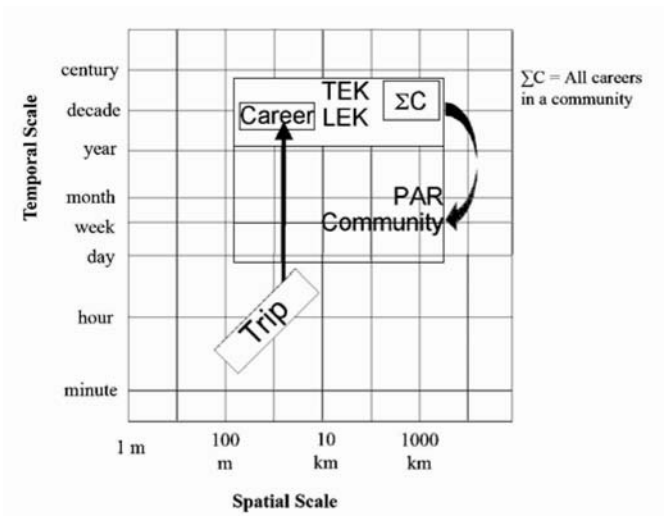

Fig. 17.2. The space and time scales of knowledge assembly by participatory action research (PAR) including the traditional or local ecological knowledge (TEK, LEK) of a community of people engaged in fishing.

A comparison of these diagrams illustrates the tendency of local knowledge to provide more spatially specific but temporally extensive knowledge, while conventional 'western' science tends toward larger scale models over limited time frames (illustrated further by the examples provided below). Both knowledge systems are required to acquire a more complete understanding at multiple scales. Faced with two different dilemmas: how to reduce the burden of inference in a stratified random survey and the burden of scaling up, Figure 17.1 shows the first step in solving the problem. Knowledge gathered on the hauls is fed into a model, which includes estimates of mortality rates and other knowledge, which is combined in computational form, to allow a generalising of haul data at point F. Figure 17.2 shows a similar kind of process for the fishing experience of individual people, in which recurrent patterns are identified through analysis of data banks of individual trips and careers. Finally, the information and analysis from both research methodologies is returned to the participants (be they government scientists or community people) and, ideally, these two groups work jointly to pool information and insights, and thus come to a shared management plan. This process represents cross-scale knowledge-sharing but also shared decision-making or fisheries co-management, a relatively well-researched form of multi-level governance (Vodden 1999; Pinkerton and Weinstein 1995; Berkes, 1996).

In future iterations one might compare diagrams for different generations of scientists and communities over time, or for different areas, to examine issues of comparative scale, such as how management plans may need to be modified over time or space. Further development of the model might seek ways to integrate such functions into Figure 17.2 to reveal how, for example, observations may vary based on occupation or function within a community (whether it be communities of place, interest or both). Discussion of the diagrams as suggested is likely to illustrate very different interpretations of the various kinds of scale and their interactions, as well as the ways that such a tool can be used and improved. Discussion about values and objectives embedded into the process of designing and using the tool may also result.

The example of this hierarchical model is but one illustration of how interdisciplinary and collaborative explorations of topics critical to sustainable coastal development can evolve and lead to innovations in coastal social-ecological systems knowledge. CUS researchers developed and examined several such fisheries-related modelling tools and techniques. One was created, for example, to identify candidate areas for marine protected area (MPA) designation in Atlantic Canada, taking into account ecological parameters such as species richness and species-at-risk protection as well as social considerations such as likelihood of acceptance and conflict with economic interests (Baker 2003). Neither the development of the model, nor consideration of its outcomes, however, involved participants outside of the academic community. Stakeholder involvement is considered an important next step for checking data and assumptions made in the model and for implementing any decisions about MPA designation and implementation that may come about as a result (Ommer *et al* forthcoming).

17.3.2 NETWORK ECOLOGICAL MODELLING

A second modelling procedure developed to provide direction for the restoration of depleted marine ecosystems made use of networks of interested parties to generate the necessary information. This mode of governance is exemplified in the Back to the Future (BTF) project undertaken by CUS. BTF 'reconstructs' systems as they might have been before they were depleted by modern industrial fishing, and then quantifies the socio-economic and ecological tradeoffs inherent in restoration. Using a whole ecosystem approach, restoration goals (an optimal restorable biomass) are set and strategies developed, including simulated optimal patterns of fishing, to rebuild the ecosystem and recapture lost productivity potential (Ommer *et al* forthcoming). The temporal dimension of scale is critical to this process, which considers present, past and future ecosystem states. Social, economic and ecological costs and benefits of varying restoration goals are evaluated using an intergenerational discounting technique that allows for division of the benefit stream between current and future generations (Ainsworth and Sumaila 2003). Methods are being sought for incorporating cultural and ecosystem service values as well.

To date, the BTF model has been applied in British Columbia and Newfoundland, Canada and in several other locations internationally (Ainsworth *et al* 2002; Heymans and Pitcher 2002; Ainsworth and Pitcher 2004; UBC 2004). BTF takes advantage of advances in ecosystem, spatial and bio-economic modelling to integrate both quantitative and qualitative information. It also adds a participative element missing in the MPA modelling discussed above. Community interviews and workshops, national and international conferences and publications are utilised to generate discussion on model development, outcomes and restoration strategies with scientists, managers, First Nations and other resource users. New model iterations have been produced as a result of these interactions. The process is innovative in its ability to integrate information from a wide range of sources. Respect and recognition of all knowledge systems is emphasised.

Despite international recognition and application of the modelling techniques it employs, BTF has not yet achieved the widespread sharing of knowledge and facilitation of multi-level dialogue among Canadian academic, community, fishing and government sectors that it warrants. Available resources for engagement of non-academic partners are limited and there has been as yet no 'take-up' by those who are exploring and implementing ecosystem-based management (Haggan 2004). Reflections on these difficulties identify the challenge of generating genuine commitment to knowledge sharing in the polarised climate of today's fishery where knowledge may be hoarded as a bargaining chip or 'edge' over other actors (Haggan 2000). As an 'honest broker' of information, the university can play an important role in encouraging knowledge sharing. Further, such iterative processes may build intellectual and social capital over time that will build a collective understanding and improve modelling techniques and outcomes, particularly as additional parties provide input and data (Ommer *et al* forthcoming; UBC 2004). This is an essential precondition for agreement on reinvestment in natural capital at the necessary scale.

Two additional (and linked) challenges encountered in BTF include the problem of matching often micro-spatial scale local and traditional knowledge (LK/TK) with macro-spatial models, along with problems associated with the diverse and changing nature of LK/TK and methods of capturing this knowledge in an appropriate and respectful manner. BTF work draws upon global scale examinations of fishing down marine webs (Pauly *et al* 1998) while seeking to address the shortcomings of fisheries landings data at the provincial-scale with the knowledge of harvesters, First Nations and non-government organisations. Local knowledge has been used, for example, to provide the micro-spatial and temporal information required to reconstruct cod migration patterns and suggest relationships between these patterns and states of recovery. It has also demonstrated spatial, temporal and ecological expansion and intensification in fisheries. The gathering and translation of such knowledge has not come without problems, however, including community tensions and disagreements due to deep conflicts between small boat and large boat fish harvesters (UBC 2004). Such tensions illustrate the complexity and diversity of LK (Murray *et al* this volume).

Collaboration on the reconstruction of past abundance and imagination of possible futures may well build greater mutual understanding of ecosystem structure and function and of recommended recovery strategies, but the question remains whether the will or resources are sufficient to continue this work and further refine these innovative tools. Further, can policy-makers who currently dominate fisheries governance, such as the federal Department of Fisheries and Oceans (DFO), be brought fully into the dialogue so that this new and integrated knowledge is translated into improved decision-making?

Individuals and groups involved in discussion about tools such as time-scale diagrams and ecological models will change over time, as will analytical tools, fish stocks and ecosystems themselves. The collection of these individuals, groups and resources can be viewed as a network. Clark (2000) describes networks as two or more people communicating back and forth. Actor networks are described by Ommer and Sinclair (forthcoming:7) as “constantly emergent linkages among people, wildlife and materials” (all actors, or agents producing effects), though the capacity for responsibility for actions is not the same for all participants. The network concept “allows for uncertainty, chaotic outcomes, positive or network transforming feedbacks, and system complexity”. Actor-network theory assumes that social structure, like notions of scale discussed above, “is not free-standing…but a site of struggle, a relational effect that recursively generates and reproduces itself…” (Law 1992:5). Actors within a network carry varying degrees of power and influence but have some common purpose for communicating and/or working together (Creech 2001). Knowledge then is a product of networks, networks that include an increasingly broad range of actors and are subject to shifting power dynamics. The recognition of local actors and social scientists beyond the field of fisheries economics as valid participants in the fisheries management knowledge network demonstrates such a shift. Under-utilisation of BTF techniques indicates, however, that rigidities remain in the system. In the case of BTF, it appears that, despite the development of a promising analytical tool, the potential for knowledge sharing and transfer between the academic community and other actors in the Canadian fisheries policy network has not been fully realised.

17.3.3 COMMUNITY RESEARCH ACTIVITY

The third mode of fisheries governance using experiential knowledge is community-based. This mode signifies another change in Canada’s fisheries networks – towards the creation of community-based research institutions to facilitate local participation in knowledge creation and dissemination with respect to fisheries and other interrelated aspects of social-ecological systems. This aspect of CUS research involved the examination of such local institutions, their interactions with other institutional actors, and their impacts on knowledge flow and decision-making (Vodden and Bannister forthcoming; Gibson *et al* forthcoming). The example of the Indian Bay Ecosystem Corporation (IBEC) demonstrates the use of modelling as a participative tool leading to fisheries policy change at scales well beyond the local. It further suggests the importance of local institutions as critical nodes in actor networks that can facilitate local input into broader-scale processes, while also bringing those knowledge generation and decision-making processes 'closer to home' and to the ecosystems and resources they impact.

Indian Bay is a fishing and former logging community on Northwest Arm at the head of Bonavista Bay, on the northeast coast of Newfoundland. A major forest fire put an end to logging as the area's primary industry in 1966. The Indian Bay watershed, an extensive freshwater system made up of more than seventeen lakes[1] feeding into the Indian Bay River and ultimately to Bonavista Bay, was renowned nationally for exceptional angling, and especially for trophy size brook trout, *Salvelinus fontinalis* (Power 1997). The system is highly productive in terms of both fish diversity and growth rates. While in operation, the forest company restricted access to the lakes. When the company pulled out of the area, and road access was provided, coupled with technological developments such as the snowmobile, the system soon became overexploited by both locals and visitors. Anglers could harvest twenty-four fish per day (or ten lbs plus one fish) legally, yet even these generous restrictions were not enforced and often ignored. Trout populations hit what is thought to be an all-time low in the mid-1980s (Gibson *et al* forthcoming). Indian Bay and neighbouring communities decided something needed to be done to protect what was an economically, socially, culturally and ecologically valuable resource. Two local development associations teamed up to form the Indian Bay/Cape Freels Ecosystem Committee, which later evolved into IBEC.

More than 5000 bags of garbage were removed from the system in the early years, along with heavy equipment left behind by the logging industry. Habitat improvements included the removal of debris, pulpwood jams, logging dams, old beaver dams and culverts; the reconstruction of collapsed bridges; and riverbank erosion control. The group conducted a public awareness campaign and a user survey that confirmed concern about the declining stocks and suggested local values related to the fish resources (Gibson *et al* forthcoming). Some government support had been obtained at this point, particularly in the form of funding from federal human resources and environment departments. However, the committee realised that to go the next step in fisheries recovery and management, partnerships with universities and provincial and federal fisheries managers would be essential.

Unlike other Canadian provinces, the Province of Newfoundland has not accepted full responsibility for the management of freshwater fisheries, because it claims that it does not have the resources to devote to scientific study related to trout management. However, although the DFO "does not currently do any science on trout" (DFO manager 2004) it did devise a Trout Management Plan (expired in 2003 and now under review). The Province got involved in trout research, in cooperation with IBEC, DFO and others,

[1] Small and medium sized freshwater bodies are called ponds in Newfoundland and Labrador.

during a federal/provincial agreement in the early 1990s and has continued a limited program since that time. Brook trout are the most commonly harvested freshwater fish in Newfoundland. Variability in life history, distribution and productivity across a wide range of habitats in Newfoundland and Labrador make management of this species "highly data dependent" (van Zyll de Jong *et al* 2002:267). Current management regulations are, however, largely determined in the absence of data and, before those in Indian Bay, few studies had been done on brook trout dynamics or on simulation exercises to examine the effectiveness of management strategies. By the late 1980s, concerns regarding declines in trout stocks were present well beyond Indian Bay. IBEC was formed in the absence of strong, defensible management (van Zyll de Jong *et al* 2002).

It was the IBEC's original intention to build a hatchery for the purpose of restocking brook trout. But this recovery strategy was not implemented because of scientific advice given by the Salmonid Research Group at Memorial University regarding potential deterioration in genetic diversity and declines in numbers and size of wild fish (Gibson *et al* forthcoming). Instead, a multi-year research and trout assessment project was launched by IBEC in partnership with Memorial University, and provincial and federal fisheries departments (including not only the Province of Newfoundland but also the Ontario Ministry of Natural Resources) to: a) provide the scientific data needed to evaluation fish population status; b) provide a model for managing exploitation in brook trout fisheries; and c) offer advice for management decisions (van Zyll de Jong 2002). Together the research partners showed that the water quality of the system was good, and that growth rates of trout in Indian Bay remained the same as before, and were greater than stocks for the Avalon Peninsula (southeast Newfoundland). They derived models to show that stocks would recover if special regulations for the system were made.

While provincial and academic partners were crucial to the development of the model itself, the research questions were established by community concerns (knowledge of local problems). Local staff and students were employed to collect data, and community members were brought in through the IBEC Board of Directors and open community meetings to discuss results and recommend regulatory changes. Special experimental regulations were put in place for some lakes, and two were closed for fishing as a result of this research and public support. IBEC recommended to the federal DFO that special regulations be implemented. DFO agreed, and seasons were shortened, and a bag limit of six fish or two lbs plus one fish was applied in 1994, from which time angling began improving (increased fish size). Legislative and policy measures in Indian Bay are now accompanied by monitoring and enforcement activities undertaken by local staff, again in cooperation with federal and provincial departments. Brook trout sizes have increased as a result, though modelling results suggest that the fishery is presently operating near full capacity.

Present regulations are not effective when effort is high, and size restrictions as well as species-based regulations are needed to contain increased effort while sustaining high quality fishing. IBEC had been in discussion with DFO about such regulatory changes for nearly ten years, and at IBEC's 2004 annual meeting with government and industry partners, a senior DFO fisheries manager announced that new regulations had finally been passed to allow for such management measures. IBEC was asked to bring a proposed management plan for the watershed to their upcoming AGM and, if approved by the community and consistent with the regulatory changes, DFO would also endorse the plan. Similar changes were to be rolled out across the Province throughout 2004 and 2005. The IBEC Manager now chairs the Province's Trout Advisory Working Group, yet another indicator of the local organisation's province-wide influence. Further, local students have completed their training and graduate research within the watershed and then gone on to work in their careers as provincial fisheries managers.

The decline of the trout resource and its recovery in Indian Bay is an excellent example of where negligence, overexploitation and lack of knowledge led to the collapse of a resource, but where local initiative and the 'bottom-up' approach, coupled with knowledge and decision-making partnerships with 'top-down' scientists and policy-makers, at least in part, has helped to restore the system. Their collaborative research efforts continue to inform and improve fisheries management at multiple scales from the immediate region to the province as a whole, and even nationally and internationally. Corporate and individual decisions within the watershed have been influenced by IBEC, while requests for information and interest in applying this approach to freshwater fisheries management have come from as far afield as Africa, the UK and US (IBEC 2003). IBEC then has a potential application in addressing challenges in freshwater and recreational fisheries worldwide.

IBEC also offers an opportunity for cross-fertilisation of lessons from these fisheries to other resources and ecosystems (for example, marine fisheries). It has broadened both its spatial and functional scale of discretionary reach over time, and now includes an ecosystem-based approach to research and planning rather than single species or even fisheries-focused efforts. Studies have been undertaken relating not just to fisheries but also to forestry practices, invertebrates, plants, anthropology and rural development. Research on logging impacts in the watershed led to some areas being set aside for protection as pristine study areas under agreement with the logging companies. An IBEC-developed land use plan resulted in still others being excluded from cabin development. There are plans underway to build more laboratory facilities, accommodation and an interpretation centre, and to create a nationally important field research centre (the Indian Bay Centre for Cooperative Ecological Studies). With these developments has come a broader focus on the ecosystem as a whole, including attention to the coastal area and linkages between freshwater and marine systems (Vodden 2004). However, this ecosystem focus would not have been possible initially. It has taken time to build capacity, knowledge and awareness about the linkages between the health of freshwater fisheries and the social-ecological systems of which they are a part.

However, all has not been smooth sailing within the IBEC. As in the BTF, attempts to engage fisheries stakeholders; community conflict; and differing opinions portrayed as knowledge, within a community have added complexity to the process. For instance, because of conflicting objectives, misinformation, lack of communication between local, academic and government partners, and inaction by those who could have intervened, a controversy emerged in the community about the impacts of fisheries research (particularly mortalities due to fyke netting). This brought the research to a temporary end, but, as Gibson *et al* (forthcoming) point out, the efforts of a few key people and their commitment to local involvement in managing the watershed and its fishery, have managed to re-establish and even expand research and monitoring activities, demonstrating the resilience of the community-based system. The presence of a local institution to facilitate discussion of these conflicts led to their resolution and a greater understanding among misinformed parties on both extremes of the debate, a learning process that will improve future research efforts and collaboration.

Nevertheless, despite the apparent resilience of the Indian Bay model, now nearly twenty years old, reliance on key individuals introduces an element of vulnerability, as does the need for ongoing, yet fragile, public, government and academic assistance. Reliance on strained public financial resources for community engagement, and for all of their ongoing work, is a challenge in the IBEC case, as it was in the BTF case. Volunteer and leadership energy has limitations, and the organisation is struggling to develop a more entrepreneurial institutional model under pressures of government downsizing and cost-cutting associated with neo-liberalism and the post-industrial era. While the organisation has been able to build understanding and negotiate compromises and win-win solutions that satisfy the very different values of local users, academic and government partners, their ability to continue to do so requires ongoing effort supported by organisational infrastructure, human resources and relationships.

In the case of IBEC, the watershed has proven a workable scale for the application of stewardship and collaborative governance. Aside from their logic as a biophysical scale with relatively clear ecological boundaries, watersheds are scales to which local communities can increasingly relate, particularly as watershed-level institutions are established and environmental awareness increases. People tend to feel a direct connection with the watersheds in which they live and rely upon for their drinking water, recreation, subsistence and/or culture. For senior governments, and academic researchers, the watershed is a scale of significant size to warrant their attention. This ability to relate to the watershed scale is an important consideration in stewardship and in knowledge generation and sharing. People are more apt to care for something they understand and feel some direct connection to. Awareness of the watershed scale (what it is and how it functions, both in terms of the larger catchment area as well as the subsystems within it) can be fostered through education and information sharing as well as through direct participation in watershed activities. Public or citizen knowledge, then, is an important knowledge type. IBEC emphasises the importance of simultaneously reaching out both above and below, engaging the grassroots along with external partners (at higher levels in the spatial hierarchy).

17.4 Discussion

These examples highlight the role of knowledge sharing, communication and social learning among coastal interests, including the application of this learning to the development of new institutions and new analytical tools. They also raise the question of whether such processes of collaborative enquiry will lead to more sustainable fisheries management decisions and, ultimately, a lighter social-ecological footprint on a globally-imperilled resource. This, of course, means thinking about how people act, their values and ethics, the networks they can create, their learning systems and the role of communications across scales in developing knowledge systems that are not only adaptive and evolving but also collaborative. It means opening up the knowledge process to input and critique from a wide range of diverse actors and avoiding the kind of 'closed shop' government science that has been widely criticised for its failure in the past (Hutchings *et al* 1997). We have inherited a legacy of barriers in understanding between actors from diverse disciplines, cultures and locales which strongly suggests that we are dealing with unproductive rigidities in our current knowledge systems, such as the unsustainable fisheries practices that led, and still lead, to ecosystem collapse. New models of collaboration – such as CUS itself and the knowledge partnership case studies it examined – show the breaking down of *some* of these barriers. Many remain. Social learning theory suggests how this change (breaking down barriers to knowledge creation and exchange) might occur. An extension of an organisational learning theory, it suggests that 'change' is a fundamental feature of modern life and hence imperative to develop social systems that are able to learn and adapt through "reflection-in-action" (Schön 1983; Argyris and Schön 1974, 1978). Networks of actors and informational 'feedback loops' that operate throughout these networks, are fundamental to the development and operation of such learning systems (Smith 2001).

Not all learning, however, is beneficial (Huber 1991). One can learn, for example, how to cheat, steal or pollute. What is required for social learning to produce positive sustainability outcomes is a re-evaluation not only of technique but also of purpose and values, with the hope that predominant values will align themselves with those compatible with ecological approaches to sustainable development. Each of our case studies and the tools and models they employed involved an examination of values and comparison of management outcomes when different values are emphasised (conservation versus economics or recreation). In each case, determining measures of effectiveness and productivity was dependent on objectives and values (weighting to social, ecological or economic outcomes). Values are a lens through which we interpret knowledge and decide what the important questions are to examine (McLaren *et al* forthcoming). Stenmark (2002) notes how all environmental policies are based on attitudes and judgements, more often implicitly rather than explicitly stated, about what is valuable, what should be encouraged and about whose interests should be satisfied. Values and goals determine where we want to go. Scientific information helps us get there, but knowledge obtained through lived experience can also tell us where we should be going, and what values should guide us along the way. Values then can be learned. The key is to recognise the importance of values, articulate and make them explicit wherever possible and openly discuss them. Stewardship, although it requires knowledge, is also a values exercise (McLaren *et al* forthcoming). Argyris and Schön (1978) emphasise the importance of learning strategies that involve a re-evaluation of governing goals, policies, values and "mental maps". Others have described this as second-order, large-scale or 'deep structure' change (Bartunek and Moch 1987; Gersick 1991).

Our research suggests that inclusion of local actors in knowledge networks helps open up these difficult dialogues about values, a discussion often avoided by scientists who aim to be 'entirely objective and value-free', despite the now demonstrated incapacity of anyone to be so. It is necessary to hold such discussions in order to develop mutual understandings and meanings and decisions that are as widely acceptable as possible. Such a process becomes particularly useful when conclusive scientific evidence is not available, as is often the cases in such complex problems as fisheries management (Bouder 2002). Workshops and conferences involving a wide range of actors were utilised in both BTF and IBEC as a tool for facilitating this dialogue.

However, our examination of knowledge partnerships in CUS offers lessons of caution as well as optimism. Collective learning is costly. Learning systems must be designed, managed and supported. They require investment in developing group policies, protocols and norms, as well as activities and organisational infrastructure. Nodes within the network, at multiple scales and within various communities of interest, must be maintained, their role being to facilitate knowledge exchange. This requires a policy framework and ongoing support for knowledge exchange and investment by private, public and civil society sectors. Networks tend to be more successful, requiring less investment of time and resources, where their component actors and nodes are more cohesive, and their resources are more equitably distributed. Yet this is rarely the case on Canada's coastlines, where controversy rages over issues of aquaculture, fisheries, forestry, tourism and offshore oil and gas development. The need for collaborative knowledge systems is great, but the capacity at present is fledgling and under-resourced. Strong leadership support and capacity for collaboration at all levels is also required but often lacking.

What of the implications of this collaborative learning process for management decision-making structures? Collaborative learning processes will, inevitably, precipitate changes in management structures: both detailed management changes in a fishery within a region based on a new, shared understanding of stock size; and strategic value-driven changes to wetlands stewardship programmes or discounting techniques. Such changes will have to be based on learning, facilitated by innovations ranging from old analytical tools revised for modern purposes (for instance, the time-scale diagram), to new technologies in computer modelling, or conferences and research projects that lead to deep structure debates. These examples illustrate the potential for extending communications networks to knowledge networks to multi-level coastal governance arrangements where decisions are made in a more equitable, collective manner.

However, given what we know about rigidity in the present fisheries governance system, is it realistic to believe that the potential of collaborative learning systems will ever be realised? Learning systems require both monitoring and an ability/willingness to respond to feedback. Will an improved time-scale diagram, better modelling techniques or more effective local institutions matter? Without a deeper value and culture change, we think not. As Bouder (2002) points out, we need more than new institutions, we need existing institutions to better integrate economic, environmental and social objectives within their mandates. Fortunately, institutions can change significantly in terms of the rules and norms that guide their behaviour, not just their form and structure (Lowndes and Wilson 2001). Tools such as those discussed in this chapter can provide not only better information (feedback) but also can help to facilitate discussion about differing perspectives and ,over time, they can yield shared understandings.

Our experience in CUS has demonstrated some ability and willingness in Canada's federal institutions to respond to feedback about the kind of deep, value-driven change required to adapt to large-scale changes in social-ecological systems. Support and willingness to collaborate with strong local institutions has been demonstrated through IBEC and Murray *et al* (this volume). On a broader scale, Canada's Oceans Act and its Strategy and Action Plan call for collaborative decision-making processes that involve multiple stakeholders and are based on principles such as ecosystem management and the precautionary approach. This new policy framework explicitly recognises a role for collaborative knowledge generation. Also promising is Canada's investment in knowledge networks, including those specifically designed to inform coastal and oceans policy such as the Ocean Management Research Network and Canadian Policy Research Network. The varied ways in which the Oceans policy is (and is not) being implemented across Canada, demonstrates that actors at scales below the national level are, indeed, important in policy outcomes.

Although significant barriers to knowledge flow continue to exist, even among members within these various networks, CUS innovations in interdisciplinary work demonstrate that boundaries can be crossed, and they provide hope that rigidities can be overcome, utilising nested multi-scale structures linked vertically and horizontally through extensive and ongoing communication, together with the development of new tools and techniques employed within knowledge networks. Common to these multi-level structures is a recognition of the importance of the local and regional scale, but also an acknowledgement that local is not enough. National and even international actors must be designed into the multi-level network, with different tools employed for effective and ongoing communication at all levels. Such efforts are difficult and costly but necessary if complex realities are to be addressed.

A 2004 International Conference on New Approaches to Rural Policy called for a "new rural governance, based on consultation, negotiation and partnerships among government, businesses and communities". The facilitation of "knowledge pooling" across and within levels of government and between public and private sectors was described as one of three key areas for investment in such a new governance system (FRB *et al* 2004). Such investments could start with the education of individuals, including school children and the public-at-large, to facilitate their engagement in sustainability debates and increase their discretionary reach. Resourcing and capacity-building must then extend to scales beyond the individual to the support of various nodes within knowledge networks that help facilitate participation and knowledge flow. We have provided examples above of nodes at both functional and territorial/spatial scales. Continued research and reporting on measures to increase the success of knowledge networks can play an important role in their continued development.

17.5 Conclusion

Our conclusion is that collaborative learning is a pre-condition of a successful management response to the complexities of marine ecosystems, and that the more extensive the net is spread to include the largest number of contributors to the collective learning experience, the better. Establishing and maintaining networks of actors across territorial and functional scales, each with varied and shifting boundaries and interpretations, is a massive challenge. But our three examples offer promise, drawn from the perspective of coastal knowledge management as evidenced in the recent experience of the CUS project, a major interdisciplinary, collaborative research effort. Visions for future policy-making create a picture of a new multi-level, multi-interest governance regime where government is not the only govern"er" yet remains a significant supporter of and participant in knowledge and policy networks capable of addressing complex realities. Integration of shared knowledge represents a starting point for developing sustainable governance systems, a much-needed shift in human systems in the face of large-scale human-induced ecological changes that threaten the very survival of marine ecosystems.

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