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Insight, part of a Special Feature on Scale and Cross-scale Dynamics

From Community-Based Resource Management to Complex Systems: The Scale Issue and Marine Commons

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ABSTRACT. Most research in the area of common and common-pool resources in the past two or three decades sought the simplicity of community-based resource management cases to develop theory. This was done mainly because of the relative ease of observing processes of self-governance in simple cases, but it raises questions related to scale. To what extent can the findings of small-scale, community-based commons be scaled up to generalize about regional and global commons? Even though some of the principles from community-based studies are likely to be relevant across scale, new and different principles may also come into play at different levels. The study of cross-level institutions such as institutions of co-management, provides ways to approach scale-related questions and deal with linkages in complex adaptive systems. Looking beyond self-governance, community-based resource management needs to deal with multiple levels of governance and external drivers of change, as illustrated in this paper with examples of marine commons.

Key Words: *common property theory; community-based resource management; complex adaptive systems; marine commons; scale.*

INTRODUCTION

Sustainable development and resource management "at all levels" (Cash et al., *in press*) is a fundamental problem for commons management. The theory of the commons has undergone major transformations over the years, moving from the simplistic "tragedy of the commons" model, to dealing with small-scale, community-based systems as laboratories for investigating self-organization and self-governance (Ostrom 1990). Proceeding from this base, commons literature has been dealing with the governance of multiple resources and user groups, and regional and global commons (Ostrom et al. 2002, Dietz et al. 2003, Dolsak and Ostrom 2003).

There are ongoing debates in many areas of commons research. One of these concerns a scale-related question: can findings from local-level commons be scaled-up? That is, can principles generated based on studies of microlevel systems be applied to mesoscale and macroscale systems? Researchers have been dealing mainly with small-scale, community-based systems. However, some of the experimental work on commons, using Prisoner's Dilemma models, has treated nation states as unitary actors in the analysis of global commons (e.g., Ostrom et al. 1994), with the implication that the same commons principles may apply across levels. More specifically, it is said "some experience from smaller systems transfers directly to global systems," but that "global commons introduce a range of new issues" (Ostrom et al. 1999:278). In this analysis, a number of factors are considered important, including the size and complexity of the system and the speed at which resources regenerate themselves. In addition to the scaling-up problem, Ostrom et al. (1999) indicate that there are several other challenges of global commons, concerning such factors as cultural diversity and interlinkages of commons.

Other researchers have argued that the transferability of the small-scale commons experience is fraught with complications. The issue "is not fundamentally a matter of extreme size and complexity at the global level. Rather, the problem

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arises from differences between individuals and states, and from the separation between those who formulate the rules and those who are subject to them" (Young 2002:153). " Solving the tragedy of the commons at the local level is fundamentally a matter of self-regulation," but at the global level, "regulation is a two-step process" (Young 2002:152). Hence, "we should be particularly careful to avoid assuming unreflectively" that global issues can be treated in the same ways as local commons problems (Young 2002:149).

This debate may be approached by suggesting that it may be more useful to pose the issue as complexity management, rather than one of scaling-up. Commons management in many cases can be understood as the management of complex systems, with emphasis on scale, self-organization, uncertainty, and emergent properties such as resilience. Several authors have touched upon aspects of this (Levin 1999, Gunderson and Holling 2002, Wilson 2002, Adger et al. 2003, Berkes et al. 2003). There is general agreement that commons are often impacted by forces or drivers at various levels of organization (MA 2003). There is also an agreement on the need to consider multiple levels of management (Ostrom et al. 1999, Young 2002, Adger 2003). Some of the commons literature explicitly deals with such multilevel management.

Co-management (Pinkerton 1989, Jentoft 1989) is by far the most widely discussed institutional form for dealing with commons management at two or more levels, but there is a diversity of institutional forms for dealing with multilevel commons (Berkes 2002). These other forms include epistemic communities (Haas 1990), policy networks (Carlsson 2000), boundary organizations (Cash and Moser 2000), polycentric systems (McGinnis 2000), and institutional interplay in which institutions may interact horizontally, i.e., across the same level, and vertically across all levels of organization (Young 2002, 2006).

These concepts have something in common: each provides an approach to understand cross-level linkages and to deal with complex adaptive systems. They all pertain to scale and to other aspects of complexity such as self-organization, uncertainty, and resilience. If so, one can argue that there is an evolution of thought toward dealing with commons management as complex systems problems. Such an approach provides an entry point to build a commons theory that proceeds to an analysis of commons as multilevel systems. The area of marine commons provides suitable examples to illustrate the phenomenon of resource management at all levels.

Using examples for marine commons, the objectives of the paper are to contribute to an understanding of commons as complex systems, and to the debate on scaling-up from the local to the global. The framework is provided by the three common scale challenges: (1) the failure to recognize important scale and level interactions, (2) the persistence of mismatches between levels and scales in human-environment systems, and (3) the failure to recognize heterogeneity in the way scales are perceived and valued by different actors. These are referred to respectively, as the scale challenges of ignorance, mismatch, and plurality (Cash et al., *in press*).

I start by reviewing the commons concept in the next section, focusing on the core issues of exclusion and subtractability, and the need to expand the analysis beyond the local level to be able to consider complexity. Next, I identify a selection of scale-related complexities, followed by illustrative case material. The first set of cases uses community-based examples to make the point that even cases of apparent simplicity may have drivers at different spatial and temporal scales. The second case is an international marine commons example, focusing on large migratory fish species of the Atlantic, to illustrate the integrated nature of social and ecological domains, and the necessity of having to consider both technical/biological factors and social/economic factors in management.

CROSS-SCALE COMMONS: EXPANDING THE SCOPE OF COMMONS THEORY

Common-property, i.e., common-pool, resources share two characteristics: (1) exclusion or the control of access of potential users is difficult, and (2) each user is capable of subtracting from the welfare of all other users (Feeny et al. 1990). These two universal characteristics of commons are referred to as the "exclusion problem" and the "subtractability problem," respectively. Thus, Ostrom et al. (1999:278) define common-pool resources as those "in which (i) exclusion of beneficiaries through physical and institutional means is especially costly, and (ii) exploitation by one user reduces resource availability for others."

In theory, and often in practice, a group using a commons can solve the exclusion problem and the subtractability problem. The key is the ability to limit the access of outsiders and to self-regulate its own use. Common property works through incentives. If members of a group are assured that future harvests would be theirs by right, and not end up being harvested by others, then they have the economic incentive to self-regulate.

Exclusion means the ability to exclude people other than the members of a defined group. Evidence suggests that successful exclusion under communal property is the rule rather than the exception. However, stresses of population growth, technology change, and economic transformation may contribute to the breakdown of communal property mechanisms for exclusion (Berkes 1989). The creation of open access by external forces, such as colonialism and globalization, limits communal property controls for exclusion.

Most national governments consider marine resources as freely open to all citizens and license holders, effectively ignoring de facto fishing territories of many maritime communities (e.g., Berkes 1989). This is an example of how national policies may adversely constrain local management (Cash et al., *in press*). Exceptions include Japanese coastal fisheries, coastal resources in some Pacific island states, and many marine lagoon systems internationally (Ruddle and Akimichi 1984, Amarasinghe et al. 1997, Johannes 1998, Seixas and Berkes 2003).

Subtractability refers to the ability of social groups to design a variety of mechanisms to regulate resource use among members. In many cases, resource users have been able to avoid Hardin's "tragedy" by devising rules for self-governance, monitoring mechanisms, and sanctions that rely neither on government control nor private property rights (Burger et al. 2001, Ostrom et al. 2002). Much of the common property literature addresses this issue, and the conditions for effective self-governance. Ostrom (1990) lists eight design principles important for the success of community-based institutions. An analysis by Agrawal (2002) expands this list and suggests that there may be as many as 40 critical enabling conditions that may be important for the success of commons institutions.

In many cases, community-based management systems are inferred to be successful, not because conservation or sustainability can be shown, but because they have survived for long periods through various crises. Such successful commons institutions have received special attention for theory building, precisely because they are long-enduring (Ostrom 1990). Many of them have historical roots such as in Swiss Alpine commons, Japanese village common lands, or *iriai*, and Japanese coastal fishery commons (Ruddle and Akimichi 1984). However, is the long-term survival of a community-based management system a good indicator of its sustainability?

Resource management systems tend to go through cycles of crisis and recovery and of institutional renewal. Societies are rarely, if ever, in balance with their resources, and commons institutions are rarely stable for long (Seixas and Berkes 2003). Instead of equilibrium, one may expect crises and cycles of change, thus shifting the analytical emphasis from stability to resilience, and to increasing the capacity of management systems to learn from experience and to adapt to change (Folke et al. 2002).

SCALE-RELATED COMPLEXITIES

The diversity and widespread prevalence of local-level commons institutions indicate that they have been important for the survival of many societies and still relevant for contemporary resource management (Johannes 1998). However, there are certain limitations of the lessons learned from the study of local-level systems. Initially, research on commons issues often sought the simplicity of community-based resource management cases to develop theory. For example, Ostrom (1990:29) explains that her strategy has been to study small-scale common property situations "because the process of self-organization and self-governance are easier to observe in this type of situation than in many others." This is not to say that such small-scale systems are isolated from the rest of the world and immune to internal and external influences that affect self-governance. There are many such influences, and here I touch upon four scale-related issues that impact sustainability and resource management: (1) complexity at the level of the community itself; (2) the existence of external drivers of change; (3) the problem of mismatch of resource and institutional boundaries, i.e., the issue of fit; and (4) the necessity for community-based management to deal with cross-scale issues.

First, the term community in community-based resource management is a gloss for a complex phenomenon, and may hide a great deal of complexity. Communities are not always simple; they often show characteristics of complex systems. They may be heterogeneous, with different interests by gender, age, class, socioeconomic group, or ethnic group (Agrawal and Gibson 1999). There often exist competing groups within a community; differences may be strong enough that a village may be thought of containing distinct communities, as in caste communities in many parts of India (Berkes et al. 1998). In some cases, a community may be a cohesive group, with shared norms and rules-in-use; in other cases, they may be less than coherent entities, representing long-standing sources of authority (Brosius et al. 1998).

Second, small-scale community-based systems are rarely free of the influences of external drivers. I use the term driver to mean "any natural or human-induced factor that directly or indirectly causes a change in an ecosystem" (MA 2003:210). More generally, drivers or external drivers such as central government policies and global markets are those key factors that cause change in a system. Theories of self-governance, based on studies of small-scale commons institutions, need to expand to embrace drivers. Identifying drivers is not always easy. In some cases, the drivers may be obvious, but in other cases, the drivers and their impact may be difficult to discern because of the confounding effects of several factors acting together. Drivers are often contested, and their identification often depends on the viewpoint of the observer, i.e., they are, at least in part, socially constructed (Adger et al. 2006, Lebel et al. 2005).

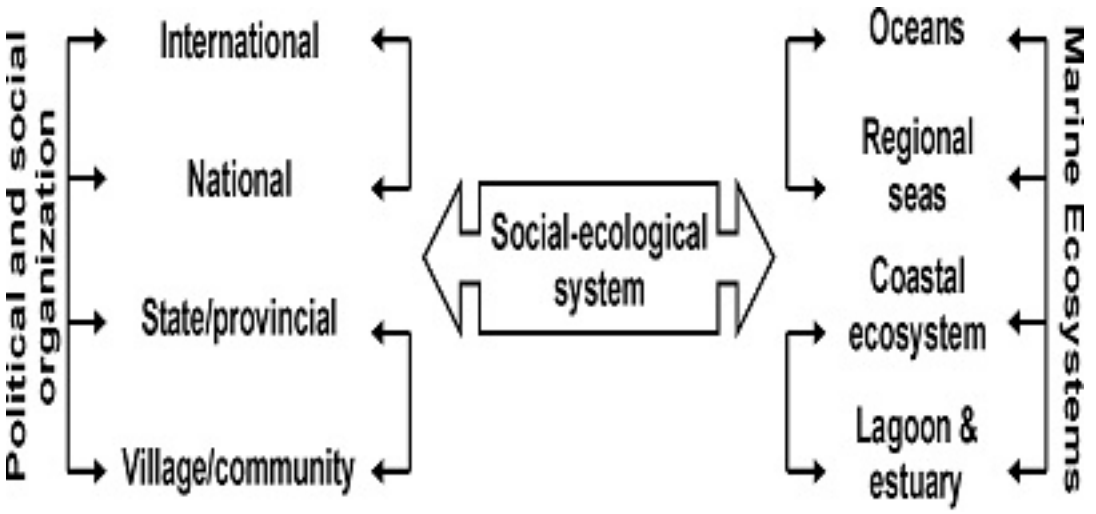
Third, resource boundaries rarely match institutional boundaries (Folke et al. 1998), and several kinds of scale mismatch problems are pervasive (Cash et al., *in press*). Institutions do not "fit" resource or ecosystem boundaries for a number of ecological reasons, including the complexity and dynamics of ecosystems, uncertainty, irreversibility, and disturbance (Brown 2003*a*,*b*). Figure 1 shows some commonly considered levels of political, social, and ecological organization, with marine resource management in mind. The number of levels can be expanded; for example, MA (2003:121) shows eight levels of each at the political and ecological scales.

As labeled in Fig. 1, the social-ecological system represents the integration of the social/political and the ecological scales. It emphasizes the view that social and ecological systems are in fact linked, and that the delineation between the two is artificial and arbitrary (Berkes and Folke 1998). Such integrated systems of humans-in-nature are more likely to work if there is a fit between the level and boundary of the ecosystem and the institution designed to manage it. However, this is not to say that there can or should be political levels that perfectly match the ecological levels.

Finally, it appears that most, if not all, cases of natural resource management are cross level. Community-based resource management, i.e., the lowest level in Fig. 1, is characterized by an emphasis at the community or the local level; governance begins at the community level. However, because cross-level linkages are so pervasive, i.e., linkages to the higher levels in Fig. 1, attention to the community level alone is never likely to be sufficient to provide for effective management. Combining the essence of community-based management, from the ground up, with the necessity to deal with cross-scale issues invokes the subsidiarity principle. This principle has been adopted, among others, by Article A of the Maastricht Treaty that lays out the framework for establishing the European community. It stipulates: "decisions are taken as closely as possible to the citizen." It articulates the normative principle of institutional design to the effect that decisions affecting peoples' lives should be made by the lowest capable level of social organization (McCay and Jentoft 1996).

In summary, overemphasis on community-based management runs the risk of defining issues at one level instead of many (Cash et al., *in press*). Communities may be complex and embedded in further complexity due to intervening layers and external drivers, and because of the problem of fit between institution and ecosystem boundaries. It is difficult to find a resource management system that does not have some cross-level linkages and drivers at different levels, especially in a globalized world. The next section turns to a consideration of some marine commons cases to illustrate and expand upon these scale-related issues.

Fig. 1. A sketch of cross-scale governance, showing levels of political and social organization and levels of ecosystem organization. The social-ecological system represents the integrated system of people and resources. Adapted from the Millennium Ecosystem Assessment (MA 2003).



SCALE ISSUES IN COMMUNITY-BASED RESOURCE MANAGEMENT: SOME CASES

The recent theory of the commons is based on relatively simple, local-level cases, but even these simple cases may have complexities at the community-level and cross-scale linkages. The first example, a coastal resource management case from Cambodia, illustrates the consequences community heterogeneity, the role of drivers and learning in the evolution of management directions, and the kinds of cross-scale issues that may be seen in coastal commons. The second example, from Kerala, India, provides an illustration of a community-based system, which itself may have emerged because of drivers at other levels. It is a simple-looking, single-resource system; small in spatial scale that involves a relatively small number of homogeneous resource users, but one that has its origins in higher-level drivers.

The Cambodia example is from Koh Sralao, a coastal village near the Thailand border. The village has a large segment of newcomers, some 60% of the residents have been in the village for 10 yr or less; many of these are people displaced by civil turmoil or environmental disasters elsewhere in Cambodia, i.e., people in search of a better life. Both groups make their livelihoods from coastal resources: fish and shellfish production, processing and marketing, charcoal making, now illegal in the area, shrimp farming, now defunct because of disease, small-scale animal raising and gardening, and selling one's labor (Marschke and Nong 2003, Marschke and Berkes 2005).

The villagers have been successful in commodifying coastal resources for local and regional markets and for export to Thailand and Vietnam: charcoal from the once-abundant mangroves of the area, timber, shrimp, following the decline of neighboring Thai shrimp farms, mangrove oysters, and grouper fingerlings for mariculture in Thailand. In the early 2000s, villagers were heavily exploiting the swimming crab, *Portunus* sp., which was showing evidence of overharvesting, and two species of mud crabs, *Scylla* spp. The problem is that resources have been serially depleted over the years. For example, mangroves were depleted and charcoal production was declared illegal in 1987, but the ban was not consistently enforced until 1999. In the meantime, conflicts were developing between fishers and charcoal producers over the shrinking resource base, because mangrove ecosystems support fish and shellfish resources.

Although the livelihood activities of the two groups, i.e., the long-term residents and newcomers, were similar, their livelihood strategies and attitudes toward resource management differed, at least initially. For example, some fishers among the long-term residents had as many as eight or nine fishing methods at their disposal, whereas the newcomers typically pursued one or two activities such as setting crab traps for *Portunus.* The long-term residents tended to prefer a health mangrove ecosystem that supported a variety of resources; the newcomers tended to pursue commodity production. However, it was becoming obvious to even the newcomers that protecting the resource base was a worthwhile objective for all (Marschke and Nong 2003).

A village management committee was elected in Koh Sralao in 2000, initially to prevent illegal resource harvesting and for environmental education in general. With the assistance of a national government development organization (NGO), the committee interacted with provincial and national levels of government, as well as several government agencies that had jurisdiction over the mangrove ecosystem and the coastal area (Marschke and Nong 2003). Soon, the committee was able to mobilize villagers for mangrove replanting; they recruited former dynamite fishers to patrol dynamite fishing, and started taking proactive measures indicating lessons learned from previous resource depletion. For example, it established a reserve area to protect a key sea grass habitat for young groupers, before the resource was fished out (Marschke and Berkes 2005).

Having established a consensus within the village to reduce damaging activities and achieved some success locally, the committee found out that their local rules were insufficient to protect resources that were regional in scale. The mangrove area and coastal resources were used as a regional commons by several villages. When the Koh Sralao Committee in 2001-2002 took the measure of increasing the mesh size in swimming crab traps to allow the crabs to grow, many of the local fishers actually switched. However, within a year, they were back to using the smaller mesh size, because they found out that other fishers in the region were still using the smaller mesh sizes, making Koh Sralao's effort futile (Marschke and Berkes 2005). Thus, the Committee in Koh Sralao has discovered in its own way the scale challenges of ignorance, mismatch, and plurality as identified by Cash et al. (*in press*). The critical challenge is this case seems to be the inability of the community to impose its rules on other communities that share the regional resource.

The India case also illustrates some of the challenges related to scale in a community-based system that appear to have emerged as a response to certain external drivers. Southern India is home to a number of traditional community institutions for coastal resource management (Paul 2005). What have been called *padu* systems are found in Sri Lanka and the southern Indian states of Kerala and Tamil Nadu. These are lagoon and estuarine resource management systems, mainly for shrimp fisheries, characterized by the use rotational fishing spots allocated by lottery. They are species- and gear-specific, with rules to define fishing sites and rights holders, often according to social or caste groups (Lobe and Berkes 2004). Some *padu* systems in Sri Lanka go back to at least to the 18th and possibly the 15th centuries (Amarasinghe et al. 1997).

We investigated three community-based fisher associations, i.e., sanghams, in the Cochin estuary of Kerala, South India that use the *padu* system. The sanghams administered the rotational allocation of shrimp fishing spots, fished with stake nets that are rows of bag-like nets fixed to stakes driven into the ground. They operated under a set of well-defined rules serving livelihood, equity of access, and conflict resolution needs among their members.

As a commons institution, the *padu* system of the Cochin estuary only dates back from the late 1970s (Lobe and Berkes 2004). Tracing their origins showed that they arose out of two events. The first was the globalization of shrimp markets. Shrimp became "pink gold," as many small-scale fishers in South India abandoned other resources in pursuit of shrimp (Kurien 1992). The second factor was the centralization of fisheries management in Kerala. In 1967, the Kerala Fisheries Department started to institute a new licensing arrangement, replacing an older system of land and fishing site holdings. Beginning in 1974, state legislation required licenses for all fishers, but the state lacked the means to enforce the new law. Because shrimp fishing was lucrative and attracted new entrants, the resource effectively became open access, forcing the fishers to self-organize to consolidate what they considered to be their rights in a large and crowded estuary and lagoon system (Lobe and Berkes 2004).

Each *padu* association in the Cochin estuary dealt with the exclusion issue by limiting the access of nonmembers, and the subtractability issue through rules that provide for equity, social responsibility, and conflict management among its members. However, the Kerala State government does not recognize the three associations in the study area, nor does it license the fishers. They continue to fish only because of a 1978 court order establishing them "as fishers by profession" (Lobe and Berkes 2004), and ongoing state-level political action by their Dheevara caste organization to protect their rights (K. T. Thomson, *personal communication*).

The sanghams seem to be effective in dealing with the subtractability problem; they have well-defined and clear rules to regulate resource use among members. However, regarding the exclusion problem they are only partially effective. They control the stake nets that are in their rows of nets and have a say about who fishes them, including those that are leased out, but they have no control over the other fishers in the area. The three sanghams control only about one-half of the 289 stake nets owned locally, and that in turn is only a small fraction of some 13,000 stake nets used in the entire lagoon and estuary system.

In the heavily used estuary and lagoon system in Cochin, there appears to be no systematic data collection or stock assessment, but there is some enforcement of restrictive regulations. The lack of state recognition and mechanisms for cross-level coordination has limited the ability of the three sanghams in the Cochin estuary to contribute to management at the regional level. However, there is no effective regional-level management. Given the lack of resources in most developing countries, is it realistic to expect the management of such resources as used by *padu* systems of South Asia? There are, in fact, well-functioning *padu* systems with both local- and regional-level management, and they are found in the well-studied Negombo Lagoon of western Sri Lanka (Amarasinghe et al. 1997, Amarasinghe et al. 2002).

Figure 2 sketches the differences between these two lagoon management cases that use variations of the same *padu* system. Both are species- and gear-specific, with rules defining sites and rights holders, and both use a lottery-based, rotational use system for fishing sites. The differences are organizational. In Negombo, the fishers are organized at the community level through four rural fisheries societies (RFSs). They are subject to the rules made by each of the RFSs at the local level, and coordinated across the four RFSs at the regional level. This local control and regional coordination was made possible by the national government through the devolution of management authority to the RFSs and the Negombo (Kattudel) Fishing Regulations (Amarasinghe et al. 1997). By contrast, no effective cross-level linkages exist in the Cochin estuary and lagoon, even though the fishers are well organized at the community level and even though there is Kerala State legislation from 1995 that provides a directive to devolve resource management to municipal-level organizations.

The *padu* examples illustrate how external drivers related to economic development, i.e., international markets for shrimp, and resource management policies, i.e., state-level reorganization of fishing rights can affect community-based institutions. The *padu* systems of the Cochin area have their origins in ancient South Asian traditions of coastal resource use, but they are in fact the product of relatively recent economic and political transformations. Their existence is fragile because of a lack of state-level policies and government recognition.

One of these two *padu* systems has effectively addressed most of the major challenges related to scale (Cash et al., *in press*), but the other has not. The Sri Lanka case has solved the scale mismatch issue though cross-level governance from the local to the national, thus engaging in management at multiple scales, both politically and geographically (Amarasinghe et al. 1997). By contrast, the Kerala case has no cross-level governance, no intermediate-level institutions, and no arrangements between the community and the government. Thus, the problem of scale mismatch remains unresolved, issues are defined only at the local association level, and cross-level linkages are developed only weakly at the state government level through lobbying by caste organizations.

CROSS-SCALE ISSUES IN INTERNATIONAL COMMONS: AN ATLANTIC FISHERY CASE

Migratory marine resources create particularly difficult problems for community-based management and pose a multitude of scale mismatch problems. A given fish stock may be used by coastal and offshore fisheries, by small and large-scale

operations, and in some cases by more than one national jurisdiction. The movement of the stocks makes it very difficult to solve the problem of exclusion. Solving the subtractability problem is also very difficult. Rarely are there shared values, mutually agreed upon rules, local monitoring, and ways to enforce social sanctions among groups who use migratory stocks. Hence, the management of migratory marine resources creates fundamentally different commons problems, as compared to the management of stationary resources and community-based users, such as in the Cambodian and Sri Lankan cases.

These different problems require different management approaches, for example, regional harvest quotas coordinated and enforced by government, because local solutions alone would not likely be effective (McCay and Jentoft 1996). Migratory stocks that range over large ocean areas pose cooperation and enforcement problems that cannot be solved at the regional and national levels. Efforts to protect such resources, as with global commons in general, have usually depended on bilateral or multilateral international agreements that require voluntary cooperation among governments.

I illustrate these issues with a case study of tuna and tuna-like fishes of the Atlantic region, managed by the International Commission for the Conservation of Atlantic Tuna (ICCAT). I start with the scientific complexities and uncertainties in the management of Atlantic bluefin tuna (*Thunnus thynnus*), and continue with the management of a suite of large oceanic pelagic species that migrate through the Caribbean region and are fished by small island states and fishing communities of the region.

Until recent years, the ICCAT recognized two stocks or management units of Atlantic bluefin tuna, one in the west, and one in the east Atlantic, consistent with larval surveys indicating two major breeding grounds: the Gulf of Mexico and the Mediterranean Sea. There has been a sharp decline in the abundance of the western Atlantic bluefin since the 1970s. In 1982, the ICCAT began setting an annual catch limit to try to conserve the stock, but it took nearly another decade before the tuna biomass stabilized (Magnusson et al. 2001). In the meantime, using new and more sophisticated tagging techniques, international researchers found that the two stocks were not discrete as previously thought. Western-tagged bluefin tuna were found to make transatlantic migrations, causing a mixing of stocks in the two feeding grounds (Block et al. 2001).

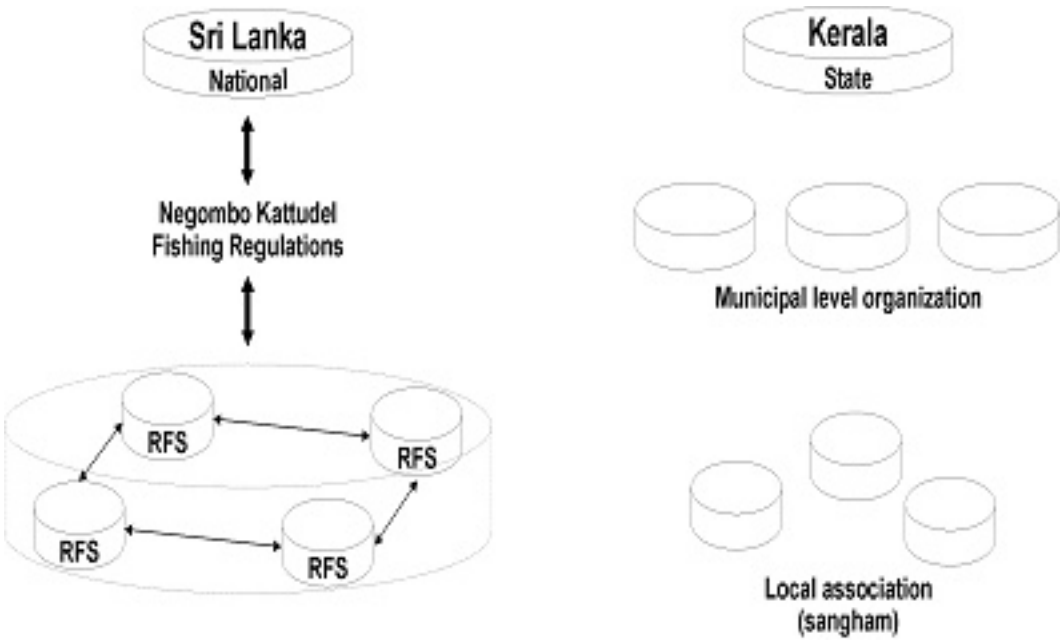
The tuna case is significant in illustrating some characteristic management directions used for international marine resources. The community level or even the national level does not match the geographical scale of migratory tuna. Therefore, an international agreement becomes necessary to solve the scale mismatch problem. Once the international management agency is set up, it relies on progressively more sophisticated technical research such as new ways of investigating migration patterns, and may become increasingly more distant from the realities of fishing communities.

Quotas are set and adjusted according to the status of the resource and the scientific information available in the judgment of technical personnel. However, resource management science rarely provides a once-and-for-all answer. Instead of providing clarity, new research may suggest additional complexities to which cross-scale management must then adjust. Nevertheless, not all these efforts may be sufficient for conservation in the face of multiple jurisdictions, possible noncompliance, and remaining scientific uncertainty.

The ICCAT, a multilateral agency, relies on "big science" to set quotas and protect the resource, but only with the full agreement of the participating nations. These nations, in turn, need to enforce the international rules on their fishing industry. When local perceptions of resource availability and sustainability are at odds with the international view, the stage is set for potential conflicts. Uncertainties in migration and other biological characteristics of the tuna create further management problems, pitting nation against nation, and perhaps scientist against scientist. Because it is an offshore resource, monitoring is difficult. Furthermore, economic stakes are high; bluefin tuna is a very high-priced commodity for sushi and sashimi and has a globalized market.

Bluefin tuna is not the only species managed by the ICCAT. Some 30 species of tunas and tuna-like species of the Atlantic Ocean and adjacent seas, including the Caribbean, are under the ICCAT mandate. A number of species, deemed to be overfished, have been coming under new conservation measures by the ICCAT through annual total allowable catch (TAC) limits. In

Fig. 2. Cross-scale governance in lagoon shrimp management cases in Sri Lanka and Kerala, India. Note the absence of arrows in the Kerala case.



addition to the bluefin tuna, TAC controls apply to several other tuna and billfish stocks, including swordfish (*Xiphias gladius*). These stocks are fished by a number of countries, including distant-water fleets. The major players include the United States and the European Union, both of which are members of the ICCAT. The Caribbean Community (CARICOM) is an observer on the ICCAT and represents the small island nation states of the region. A new agency, the Caribbean Regional Fisheries Mechanism (CRFM), replaces the CARICOM Fisheries Unit (CFU), and it networks with all the fisheries stakeholders in the Caribbean (Haughton et al. 2004).

The ICCAT allocates the TAC in catch quotas based solely on historical harvests. This puts the CARICOM countries at a disadvantage, because their fleets have been small-scale and have only recently expanded into the long-line fishery for large pelagic species (Chakalall et al. 1998). Internationally accepted catch allocation criteria include other considerations as well, including socioeconomic criteria such as the interests of small-scale coastal fisheries and the needs of coastal communities. The dominant discourse for decision making at the ICCAT is based on biological and technical considerations and uses historical data for allocations. Caribbean scientists do not dispute the scientific data, but point out that an alternative discourse could use socioeconomic criteria in addition to science (Singh-Renton et al. 2003).

The study of the community-based fishery in Gouyave on the small island state of Grenada, a CARICOM member, is used to illustrate the issue (Grant and Berkes 2004, Grant and Rennie 2005). Gouyave has one of the larger operations of small-scale long-line fisheries in the region. Although this long-line fishery dates back only from the late 1970s, there is a tradition of fishing large pelagic species by handline. The main species in the community harvest are yellowfin tuna *(Thunnus albacares)* for the export market, Atlantic sailfish, locally called "ocean gar" (*Istiophorus albicans*) for the local market, and a variety of small tunas, marlins, and swordfish.

From the point of view of the fishing community in Gouyave, its fishery is too small to impact

international stocks. However, at the same time, the Grenada fishery is vulnerable to powerful international players. It has grudgingly accepted to stay out of the swordfish fishery, mainly by setting long-lines in ways that avoid the species. Community opinion is still brewing with respect to possible TAC limits on marlins. However, in the case of possible TAC limits on sailfish, or ocean gar, it draws the line since this species is locally important for both food and income.

As Singh-Renton et al. (2003) have argued that the ICCAT needs to be persuaded that top-down enforcement is unlikely to be effective for small-scale fisheries, requiring a focus on community-based management instead. What are the prospects for such community-based, cross-scale management? Figure 3 maps out the linkages across four levels of management in the case study. The CARICOM Fisheries communicates effectively with the member countries such as Grenada and St. Vincent and the Grenadines, and it passes along information from the ICCAT regarding management measures. In turn, the Grenada Fisheries Division informs the fishing industry. Fishing communities such as Gouyave are organized internally, but lack a consistent voice through well-established associations; this creates a weak link between the national and the community levels. Within the fishing communities in Grenada, there are often groups of fishers who do not communicate well with one another. Overall, top-down information flow is effective for the most part, but bottom-up flow is poor or nonexistent (Grant and Berkes 2004).

All three scale challenges (Cash et al., *in press*) are illustrated by the case. The mismatch between scales of human systems and scales of natural systems is addressed by scaling-up to establish an international agency, the ICCAT. This agency has the potential to deal with issues at multiple levels, but it is constrained by the weak vertical linkages from the bottom up. In effect, the domination of the ICCAT by large, powerful nations and by big science creates a tendency to define issues predominantly at one level, i.e., the largest ecological level. There are scientific uncertainties about the resource, but the challenge of ignorance is not an issue. However, more problematic is the plurality challenge. Defining issues predominantly at the international level works to the detriment of small Caribbean nation states and fishing communities. The local fishers see the international level as insensitive to their needs unresponsive to their voices, creating a potential enforcement problem as more species are added to the restricted list.

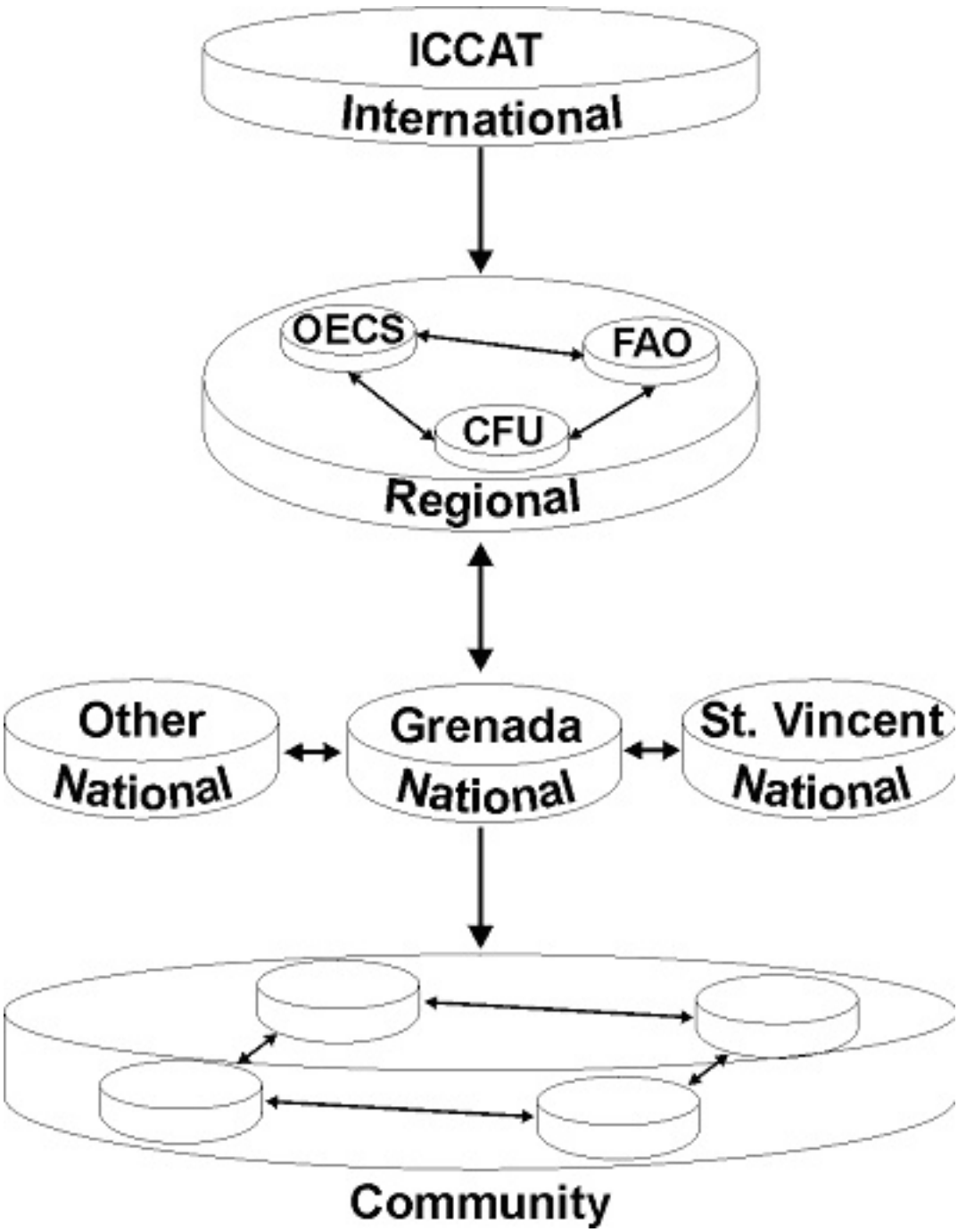
CONCLUSIONS

Commons thinking has been evolving to deal with the complexities of resource problems, turning to the examination of scale, self-organization, uncertainty, and resilience, all of which are concepts of complex adaptive systems (Gunderson and Holling 2002). Commons research has evolved through the critique of the "tragedy of the commons" model used "to paint a disempowering, pessimistic vision of the human prospect," and to rationalize central government control or privatization of all commons (Ostrom et al. 1999:278). Studies over the past 30 yr have documented, in considerable detail, the self-organization and self-regulation capability of communities to solve the exclusion and subtractability problems of the commons.

However, research has also shown that community-based resource management is vulnerable to external drivers and is often insufficient by itself to deal, for example, with problems of migratory marine resources. As the examples in this paper indicate, cross-level issues are pervasive in commons management. The marine commons cases considered here illustrate many of the scale challenges of ignorance, mismatch, and plurality (Cash et al., *in press*). However, all three cases, Cambodia, Kerala, and Sri Lanka, and the ICCAT Caribbean, show various degrees of recognition of the scale problem.

Hence, the challenge of scale ignorance is not the dominant issue. The ICCAT does not respond to the livelihood problems of Gouyave fishers and the Government of Kerala seems unwilling or unable to set up regional level management, but nevertheless, most actors in the cases considered recognize scale and level interactions. Similarly, mismatch problems are addressed, although with mixed success. All three cases grapple with the tendency to define issues at only one scale. In Cambodia, Kerala, and Sri Lanka, the local level is the focus of management, whereas in the ICCAT Caribbean, focus is the level. The other levels are present but not effectively engaged, except in the Sri Lanka case. The Kerala case is unusual in that it lacks even an attempt at forging vertical institutional linkages.

Fig. 3. Cross-scale governance in the Caribbean tuna management case. ICCAT=International Commission for the Conservation of Atlantic Tuna, CFU=CARICOM Fisheries Unit (now replaced by CRFM), CARICOM=The Caribbean Community, OECS=Organization of Eastern Caribbean States, FAO=Food and Agricultural Organization of the United Nations (Regional Office, Barbados).



The challenge of plurality is pervasive, and resources are contested by multiple actors in each case. Kerala is the most crowded and contentious case, and it is possible that the lack of institutional solutions is related to the pessimism of the actors that win-win solutions are possible. Commons theory holds that solving the subtractability problem depends, among others, on the users having workable relations for monitoring, sanctioning, and conflict resolution (Ostrom 1990). The ICCAT Caribbean case provides a striking example of an asymmetrical relationship. Regional and international science is filtering down the levels (Fig. 3), but fisher's knowledge and values are not being heard. The mismatch in this case is about scale of management; the dispute is about equity and fairness. What is at odds is the management discourse of the politically powerful countries vs. the Caribbean nation states (Singh-Renton et al. 2003), reaffirming the socially constructed nature of knowledge (Lebel et al. 2005, Adger et al. 2006).

There are a number of implications of these findings for the scaling-up debate (Ostrom et al. 1999, Young 2002). Can the findings of small-scale, community-based commons be scaled-up to generalize about regional and global commons? It may be more illuminating to approach the debate by suggesting that commons management in many cases should be understood as the management of complex adaptive systems, rather than merely a question of the transferability of community-level findings to the global level.

Starting from this point of view, the results of this paper do not support Young's (2002:152-153) contention that self-regulation may suffice to solve the tragedy of the commons at the local level, but that at the global level, regulation is a two-step process involving those who formulate the rules and those who are subject to them. First, none of the cases show that self-regulation alone is sufficient to solve the commons problem at the local level. Second, there are no cases that show such a two-step process; all cases include multiple levels and none of them shows a pure community-based case in which people who formulate the rules are those who are subject to them. These considerations indicate that, when multiple levels are involved, the emphasis of the inquiry should shift from the question of scaling-up to understanding linkages, their nature, and dynamics.

The study of cross-scale institutions such as co-management agencies, boundary organizations, and epistemic communities is important because these institutions provide a means to bridge the divide between processes taking place at different levels. In effect, they provide ways to deal with linkages in complex adaptive systems. Examining horizontal and vertical linkages, analyzing polycentric systems (McGinnis 2000), and dealing with policy networks (Carlsson 2000) are among the various means to understand the nature and dynamics of cross-level linkages and governance in general (Lebel et al. 2006).

Commons theory can provide insights into the solution of regional and global commons problems by looking beyond the community-based resource management paradigm, toward commons governance in complex systems (Dietz et al. 2003, Berkes et al. 2003). Communities, which themselves may be complex systems, are embedded politically and economically in larger complex systems. They respond to a range of drivers of change such as markets, central government policies, and international economic policies. The community level is important as the starting point for the solution of the tragedy of the commons (Berkes 1989, Ostrom et al. 2002). However, higher levels of organization are also important in providing monitoring, assessment, enforcement, and fostering local management. The importance of institutions that straddle levels and provide incentives for sustainability is increasingly recognized in marine resource management (Hilborn et al. 2005) and environmental management in general (Adger et al. 2003). All types of commons governance seem to start from the ground up and deal with cross-scale linkages in a complex systems context.

Responses to this article can be read online at:
http://www.ecologyandsociety.org/vol11/iss1/art45/responses/

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