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Indicators as a means of communicating knowledge

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Indicators represent the link between objectives and action in management. The identification of ecosystem indicators must therefore be embedded in the decision-making process. Fisheries management can only be effective if the measures are considered legitimate by stakeholders. The choice of indicators to guide management should not be evaluated from a technical perspective alone, but also in relation to their effectiveness in communicating knowledge. More specifically, indicators should serve as a communication bridge between different knowledge discourses. Reference is often made to "local ecological knowledge" as a source that should be integrated in the process for management to be legitimate. However, while extensive studies have been made on local ecological knowledge *per se*, few have addressed the issue of its integration into co-management institutions with research-based knowledge. The challenge is consequently to identify indicators that have both research-based validity and reflect features that correspond to stakeholder knowledge, while relating to shared understandings of objectives and actions. This challenge is discussed from a developing-countries perspective. Problems and possible ways forward are illustrated on the basis of experiences from a range of case studies of knowledge discourses regarding living aquatic resources in southeast Asia and southern Africa. The studies have shown that the different knowledge discourses, and candidate indicators therein, relating to a specific ecosystem may be identified and characterized. Often, however, such indicators will have very little in common across knowledge discourses, and the differences cannot be overcome through a simple translation process. The perspectives of formal research-based knowledge and of fishers differ systemically, reflecting the different interests and scales of observation between the two parties. Also, fishers focus on a wider agenda than research alone, on allocation problems and conflicts among users. Allocation/access issues must therefore be addressed as an integral aspect of an ecosystem approach if management is to be effective.

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Introduction

An expansion of the scope for fisheries management to include extended ecosystem considerations implies extensive changes in management institutions. Changes are required because of the normative changes implied: a changed set of objectives will implicitly cater to the interests of an expanded set of stakeholders, or will balance the interests differently. Changes are also required because the knowledge base is changing: management with an expanded scope will have to deal with new issues and with more complexity and uncertainty in terms of knowledge, decision-making, and implementation.

Following Scott (1995), "institutions consist of cognitive, normative, and regulative structures and activities that provide stability and meaning to social behaviour". Several studies have revealed that management institutions that do not address the cognitive, normative, and regulatory aspects in an integrated way will have little chance of achieving their objectives (Wilson *et al.*, 2003; Nielsen *et al.*, 2004). Those studies have highlighted the fact that institutions that are not considered legitimate by those having to comply with the measures taken will either have little impact because the measures are circumvented, or will need to invest heavily in top-down policing to be effective. If fishers disagree with the normative aspects (such as objectives) of management, or have perceptions that differ from the cognitive base used for management decisions (such as research-based stock assessment, and projections of stock size and yields), one should not expect voluntary

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compliance with the regulative measures or even with the objectives being achieved.

The expansion of issues to be addressed as a consequence of an ecosystem approach to fisheries management does not resolve the problem, but rather impedes it further by expanding the set of objectives and by opening a request for even more complex knowledge to support management decisions. The introduction of an ecosystem approach therefore implies changed cognitive, normative, and regulative structures. The real challenge is to develop institutional change that maintains or expands the legitimacy of management and keeps the costs from skyrocketing. Existing management institutions may initially be seen as the carriers for implementing such an approach, but they must change in the process if management is to maintain (or develop) legitimacy, efficiency, and efficacy. The question is, how they must change, and to what degree.

This question is addressed here by focusing on the cognitive implications of the call for an ecosystem approach, and specifically on the role of ecosystem indicators in management institutions. The reasoning is based on the assumption that involvement of users of the resource system is necessary if the approach is to be at least as effective as management systems implemented so far. This may seem a modest ambition, but the basic argument that will be made is that the addition of more complexity will require stronger incentives for compliance just to maintain the former level of efficiency. The focus is therefore on the relevance of various forms of knowledge to users, and how knowledge is communicated in the management institutions. The term "user" is used throughout to designate all those directly and indirectly concerned with the resource system, including fishers, traders, dependent industries and citizens, and organizations with a recreation or conservation interest in the ecosystem. The institutional aspects of user participation in fisheries management have been developed largely within the context of co-management since the late 1980s (Wilson *et al.*, 2003). Conclusions regarding the conditions for the identification of knowledge that may be considered a common ground for use in co-management institutions are presented on the basis of case studies from southeast Asia and southern Africa.

Knowledge in management institutions

The normative, cognitive, and regulatory pillars of fisheries management institutions are mirrored in the statement that indicators are the bridge between objectives and actions (FAO, 2003). Ecosystem indicators represent the cognitive element for an ecosystem approach, but they are only useful if they relate to objectives and can guide actions. Objectives should be agreed-upon by the users, and the choice of relevant actions will depend largely on the capacity of the management institution itself in terms of physical and human resources, and its legitimacy to those affected by the actions. Indicators can therefore not be defined on a natural-science base alone, but must be agreed by users as being relevant to both objectives and actions. Indeed, the failure of many attempts to involve users in co-management systems in Africa and Asia can be associated with the fact that user participation was invited only to implementation issues, not to normative or cognitive issues (Nielsen *et al.*, 2004). This observation is the basis of that published critique from a democratic perspective. The authors distinguished between types of management implementation on the basis of the scope for user participation: "modern management" exercises top-down control in terms of definition of objectives, identification of knowledge, and implementation, and has been the prevailing model in industrialized countries; "instrumental co-management" involves users in solving implementation aspects; and "empowering co-management" involves user participation in all three aspects. From a democratic perspective, it can be argued that instrumental co-management merely serves as a means to achieve legitimacy and compliance, without giving up control over the central management issues.

There may, however, also be less sinister reasons for not inviting users' knowledge in a co-management arrangement: to include this type of knowledge formally is no trivial task, even if there is agreement to do so. The common ground of empirical user knowledge and the research-based knowledge underlying modern management decisions may be difficult to identify, and even if it can be identified, it may not provide useful guidance to decision-making. In some cases, the gap may be bridged by different presentations of the same problem. Gasteyer and Flora (2000) provide a good example of monitoring water quality both through laboratory tests and through an annual public event, during which the mayor measured turbidity by the distance he had to walk into the river before his white tennis shoes could no longer be seen. However, the situation in fisheries management is generally more complex (Neis and Felt, 2000). The perceptions of fishers are often incompatible with those of researchers, because the two forms of knowledge are acquired through different practices, one driven by the immediate incentive to catch fish (so focusing on local-scale availability), the other addressing longer-term productivity of the population or ecosystem on the basis of larger scale observations with lower resolution. Differences in perception therefore relate to the different temporal and spatial scales on which managers/scientists and fishers view the problem (Degnbol, 2003). The discourses often have very little in common, which leads to contradicting and incompatible views when presented during public debate or in management institutions.

Bridging this knowledge gap is not just an issue of better communication, but rather involves a complex process of developing mutual understanding and trust. A modest but more realistic objective may be to base management decisions on the identification of what is the common ground, without attempting to mediate among users holding fundamentally different views. The common ground may cover reflections on identical features of the resource system that, although represented differently, can be translated across users. For instance, fishers may see changes in the geographical extent of fishing grounds, which in the research domain may translate into changes in overall abundance of populations with a patchy spatial distribution. Such a process requires that a shared understanding of the resource system is not only identified but also translated into mutually agreed indicators providing at least the direction for management action. Such translation is not trivial.

Different approaches to the use of knowledge

The approach to knowledge use is often characterized by some requirement for quantifiable predictability. All variants of TAC-based systems are founded on the assumption that landings are linked to impact, and that catches in relation to specific objectives regarding impact can be predicted. This approach is closely linked to single-species stock assessment, and has often developed into increasingly complex micromanagement, with new regulations accumulating as the shortcomings of the TAC approach are revealed or new issues emerge. It becomes increasingly apparent that the predictability requirement cannot be met even within the limited scope of single-stock management without considering extended ecosystem impacts (Wilson *et al.*, 1994). Major uncertainties related to the biological system itself are recruitment variability and stock distribution, but the adaptation of fishing fleets to new regulatory measures and implementation failures are also important sources of uncertainty in the linkage between regulations and outcomes.

An approach assuming hard predictability is closely associated with a specific form of knowledge production and a specific selection of what is considered valid knowledge. Quantitative predictions are produced as mandated research (Salter, 1988) in specialized organizations that may be largely detached from other responsibilities of the management institution. This leads to exclusion of other knowledge, such as exists among fishers and NGOs. The resulting conflicts have important institutional implications: if the knowledge base cannot be shared and mechanisms to mediate between these different sources fail, management decisions may ultimately have less or no legitimacy. This type of problem is associated with both modern management and instrumental management systems.

An ecosystem approach to fisheries cannot be based realistically on extending the hard predictability requirement even further. Not only is it impossible to trace all interactions in an ecosystem and to predict and quantify all effects of specific management measures. New concerns of new stakeholders must also be taken on board as the concept of users is expanded from those with an immediate economic interest in the resources to groups with a recreation or conservation interest in populations of fish and their environment. The limitations to the hard predictability approach are ultimately economic. The costs of research and implementation explode and sooner or later become prohibitive, if the requirements for understanding, precision, and implementation efficiency are to be maintained while the complexity of issues to be addressed increases and a larger group of users with diverse interests are to be accommodated in the management institution.

An intermediate solution would be to maintain but soften the predictability requirement by addressing specific ecosystem issues separately, and to base management on a comprehensive but restricted set of indicators of pressures, states, and impacts covering a range of important issues, without necessarily attempting to quantify outcomes of management actions in each case. This approach is based on assumptions about the processes linking pressures (e.g. exploiting forage fish) on an aspect of the system (breeding success of seabirds dependent on the same prey), with the resulting impacts and state (population size of seabirds). It is also based on assumptions about the mechanisms through which regulatory measures (reduction in fishing effort close to seabird colonies during the breeding season) can modify the pressures and therefore the states. This model has been used in developing the drivers-pressure-impact-state-response (DPSIR) system for environmental management (OECD, 1993), and the closure of sandeel fisheries close to Scottish seabird colonies (ICES, 2003) is a good example. Within such a framework, predictions provide the direction of likely outcomes regarding the issues of interest, but should not be used as quantitative estimates obtained with great precision. Also, because separate issues are not necessarily addressed in a connected way, there is no requirement to understand all linkages in the system. On an institutional level, this approach represents extensions of the existing mode: understanding and tracking of specific processes linking pressure and outcome is still required, the knowledge base is still comprehensive and complex, and produced in specialized research organizations. However, the hard predictability requirement no longer precludes inclusion of other types of knowledge. Such a system is subject to development into patchwork management, in which new indicators and associated regulations are developed *ad hoc* and added according to the interests and influences of different users. Consequently, there is a potential for inconsistency when various issues are addressed in what appears to be an *ad hoc* manner.

Another solution may be to give up the requirement of comprehensive causal understanding altogether, and to focus on the overall pressures on the resource system and to guide management by meta-indicators that reflect their overall impacts. This may be possible because many types of fishery impacts are strongly correlated (ICES, 2002). High exploitation rates lead simultaneously to a great probability of reducing target species below sustainable levels, of reducing populations of non-target species through bycatches, of measurable impact on bottom fauna or sensitive habitats, of increased competition with top predators, etc.

Two implementation mechanisms have been suggested on the basis of overall pressures rather than detailed mapping of linkages:

(i) Effective reduction of overall effort to sustainable levels. To achieve it, capacity control may be required, because the presence of idle vessels causes continuous pressures on the management system to increase effort. Clearly, effort reduction addresses many environmental concerns simultaneously (NRC, 1999; ICES, 2000; FAO, 2001).

(ii) Seasonally or permanently closed marine protected areas (MPAs). Closing areas for fishing has been claimed to be an important tool to make fisheries management more effective (reviews by Roberts and Hawkins, 2000; Salm *et al.*, 2000). Although MPAs may also serve specific purposes (protection of sensitive habitat, spawning grounds, etc.), the relevant argument here is that they serve as refuges for a cross-section of marine life, which should ultimately limit the possible impact.

If management were to be based largely on such generalized measures, overall impact would still have to be monitored through a set of meta-indicators that synthesize the overall state of the system. Such meta-indicators might include abundance indices of sensitive species, proportion of mature individuals in critical populations, or ecosystem metrics such as size composition or average trophic level of catch (ICES, 2002). Overall pressure control, monitored through meta-indicators, can only be implemented within an adaptive management framework, because the lack of *a priori* understanding of the underlying processes prohibits the prediction of the long-term impact of specific fishing activities. The knowledge base must be developed through adaptive learning.

One of the major challenges to such an approach is to reach consensus on relevant meta-indicators and reference points or reference directions (Jennings and Dulvy, 2005) for them, because they provide the direction of action required. Such consensus cannot be reached on a natural-science base alone, and evidently requires negotiation among users to reach an acceptable compromise. Management targets must always be identified through negotiation and acceptable risk levels in relation to "serious or irreversible harm" (UN, 1992), and must be decided through negotiation too. In contrast to a patchwork management approach, conflicting interests must be reconciled beforehand, and users must agree on both meta-indicators and their implications in terms of management measures, because they no longer relate to specific issues, but to all issues simultaneously. The technical basis for indicators cannot be discussed independently of the balance between objectives, because indicators integrate objectives, and their selection implies specific choices of the balance between the objectives.

Another set of problems relates to global comparisons of management systems as required by international agreements such as the World Summit on Sustainable Development (UN, 2002) or by market forces requesting green labelling. Indicators that are considered meaningful locally by users are often system-specific and may not fit a global set of indicators (Degnbol and Jarre, 2004). This problem may be resolved by developing agreed procedures and criteria for comparative evaluations, rather than by comparing systems directly on the basis of a unified set of indicators.

Case studies

Approaches to identifying the common ground between users' perception and research-based knowledge have been studied in the research project "Knowledge in Fisheries Management" (KNOWFISH), involving seven different cases in southeast Asia and southern Africa. The project addressed the need to develop new types of knowledge that are appropriate for dealing with the complexity of tropical aquatic ecosystems and that build upon procedures already accepted by management institutions in developing countries, and that are both scientifically valid and widely acceptable to users. Local ecological knowledge was identified through interviewing stakeholders using means such as drawing maps and timelines. Statements about the ecosystem and their resources were then evaluated to identify the knowledge that had validity from both a research and user perspective. Indicators relating to shared knowledge might be used as the basis for decisions in a co-management institution.

The types of candidate indicators that emerged differed widely among the seven cases. They were generally case specific. Sometimes, environmental drivers were emphasized, especially in relation to freshwater systems. Also the types of conflicts involved differed. In most cases conflicts had arisen among different fisher groups, but sometimes other users were involved (such as between fishers and dam-builders regarding the use of riverine resources on the Mekong River in Laos). The extent of local ecological knowledge differed markedly. In some cases, being a fisher is only a temporary occupation, and the high turnover has implications for the accumulation of local knowledge and results in limited historical perspective.

A recurrent observation was that local ecological knowledge is linked directly to the problems users are facing. Long-term sustainability may be an issue, but allocation issues, conflicts among user groups, and environmental degradation are positioned prominently in the knowledge landscape. This observation highlights another issue regarding the selection of indicators to serve management decisions: they must relate to local agendas if they are to be meaningful to the stakeholders. From a user perspective, the most important knowledge relates to the means of addressing allocation, if the major concern, as is often the case, is allocation of access among users. This means that the search for solutions to the problem of adding complexity, and thus to the search for multiple supplementary indicators, is further obstructed.

The general experience across cases has been that local knowledge does not relate to research-based knowledge in a simple manner. Rather, observations made elsewhere that a major difference relates to scale were confirmed: local knowledge relates to much smaller space and time scales than the type of research-based knowledge usually generated for fisheries management. Consequently, user statements may not be verifiable from a research perspective because of lack of data (or lack of understanding of the processes operating) on a comparable level of resolution.

Also, local knowledge is not expressed in terms that relate directly to indicators in the research-based sense. The case studies produced a plethora of examples of specific statements about local phenomena that could not be related to overall resource conditions or ecosystem health. One important reason is that statements about nature relate to processes and phenomena that are important in the context of daily fishing operations. They may reflect local abundance of commercially attractive resources, but may not relate to overall productivity or overall changes in species and/or size composition. Another reason is that changes in fishing practices obscure the temporal perspective of ecosystem change (e.g. changes in gear composition and in mesh size used have been normal in some lakes). A third reason is that local knowledge often does not have a time perspective sufficiently long enough to avoid the shifting baseline syndrome. For instance, scientific data demonstrate that the larger cichlids in Lake Mweru (Zambia) were depleted 20 years ago, but fishers consider the present situation as normal.

Overall, the discrepancies between local ecological knowledge and research-based knowledge were much larger and more systematic in most cases than, maybe naively, had been assumed at the start of the project.

Conclusions

The case studies highlighted the urgency, and also the difficulties involved, in identifying a common knowledge ground that might be utilized to guide management decisions. The results also show that indicators that fulfil the criteria of both scientific validity and legitimacy as perceived by the users tend to be system-specific, and may not be compared across systems. User perceptions focus on local allocation issues at least as much as on longer-term sustainability issues. Consequently, to be legitimate to users, management institutions must address allocation and sustainability in an integrated manner, and indicators should inform decisions on both aspects. The challenge to select meaningful indicators to guide management decisions therefore involves the identification of a common ground between users' and research-based knowledge, which relates to shared objectives and actions and which addresses both allocation and longer-term sustainability. This requires a multidisciplinary approach to both research and implementation, to support management institutions.

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