The ecosystem approach and fisheries management institutions: the noble art of addressing complexity and uncertainty with all onboard and on a budget.

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Abstract:

The inclusion of ecosystem considerations in fisheries management implies two changes with extensive institutional repercussions: the uncertainties about states and outcomes rise dramatically and a multiplicity of new stakeholders, interests and objectives must be accommodated in the management institutions. The first change may potentially add immense costs to the management process while the latter may undermine legitimacy if the institutional repercussions of these changes are not taken care of from the outset. This paper discusses the institutional requirements of various models of ecosystem approaches to fisheries management. The paper sets out reviewing the models for ecosystem approach integration in fisheries management which are emerging in the debate. The three basic – not mutually exclusive - models discussed are 1) an extension of the present fisheries management paradigm with a requirement for quantified predictability, 2) an approach based on a comprehensive set of structured indicators, 3) an approach based on metaindicators and implementing regulation of overall pressure such as marine protected areas or capacity reduction supplemented by technical measures. These models are then evaluated in terms of their knowledge requirements, implementation costs and to which extent they are likely to enable participation. The evaluation of knowledge requirements discusses data requirements, requirements for institutional capacity to produce knowledge, model and data uncertainties and the costs of producing knowledge. The evaluation of implementation costs discusses requirements for MCS for the various approaches. The evaluation of participatory potentials discusses the discourse basis of the various approaches, to which extent objectives and knowledge are or can be shared, the institutional requirements for participation in the various approaches and implementation issues related to participation.

Keywords: fisheries management, ecosystem approach, institutions, participation, cost-efficiency, knowledge, indicators

1 INTRODUCTION

Fisheries management decisions have always been facing uncertainty. An expansion of the scope for management to include extended ecosystem considerations will increase the uncertainty about the present state, appropriate reference points and expected outcomes dramatically. When the multiple interests of new stakeholders and the need for fisheries management to be both legitimate, effective and efficient are added it is clear that the introduction of ecosystem considerations will put considerable strain on fisheries management institutions, even to the point that they must change fundamentally.

The call for ecosystem based approaches to fisheries management follows other, similarly far-reaching calls for changes in the basic approaches of fisheries management such as integrated cross-sectoral approaches, the precautionary approach and including participation from a wide range of stake holders. These approaches are interlinked but they are also accumulative in terms of their requirement for increased institutional capacity to define objectives, produce and evaluate knowledge and implement management.

Renovating management institutions has implications. Changes are required because of the normative changes implied - a changed set of objectives will implicitly cater for the interests of a different set of stakeholders or will balance the interests differently. Changes are also required because the knowledge base is changing - a management with an expanded scope will have to deal with more complexity and uncertainty both in terms of knowledge, decision making and implementation. Changes will ultimately come about one way or another for economic reasons. The costs to produce knowledge and to implement management explode if the requirement for understanding, precision and implementation efficiency is to be maintained while the complexity of issues to be addressed increases and a larger group of stakeholders with diverse interests are to be accommodated in the management institution.

Following Scott (1995) 'institutions consist of cognitive, normative and regulative structures and activities that provide stability and meaning to social behaviour'. The expansion of issues to be addressed implies changed cognitive, normative and regulative structures. The real challenge is to develop institutional change which maintains or expands the legitimacy of management and keeps the costs of management from skyrocketing while management addresses more complex issues. Existing fisheries management institutions may initially be seen as the mechanisms for implementing ecosystem based management but these institutions 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 which degree. We will address this question by investigating the normative, cognitive and regulatory implications of the call for ecosystem based management.

2 THE OBJECTIVES FOR ECOSYSTEM APPROACHES TO FISHERIES MANAGEMENT: UNCLEAR CONCEPTS REFLECT UNRESOLVED CONFLICTS

The debate about what has now been assigned the standard term 'ecosystem-based management' (EBM) was initiated from a natural science perspective and has so far mainly centred around the natural science issues involved in such management. The literature about the ecosystem effects of fisheries has developed dramatically over the last decade and has now matured to the degree that comprehensive reviews are produced just to keep track of the knowledge (The ICES/SCOR Symposium on Ecosystems Effects of Fishing 1999 (Gislasson et al 2000), Hall 1999, Kaiser and deGroot 2001). Major research programmes have been dedicated to produce an understanding of the ecosystem effects of fishing including projects within the European research framework (such as Lindebom and de Groot 1998) and the Sea Around Us project (http://data.fisheries.ubc.ca/saup/). The discussion has proceeded to the next step, to develop an advisory basis for management such as reference points and indicators (the ICES Working Group on Ecosystem Effects of Fishing (ICES 2001a), the Ecosystem Quality Objectives of OSPAR (Anon 1998, 1999), and the SCOR working group on Ecosystem indicators). These developments have however largely taken place within the natural science domain. It has within this debate largely been ignored that the knowledge base for management is an integral part of management institutions and therefore must be congruent with the overall institutional setup. This is in line with the dominating (self)understanding of the role of science within mandated fisheries research organisations – that scientific advice for management is system-neutral, independent and external to management institutions and that researchers are not stakeholders in fisheries management. The shortcoming of this understanding comes into the open in the discussions about reference points: a reference point connects management action and outcomes; the reference point is the yardstick by which it is measured whether management has achieved its objectives and which indicates the direction for future management action. Attempts to identify reference points on a non-normative basis, independently of management objectives, are therefore futile. This problem is amplified in the case of ecosystem based management which relates to multiple and conflicting objectives.

The discussion of the institutional implications is now emerging. Institutional aspects were the main focus for the Report to (USA) Congress of the Ecosystem Principles Advisory Panel (Ecosystem Principles Advisory Panel 1999). This report includes an early attempt to identify a possible link between research based knowledge to ecosystem based management decisions, mainly through its recommendation that each fisheries council should develop Fisheries Ecosystem Plans with a specified scope and content. Institutional implications were further discussed at the Reykjavik Conference on Responsible Fisheries in the Marine Ecosystem (FAO 2001, Sissenwine and Mace 2001 and other presentations at the conference) and the WWF has published a very comprehensive discussion of experiences and operational guidelines (WWF 2002). These contributions are still preliminary in their indications as there are very few experiences on which an analysis can be based. They share an emphasis on participatory approaches and on recommending some use of spatial zonation as an important regulatory tool to reduce overall impact or protect sensitive habitats.

In the policy domain the call for ecosystem considerations to be integrated into fisheries management has become commonplace in international and national policy statements regarding fisheries through the last decade, largely inspired and informed by the natural science debate on the ecosystem effects of fisheries. Different variants of phrasing have been used including 'biodiversity of aquatic habitats and ecosystems is conserved and endangered species are protected' (FAO Code of conduct 1995), 'taking into account the biological constraints with due respect for the marine eco-system' (EU Common Fisheries Policy 1993), 'Maintain ecosystem health and sustainability' (Ecosystem Principles Advisory Panel (US) 1999) and 'protection of the biodiversity and the integration of environmental protection requirements into the CFP' (European Commissions Green Paper on the CFP 2001). These policy statements all share a weakness when it comes to the precision of concepts used and their specifications for oparationalisation of the intentions. It is not clear from these documents whether the differences of wording like 'taking account' and 'maintain ecosystem health' reflect an intention of real distinction between different priorities. A requirement to take account may seem to refer to an extra priority within and subsumed to existing fisheries management objectives while maintenance of health may refer to a priority to ecosystem based objectives separate from and beyond fisheries objectives.

The lack of clarity regarding the relative priorities reflects a basic distinction line in all environmental debates and management including fisheries management – whether ecosystems should be protected and conserved due to their intrinsic value in their own right or due to their utility value for human societies. The lack of clarification regarding intrinsic versus utility value represents a temporary solution to the problem of reconciling incompatible stakeholder interests. The UNCED concept of ‘sustainable development’ (UN 1992) represented a temporary reconciliation of these viewpoints by emphasising that the sustainability of societies depends on sustainable interactions with the environment and natural resources. However, the recent debate on fisheries management has demonstrated that genuinely incompatible viewpoints are presented by strong stakeholder groups which ultimately are divided on whether they interpret ‘sustainable’ as zero-impact or anthropogenic impact which can be sustained.

One example of this dilemma is the position of the Agreement on the Conservation of Small Cetaceans of the Baltic and North Seas (ASCOBANS) regarding by-catches of small cetaceans in fisheries. The immediate target is to reduce such bycatches to what can be sustained by the cetacean populations. However, in the ASCOBANS 2000 meeting it was added that the ultimate objective was to reduce such bycatches to zero: ‘the aim of ASCOBANS can be interpreted as "to restore and/or maintain biological or management stocks of small cetaceans at the level they would reach when there is the lowest possible anthropogenic influence" - a suitable short-term practical sub-objective is to restore and/or maintain stocks/populations to 80% or more of the carrying capacity.’ And ‘the general aim should be to minimise (i.e. to ultimately reduce to zero) anthropogenic removals within some yet to be specified time frame’ (ASCOBANS 2000). This change in policies is a change from a criterion of sustainable economic activities based on long term utility value to a criterion of full restoration of natural states based on intrinsic value. This change took place implicitly, without any specific highlighting or discussion in the document.

The intrinsic value approach may, in the more fundamentalist version, lead to policies which ultimately aim at reversing any human impact to restore some natural state of ecosystems such as expressed by the deep green movement. Most environmental NGO’s do however take a more balanced and pragmatic approach as exemplified by the WWF (2002) which states that

‘The Principles of Ecosystem-Based Management are: 1. Maintaining the natural structure and function of ecosystems, including the biodiversity and productivity of natural systems and identified important species, is the focus for management. 2. Human use and values of ecosystems are central to establishing objectives for use and management of natural resources. 3. Ecosystems are dynamic; their attributes and boundaries are constantly changing and consequently, interactions with human uses also are dynamic. 4. Natural resources are best managed within a management system that is based on a shared vision and a set of objectives developed amongst stakeholders. 5. Successful management is adaptive and based on scientific knowledge, continual learning and embedded monitoring processes.’

The reference to ‘natural’ features and ‘natural’ systems as the focus indicates the priority of the intrinsic value perspective which is then modified by the notion of human use and values being ‘central to establishing objectives’.

The utility value approach has similarly been struggling with the practical interpretation of the sustainability concept. The operationalisation of sustainability within a policy emphasising the precautionary approach has been confronted with definition and delimitation problems. The need to define precautionarity in an operational sense has in fisheries led to an urge to quantify uncertainty and identify (and even quantify) the limits of knowledge. A quantification of risks has been seen as the only way to avoid opening an abyss of lack of knowledge which might justify an interpretation of the precautionary principle which would require a policy of zero-impact. In mainstream fisheries management this dilemma has led to a reliance on formal research based knowledge which technically extends far beyond what can be delivered by the research institutions dedicated to the production of advisory inputs to management as discussed below.

The normative aspects of the debate about ecosystem based management are thus complex and conflicts and dilemmas which ultimately have a normative basis are not articulated and debated as such. Policies and even contributions to the debate are formulated in such terms that the normative distinctions remain unarticulated and unresolved.

It may on this background not be a paradox that the high profile of the integration of ecosystem approaches into fisheries management in international policy documents is in stark contrast with actual proposals for the modalities for such an inclusion. The real challenge of ecosystem based fisheries management is the implementation and the examples of implementation modalities are still few and to a large extent ad hoc solutions developed to address specific urgent issues. One of the early approaches was the Essential Fish Habitat concept of the USA Magnus-Stevens Fishery Conservation and Management Act 1996. The essential fish habitat is based on a realisation that fish stocks are dependent on the functioning of the wider ecosystem. Since then various suggestions for implementation of ecosystem based management have been proposed including the Fisheries Ecosystem Plan of the Ecosystem Principles Advisory Panel (1999 and qualified by Sissenwine and Mace (2001)), Gislasson et al (2000) and the principles presented by WWF (2002). These proposals share an emphasis on spatial management through zonation, marine protected areas etc.

3 THE KNOWLEDGE BASE FOR ECOSYSTEM BASED MANAGEMENT

The dilemmas confronting the implementation of ecosystem based management are not only rooted in the unresolved normative basis but also on the cognitive level in some basic limitations in our ability to understand ecosystems. These were clearly expressed in the principles of the Ecosystem Principles Advisory Panel (1999):

'The ability to predict ecosystem behavior is limited. Ecosystems have real thresholds and limits which, when exceeded, can effect major system restructuring. Once thresholds and limits have been exceeded, changes can be irreversible. Diversity is important to ecosystem functioning. Multiple scales interact within and among ecosystems. Components of ecosystems are linked. Ecosystem boundaries are open. Ecosystems change with time.'

Decisions and implementation in ecosystem based fisheries management must currently be based on considerable uncertainty about states, processes and outcomes combined with evasive reference points. More stakeholders with multiple interests and objectives must be accommodated and must deal with these uncertainties in the management institutions. These requirements will add immense strains on fisheries management institutions if fisheries management is to be legitimate, effective and efficient.

The inclusion of ecosystem considerations in fisheries management opens an immense field of unknown territory; the choices made regarding how uncertainty and lack of knowledge is dealt with will to a large extent frame the institutions which are to develop and implement ecosystem based management.

The debate has so far indicated two extreme approaches to the knowledge base for ecosystem based management (and a whole range of intermediate approaches as well). The extremes are on one side a continuation of the classic approach of management based on understanding processes and quantifiable predictability of outcomes and on the other side turning away from a requirement for quantifiable predictability by using metaindicators of impacts in an adaptive management framework. We will discuss some of the options in this spectrum.

1) Hard predictability: An extension of the present fisheries management paradigm with a requirement for quantified predictability, the micromanagement approach

The basic approach to the use of knowledge in present mainstream fisheries management is characterised by some requirement for quantifiable predictability. All variants of TAC based systems are based on the assumption that there is a link between landings and impact and that catch predictions based on certain outcome objectives can be produced. This approach is presently closely linked to management based on single stock considerations. It has more often than not developed into micromanagement systems where new regulations are accumulated as new issues are raised and addressed.

It is increasingly realised that the predictability requirement cannot be fulfilled even within the limited scope of single stock management without ecosystem considerations. There are considerable uncertainties involved even in the simplest situations. The major uncertainties related to the biological system are generally the variability in recruitment and distribution of stocks but fleet adaptation is also an important source of uncertainty in the linkage between regulations and outcomes.

The precautionary approach has now become a standard component in fisheries management policies. Mainstream fisheries biology has addressed the uncertainties and the precautionary approach by internalising these in the normal predictability approach. Predictions are produced using stochastic models and predicted outcomes are associated with quantified probabilities which can be considered as risks from a management perspective.

Ecosystem based management based on the existing mainstream predictability requirement is not suggested in full in the debate but a strong inheritance from this approach is evident in several statements. The Reykjavik declaration will undertake to 'identify and describe the structure, components and functioning of relevant marine ecosystems, diet composition and food webs, species interactions and predator-prey relationships, the role of habitat and the biological, physical and oceanographic factors affecting ecosystem stability and resilience' (Declaration of the Reykjavik conference on Responsible Fisheries, FAO 2001). WWF (2002) pays considerable attention to the uncertainties involved but has also has produced a proposal for implementation which is far reaching in its requirements for knowledge some of which also include requirements for predictability:

'In a typical fishery, the ecological aspects of EBM would be implemented using the following steps: 1. Identify the stakeholders: the interested parties. 2. Prepare a map of the ecoregions: species, habitats and oceanographic features. 3. Identify the partners and their interests: stakeholders directly interested or affected by the fishery. 4. Establish the ecosystem values: habitats, species and uses. 5. Determine the main potential hazards of the fishery to the ecosystem values. 6. Conduct an ecological risk assessment: determine the actual risks of the fishery. 7. Establish the objectives and targets: agreed goals for the ecosystem and the fish stock. 8. Establish strategies for achieving targets. 9. Design the information system: includes monitoring of stock and ecological indicators. 10. Establish information needs and research priorities. 11. Design performance assessment and review process. 12. Design and implement an EBM training and education package for fishers and managers.'

An extension of the hard predictability approach to include ecosystem considerations will require immense resources dedicated to research in marine ecosystem processes and there will ultimately be limits to the predictability independently of the resources invested to produce knowledge (Figure 1).

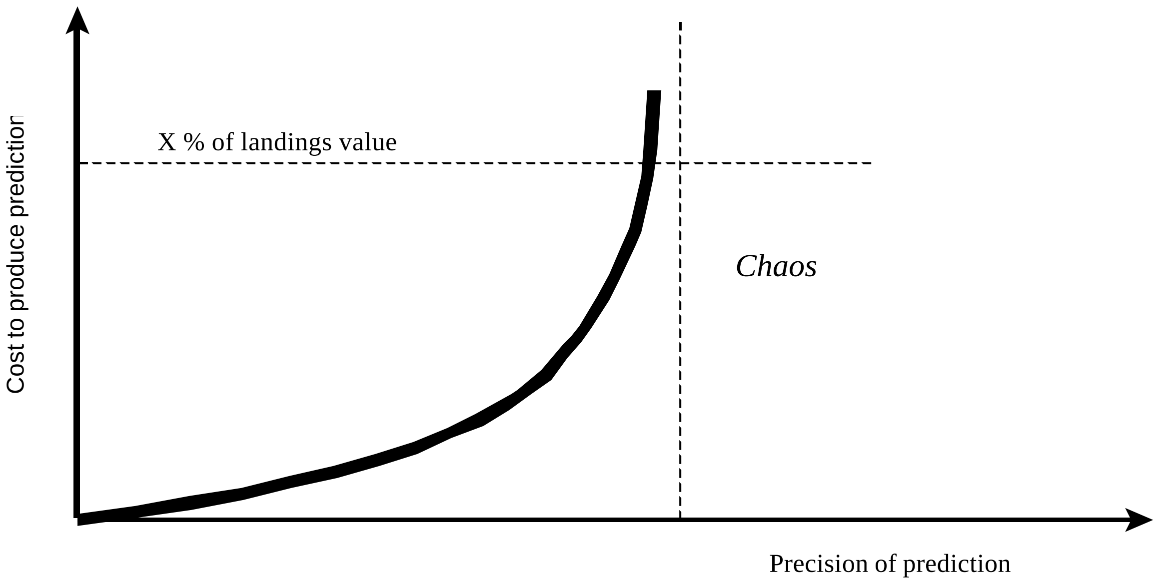

Figure 1 The cost-complexity trap of predictions. The precision of a prediction is associated with a price to produce the data required and to develop and implement the analytical and predictive model. There are absolute limits to the precision that can be obtained at any cost, given by the chaotic nature of the aquatic environment (Wilson et al 1994). The marginal returns in terms or precision gained by a given investment are expected to decrease, eventually to zero, when this limit is approached. Similarly, if predictions are considered instruments for management and not research in its own right, considerations of maximum acceptable costs to produce such predictions relative to the benefits to society will be relevant, for instance measured as a maximum fraction of the primary landings value of the fisheries in question (Degnbol 2002).

The present implementation of single-stock fisheries management is already approaching the limits of knowledge if fisheries management is still to be cost-effective. The inclusion of even simple ecological relationships on a predictive basis will in most cases result in considerable increases in research costs. An example of this is the debate concerning the interaction between protein fisheries and see birds in the North Sea. In 1998 the European Commission send a request to ICES to evaluate the effects of the sandeel fisheries in the North Sea on the breeding of seabirds, the assumption being that there potentially is competition between the fisheries and sea birds for food. A predictive response to this request would require detailed information about population sizes of both sandeel and sea birds with high spatial and temporal resolution, data on food requirements of various sea bird species at various life stages, data on the search range and the economy of energy and time for parents collecting food relative to the distribution of the sandeel etc etc (ICES 1998). Very little of this information is available and most of what is missing can only be collected at great cost.

The sandeel case described above represents one of the simpler cases where there is a clear hypothesis about the possible interaction processes and it is not very complicated to develop a model which would enable a reasonable estimate to be made. The limiting factor in this case was data. The analysis of most other interactions will suffer from both a lack of understanding of possible interaction processes, which may be very indirect, and lack of data. It is thus very likely that ecosystem based management at best can be based on very weak predictability requirements.

The predictability approach is closely associated with a specific form of knowledge production and a specific selection of what is considered valid knowledge. Quantified predictions are produced as mandated research (Salter 1988) in specialised research organisations which may be largely detached from other aspects of the management institution. This leads on the other side to exclusion of other types of knowledge such as the local ecological knowledge of fishermen of environmentalists. Research based knowledge relates to other scales (space and time) and practices than local knowledge and the different sources of knowledge may as a result be in conflict (Degnbol 2002). This has important institutional implications: the knowledge base for management is not shared, there are no mechanisms to mediate different sources of knowledge and management decisions may in the end have less legitimacy. This approach is therefore also associated with top-down management models where stakeholder participation is largely limited to consultations and implementation details such as is the case in the EU CFP or where stakeholder participation in discussions about the knowledge base is entirely framed by the research based discourse such as is the case in the US fisheries councils (Wilson and Degnbol 2002).

2) Soft predictability: Based on a set of structured indicators, the patchwork management approach.

The intermediate solution to the knowledge problem is to maintain soft predictability by basing management on a comprehensive set of indicators of pressures and states. This approach is based on assumptions about the processes linking pressures on the system and the resulting state and about the mechanisms through which specific responses or regulatory measures can modify the pressures and thus the states.

This approach was the basis for OECD's pressure-state-response system for environmental management (OECD 1993) and is in single stock fisheries management inherent in the limit and 'pa' reference point system used in the advice by ICES where fishing mortality is the pressure indicator, the spawning stock size the state indicator and the projected TAC the corresponding response indicator (ICES 2001b).

The development of such comprehensive sets of indicators in relation to ecosystem based fisheries management has been pursued under the Oslo-Paris Convention with the development of Ecological Quality Objectives (Anon 1998, 1999). EcoQO's and reference points are being developed for the North Sea for a set of issues including commercial fish species, threatened or declining species, sea mammals, seabirds, fish communities, benthic communities, plankton communities, habitats, nutrient budgets and production and oxygen consumption. This work has not yet reached implementation where indicators are associated with specific management measures.

Approximations to structured indicator sets are the SDRS system of FAO (Garcia and Staples 2000) and the RAPFISH approach (Pitcher and Preikshot 2001). These approaches do not assume specific linkages between pressures and outcomes. Instead they seek insurance through quantity and diversity: several indicators are selected which represent different key dimensions of the fisheries system. These indicators are then collapsed into a graphic display or a composite indicator. The SDRS and RAPFISH approaches were not developed to serve as tools for local management but rather as tools to enable comparisons across different fisheries, for instance in relation to international codes or ecolabelling. They do thus not relate to local fisheries management institutions.

The most extended use of this indicator approach in relation to local management has been in Australia (Ward 2000).

On the institutional level these approaches represent extensions of the predictive mode: there is still a requirement for some understanding and tracking of specific processes linking pressure and outcome, the knowledge base is still comprehensive and complex, it is produced in specialised research organisations and management decisions are taken within the same framework. The work with EcoQO's is based on a realisation that predictability in the same sense as what has been the aspiration for single stock fisheries management is unattainable and addresses the cost effectiveness and chaos limitation problem of the predictive approach. One problem with this approach is that EcoQO's are developed in the natural science domain out of context with other parts of the management institutions. This is critical as any identification of issues to be addressed and associated objectives and reference points will have a normative basis which in this case will be implicit and represent a specific stakeholder group.

This approach does not necessarily pretend to address separate issues in a connected way. Indicators reflect specific features of the ecosystem separately. If the indicators in this approach are not developed as a part of a consistent framework it may thus prove possible to base management on a different knowledge base for specific issues, that is other types of knowledge beyond research based knowledge are not necessarily excluded. A management system based on this approach is therefore open to a development into patchwork management where new regulations with associated indicators are developed ad hoc and added on according to the interests and influences of various stakeholder groups.

3) Adaptive learning: Based on metaindicators, limiting overall pressure

There are considerable correlations between many types of impacts of fisheries on marine ecosystems. High levels of exerted fishing effort on the system will simultaneously have high probability of reducing target species below acceptable levels, of reducing populations of non-target species through by-catches, of high impact on bottom fauna or sensitive habitats, of high competition with other top-predators such as seabirds, sharks and seamammals etc.

Given the correlation between many types of impact and the complexities and costs involved in understanding, monitoring and regulating fisheries specifically in relation to many impacts separately an option could be to renounce the detailed control and thus the requirement for detailed understanding and predictability altogether and regulate the overall pressure on the ecosystem.

Two main implementation mechanisms have been suggested on this basis:

1) Reduction of exerted effort to sustainable levels. In the longer term effort would most effectively be reduced through capacity reduction. Effective reduction of effort will address many environmental concerns simultaneously (NRC 1999, FAO 2001).

2) Seasonal or permanent closures of areas for fishing. Marine protected areas have been proposed as an important or even the major contribution to ecosystem based management by many authors (for an overview see of this approach see Salm *et al* 2000, Roberts and Dawkins 2000). In the present context the relevant argument is that marine protected areas will serve as refugees for a large cross section of marine life which will ultimately limit the possible impact from fisheries. Marine protected areas have also been proposed to serve other purposes such as protection of sensitive habitats or protection of feeding or breeding grounds.

If ecosystem based fisheries management would mainly be based on such generalised measures there would be a need to monitor impact through a set of metaindicators which synthesises the overall state of the ecosystem without pretending to track specific interactions. Such metaindicators were for instance discussed by the ICES working group on ecosystem effects of fishing (ICES 2001a) and could include abundance indices of sensitive species, proportion of mature individuals in sensitive populations or ecosystem metrics such as size compositions or average trophic level of catch. The identification of these specific metaindicators and a general understanding of their significance are based on extensive research in various ecosystems. Such research may be conducted in the specific system in which case there will be some understanding of the specific processes linking pressures and indicator. In other cases the choice and interpretation of metaindicators may in lack of better options be based on analogies from similar ecosystems. However, a better understanding of the ecosystem will in all cases improve the possibilities for relevant choices and interpretations of indicators.

A control of overall pressure monitored through metaindicators can only be implemented within an adaptive management framework. There is not necessarily *a priori* understanding of the specific processes which link fishing activities and indicators and the long term impact of a specific activity level can therefore not be predicted. The development of the knowledge base must basically take place through adaptive learning.

One of the major challenges for such an approach would be to reach decisions on relevant metaindicators and not least reference points for these indicators since it is the reference points which will indicate the direction of management action. It will in this case be evident that such decisions cannot be made on a natural science basis alone and could only be produced by a negotiation process between stakeholders which would require conflicts to be reconciled and the necessary compromises to be made. Contrary to the patchwork approach conflicting interests must therefore negotiate and agree on both regulations and indicators as regulations and indicators do not relate to specific issues or problems but to large groups of issues simultaneously.

4 KEEPING EVERYBODY ONBOARD ON A BUDGET

The different approaches to the knowledge base would each be associated with increasing costs when increasingly complex issues are addressed or increasing precision is required as indicated in figure 1. However, costs to produce the knowledge base and to implement regulations are highest for the approach based on hard predictions with high precision in a micromanagement regime. Costs are expected to become lower as one moves through structured indicators to metaindicators in an adaptive regime as illustrated in figure 2.

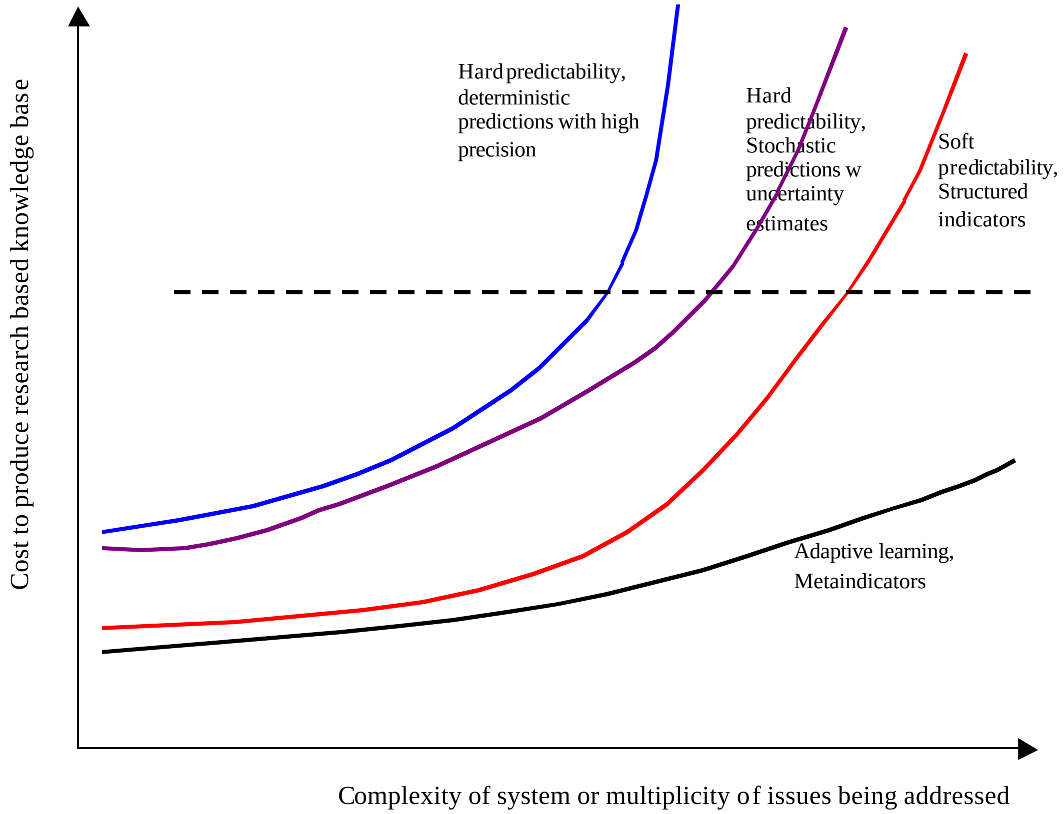

Figure 2 The cost to produce research based knowledge for fisheries management. When increasingly complex systems are managed or when the scope of management is expanded to include increasingly complex issues the cost to produce a specific type of knowledge with the same precision increases. If costs are to be maintained at the same level (dashed line),

the knowledge base for management institutions must change with increasing complexity as requirements for predictability cannot be met. This change in knowledge base has implications for the overall institutional setup of management, see table 1.

If costs to produce knowledge base and implement management cannot increase substantially, as will be the case in most fisheries, the introduction of EBM would imply (necessitate) a change in approach from hard predictability through soft predictability to adaptive learning which would eventually imply fundamental changes in the institutional setup of management. A transition from single stock management through addressing a multitude of concerns separately to ecosystem based management based on metaindicators must therefore imply a transition through different cognitive, normative and regulatory structures. The management institutions must change fundamentally in the process as discussed above. These changes are summarised in table 1 below.

Object of management	Single stock/ optimisation	Single stock/ Precautionary approach	Specific considerations (stock, birds, corals)	Ecosystem based management on adaptive basis	Ecosystem based management on hard predictability basis
Regulatory framework	Instrumental / micromanagement	Instrumental / micromanagement	Instrumental/patchwork management	Adaptive – general measures to reduce overall pressure	Instrumental/micromanagement
Knowledge base	Hard deterministic predictability.	Hard probabilistic predictability	Soft predictability, structured indicators	Adaptive learning, metaindicators	Predictive – presumes immense research input
Normative base	Utility / optimisation of long term economic and social utility	Utility – risk avoidance or precautionary approach	Multiple objectives addressed separately – production and conservation related. Conflicts not resolved	Multiple objectives must be reconciliated	Multiple objective accumulation – objectivation of interests?
Participation	Top-down or negotiation framed by research based knowledge – largely consultative	Top-down or negotiation framed by research based knowledge – largely consultative	Multiple stake holders, negotiation based on research based knowledge on state, processes and outcomes but other types of knowledge may be used.	Multiple stakeholders, negotiated reconciliation of interests / compromises	Top-down, consultative. Complex participation processes must be established to deal with a complex knowledge base with high uncertainty.

Table 1. The transition of management institutions as the object of management changes from single stock through multiple concerns to ecosystem based management on a constant cost basis . The transition corresponds to the dashed line in figure 2. The last column is not a constants cost scenario but indicates the institutional setup with ecosystem based management based on an extension of the present single stock management, that is if hard predictability according to the left most path on figure 2 is pursued to ecosystem level.

5 OKHAM'S RAZOR

In most fisheries there may however be a more direct, effective and efficient approach to addressing environment and ecosystem concerns in relation to fisheries.

The basic problem in a large part of the world's fisheries is that there is considerable overcapacity and that it has proven immensely difficult to reduce actual fishing mortalities or the exerted fishing effort in overcapacity situations. An example is the North Sea demersal fisheries where it has been demonstrated that fishing mortalities have remained constant on high levels even though seemingly restrictive TAC's according to the biological advice have been implemented for a decade (ICES 2001b). Several contributions in the research literature and in the policy domain have in recent years made the observation that the most effective way to address ecosystem considerations is to do what fisheries management should do anyway, also from a single stock or economic perspective – to address the overcapacity problem or at least to reduce exerted effort considerably. The NRC Committee on Ecosystem Management for Sustainable Fisheries stated in 1999 that 'The committee concludes that a significant overall reduction in fishing mortality is the most comprehensive and immediate ecosystem-based approach to rebuilding fisheries and marine ecosystems.' (NRC 1999). The Reykjavik conference on responsible fisheries in the marine ecosystem 2001 also started out noting the immediate need for 'reducing excessive fishing efforts to sustainable levels' (FAO 2001). The European Commissions' Green Paper on the future CFP (European Commission 2001) put the reduction of fleet capacity in the centre of the future policy as that core measure which simultaneously would address multiple problems including the environmental interactions of fisheries.

The discussion on the introduction of ecosystem based management includes contributions which point to an expansion of the knowledge base to ever more complex ecosystem models with some predictive capability and development of institutions which can utilise such models and transform their outputs into detailed regulations with participation of multiple stakeholders in ever more complex institutions. It is quite likely that such proposals and discussions will distract the fisheries management debate away from addressing how overcapacity can be reduced. This was a tendency in the discussion following the EC Green Paper, the Declaration of the Reykjavik Conference 2001 hints in this direction and WWF's proposal for operational guidance for EBM (2002) includes a list of knowledge requirements which potentially may require very extensive research inputs. Sutinen and Soboil (2001) concluded on basis if similar observations that 'ecosystem based management will tend, we believe, to increase the chances of governance failure'.

In many fisheries the majority of ecosystem concerns would be addressed by reducing fishing capacity. Most of the remaining concerns could in many cases subsequently be addressed through some supplementary technical measures to reduce the impact of gear damage on habitats and some closed areas to protect sensitive habitats. There may then be very few if any concerns left which would need to be addressed through specific ecosystem based management approaches beyond capacity reduction, regulation of damaging gear and protection of sensitive habitats.

6 CONCLUSION

The basic problems in integrating ecosystem aspects in fisheries management which must be addressed if ecosystem based management is to proceed from debate and policy to implementation are in summary:

1) The objectives have not been clarified: the concepts as stated in policy documents are open to very diverse interpretations; this reflects that different stakeholder groups have incompatible interests and objectives which have not been mediated or even articulated in policy documents.

2) The knowledge base is characterised by uncertainty and lack of knowledge: the knowledge about states, processes and outcomes regarding ecosystem impacts is and will be very uncertain; existing knowledge about the interdependence of fisheries and the marine ecosystem is insufficient or cannot be generalised.

3) Methods to operationalise the existing knowledge in relation to management have not been developed; specifically, objectives and associated criteria and reference points have not be developed

4) An institutional framework within which decisions about policies and implementation can be made has not been developed (or the existing framework has not yet been developed to accommodate this). However, as more complex issues including ecosystem concerns are addressed the objectives for management and the knowledge base for management must change dramatically because new objectives are added and the costs to produce knowledge will require that decisions cannot be based on hard predictability. This implies fundamental changes in the management institutions.

5) Existing fisheries management institutions have been unable to decide and implement those basic measures which would be needed to achieve the existing and limited objectives of fisheries management. This does not form a good basis for an expansion of scope, but much can be achieved without such an expansion if existing institutions could be effective in what they are already supposed to do as this would also contribute substantially to reducing pressures on marine ecosystems beyond the target stocks. The single most effective and efficient measure which could be taken to address a wide range of ecosystem considerations simultaneously is the reduction of fleet capacity to levels which are indicated from single-stock and economic considerations. Effective capacity reduction supplemented with measures to reduce habitat damage from fishing gear and to protect sensitive habitats may address most ecosystem concerns without requirements for detailed tracking of all interactions and addressing of all issues separately.

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