Recent developments in the inclusion of biodiversity concerns in the management of fisheries

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Of the many formulations of what an "ecosystem approach" really means, four features are always included (FAO 2004, Rice in press) . Two deal with what information goes into management decision-making; two deal with how the decisions are made. The latter two – more inclusive decision-making, and more integrated planning and management are governance issues important to the meeting, but not central to my talk. I will address what is being done on the first two features, relative to addressing biodiversity issues in fisheries management. In terms of scientific assessments and advice to fisheries management, biodiversity concerns are addressed in two complementary ways. The first is by taking better account of how the state of the marine ecosystem affects the status and productivity of the stock(s) being harvested. The second is by giving fuller consideration to the effects of harvests on structural and functional components of marine ecosystems.

To do either task completely poses an insurmountable task to scientists. We will never know all the ways that the physical oceanography, predators, prey, and competitors may affect an exploited fish stock. We will never know all the ecological consequences of removing whatever numbers of target and non-target fish are killed in a fishery, nor how all the effects that fishing gears have on ocean habitats. Critics exploit the immensity of the task both to scare-monger from a harvester's perspective and to trivialize management efforts from a protectionist perspective. Both extremes are wrong. The very scale of an ecosystem approach to fisheries management invited stepwise progress, reconciling commitments to protect biodiversity with the need for food security and sustainable social and economic benefits from the seas. It is possible to present examples of how such steps are being taken successfully for each of the major ecological aspects of taking an ecosystem approach to fishing.

The "ecosystem inputs" to dynamics of the exploited stocks include both effects of the physical ocean conditions on growth, maturation, and reproduction, and effects of predators and prey on the survivorship and growth of the harvested stocks. Probably the most scientific effort has been spent relating ocean conditions to recruitment dynamics (Corten 1990, Jarre-Teichmann et al. 2000, O'Brien et al. 2000). Success has been spotty. Frequently it has been possible to explain some past recruitment anomaly as a consequence of ocean temperature, salinity, etc, and often propose causal mechanisms rather than just report correlational results (Williams and Quinn 2000, Brander and Mohn 2004). However, the forecasting power of such relationships has been disappointing (ICES 2002), and occasionally scientific advice using such relationships has been embarrassingly inaccurate. An example is the 1999 ICES advice on anchovy, where environmental signals indicating poor recruitment were used to support pessimistic catch advice yet the recruitment was no worse than that in adjacent years, leading to widespread criticism of the advice (ICES 1999).

More recently, scientists have been focusing on explaining variation in growth with oceanographic factors, with more success (Brander 1995, ICES 2003, Yndestad 2004). In fish population dynamics variation in growth has received less attention than variation in recruitment, but improvements in that aspect of assessments can lead to much better advice, and more sustainable fisheries. For two reasons the consideration is particularly acute when growth is slower than expected. First, even if an assessment estimates numbers at age correctly and applies a sustainable exploitation rate, standard practice uses recent average weights at age for the catch forecasts. If growth is slow because of unfavourable environmental conditions the catch forecast will thus overestimate these weights and total stock biomass resulting in an advised catch that is too large. Because TACs are set in weight, not numbers, the TAC will allow too many fish to be taken and result in excessive mortality. Second, generally fish grow fastest around the age when they are becoming large enough to be taken by the fishery. If growth is slow, the assumption of average growth will result in overestimating the proportion of recruiting year-classes which have grown large enough to be harvested. Again this overestimate leads to catch advice which is too high. A TAC based on such advice will be taken out of the larger fish in the stock, further increasing the over-exploitation of these fish. In stocks like North Sea plaice in the late 1990s and Newfoundland cod in the early 1990s, the overfishing due to scientific advice which did not take account of decreasing growth rate was a serious conservation concern. The promising results in forecasting growth anomalies from environmental variables may be a very practical and valuable contribution to more sustainable fisheries, even if the work is not glamorous.

In the 1990s a third research area has emerged where knowledge ocean environment can lead to more sustainable fisheries. There is now substantial evidence that ocean variation has strong pattern on scales of decades, and sometimes even longer – features such as the Pacific Decadal Oscillation and the North Atlantic Oscillation (Bogred et al. in press, Eden and Willebrant 2001). Even though the causes and consequences of these ocean regimes are not fully documented, it is clear than they have many effects on marine ecosystems. For fisheries, it is clear than productivity of exploited stocks will differ with the regime (Klyastorin 20001, McKinnel et al. 2001, Chavez et al. 2003). This, in turn, means that there is not a single exploitation rate which is sustainable. Rather, in regimes of poor productivity exploitation rate must be reduced to prevent depletion of the stock at the very time when recovery is most difficult because of the low productivity. These regime considerations are just entering the field of practical fisheries management, but they show promise of contributing substantially to making fisheries more sustainable (Rice 2001).

There has been progress in taking account of the state of the biological environment, as well as the physical one, in improving the sustainability of fisheries. In all but a few systems, marine food webs have many species, and many connections, and even a single species may feed very differently as it grows. These numerous linkages have made it nearly impossible to manage individual predator and prey species as a pair. For example there have been calls to reduce numbers of marine mammal predators to help rebuild fish stocks like Canadian cod and South Africa hake. However scientific studies consistently show that the predators have so many prey that were the predators culled, there is no way to predict which of many prey species would benefit most and quickest, such that the prey species of interest (cod or hake) might end up worse off, rather than better (Shenton et al. 1997, Butterworth and Punt 1999, Hammill and Stenson 1999, Yodzis 2001).

Although the specific linkages are usually not tractable to management, there are many positive messages. For nearly two decades, ICES has been able to use multispecies models to estimate how the predation mortality of most of the exploited species varies with the changing abundance of predators. This practice is now routine for the North Sea, Baltic Sea, Barents Sea and practice is spreading as the necessary information accumulates. For even longer, fisheries on important prey species such as capelin have provided for a considerable amount of biomass to be left in the sea for predators that depend on that species (Harwood et al 2000, DFO 2004). Predator needs were estimated crudely when this practice began. However, organizations such as CCAMLR have developed very sophistical analytical tools for managing the harvest of zooplankton important to many fish, bird and mammal predators, and supported them with monitoring and decision rules focusing on many parts of the ecosystem (CCAMLR 2004). Managing such fisheries sustainably in an ecosystem context is neither easy nor cheap, but it is possible.

The future gives cause for optimism that practice in applying an ecosystem approach to the ecosystem inputs to a fishery can improve further. For example, the environmental and biological inputs may be brought together in many marine ecosystems which are characterized as "wasp-waisted" – that is, there is some species like capelin, euphausids, or sardines and anchovies which are simultaneously a major prey for many top predators in the ecosystem and strongly affected by the physical ocean environment (Rice 1995, Cury et al 2004). Understanding the dynamics of that node in the food web, and of its major biotic linkages, is a scientifically tractable task. Moreover, conceptual developments and supporting analytical tools have moved thinking from assuming only linear correlations to optimal windows where productivity becomes less favourable in both directions away from the optimum (Cury and Roy 1989). Combining these two developments with the new information on ecosystem regimes are providing powerful but practical tools for bringing the ecosystem into fisheries assessments and management.

There are equally promising steps being taken to reduce the "fishery outputs" to the ecosystem. Whereas the major biodiversity gains in accounting ecosystem inputs to the fishery were better sustainability of the exploited species, reducing the fishery outputs to the ecosystem benefit may parts of marine biodiversity directly and indirectly. One of the areas of greatest direct benefit is through attempts to reduce bycatch of non-target species. Multinational programs were adopted in the 1990s for reducing bycatch of seabirds (FAO 2004a), elasmobranches (FAO 2004b), and cetaceans (Kaschner 2003, Bache 2001). In many countries growing attention to protecting marine species under species-at-risk (IUCN 2003, Dulvy et al. 2004) legislation, has focused more attention on bycatch of fish and invertebrates as well. Canada, for example, has implemented formal protocols for reporting, careful handling, and live release of protected fish species such as wolfish (CSAS 2004). Even where species have not been designated at some category of risk of extinction, the global levels of waste in fisheries (Alverson et al. 1994) have led to commitments by many countries and international organizations to reduce bycatch and waste through fishing with more selective gears and avoiding areas known to have high bycatches. Moreover, it is not necessary to monitor and manage bycatch of every marine species. There is substantial knowledge which can be applied to identify species which are particularly exposed to being taken as bycatch, and if bycatch mortality of these species is sustainable, then it is a fair (but not universal) assumption that bycatch of less vulnerable species will also be sustainable. This is an important and practice step towards reconciling fishing with protection of biodiversity.

Spatial management is another important step. The use of marine protected areas as a tool to promote conservation of biodiversity has been pushed aggressively by many advocates (Sladek Nowlis and Roberts 1999). Although there are reasons to question many of the more extreme claims made about the benefits of MPAs (Hilborn et al. 2004) without question MPAs have benefits for biodiversity (Pastoors et al 2000, Collie et al 2001). Combined with initiatives to map sensitive and vulnerable marine features such as coral beds (Thomas 1999, Mortensen et al 2001) and sponge reefs (Conway et al. 2001), it is realistic to expect many areas of greatest importance to biodiversity due to their unique and complex physical structure and species composition will soon be protected from damage by fishing gear. More generally, the integrated management aspect of the ecosystem approach has promise for bringing zoning practices into marine regions as well. The detrimental effects of fishing gears on biodiversity often have been exaggerated (ICES 2001), but in part because the historic patterns of fishing often concentrate effort in only a portion of the available seafloor (Rijnsdorf et al. 1998, Kulka and Pitcher 2001,). This has meant large parts of the seafloor still have a rich and diverse biological community, although this is vulnerable to changes in fishing practices, such as ill-thought-out conservation closures (Dinmore et al. 2003). Recently effort reductions necessary to reduce pressure on the target species have amplified this tendency of fisheries to operation in only portions of the seas, and if zoning is added wisely as an additional management tool, it is possible to establish substantial harmony between sustainable fisheries and conservation of biodiversity.

There has been much written about ecosystem effects of fishing on biodiversity at the food web and community level as well (Bianchi et al. 2001, Myers and Worm 2004, Jennings et al. 2002,). Without question, where fishing has been excessive even on the target species, abundance of large fish in ecosystems has been reduced and food webs altered in harmful ways. As noted when discussing fisheries on forage species, it is difficult – probably impossible – to conduct fisheries as an "engineering tool" – tailoring the whole food web to a pre-selected configuration. However, such engineering may not be necessary to bring fishing back into harmony with biodiversity interests in this context. With current evidence, the thesis is still valid that if fisheries can be made sustainable with regard to their target species and bycatch species, and what we know already about managing fisheries on forage species is applied, then the structure and function of marine food webs will be conserved as well (ICES 2001).

The examples above show how incremental changes to fisheries management have been made. These steps represent significant contributions to allowing fisheries to exist in harmony with conservation of biodiversity. We can implement an ecosystem approach the way great cathedrals and the pyramids were built – one bring at a time. However, I do not want to leave the false impression that, even if the task is tractable, all is well. All us *not* well, and significant challenges remain.

Moving to an ecosystem approach necessarily means that there will be greater uncertainty (Rosenberg and Restrepo 1994) in all the analyses and scientific advice. This is true because every assessment model will have more functional relationships and more parameters, yet we will have fewer data on many of terms and less knowledge of which equation is correct than we do in single-species approaches. The precautionary approach (FAO 1996a,b) is a part of the ecosystem approach, and gives clear guidance that when uncertainty is high, decision-making should be more risk averse. However, fisheries decision-making currently is *not* risk averse (Piet and Rice 2004, Rice in press) with fish quotas well above scientific advice on many depleted stocks in both Europe and North America, and without formal advice in many parts of the world. As long as fisheries decisions remain risk prone when choices involve significant short term social and economic pain, the increase in uncertainty due to an ecosystem approach is likely to used as an excuse for even more aggressive harvesting, rather than as an incentive to greater precaution.

The second cause for pessimism is that accommodating biodiversity concerns in fisheries management can only mean harvesting less. Whether it is reducing harvest to allow for environmental uncertainty about growth and recruitment, to reduce the mortality on bycatch, or simply to allow target species to remain at biomasses which allow them to fulfill their historic role in the ecosystem the simple fact is that a ecosystem approach must lead to lower exploitation rates and higher biomasses. This is already been the scientific advice from single-species perspectives for years, sometimes decades, and with limited impact. Also 2/3 of the stocks currently assessed by ICES and in Canada are outside safe biological limits and/or at historical low biomasses. Jurisdictions simply have found the advised harvest reductions hard or impossible to implement successfully even for conservation of the target species of fisheries, with the promised reward of greater harvests and higher catch rates in the medium term. They will be no easier for conservation of biodiversity, when the benefits are to the ecosystem and the diversity of choices available to future generations rather than profits to the fisheries.

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