

# Environmental Effects of Marine Fisheries

**June 2003**

This document is the Royal Society response to both the Royal Commission on Environmental Pollution (RCEP) consultation on the Environmental Effects of Marine Fisheries in May 2003<sup>1</sup> and the Royal Society of Edinburgh Inquiry into the Scottish Fishing Industry in June 2003<sup>2</sup>. The answers in this response follow the format of the questions as asked in the RCEP *invitation to submit evidence*<sup>3</sup>. The Society has only responded to issues where it has expertise and as such, not all the questions have been addressed.

This submission has been approved on behalf of the Royal Society Council, by Professor Sir Patrick Bateson, the Vice-President and Biological Secretary. This response was prepared in consultation with Professor John Beddington FRS (Department of Environmental Science and Technology, Imperial College), Professor Colin Clark FRS (Department of Mathematics, University of British Columbia), Professor IN McCave (Department of Earth Sciences, University of Cambridge), Professor Callum Roberts (Environment Department, University of York), Professor John Reynolds (School of Biological Sciences, University of East Anglia) and Professor John Shepherd FRS (School of Ocean and Earth Science, University of Southampton).

## Summary of key points

- Many of the world's fish stocks are significantly overexploited. This has been the result of the continued difficulty in dealing with the problems of regulating the use of a resource that is accessible to all. This 'common property' nature of most marine resources pushes users to compete with each other as they try to realise the largest gains from a given resource. Increasing competition, without enforceable regulation, eventually causes the resource to be reduced and inevitably overexploited.
- Overexploitation of major stocks has had a very detrimental impact on the marine environment. Fishing intensification and its related environmental impact has led to a massive reduction in targeted species as well as the extinction, by indirect effects on the ecology, of species from marine food webs. However, the environmental impact of fishing practices on other species and habitats is still poorly understood and is likely to remain so within a reasonable timescale.
- The sizes of fish populations are naturally highly variable and driven by a multitude of interacting factors, including the intensity of exploitation. However, conventional fisheries management only considers one species at a time, ignoring the complexity of the ecosystem. For effective management, modelling is required that considers the impact of the fishery on the target species as well as the wider marine system. This ecosystem approach to fisheries management is difficult at present, as the underlying science of marine ecosystems is inadequately developed and the uncertainties that are inherent in modelling one species are compounded over the whole system. What is known for definite is that marine ecosystems and the fisheries dependent on them are fundamentally uncertain.

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<sup>1</sup> <http://www.rcep.org.uk/fisheries.html>

<sup>2</sup> <http://www.ma.hw.ac.uk/RSE/>

<sup>3</sup> <http://www.rcep.org.uk/fisheries/fishp2an.html#annexa>

- We recommend that this considerable uncertainty be reflected explicitly within fishery models underlying management decisions. To aid the necessary development of the ecosystem approach to fisheries management, it is important that research is continued and augmented to understand the complex interrelationships within marine systems. This research should include species and habitats that may not have commercial value but are still affected by fishing activities.
- An additional method to address this uncertainty and enhance precaution within fishery and ecosystem management is through the continued research and use of no-take marine reserves.
- Fisheries management as a whole would benefit greatly from conservation goals that are more enforceable. However, regulations to achieve these goals are complex and difficult to implement. One achievable action would be to replace the traditional emphasis on methods of controlling catches with controls on fishing effort, a strategy that would also address the cumbersome and costly nature of enforcing current management strategies.
- Government subsidies and other financial support must be withdrawn from the fishing industry. These subsidies and the short-term nature of politics are preventing sound fisheries management and restrain the effectiveness of any new regulatory approaches. Politicians should further incorporate the precautionary approach within management decisions to account for the high levels of uncertainty within the marine system. Achieving this shift in fishing practice may require measures such as transitional aid to support the fishing industry. It is also important that any changes introduced are underpinned by sophisticated bioeconomic models that incorporate the behaviour of fishers.

## Geographical scope

- 1** *The Commission intends to set its study in a global context but with a principal focus on the OSPAR area, other areas fished by the fleet from this area, and areas fished to supply European aquaculture. Is this choice appropriate in policy and scientific terms?*

## The current situation and possible futures

- 2** *What are the key current strengths of the fishing industry (including industrial and other capture fisheries, aquaculture and producers of fish meal for aquaculture). What are its main weaknesses or challenges faced? How might these affect its future environmental impacts?*

Many recent reports have shown that global fisheries are in a poor state, with many stocks significantly overexploited. Unsustainable exploitation has left a number of fisheries so depleted that they do not provide anything like their potential yield.

This overexploitation has been the consequence of the continued difficulty in dealing with the common property nature of most marine resources. Common property is a term used to describe resources where their use and access is unrestricted, leading to increased competition between the users (foresters, fishers, air polluters) to gain the greatest benefits from the resource. Unless the common property resource is carefully regulated, it will eventually be reduced and potentially overexploited, which would effect the income of those dependent on it. Note that the term 'common property' does not simply imply that 'all may exploit'. This wording leads to a possible misconception. Any fishery with multiple users and without individual assigned rights is still common property, and subject to all the associated problems.

In most developing country fisheries the conditions of open access and lack of enforceable regulation to common property resources are driving marine resources towards over-exploitation.

A weakness of management decisions at the European level is that Policy Makers are still not fully adopting a precautionary approach to fisheries management to address the high levels of uncertainty within the marine system. Furthermore, even when there is consensus among scientists about the need for reductions in fishing, the level of reduction that is adopted is often less than required, due to lobbying by fishers and by disputes between different countries.

- 3** *Is there firm evidence of substantial damage to the marine environment attributable to capture fisheries or aquaculture? If so, is the damage widespread or limited to particularly vulnerable areas? To what extent is it short-term or reversible? How do the environmental effects of fisheries compare, in magnitude and nature, with the impacts on the marine environment of the oil industry, dredging and other marine activities? How do they compare with the effects of natural variation?*

The overexploitation of major fish stocks has had a very deleterious effect on marine biodiversity, directly and substantially altering the composition of marine ecosystems. Fisheries tend to target the largest and most valuable species first and as each is depleted they move on to others that are smaller and less desirable (Pauly *et al* 1998). Intensification of fishing has led to a massive reduction in numbers of targeted species as well as the ecological extinction of species from marine food webs. Evidence of this impact is apparent in the contrast between intact, comparably pristine ecosystems, which often support high levels of biomass of large-bodied and higher trophic level species with disturbed, exploited and polluted ecosystems, which can

be characterised by the absence or rarity of such species, and by dominance of small-bodied species with high rates of population turnover, usually from lower trophic levels (Odum 1969; Christensen and Pauly 1998; Myers & Worm 2003). Recent analyses of fisheries and historical data suggest that over the last 500 years, marine ecosystems have undergone major losses in biomass of larger-bodied and higher trophic level species (Jackson 1997; Jackson *et al* 2001). These disturbed ecosystems may have simplified food webs and can be prone to blooms of algae, microbes and plankton (Jackson *et al* 2001). This damage is rarely considered in fishery management strategies. Such damage can undermine the productivity of fisheries, aside from any effects on habitats and species of conservation concern.

Some stocks are particularly vulnerable to fishing pressure. Typically these are slow-growing long-lived species which, due to their demography are vulnerable to overexploitation (Reynolds *et al* 2001; 2002). Such species can be placed in particularly problematic situations when they are part of the bycatch (fish caught other than the target species) of a fishery for more abundant resilient species. This is clearly the case for marine mammals, turtles and birds, which form the bycatch of many fisheries. This is also the case for certain slow-growing species of fish, particularly, but not exclusively, sharks, skates and rays (Walker & Hislop 1998; Dulvy & Reynolds 2002; Baum *et al* 2003)

The specific environmental impact of fishing practice on other species and habitat is still poorly understood and is likely to remain so. It is highly unlikely that in a reasonable time scale information will be gleaned on the way in which habitats are affected by the operation of fishing gear. However, some particular solutions can be considered to regulate fishing practice, which is manifestly destructive. Examples such as the ban on high seas drift netting or dynamite fishing are manifestly sensible. More problematic are proposals for a ban on bottom trawling.

**4 *The Commission intends look at plausible scenarios for capture fisheries and aquaculture over the next 20-30 years. Which environmental, social and economic scenarios should be examined? Are considerations of energy balances and available resources key factors in determining which scenarios are feasible? What are the likely effects of climate change on the European marine environment? How important will these effects be compared with natural variability?***

Research by Perry and Reynolds (unpublished) has shown significant northward shifts by a number of fish species in the North Sea over the past 20 years. Their analyses indicate that this has probably been due to climate change. If present trends continue, some species that are currently important, such as cod, will become less available to fishers. On the other hand, some southern species, such as sea bass, will probably continue to shift northwards. So, at the very least it can be predicted that the species composition of the North Sea will change.

**5 *What are the main environmental factors, which could or should provide limits to the growth of aquaculture? Does current aquaculture of carnivorous fish use more than the sustainable yield of other fish for fish meal and, if not, what limits if any should the supply of fish meal place on aquaculture growth?***

The potential for aquaculture to meet the requirements of human demand for fish products is good, but there are currently a number of difficulties. These include the problems of disease, which can be passed between domestic and wild stocks, the excessive use of antibiotics and other chemicals to combat such diseases, and the overexploitation of species to form food for aquaculture. Bad practice is widespread, for example, tropical shrimp farming, which is effectively 'slash and burn' aquaculture.

**6 What key social and economic factors need to be considered alongside the environmental impacts of fisheries? For example, what are the extent and nature of fisheries subsidies, and how do they compare with those in other countries? What should be the role of subsidies for the fishing industry? If they were to be reduced, what transitional measures would be needed? Are there lessons to be learnt from the use of subsidies in European agriculture?**

Government subsidies intended to aid the fishing industry are now widely recognized as having perverse consequences in that providing funds for new vessels and gear is encouraging the overexploitation of fish resources. A consequence of the open access nature of 'the commons' is over capitalisation in the fishing industry. Officially reported subsidies are \$13 billion and unofficially estimated to be even higher. These subsidies often exacerbate the problems of over capitalisation and increase pressure on fish stocks. Eliminating these subsidies, although unpopular, would be required for successful environmental management. These subsidies are recognised as being so deleterious that it has been proposed that resource users should pay negative subsidies, or royalties as is normal in the petroleum or forestry industries.

Generally speaking, in a common property situation the users will always find ways to circumvent management objectives. Economic incentives will be required to modify fishers' behaviour towards the protection of fish stocks. It is vitally important to study and model the behavioural responses of fishers to various management scenarios. Therefore, rather sophisticated bioeconomic models are needed to address these issues. Economic data are, however, fairly inaccessible at the UK and European level. Those associated with the fishing industry and resource conservation have called for an increased collection and use of economic information by Government. Currently, long-term management decisions at the European level are being taken without sufficient robust economic information.

Achieving any change in fishers' behaviour may require measure such as transitional aid to support the fishing industry. In a personal submission to the RCEP, Professor John Shepherd provides a discussion on the benefits and difficulties with transitional aid for fishers as quotas are reduced. These measures can financially compensate the industry to accept short-term losses during as the industry moves to a permanently lower level of fishing effort and capacity. He explains that this aid should be available during times only where chosen conservation measures enforce lower catches than will eventually be allowed. He also explains that this transitional aid needs to be linked to a timetable of stock recovery, which allows for flexibility in the aid if the stocks have not recovered. A problem he outlines with transitional aid is how to ensure that the aid does not end up contributing to a maintained or even increased capacity of the fleet at a time when it is vital to reduce capacity. This would lead to the situation where stocks are allowed to recover only to be fished by a more powerful fleet financed by transitional aid.

**7 It is frequently claimed that there are health benefits in having a substantial amount of fish in people's diets. What is the evidence for these claimed benefits? What are the other major factors, which influence the demand for fish products?**

**8 Are fisheries agreements with developing nations likely to change their scope or nature? In what ways are current fisheries agreements advantageous and disadvantageous to developing countries' interests? Should there be a specific requirement for assessment of their likely social, economic and environmental effects before they are established?**

There is evidence from some western African nations of a rapid depletion of coastal stocks as a result of fisheries agreements, much to the detriment of local fishers.

## Marine science in relation to the issues covered by the study

- 9** *Is it possible to generate a set of indicators of marine environmental quality that would be useful for management purposes? What are the preconditions for achieving this and can ecosystem models assist? When indicators do change, how is it possible to distinguish between changes due to fishing pressure, natural variability, predation by larger sea creatures or birds and other factors? In what other ways can current ecosystem models assist management decisions? Could they be more effective for this purpose and, if so, how?*

Ecosystem models are poorly developed and lack of significant empirical underpinning. It is difficult to see how in their current state of development they can be useful to management.

- 10** *How reliable are models of fish populations and what practical steps could be taken to improve them? Do single species population models and 'safe allowable catches' provide an adequate basis for management decisions? How good is our understanding of the conditions for re-establishing fish populations once they are seriously depleted? How useful are the concepts of sustainability and sustainable yield?*

Most current models that underlie conventional management usually only consider one species at a time. These single species models are probably not adequate as they ignore the ecosystem in which the species is embedded and in doing so leave out too much ecological complexity to be reliable. Fish populations are also highly variable with fluctuations driven by a multitude of interacting factors, particularly the recruitment of young fish. This is especially important where stocks are heavily exploited as it means the recruitment of juvenile fish, which is fundamentally stochastic, is the major component of the biomass of the fish stock. Therefore marine ecosystems and the fisheries dependent on them are fundamentally uncertain.

Regulation and management therefore need to reflect the fact that there will always be uncertainty within models. One method of incorporating uncertainty into decision-making is to reflect it explicitly into estimates by using methods such as Bayesian statistical techniques. The use of decision tables would help managers to assess alternative management options. What is also required are regulations that ensure that there is feedback within management decisions to incorporate stock fluctuations.

Our understanding of the conditions for re-establishing fish populations once they are seriously depleted, depends on the biology of the species. Pelagic stocks tend to recover quite well when fishing is reduced, but for demersal (bottom dwelling) stocks, reducing fishing does not guarantee recovery, at least within 10-20 years. An example is the 'Northern' cod stock(s) off Newfoundland, which are still showing little sign of recovery, despite a nearly complete cessation of fishing since 1992. The reasons are not well understood, but they may involve ecosystem shifts that occurred in response to the removal of over 99% of the biomass of the cod in the 2 or 3 decades leading up to the closure. This provides an important lesson in that recovery after reductions in fishing cannot be taken for granted. It also emphasises that there is only a limited understanding of the processes that govern recovery.

As general concepts sustainability and sustainable yield are fine to define what is a sustainable level of fishing. However, they are not useful in terms of setting management targets, as they can lead to the dangerous practice of trying to achieve maximum sustainable yields.

- 11** *To what extent does the available data match, both in type and range, that required to support management and research needs? Where relevant data exists, is it normally available to managers*

***to assist their decisions? To the extent that there are data deficiencies, can new technology solve the problem of data acquisition or distribution? Who should be responsible for providing management data on the marine environment, and how can we ensure the data is robust?***

As with modelling, data will almost always be insufficient or inadequate, regardless of the cost. The question is how to manage fisheries given this inherent uncertainty. For example information may show a trend of sustained catch per unit effort, suggesting all is well with a stock but innovations in technique and fishing gear may mask what has actually been a decline. Currently, much data is collected by the industry itself, which may lead to bias in the information gathered. Data gathered also generally omits by-catch, discards and illegal landings of over-quota fish catches. Addressing these issues and providing further funding for the collection of data would help ensure data collected is more robust and applicable.

Further information about the ecology and behaviour of marine organisms would inform management efforts aimed at protecting habitats and incorporating species interactions into multi-species models. We also need to learn more about non-target species. For example, most European countries do not distinguish between individual species of skates and rays when collecting landings statistics. Yet, some species, such as the common skate, thornback ray, long-nosed skate and white skate have disappeared from large parts of their ranges (Dulvy 2000). Resources are limited to study species with low commercial value but affected by fishing activities through by-catch or their biological relationship with the target species. Funding should be made available to address this issue.

***12 Can the environmental impact of trawling be reliably assessed, including the effect on benthic biodiversity, population abundance, nutrient cycling and other key ecosystem processes? How reliably can marine science assess the full environmental effects of aquaculture? To what extent could it help to mitigate these, where mitigation is necessary, and on what timescale?***

There have been many published assessments of impacts of trawling on benthic biodiversity and population abundance. As more precise information becomes available on the spatial distribution of fishing effort, it should become possible to get a better match between known fishing intensity at a given location, and biodiversity of the seabed. Assessments are needed of the distribution of fishing at small spatial scales.

Side-scan sonar data can show trawling disturbance. Data exists showing surface trawling disturbance of most depths in the North Sea. Use of this technique has led to concerns about the impact of deep-water trawling on *Lophelia* (deep water coral) banks at depths of ~ 500 m. Further side-scan sonar and photographic data can be found Dr J.P. Henriët at R.U. Gent. (Co-ordinator of E.U. programme on deep carbonate mounds)

***13 How advanced is the development of combined physical, chemical and biological models of the UK shelf seas and what might be their role in understanding and managing the impact of fisheries?***

***14 How can the scientific uncertainties and indeterminacies in the environmental effects of fisheries be substantially reduced and/ or overcome? Is there a knowledge base on fisheries in the fishing community which science ignores?***

(Please see points 10 and 11). Well-enforced marine reserves should also provide good baseline information for comparison with areas that are fished heavily, including the time course of recovery. Conservation is dependent on developing the baseline data available to inform management strategies. As recommended in a recent Royal Society report on measuring biodiversity (2003), a framework is required to help co-ordinate the work of conservation practitioners to elucidate gaps in scientific knowledge. As scientific uncertainties are

reduced, conservation efforts can be focused where fishing practice is having a significant impact on marine biodiversity.

### **Regulatory or management practices and regimes**

**15 *To what extent has the EU approach to regulation of fisheries and of the marine environment been effective and what is the likely effect of the proposed reforms to the CFP? How well integrated are the management of fisheries with the management of habitats and other aspects of the marine environment?***

Politics should enforce sound science within fisheries management decisions. Currently politicians look to the short-term while fisheries management science is concerned with the long-term survival of fish stocks. The annual competitive bargaining over quotas by fishery ministers exacerbates this problem. This management strategy often sidelines the scientific underpinnings of management, by recommending higher annual quotas than advised. Uncertainty is used politically as the basis for making risky decisions as opposed to being used as a tool to urge caution. Ultimately, fishery management must be based on science, not political bargaining if it is to realistically succeed.

Professor John Shepherd's personal submission to the RCEP provides a detailed summary of the new Common Fisheries Policy (CFP) legislation. In which it is explained that some advances have been made in the new CFP, which advocates the long-term management plans for fish resources and recovery plans for overexploited stocks. However, he explains that this idea is critically weakened as no deadlines have been decided for establishing the recovery plans.

**16 *Are there particular management or regulatory approaches, for fisheries or other aspects of the marine environment, used by other countries that the Commission should examine, as examples of models that either could be, or should not be, adopted? Are different approaches needed to control the environmental effects of deep-water fisheries?***

We consider that management approaches should be regulated to ensure conservation goals are met in a more enforceable way. Replacing TAC's (Total Allowable Catches), and catch quotas with more enforceable conservation strategies, as suggested in point 24, have the potential to be greatly beneficial.

The Royal society agrees with Professor John Shepherd personal submission where he states, 'the development of recovery and management plans, based on the precautionary and ecosystem-based approaches to the maximum extent possible, would represent a major step forward for the management of European fisheries'. Setting high levels of precaution, informed by sound science would allow management decisions to incorporate fluctuations in stock levels, which may occur through stock collapses or recruitment failure.

**17 *Can marine reserves be established without a net loss in commercial catches through providing breeding and spawning grounds? How effective are they in protecting the marine environment? Are there minimum sizes at which they are effective? Is it important to embed them within more general marine or coastal strategies for a wider area?***

We believe that a highly promising area in fisheries and environmental management is the use of no-take marine reserves (Gell 2003; Houde *et al* 2001; Roberts 2000). A large quantity of evidence, mostly in the tropics, suggests that these reserves can be a powerful tool to help rebuild stocks and habitats damaged by fishing. For example, a meta-analysis of studies has shown recently that the overall abundance of fish inside reserves is on average 3.7 times higher than outside reserves, and most of this effect is due to increases in



target species (Mosqueira *et al* 2000). Due to a reluctance to experiment, knowledge is currently limited about potential positive impacts on commercial catches in temperate areas.

Using reserves is one of the best ways of adopting a more ecosystem-based approach to fishery management. We also consider it important to embed reserves within general marine strategies to avoid simply displacing fishing mortality to other locations.

Reserves can be important for a number of reasons; firstly reserves could build insurance into management. Insurance is needed as a result of the scale of uncertainty in fisheries. Reserves can put fishery management on a more precautionary footing. Secondly and critically, they will also address many of the concerns over conflicts among fishery sectors. For example a conflict may arise where one fishery catches and discards species of interest to another fishery sector, a reserve would ensure a certain quantity of the species is protected. One way in which they can achieve this is by protecting important nursery areas from fishing. A further benefit of reserves is supplying an important recreational value, which can provide an alternative source of income in some parts of the world.

It may be useful to note when considering if there will be any net loss to commercial catches, that in an investment of any kind, risk avoidance typically costs something. Marine reserves may protect certain species from exploitation but at a cost of lower annual catches.

**18 *Can regulation on fishing gear be effective without the active cooperation of fishers? How can this best be achieved? Is there a need for tighter regulations to reduce bycatch and discards? Are current monitoring methods, to ensure that regulations are observed, effective? If not, how can they be improved? Are the levels of fines and other punishments sufficient?***

The question of why fishers often oppose suggested regulations designed to improve their long-term economic prospects still deserves careful study. It will be useful to determine the effect of fishers' dependence on government subsidies, or other factors such as disbelief in the authorities' ability to control illegal fishing, given the relatively low probability of being detained. It is already clear that to act as any deterrent, fines and other punishments need to be significantly higher. However, more easily enforced regulations with an associated higher probability of the detection of illegal fishing can act as a deterrent with more modest fines and punishments.

**19 *Should regulations be changed so that bycatch and potential discards are used for purposes such as fishmeal, with the aim of reducing the pressure from industrial fishing? What would be the overall environmental consequences of such changes?***

**The institutional/ legal framework**

**20 *Do the current institutions provide a coherent and complete framework for managing the marine environment? How should the proposed new regional management councils be constituted and what powers should they be given?***

We support the use of Regional Management Councils in developing a more regional fisheries policy less restrained by the current process of annual fish quotas. The personal submission supplied by Professor John Shepherd provides more information on this issue.

**21 *How should responsibilities for the protection of the marine environment be divided between government, fishers, fish product manufacturers, importers, retailers, consumers, other ocean users***

***and conservation bodies? What could be their roles in efficient and effective marine stewardship and control?***

**22 *Is the current framework of international conventions on migratory species effective in managing the effects of human activities on these creatures?***

Management problems of the southern Bluefin tuna by the Commission for the Conservation of the Southern Bluefin tuna (CCSBT) provide an example of how the current framework of international conventions on migratory species is clearly not being effective for some species.

**23 *How should society ensure fair and reasonable public participation in the management of the marine environment and how can this be facilitated?***

**24 *Are existing rights and responsibilities conducive to sustainable use of the marine environment? If not, what changes are needed? To what extent are fisheries still treated as a common good which all may exploit? Are there potential benefits from a greater degree of ownership of fishing rights and the ability to trade these? What environmental effects might flow from any changes? Is there anything to be learnt from common property institutional arrangements (traditional or recent, formal or informal, community based or regional) for fisheries or natural resources.***

To address the common property nature of marine fisheries it is important to limit access to the resource. However regulating this access has usually proved to be a fraught and difficult problem. Regulations aimed at achieving conservation goals are usually more complex and problematic to enforce. A move to assess and alter the way fisheries are regulated to ensure that conservation goals are met in a more easily enforceable way would be an appropriate first step to improving fisheries management. For example, a simple substitution of effort for catch control has the potential to help enormously. This is explained more fully in Professor John Shepherd's submission. Enforcing current regulatory approaches of Total Allowable Catches (TACs) and catch quotas is very difficult and costly, due to the level of information and inspection from fishing vessels and landing sites required. Using restrictions on fishing effort (for example days at sea) would be much cheaper and with the extensive use of satellite monitoring, it would be far easier to enforce. Effort control would remove the need for detailed inspections and catch controls as all fish caught may be landed. This management strategy would therefore nullify the current discard problem. Individual Transferable Quotas (ITQs) and Total Allowable Catch are currently used as the methods to divide the resource between the users, providing a form of resource ownership. Similarly, effort control can be used to gain the economic benefits of establishing rights of access to the resource.

### **General**

**25 *There is a general commitment to using an 'ecosystems approach' to marine management. What do you understand by this term? How can it be realised in the multitude of individual management decisions concerning the marine environment?***

The obvious failure of fisheries management has resulted in a call for what has been termed ecosystem management. This is rather naïve as the underlying science of marine ecosystems is poorly developed and the fundamental uncertainty referred to above applies even more in the context of ecosystem management than in more simple management approaches. However, there are sensible principles in ecosystem management that can be incorporated into fisheries management. Such examples stem from the importance of distinguishing between the trophic levels of targeted species encapsulated in the practice of Convention on the Conservation of Antarctic Marine Living Resources (CCAMLR) and methods for attempting to control the bycatch of marine mammals and other species.

Much has been learned about impacts of fisheries on ecosystems during the past decade, and this information, combined with further research into marine ecology, should make it increasingly feasible to use ecosystem-based management. Specifically, we need a better understanding of fish, recruitment, juvenile and adult interactions, competition within and between species and predation-prey interactions to be able to incorporate ecosystem information with management advice. We recommend further long-term research to understand the complex interrelationships within marine ecosystems.

**26 The Commission would welcome views on the merits and likely consequences of adopting one or more of the following general approaches to management of the marine environment. Respondents may wish to suggest additional ones.**

- a. Basing management decisions on scientific knowledge concerning the integrity of highly dynamic ecosystems and monitoring the changes in appropriate indicators of, against benchmarks for, marine environmental quality;  
Agree and we suggest adding: 'taking account of inevitable and irreducible uncertainties regarding the state and dynamics of marine ecosystems.'
- b. Giving major weight to the impact of changes on the welfare of fishers and fishing communities;  
It is our view that all stakeholders should be fairly considered within management decisions and fishers are not the only stakeholders. It is raised in a Royal Society report on *Measuring Biodiversity for Conservation* (2003), that in planning research and consequently devising appropriate management strategies, an essential first step is to decide on the different interests of the stakeholders. In this case many people who are concerned about conservation of biodiversity have a considerable interest in trying to protect and restore marine ecosystems. Giving 'major weight' to impacts on welfare of fishers has not worked so far, either in terms of achieving sustainable exploitation, or in terms of preserving marine ecosystems. This statement also fails to confront the question of intra- versus inter-generational conflict. Today's fishers may need to make serious sacrifices for tomorrow's fishers. So we must be clear about which fishers we are referring to.
- c. Reversing the burden of proof for capture fisheries and aquaculture: permitting them only where it is clear that serious environmental damage is unlikely;  
Agree
- d. Establishing protected areas covering all vulnerable habitats, within which fishing, dredging etc would not be allowed;  
Strongly Agree
- e. Requiring information to be available to buyers on the environmental performance of individual fisheries, so that they can make informed decisions on fisheries products;  
We agree and suggest adding: 'fisheries and aquaculture industries...'
- f. Basing objectives on social expectations of a healthy or 'pristine' environment;  
This is a worthy aspiration, but it is hard to define 'healthy', and it is difficult if not impossible to find a 'pristine' part of the ocean
- g. Removing market distortions caused by subsidies and other financial support to the fishing industry, with appropriate transitional measures.

Agree

Plus: h. Management approaches should be regulated to ensure conservation goals are met in a more enforceable way

**27 Are there other aspects of the environmental effects of marine fisheries that should be addressed in the study? Do you have any other comments on the study?**

Two areas that may need further attention are firstly the impacts of aquaculture on the marine environment, including the extent to which aquaculture reduces pressures on wild stocks and secondly the likely impacts of transgenic fishes.

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