

## ANNEX 5 - Impact of World Fisheries Harvests on Marine Ecosystems

### The Impact of World Fisheries Harvests on the Stability and Diversity of Marine Ecosystems SCOR Working Group 105

Report of First Meeting Halifax, Nova Scotia, Canada  
5-7 November 1997

#### Introduction to the Meeting

Mike Sinclair opened the meeting with some introductory remarks. The principle aim of the meeting was to develop a work plan to fulfill the terms of reference within about three years (end of 1999). The terms of reference and list of members are attached (Annex 1, 2). SCOR Working Group 105 reports to John Field the new President of SCOR. The role of working groups is to summarize the state of knowledge in a particular subject area of marine science, and to identify key issues for future research. It was noted that there is potentially some overlap of our working group with both WG 93 (Pelagic Biogeography) and WG 98 (Worldwide Large-scale Fluctuations of Sardine and Anchovy Populations). Steps will be taken to ensure that there is no duplication of effort and that the results of these WGS (which are near completion) are taken into consideration. The end product of the Working Group is to be a publication. The SCOR publication policy is attached as Annex 3.

The issue of ecosystem effects of fishing is becoming increasingly topical. Two examples from a Nova Scotia perspective were mentioned. A recent application for an experimental kill fishery in the Gulf of Maine area and on the Scotian Shelf off Nova Scotia is being resisted by many stakeholders, due to the intuitive expectation that fishing at lower trophic levels will result in disruptive ecosystem effects involving commercially important species and marine mammals at higher levels of the food chain. The scientific advice infers that a restricted fishery should not be a concern from an ecosystem perspective. Atlantic cod, haddock and halibut have recently been placed on the red list by the Species Survival Commission of the World Conservation Council (IUCN). The list identifies species that are threatened by extinction. Canada has questioned the criteria that are being used due to the dynamic nature of marine ecosystems and the life history features of the species in question. These two recent local examples provide a context for the importance of our work at the policy and operational level of ocean management

A recent book review of *Betrayal of Science and Reason* (Paul and Anne Ehrlich), in the journal *Science*, highlights the need for peer review and consensus by the scientific community with respect to environmental issues. The book tackles the backlash against "green" policies by some scientists. This reaction is coined "brownlash". The reviewer states:

"At the heart of the brownlash movement they see a range of ideologically and economically motivated journalists, politicians, charlatans, and congenitally iconoclastic scientists who misrepresent the state of scientific knowledge about the environment in order to minimize, or even discount entirely, the challenges facing humanity in the next century... The stated goal of the book is to set the scientific record straight. (emphasis added)

The final sentence of the quote captures the challenge of our Working Group, i.e. to set the scientific record straight with respect to the ecosystem effects of fishing.

The agenda for the meeting was then reviewed and some modification noted. Steve Murawski and Jake Rice were not able to participate due to work conflicts. It was hoped that aspects of their presentation on the conceptual framework for the evaluation of ecosystem effects would be covered by, respectively, Henrick Gislason and Steve Hall. A presentation by Jill Casey and Ram Myers on the effects of fishing on fish community structure of the southern Grand Banks and St. Pierre Bank (off Newfoundland) was added. The final agenda is attached as

Annex 4. The structure of this first meeting was designed to facilitate a discussion of the full range of issues involved in ecosystem effects of fishing during the presentations made in the first two days. Subsequently, during the third day we could focus in on what can usefully be achieved by 1999 given the expertise and interests of the members.

#### Points from the Discussion of the Presentations

Presentation #1 (Platt): The paper provided perspective on the degree to which annual fishing harvests at present levels may be a concern from a trophic dynamic perspective. The methodology for estimating primary production within "Longhurst Areas" was reviewed. Given technological developments involving remote sensing, and good conceptual understanding of production processes, we now have the capability to estimate primary production at a wide range of spatial and temporal scales. Three problems were identified "New production", that component which supports fisheries yields cannot be readily estimated without empirical observations on nitrate fluxes or proxies for this process. Also, it is difficult to aggregate global fisheries yields by biogeographical zones of interest for ecosystem analysis, due to constraints of the Systems of fisheries statistics. Finally, the "Longhurst Areas", although sensible from an ocean physics perspective, are rather large for many shelf seas and semi-enclosed seas within which most of the fisheries are prosecuted. This mismatch in spatial scales needs to be addressed.

Presentation #2 (Pauly): A methodology for the analysis of fisheries removals within a trophic dynamic context was presented (ECOPATH). Work is being carried out in many parts of the world using the ECOPATH methodology, which is itself evolving over time. It was proposed that a synthesis of the results of these studies be brought together as part of the publication of the Working Group in 1999. The timing of the ECOPATH studies and the deadline for our synthesis appear to be consistent. It was stressed that the "Longhurst Areas" used for estimates of primary production are the preferred starting point for the trophic dynamic aspect of ecosystem effects of fishing. These areas, however, can be sub-divided where appropriate. Main Fonteneau (ORSTOM, France) is presently using the "Longhurst Areas" in his global analysis of tuna fisheries. There was again a discussion of the feasibility of using the FAO data base on fisheries landings. This issue will be followed up. The model results suggest that for some geographic areas annual carbon removals by fisheries account for up to 30% of primary production. Should society be concerned if a particular percentage of primary production is being removed by fishing? From a theoretical perspective little work has been done on this question. In general terms, however, the trophic dynamic modelling approach allows an analysis of the competing roles of fishing and other components of the marine community such as marine mammals. It has been estimated that the latter consume annually three times the removals by fishing. The energetics approach also provides a tool within which to evaluate the removal of production from intermediate trophic levels (such as krill and small pelagics). Gaps in knowledge, such as that in meso-pelagics and sea-bird abundances were noted. Although there was some concern that the trophic dynamic approach generates results that are difficult to interpret within an ecosystem effects context, there was a general consensus that the approach provides important insights to energetics constraints within marine ecosystems.

Presentation #3 (Reid): The continuous Plankton Recorder Program (CPR) has been running since 1947. The presentation provided a flavour of the scope of the data set, both geographically and temporally. Can this information on plankton species composition and abundance be used to evaluate the degree to which fishing practices in the North Atlantic have impacted on pelagic zone community structure? The trophic cascade hypothesis developed within north temperate lakes, and the key predator hypothesis based predominantly on intertidal experiments, infer that reduction in abundance of higher trophic level species can result in substantive changes in community structure at lower levels. The one study using the CPR data for the North Sea (by Koslow in the early 1980s) did not provide support for these hypotheses. However, a systematic evaluation of the CPR data from a perspective of ecosystem effects of fishing has not been made. It was suggested that an analysis of the patterns of fishing effort over time and space would provide background for the CPR data analysis. It was cautioned that due to the parallel impacts of pollution and climate variability it may be difficult to extract the degree to which fishing has had an impact (particularly in the coastal waters). The increase in the abundance of echinoderm larvae in the North Sea over several decades was one observation that suggested that the benthos in

this area may have been impacted due to trawling. Although there was some concern that the plankton community is irrelevant to the ecosystem effects issue, it was recognized that this data set provides one of the few descriptions of marine communities on time and space scales of relevance to the fishing impacts issue. It was generally felt that a judicious analysis of the CPR data set should provide conclusions on impacts on this restricted, yet central, component of the marine ecosystem.

Presentation #4 (Quinones): A site specific study on the Jack mackerel fishery in the southeast Pacific Ocean off Chile introduced the issues involved in small pelagics fisheries of eastern boundary currents. Around 4.4 million tonnes of this species was removed from the waters off Chile in 1995. The estimations available of the total biomass of Jack mackerel in the southern Pacific point at a value of approximately 17,000,000 tonnes (1+). According to the consumption rates of euphausiids by Jack mackerel estimated in the Chilean economic zone, the (1+) biomass in the southern Pacific can consume around 122 million tonnes of euphausiids per year. It was estimated that the portion of the population complex that is being extracted in the Chile-Peru current would have removed around 34 million tonnes of zooplankton per year. The channeling of this zooplankton biomass otherwise unavailable through the trophic web is an interesting impact of fishing on the ecosystem. The scale of this particular fishery (perhaps the largest single fishery during the early 1990s) provided perspective on the high productivity of eastern boundary currents and the roll of large-scale migration on energy fluxes between systems. There was general consensus that a comparative study of ecosystem impacts of fisheries within eastern boundary currents should be included within our work plan. It was noted that the CalCOFI data set provides a time series of zooplankton changes over several decades. There is also a good data set on zooplankton trends for the Chilean part of the eastern boundary current off South America.

Presentation #5 (Caddy): Temporal trends in the annual fisheries yield per km<sup>2</sup> for all parts of the globe were estimated using the FAO statistics on reported landings. The patterns provided perspective on which areas have already peaked in terms of landings, and thus a rough index of the degree of potential impact of fishing on the diverse ecosystems. The aggregate North Atlantic fisheries landings, for example, peaked early. Thus one might expect that the modifications in community structure have been occurring for a longer time period, and potentially be more dramatic. The analysis may provide a taxonomy on the degree of overfishing on a global scale and a framework to select representative case histories to ensure a balanced global synthesis. Most of the discussion was on the reasons for certain anomalies (e.g. the southwest of Africa shelf sea production) and on the deficiencies in the FAO data base for subdividing landings by biogeographic areas defined by physical oceanographic parameters.

Presentation #6 (Beckett): The implications of recent international conventions on ecosystem considerations for fisheries management was summarized. The CITES categories and the IUCN Redlist, both of which identify species which are threatened with extinction, are based on criteria applicable to both terrestrial and marine systems. This may cause problems during their application. The code of conduct for responsible fishing and the straddling stocks convention identify ecosystem considerations, as does the recent Convention on Biodiversity at Rio. It was considered important to fully understand the diverse technical statements in these texts, and where necessary, to translate them into operational terms. The discussion was very animated, but there was a general consensus that the new conventions provide powerful legal or institutional frameworks for the consideration of the ecosystem aspects of fisheries management. There was debate on a number of issues:

- the degree to which principles from terrestrial ecology can be applied to marine systems;
- to what degree is the loss of populations of a species, due to overfishing, a threat to genetic diversity and long term persistence of species?;
- do keystone species exist in the oceans, and if so, are they being reduced in abundance in a detrimental manner for community structure;
- does the loss of larger fish within a population result in less extensive migrations, and thus less adaptability of exploited species to climate variability?;
- what is habitat diversity for different ecosystems, and what proportion should remain pristine?;
- how can the precautionary approach be made operational?;

- should we include the role of aquaculture escapees as an ecosystem effects issue for fisheries?; and,
- are the eco-certification discussions relevant to our deliberations?

A consensus point from the wide-ranging discussion was that the ecosystem implications of the conventions need to be translated into operational terms, and that this is an issue that the Working Group should address.

Presentation #7 (Sinclair/Mohn): From one perspective the effect of fishing on recruitment potential of the target species falls outside of our subject area. From another perspective, however, these studies may be relevant. Two points were addressed. The loss of spawning components due to overfishing may lead to spatial changes in fish community structure (e.g. a coastal ecosystem may lose a species within the management unit even though the overall abundance for the target species is at moderate levels). Two examples of loss of spawning components for gadoids were provided. The second point is that studies of recruitment overfishing may provide increases in understanding about the regulation of abundance of non-commercial marine species with similar life history features. As such, the narrowing of theory may prove to be helpful in providing guidelines or "listing" criteria for endangered species. A model to evaluate the spatial dynamics of a population complex to fishing pressure was described. Much of the discussion focused on the functional relationships of the model rather than on the usefulness of incorporating spatial complexity into the modelling of population persistence. The approach may be helpful in the analysis of the importance of leakage between populations for the persistence of small populations.

Presentation #8 (Hall): The lack of long-term monitoring of the benthos on the European Shelf seas makes it difficult to evaluate the impact of trawling on this component of the ecosystem. There are only two long-term monitoring locations - the Kattegat and off Northumberland. A second constraint is the limited data on fishing effort. A general conclusion of the European studies is that climate variability has had a greater impact than trawling, and that the changes over time have been minimal. It was recommended that historical data sets (such as fish stomach collections) be mined to evaluate whether changes in the benthos occurred prior to the initiation of benthic monitoring. An additional approach to evaluating impacts is the study of changes in the benthos within MPAs where trawling is prohibited. It was pointed out that the North Sea is a relatively featureless area and perhaps resistant to fishing. There is a need to quantify the vulnerability of benthic species, and some approaches developed by John Pope were summarized. Length frequencies for benthic species are contrasted with expected length frequencies without fishing mortality. Much of the discussion focused on the degree to which major change predated our descriptions of benthic communities and the representativeness of the North Sea and Irish Seas as study areas.

Presentation #9 (Gordon): An experimental study of the impacts of trawling on the benthos community off the Grand Banks was described. The design of the experiment, as well as the advanced technology used to sample the habitat, should allow firm conclusions to be drawn. Initial results are available for the epifauna only. The abundance of some taxa declined significantly subsequent to trawling, while others were unaffected. Changes in benthic production will be estimated. The area chosen has not been fished for some years, and there was a discussion on the degree to which the experimental site is representative of fishing areas. It would be useful to compare the benthic community of a heavily fished area of similar habitat features to the experimental site that has been repeatedly trawled. There is a need to quantify the impacts at the level of the population (a scale of the bank), as well as to evaluate the degree to which impacts on the benthos influence other components of the demersal food chain (including commercially important species). The video presentation on the sampling methodology was impressive. The discussion was truncated due to time constraints. The two presentations on benthos impacts provided a framework for discussion of how best to carry out a synthesis.

Presentation #10 (Gislason): The trawl survey data for the North Sea provide data on trends for 146 species. There has been little change in the non-commercial component of the fish community off Scotland between the 1950s and 1990s. Recent work has addressed approaches to integrate the information using community level indices of diversity and size composition. The size spectrum of the North Sea fish community has changed, with the slope

becoming steeper and the intercept higher. Analysis of the diversity at size changes were less clear (non-linear). The response of the indices to fishing pressure were modeled, and the empirical observations on size spectra fit well with the model results. During the discussion it was concluded that these methods should be applied to comparable data sets from other parts of the world. The North Sea results infer structural changes in fish communities due to overfishing. There was no discussion on whether such size composition changes generate functional modifications. Much of the discussion addressed the meaning of various diversity indices. There was a general consensus that in contrast to the size composition such indices are not particularly helpful in quantifying the impacts of fishing on community structure. The evidence for "extinction" of larger length categories of the fish community in the North Sea, and the progress in modelling size composition responses to fishing intensity, generated several ideas for future work.

Presentation #11 (Zwanenburg/Howell): The trawl survey study data from Cape Hatteras to the northern tip of Labrador has been put on GIS to facilitate large scale analysis of fish community structure in response to changes in the environment and in patterns of fishing effort. The analysis suggests that although community structure is weak, it has been stable during the 1975 to 1994 time period. There have, however, been geographical displacements in locations of biogeographic discontinuities in response to cooling in the north and warming in the south during the 1990s. The overall results infer that environmental variability modifies geographical distributions of species and latitudinal shifts in fish communities, but that the fish community composition has been relatively persistent over several decades. Overfishing has impacted populations, but perhaps not the fish communities. An analysis of cod abundance and bottom temperature for several management units was presented to illustrate methods to separate out fishing and environmental impacts. The results suggest that large-scale changes in bottom temperatures have modified the habitat characteristics and suitability of certain areas for cod. Above 10°C and below 2°C cod tend to move to respectively contiguous cooler and warmer areas. The dynamic range of adaptability to temperature appears to be stock specific. The discussion digressed on the causes of the cod collapses in the northwest Atlantic rather than on the utility of trawl surveys to evaluate ecosystem effects of fishing.

Presentation #12 (Sainsbury): The research on the ecosystem effects of fishing in Australian waters was summarized within three categories: case histories; experimental studies; and, comparative studies (meta-analysis). For the shelf southeast trawl fishery there have been clear changes in species composition during the latter part of steam trawling (1940s and 1950s). For the more recent deeper water slope fishery in the same area several species have declined significantly since fishing began in 1976. There have also been marked changes in community structure within the Gulf of Carpentaria. In contrast, the diverse Great Barrier Reef prawn fishery studies have generated equivocal results (closed area similar to open area, before/after differences not significant) although repeated trawling has been shown to effect epibenthic habitats. The experimental management of gear types in the northwest Australian demersal fishery illustrates that benthic community impacts of trawling are reversible. Trawling had modified the structural complexity of the benthos in this area with associated change in commercial fish species mix. Removal of trawling resulted in a return to original species rank order. An emphasis was put on the need to study the pelagic ecosystem. For example, the Pacific tuna fishery results in a 250,000 t by-catch of sharks. what are the impacts of the removal of top predators? A by-catch of seabirds is also taken, but there is little information available of the effect on these populations in the ecosystem. The Australian "experience" with ecosystem impacts provided an excellent conceptual framework for the working group activities. It also appears as if the impacts on the ecosystem by fishing off Australia have been more dramatic than is the case of north temperate shelf seas, but it was also pointed out that Australian fisheries are more recent with several examples of research survey information on the unfished state. There was further discussion on the desirability of including ecosystem management considerations within our terms of reference.

Presentation #13 (Bianchi): The presentation began with a discussion of the constraints of the data sets in topical groundfish fisheries. Until recently there have been good taxonomic descriptions at the species level, thus much of the earlier trawl survey data describes distributions at the genus or family level. As a result extinction of species, if it has occurred, may not be possible to evaluate. The global coverage of trawl surveys by the Norwegian research vessel (*Nansen*) was summarized. "The results from a study based on the data collected by this vessel in three

oceans, showed that tropical continental shelves display a wide variety of fish assemblages, often separated by clear environmental boundaries such as the thermocline or the oxycline. These differences are reflected in the species composition, diversity and size spectrum. The vulnerability of these communities to fishing may also differ. Therefore, it was recommended that studies on the impact of fishing on species composition and size spectra should be preceded by an identification of main communities (or habitats) in the areas under study". There are some areas that have been surveyed more than once using the same methodology. The size spectrum method of Henrik Gislason was applied to several surveys and the initial results look promising. The need for an inventory of trawl surveys in tropical waters was discussed. Some approaches to describing species diversity in tropical environments were reviewed. The discussion focused mostly on the degree to which there is data available for tropical groundfish fisheries that will allow generalizations to be made concerning ecosystem impacts. This is an area to follow-up upon. There was general consensus that similar methods could be used to characterize changes in groundfish communities in diverse ecosystems.

Presentation #14 (Casey): Trawl survey data from the 1950s for the southern Grand Banks and St. Pierre Bank have been recently added to the results of standard surveys conducted since the 1970s. The longer time frame allows conclusions to be drawn concerning the impacts of the European distant water fleet activity in the northwest Atlantic during the 1960s and early 1970s. There have been major changes in relative abundance of categories of species. The gadoids declined dramatically whilst the flatfish species increased in absolute abundance as well as proportionally. Barndoor skate has become very rare. The study highlighted the value of including data sets prior to the onset of modern industrial trawling. The discussion was cut short because of a shortage of time at the end of day 2.

Presentation #15 (McManus): A slide presentation of the dramatic effects of intensive fishing on coral reefs provided a reality check on the scope of the problem in heavily populated tropical coastal areas. The concept of "Malthusian overfishing" (resulting from overcrowding, poverty and lack of alternate livelihoods) was particularly helpful for focusing on the coastal fringe impacts which had not been covered in previous presentations. A conceptual framework involving raising of the cost curve of the Gordon-Schaefer bio-economic model through restrictions on fishing methods was suggested as the only management method applicable to artisanal high participation, open access systems (the Schumacher "Small is Beautiful" approach to development of the early 1970s). A site specific study in the Philippines on the impacts of fishing on both habitat and species diversity was described. The study illustrated some methods for dealing with statistical descriptions of community structure. It was concluded that present fishery practices could well lead to extinction of the species level, which until recently had not been considered a serious threat for wide ranging marine fish species having complex life histories (relatively high dispersal capability and fecundity). The discussion ended with the need for indices of ecosystem health to compliment species and population indices of overfishing. As was the case of several of the other presentations, the issue of multiple causes of changes in ecosystems was discussed (climate variability, pollution, overfishing). For many tropical coastal zone ecosystems it may not be possible to tease out the fishing impacts from others.

### Discussion of Work plan

Mike Sinclair briefly explained that SCOR and ICES will co-sponsor a symposium on "The Ecosystem Effects of Fishing" to be held in 1999 with Sinclair and Gislason as co-conveners. ICES will help with the organization.

The framework of the symposium was discussed and it was decided to aim for a three to four day symposium comparable in structure to the symposia organized by the British Ecological Society. This means that the presentations will be restricted to invited keynote papers, giving the authors more than the usual 20 minutes to present their results. The papers should all be subject to peer-review before the symposium. Additional contributions will be as posters presenting specific case studies.

The aim of the symposium will be to provide a global synthesis of what is known about the impact of fishing

on marine ecosystems, report on new methods for quantifying the impact at the ecosystem level and provide a forum for discussions on how these methods can provide the basis for formulations of management strategies. In order for the symposium to be successful it was felt important to investigate the scope of other symposia planned for the intervening period so that undue overlap could be avoided. It was also noted that representation from all areas of the globe would be encouraged. Representatives from environmental NGOs (e.g. WWF) and other environmental organizations (e.g. IUCN) should be invited to present viewpoints on fisheries impacts and environmental quality objectives. In view of the very broad scope of the symposium it was decided to form a number of groups responsible for providing the input is required.

It was decided that the symposium should consist of the following themes:

- a) Case histories - documenting investigations of fisheries impacts on the local scale or presenting new methods for the study of ecosystem effects of fishing. These contributions should be presented in the form of posters;
- b) Ecosystem synthesis - presenting overviews of fisheries impacts on particular ecosystems;
  - Coastal and estuarine fisheries: Sainsbury will contact Blaber (CSIRO) and a group will be formed including, if possible, Yanez-Arancibia (Mexico) and Omar Defeo (Uruguay);
  - Coral reefs: McManus will form a group;
  - Eastern boundary currents: Quinones will form a group and make contact with SCOR WG 98 and the SCIOS project of ORSTOM and,
  - Continental shelves:
    - Demersal fish: Bianchi, Hall, Gislason, Sainsbury and Zwanenburg;
    - Benthos: Hall will form a group including Gordon, Poiner (Australia), Collie (US) and Juan Carlos Castilla (Chile). The group should contact T. Pitcher regarding a synthesis of benthos responses in areas closed to fishing;
    - Pelagic ecosystem: Reid will form a group including Andy Bakun (US) and Alain Fonteneau (France). The group will cover zooplankton, tunas, small pelagics, sharks and possibly also marine mammals and seabirds; and,
    - Semi-enclosed seas: Caddy will form a group.
- c) Cross-ecosystem comparisons:
  - Trophodynamics: Pauly will organize a group. Work is in progress to construct a model of global fluxes in the marine environment based on the ECOPATH approach. A series of workshops has already been planned and it is expected that a preliminary synthesis of the model results will be available in 1999.
  - Community structure: Sainsbury will organize a group including Rice, Bianchi and McManus.
  - Vulnerability: Gislason will contact John Pope (UK) and ask him whether he will be interested in forming a group on the quantification of species vulnerability to fishing. The group will include Mohn.
  - Genetic diversity: Sinclair will find someone to lead the group. The group may include Robert Ward (Australia) and Ricardo Galleguillos (Chile).
- d) Ecosystem Quality Indices (Sustainable development indices): Gislason will contact Niels Daan (The Netherlands). The group will include Tundi Agardy (WWF), Sainsbury and McManus.

There was some discussion about the possibility of including habitat changes due to fishing as a special item in either b or c, but it was concluded that this topic should be dealt with under each of the separate items in b.

Most of the work will have to be done through networking, but the groups should also have a possibility to meet at least once in order to prepare the input for the symposium.

To advertise the SCOR Working Group, and the Symposium, it was decided to make a Home-page on the Internet and to make a folder with the SCOR logo containing a two-page synthesis of what the group is trying to achieve and a work plan. Members of the group should provide Mike Sinclair with suggestions on whom to send it to. The folder would be helpful in raising additional funds for the symposium and for the costs associated with the meetings of the groups.

The time and venue of the symposium were briefly discussed and it was suggested to have the symposium in March 1999. Rome was suggested as a convenient place, provided FAO was willing to help with the organization.

The SCOR working group should meet again for two days in approximately one year's time in order for the members to report on progress. It was suggested to have the meeting in Copenhagen in connection with the meeting of the ICES Working Group on Ecosystem Effects of Fishing in November 1997 (dates yet to be fixed by ICES).

Based on the work plan discussion Henrik Gislason expanded upon the symposium outline. During the meeting at least 12 invited presentations for the symposium were identified. Assuming the symposium to last for about four days and having three one-hour presentations during the morning session and four in the afternoon we would have plenty of room for additional contributions. Among the areas not sufficiently covered at present are marine mammals and seabirds, which would provide two additional presentations. A special presentation would be needed on sharks, tunas and other highly migratory top predators (separating them from the plankton issues). Also small pelagics on continental shelves deserve a special presentation, as does the impact of fishing on the Arctic/Antarctic ecosystem (involving if possible CCAMLR). The continental slope and the deep sea could be treated in a special session. We should also try to present something on sustainable management strategies. ACFM of ICES is now moving towards including the precautionary approach and ecosystem considerations into their advisory framework. The chairman of ACFM could be invited to provide a paper on the advances they have made so far.

An outline of an expanded programme could therefore be:

Ecosystem synthesis:

Coastal and estuarine fisheries

Coral reefs

Semi-enclosed seas

Continental shelves:

Demersal fish

Small pelagics (new)

Benthos

Continental slopes and the deep sea (new)

Arctic and Antarctic ecosystems (new)

Eastern boundary currents

Pelagic ecosystem (top down effects on plankton) (modified)

Sharks, tunas and other highly migratory species (new)

Seabirds (new)

Marine mammals (new)

Cross-ecosystem comparisons (methods for quantifying the impact of the ecosystem level)

Trophodynamics

Community structure

Quantifying species vulnerability

Genetic diversity

## Separating natural and fisheries-generated changes in recruitment

### Ecosystem quality indices (sustainable development indices)

The scientist's view (N. Daan)

The view of environmental NGOs (Tundi Agardy)

### Management strategies (new)

Options for sustainable development? (A. Garcia?)

Integrating fisheries and ecosystem management (J.J. Maguire?)

This would provide us with a total of 22 presentations. Additional presentations could be generated by subdividing the continental shelves into say boreal, temperate and tropical systems or by having more contributions for the two last sessions. Another possibility would be to include a panel discussion at the end of the Management Strategies session; thus providing WWF, IUCN and others a forum for providing input to the Symposium.