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### ACP – EU Fisheries Research Report Number 5

#### ACP-EU Fisheries Research Initiative

#### Proceedings of the EXPO'98 Conference on Ocean Food Webs and Economic Productivity

Lisbon, Portugal, 1-3 July 1998

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**ACP-EU** - Development co-operation between African, Caribbean and Pacific (ACP) countries and the European Union (EU) and its member states in the framework of the Lome Convention.

**CNROP** - Centre National de Recherches Océanographiques et des Pêches, Mauritania

**CNSH** - Centre National des Sciences Halieutiques de Boussoura, Guinea

**CRODT** - Centre de Recherches Océanographiques de Dakar-Thiaroye, Senegal

**DGVIII** - Directorate General for Development of the EC

**DGXII** - Directorate General for Research of the EC

**DSL** - Deep Scattering Layer, an assemblage of organisms at depth of about 1000 m

**EC** - European Commission

**EIA** - Environment Impact Assessment

**FAO** - Food and Agricultural Organization of the United Nations

**FRI** - Fisheries Research Initiative

**GFCM** - General Council for the Fisheries of the Mediterranean

**GPS** - Global Positioning System

**ICES** - International Council for the Exploration of the Sea

**ICLARM** - International Center for Living Aquatic Resources Management

**INCO-DC** - International Cooperation in Science and Technology with Developing Countries

**IPIMAR** - Instituto de Investição das Pescas e do Mar, Lisbon, Portugal

**ISM** - Island Systems Management

**ITQ** - Individual Transferable Quota

**JRC** - Joint Research Centre of the EC

**LP** - Linear Programming

**MCS** - Monitoring, Control and Surveillance

**MPA** - Marine Protected Area

**MRAG** - Marine Resources Assessment Group

**MSC** - Marine Stewardship Council

**NGO** - Non-governmental organisation

**OECS** - Organisation of Eastern Caribbean States

**SIDS** - Small Island Developing States

**SIFR** - Study on International Fisheries Research

**SCUBA** - Self-Contained Underwater Breathing Apparatus

**SRFC** - Sub Regional Fisheries Commission

**TAC** - Total Allowable Catch

**UK** - United Kingdom

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### ACP – EU Fisheries Research Report Number 5

#### Introduction and executive summary

A three day scientific conference on “Ocean Food Webs and Economic Productivity” was held from July 1-3, 1998 at the Instituto de Investição das Pescas e do Mar (IPIMAR) in Lisbon, Portugal, under the auspices of the ACP-EU Fisheries Research Initiative and the European Commission (DG VIII), and as part of ‘Ocean EXPO’98’. The conference was based on the premise that the continued economic productivity of the oceans depends on the maintenance of their ecological integrity, much threatened by a global fisheries crisis, which manifests itself in runaway fishing mortalities and vanishing social benefits.

This report documents the conference through 36 short contributions arranged in a three-step structure, each step corresponding to one conference day, and moving from a ‘General Diagnosis’ of the status of fisheries and ocean ecosystems to ‘Sectoral Responses’ and thence to ‘New Arrangements’. The ‘General Diagnosis’ documents the crisis of fisheries, and the magnitude of their impact on ocean ecosystems, and their productivity. ‘Sectoral Responses’ shows how the fisheries sector (including fisheries science) views the crisis, and illustrates approaches that might be used to mitigate fisheries impacts, with emphasis on Marine Protected Areas. ‘New Arrangements’, finally, deals with the new institutions and actors that may contribute to resolving the crisis of fisheries, and the ecological threats to ocean productivity that emanate from it.

The 1990s have seen so many accounts of a global crisis in marine fisheries and of fisheries impact on their supporting ecosystems being published in mainstream publications that another restatement of the crisis may appear superfluous. Yet the expansion of fisheries effort continues, the subsidies, which drive this build-up, continue, and more fish and invertebrate populations throughout the globe, including populations from increasingly great depths, are being pushed to the point of collapse. Thus, one can legitimately infer that the message has not yet reached decision-makers of sufficient stature.

This report is another attempt to get the message ‘across’. Given its grim nature, much emphasis was thus given to establish the strength of the ecosystem impacts alluded to above, and thus to provide a basis for the subsequent contributions, describing the economic and other societal

ramifications of these impacts, before proposing remedial measure.

One major conclusion from the economic studies is that the globalised market, through changing valuations over time, has helped mask the real economic effects of resource depletion. Thus, small fish and invertebrates earlier fetching low prices now go for relatively higher prices, as previously desirable fishes such as cod, groupers, snapper and other relatively large fish, located high in food webs, became scarce. This conferment of value to previously cheap fish has led to fisheries that appear to be in good economic health, but which have wasted their economic potential, not to speak of the biological damage they inflict to the ecosystems. Indeed, fisheries management has hitherto been exerted in close to complete disregard for the ecosystems in which the target species are embedded.

Another key conclusion is that markets cannot be expected to halt and even will accelerate the trend of fisheries toward fishing down marine food webs, with all that it implies for the extermination of populations of large fishes.

The news from the research front, on the other hand, are cautiously optimistic: several practical approaches are presented for modelling ecosystems and fisheries, and thus to better understand their dynamics. One of these approaches is the 'Ecopath with Ecosim' package, which generated and/or can emulate many of the results presented at the conference. Other useful approaches include individual-based modelling, found to lead to a fair representation the decision-making by artisanal fishers, and bioeconomic modelling, which can explain much of what industrial fisheries do.

Marine Protected Areas (MPAs) also generated optimism. The conference participants were in agreement that their establishment, at least in tropical developing countries, not only has been generally positive, but that establishment of more MPAs is mandatory, if certain fisheries (e.g., those relying on large, long-lived fishes such as groupers) are to survive. In principle, MPAs should also work in temperate areas, especially for non-migratory species. However, the tasks of convincing managers of their efficacy will be arduous, given the novelty and tropical origins of MPAs. Thus, it is anticipated that MPAs will become established only after a number of detailed experiments have been performed on temperate species, in temperate waters. An early experiment of this type, concerning the North Sea's 'Plaice box', is briefly described.

Implementation of MPAs, and of other measures departing from traditional management measures (mesh size, effort, and quota regulations) – i.e., those that have brought about the present crisis – require looking beyond single species, and beyond the industry itself. Consumers, NGOs, and other groups must be enabled to contribute to the safeguarding of resources that are, after all, public property. Various schemes were presented and discussed which would contribute toward opening the required debates, ranging from the eco-labelling scheme of the Marine Stewardship Council to the 'New Governance' arrangements that are seriously discussed, and/or partly implemented in some Caribbean countries. Here again, MPAs appear to provide be ideal focal points for the required debates, and for actors other than those traditionally privileged (i.e., the industrial fisheries sector) to contribute

their insights and vision.

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### ACP – EU Fisheries Research Report Number 5

#### Foreword

This document represents the proceedings from the first of three complementary and thematically interconnected scientific conferences of the ACP-EU Fisheries Research Initiative, convened at EXPO'98 in Lisbon, Portugal during the summer of 1998. Three main and closely interrelated areas were identified as crosscutting issues for that Initiative, namely: (a) resource system understanding, policy and governance; (b) data, information, knowledge and communication among stakeholders; and, (3) interdisciplinary scientific approaches and methodologies.

The European Commission provided some support to individual activities in all three areas. While extremely relevant to the ACP-EU partnership, these go well beyond the geographical scope of this relationship, since they address themes of global scientific, environmental and economic importance. The scale of the problems requires considerable attention from the scientific community world-wide, as well as from all other actors, private and public, involved in the use of aquatic ecosystems.

The objective of the conferences was to promote a coordinated approach to research and more specifically to scientific cooperation involving European and Third Country scientists and creating an interface between research and decision makers. This is grounded in the rationale that management for the sustainable and equitable use of natural resources requires an enabling societal environment and needs to be based on sound scientific knowledge.

This first conference is a contribution towards mapping out avenues for underpinning with the necessary research the broad principles for ecologically and socio-economically sound fisheries governance as enshrined in the major international treaties and codes. The speakers documented the gravity of changes that have occurred in marine ecosystems around the world. They analysed the contributing mechanisms, such as masking effects in the market pricing mechanisms, which do not adequately reflect scarcity adequately. Among the options available to rehabilitate lost ecological and economical productivity marine protected areas stand out as warranting increased attention by the scientific community, fisheries managers and the wider public.

But most importantly, the conference asked some questions about new

institutional arrangements, which would allow addressing the mechanisms that have led to the current crisis. Two basic considerations here come to mind: (1) ocean resources are a public good and their management must reflect the legitimate public interest of this and future generations; and (2) the value our societies want to assign to economic efficiency over other fundamental concerns such as equity.

This conference provided an innovative focus on some of the very real and practical challenges in ocean governance today. It also highlighted areas where scientific hypotheses and approaches need to be sharpened to contribute more effectively to society's tackling of those challenges. All interested in contributing to this process through research collaborations between scientists in Europe and ACP countries and their institutions, are invited to participate actively in the successive calls for international cooperation under the INCO-DC programme, a component of the European Community's 5th Framework Programme for Research and Technology. The definition of priorities takes inspiration from the ACP-EU Fisheries Research Initiative and supports it. This is at least one of the practical options to follow-up on the new leads arising from the conference, with other mechanisms also waiting to be used.

Our shared ocean calls for improved governance, underpinned by scientific collaboration. Cooperation based on mutual respect and interest, shared responsibility and reciprocity is the most logical and reasonable mode to go forward.

*Cornelia E. Nauen and F. Tilak Viegas*

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### ACP – EU Fisheries Research Report Number 5

#### 'Fishing down marine food webs' as an integrative concept

*Daniel Pauly (University of British Columbia, Canada)*

The 1990s have seen so many accounts of a global crisis in marine fisheries and of fisheries impact on their supporting ecosystems being published in mainstream publications, that yet another restatement of the crisis may appear superfluous. Yet the expansion of fisheries effort continues, the subsidies, which drive this build-up, continue, and more stocks throughout the globe are being pushed to the point of collapse. Thus, one can legitimately infer that the message has not yet reached decision-makers of sufficient stature.

The conference documented in this report may be seen as another attempt to get the message 'across'. Given the grim nature of that message, this first contribution is to establish the strength of the ecosystem impacts alluded to above, and thus to provide a base for later contributions. These will then describe the economic and other societal ramifications of these impacts, before proposing remedial measures.

However, for the sake of clarity and space, we shall limit ourselves, when describing the ecosystem impacts of fisheries, to a limited set of such impacts. Hence, we concentrate on the impacts fisheries have on food webs, i.e., on the network of flows of matter (= biomass), which in ecosystems, link the plants with the herbivores, and the latter with their predators. These networks of flows are affected directly by fishing, which removes predatory fish, or competes with them for their preys, in either case affecting the web within which predators and preys are embedded.

**Figure 1** gives an example of a simplified food web, and defines the various elements of such webs ('functional groups'), the flow between them, and so-called 'trophic levels', which indicate the position of each functional group within the web.

Herein, the plants have a definitional trophic level of 1, as does dead organic matter ('detritus'), while exclusive plant or detritus feeders ('herbivores', 'detritivores') have a trophic level of 2. Carnivores feeding exclusively on herbivores and/or detritivores have a trophic level of 3, and so on up. Important is, however, that carnivores do not necessarily have trophic levels of exactly 3, or 4, but are more likely to have intermediate values, reflective of the mix of preys they consume. Thus, e.g., a shark that should have a trophic level of 5.0 because it feeds on

groupers with a trophic level of 4.0 will end up having a trophic level of 4.5 if it feeds, equally, on a small carnivore with a trophic level of 3.0.

Because of this effect of mixed diets, top predators in marine ecosystems rarely have trophic levels in excess of 5. Indeed, such high values occur only in transient killer whales, and polar bears, which, by feeding exclusively on marine mammals (which themselves prey on piscivorous fish), can reach trophic levels much higher than those reached by fish – even the great white shark (Pauly et al. 1998a). Moreover, while some fish reach trophic levels in excess of 4.0, the overwhelming bulk of them have trophic levels between 2 (in herbivorous species such as anchovies, and in most commercial invertebrates) and 4 (in cod, snappers, tuna and other predators).

**Figure 1** is an example of a simple food web, representing the oceanic part of the South China Sea (based on Pauly and Christensen 1993). Biomass fluxes were quantified using Ecopath (see also Christensen, this vol.)

This point is relevant because, as we shall see further below, world fisheries landings increasingly consist of organisms with low trophic levels, a process now called ‘fishing down marine food webs’ (Pauly et al. 1998).

The demonstration of this process was based on two data sets:

1. Fisheries landings, for all areas of the world, as compiled by the Food and Agriculture Organization of the United Nations; and
2. Estimates of trophic levels for all groups in the FAO landing statistics, as obtained by ecosystem models such as illustrated in Figure 1, describing the major types of marine ecosystems, and documented in FishBase (Froese and Pauly 1998).

From these, the mean (weighted) trophic level of the fisheries landings can be straightforwardly estimated, by year and region, by averaging, after weighting the trophic level of each species group by its landings (Pauly et al. 1998a).

**Figure 2** shows some trends of mean trophic level in landings from the Eastern North Atlantic and the Mediterranean, i.e., encompassing the waters around Europe. Note that the trends in the Mediterranean started from a lower base, suggesting that high-level carnivores were depleted in earlier times (see also Stergiou, this vol.)

The results are striking: there is globally a decline in the mean trophic level of fisheries landing of about 0.1 per decade, well illustrated by the trends in FAO areas 27 and 37 (Eastern North Atlantic, and Mediterranean and Black Sea, respectively), representing European waters (see Figure 2).

In the intertropical belt, this trend is not as marked when one uses FAO regional data, which tend to be over-aggregated as far as developing countries are concerned. The effect itself (i.e., ‘fishing down marine food webs’) occurs, however, in developing countries as well. In Senegal for

example, large predators such as the thiof (*Epinephelus aeneus*), previously a staple fish, have become very rare.

Fishing down marine food webs also occurs in Antarctica, and in freshwaters, where, in both cases, the trophic levels of the catch have strongly declined, nearly down to the herbivore level.

These results have been widely discussed in the press of several countries, and have been generally perceived as indicating a serious problem. Particularly worrisome are the usually backward-bending plots, which result when mean trophic levels are plotted against catches (Pauly et al. 1998a). Such plots indicate that, contrary to a widely held, if usually unstated assumption, fishing down marine food web does not lead to ever-increasing catches. Rather, below a certain trophic level – which may vary between ecosystems – further declines in trophic levels lead to decreasing catches.

This and related findings are presently being actively debated in the scientific literature. Given the ubiquity of 'Fishing down marine food webs', these discussions are likely to continue for a while. This report may be seen as a contribution to the debate.

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### ACP – EU Fisheries Research Report Number 5

#### Developing deep-water fisheries: toward an understanding of their ecological impacts

*John D.M. Gordon (Scottish Association for Marine Science, Scotland)*

The 1990s have seen so many accounts of a global crisis in marine fisheries and of fisheries impact on their supporting ecosystems being published in mainstream publications, that yet another restatement of the crisis may appear superfluous. Yet the expansion of fisheries effort continues, the subsidies, which drive this build-up, continue, and more stocks throughout the globe are being pushed to the point of collapse. Thus, one can legitimately infer that the message has not yet reached decision-makers of sufficient stature.

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### ACP – EU Fisheries Research Report Number 5

#### Deep water fisheries of the North-western Mediterranean

*Beatriz Morales-Nin (CSIC-UIB, Spain)*

The "North-western Mediterranean", as defined here, encompasses the Gulf of Lions, off southern France and the northeastern tip of Spain, while the "Spanish Coast" consists of the Balearic, Levantine and Alboran Seas.

The deep-water fisheries of the Gulf of Lions consist of two groups of fleets. The first is composed of trawlers used to exploit a community dominated by blue whiting (*Micromesistius poutassou*) over the shelf slope, in winter, at depth of about 400 m.

The second set of fleets use a number of gear to exploit hake (*Merluccius merluccius*), whose economic value is very high. Juvenile hake are exploited in shallower waters. The adults are exploited by a French trawler fleet at depth of 30-300 m and by a Spanish trawler fleet at 50-500 m. Also, adult hake are taken by gill nets set at depth of 90-300 m and, in canyons, by long lines set at depths of 160-600 m.

Off the Spanish Coast, only trawls are used, and invertebrates represent the most important part of the catch, which is landed daily on ice. Target species, depths and habitat define two distinct fisheries:

1. at depth from 150-800 m, over even grounds, Norway lobster (*Nephrops norvegicus*) is the target species, and the by-catch consists of monkfish (*Lophius piscatorius*), hake, greater forkbeard (*Physis blennoides*) and the Atlantic mud shrimp (*Solenocera membranacea*);
2. at depth of 400-800 m associated with submarine canyons and banks, the target species is the blue and red shrimp (*Aristeus antennatus*), with a by-catch consisting of deep-water rose shrimp (*Parapenaeus longirostris*), giant red shrimp (*Aristeomorpha foliacea*), hake and greater forkbeard.

These fisheries are meant to be regulated through limitations on the number, engine power and size of vessels, the mesh sizes of their gear, and their fishing times (12 hours per day from Monday to Friday). However, these regulations are largely ineffective. Thus, engine power,

meant to be restricted to 500 HP reaches 1000 HP, and even 1500 HP in some cases. Also, mesh size regulations are circumvented, and use of global positioning systems (GPS ) and remote control of the gear have increased the effective fishing power of the fleets. This has lead to clear signs of overexploitation of the populations of hake and Norway lobsters.

Biological investigations, ongoing for several decades and documented, e.g., in publications of the General Council for the Fisheries of the Mediterranean (GFCM), have confirmed these worrying results. Moreover, six years of catch data on blue and red shrimp (*Aristeus antennatus*) from Catalonia and Valencia, studied through Length Cohort Analysis and Virtual Population Analysis, suggested that exploitation levels were close to optimum. Thus, the trends of increasing fishing effort alluded to above will have to be countered, if this valuable resource is not to become overexploited as well.

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### ACP – EU Fisheries Research Report Number 5

#### Regimes shifts in upwelling systems

*J.M. Zaldivar, N. Kourti, C. Villacastin, F. Strozzi and F. Campolongo (JRC, Italy)*

One major problem in ecology in general, and in fisheries science in particular is that of separating the effects of environmental factors from the effects of fishing. It is true that, due to the complex nature of the ecosystems through which these effects are mediated, a clear-cut distinction of anthropogenic from natural effect is usually not possible. However, the prospect of separating these effects through non-linear models of population dynamics still inspires much research, in spite of debates on the difficulties associated with connecting data to models. This is not surprising, as sampling reliable data from real ecosystems requires considerable effort.

**Figure 4** shows the apparent fluctuations of biomass in California sardine (*Sardinops sagax*) and Northern anchovy (*Engraulis mordax*), as reconstructed from scales in marine sediments (redrawn from Baumgartner et al. 1992).

These problems, moreover, are amplified by the fact that ecosystems – along with their components - evolve over millennia, and undergo regime shifts at decadal scales (Bakun 1996). On the other hand, we are often forced, when attempting to characterise the dynamic behaviour of ecosystems, to assume that some steady state has been reached, rather than making the more realistic assumption that the system under study is on a transient. Moreover, and especially so in upwelling ecosystems, environmental fluctuations play a structuring, rather than a subsidiary role in shaping ecosystem configurations (see Moloney, this vol., and contribution in Durand et al. 1998). Thus, it is extremely difficult to distinguish cases where pelagic fish populations change their relative abundance due to non-linear interactions among species from cases where the change is due to one or several environmental factors.

We have nevertheless attempted to address this problem, based on an approach combining relatively simple Lotka-Volterra non-linear differential equations (Takeuchi 1996) with stage-based discrete models (Caswell 1989). Our outputs were then calibrated to observed time series of pelagic fish scales in marine sediments, both off Namibia (Shakleton

1989), and California (Baumgartner et al. 1992; Figure 4).

The comparison of our calibrated model results with the patterns derived from sediment samples suggested that environmental effects may explain the shorter term (<150 years) component of the observed population fluctuations, but not their longer term components. This implies that non-linear, biological mechanisms must be included in models seeking to explain longer-term fluctuations in upwelling populations of sardine and anchovies.

Thus, it can be expected that fisheries, which modify the relative abundance of competing populations of sardines and anchovies would also impact the interactions between these species, and induce species shifts that would otherwise not occur naturally, and conversely.

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### ACP – EU Fisheries Research Report Number 5

#### The pelagic food web of the Western Indian Ocean

*Evgeny Romanov and Veniamin V. Zamorov (Yugniro, Ukraine, Odessa State University, Ukraine)*

The Indian Ocean catch of tuna, presently at about 900,000 tonnes annually, has greatly increased since the 1980s. Indeed, the Western Indian Ocean (FAO statistical area 51), contributing about  $\frac{3}{4}$  of the total tuna catches from the area, has now become a major tuna fishing ground, ranking right after the Western and Eastern Pacific in terms of overall tonnage.

The major part of the catch is taken by purse seines (47%) and long lines (24%), while the major species are yellowfin tuna (*Thunnus albacares*; 34%), skipjack (*Katsuwonus pelamis*; 30%) and bigeye tuna (*Thunnus obesus*; 11%).

Given their catch levels, it may be assumed that these three tuna species have the highest biomass among large pelagic predators in the Indian Ocean ecosystem. Other large predators include pelagic sharks, billfishes and toothed whales. Hence, these three tuna species are likely to have a major impact on the pelagic food webs of the tropical Indian Ocean. Our analysis of this impact is based on data from longlining, purse seining, and other research expeditions conducted by Yugniro from 1961 to 1991, mainly in the western part of the Indian Ocean.

Based on tuna stomach contents and the method of 'restored weights', the diet compositions (in weight) were identified for the three species of tuna. Then, a detailed energy budget was established, which allowed estimating the amount of food consumed per year, per tonne of tuna biomass. Table 1 summarises our results, assuming standing stocks of 1.8, 0.5 and 2.0 million tonnes for yellowfin, bigeye, and skipjack, respectively.

As can be seen, the food of these three tuna species consists predominantly of fatheads (mainly *Cubiceps pauciradiatus*), anchovies (mainly *Engraulis japonicus*), squids (mainly flying squid *Stenotheuthis oualaniensis*), barracudina (*Paralepis elongata*), frigate mackerels (*Auxis* spp.) and flying fishes. The rest consists of invertebrates (swimming crabs, hyperiideans, euphausiaceans, etc.), and fishes such as

*Alepisaurus ferox* and *Omosudis lowei*.

As most of these food items cannot presently be exploited directly, fishing the predators, the tuna appears to presently be the best option in ecological and economic terms. This option has the clear advantage, as well, of leaving the animals at lower trophic levels in reserve as it were, i.e., as a potential resources for the future.

**Table 1.** Estimated food consumption and diet composition of three species of tuna in the Western Indian Ocean

	<b>Yellowfin</b>	<b>Bigeye</b>	<b>Skipjack</b>
Population biomass [t]	1800000	500000	2000000
<b>Food Item</b>	<b>Consumption</b>	<b>[t*year-1]</b>	
Swimming crab	4517773	1316189	4393722
Shrimps	-	318936	-
Hyperiiidea	-	-	1098431
Euphausiidae	-	-	1098431
Squids	5771702	820438	3295292
Lancetfish	1213111	1606175	-
Frigate mackerel	2782379	-	3295292
Barracudina	1025711	3151692	2196861
Omosudids	-	941092	-
Anchovy	1917574	651621	13181166
Fathead	8424269	1303242	10984305
Flying fishes	1262353	285272	4393722
Others	2195087	137578	-
<b>TOTAL</b>	<b>29109959</b>	<b>10532235</b>	<b>43937222</b>

On the other hand, our present focus of exploiting upper trophic level species has a strong impact on the composition of the pelagic ecosystem in the Indian Ocean. Thus, there is a suggestion that skipjack are gradually replacing yellowfin and bigeye tuna, especially when the large-scale fishery targeting juvenile yellowfin and bigeye, as is increasingly the case in purse seine fishing on logs and FADs. Thus, species replacement issues may occur here as well, as they do in demersal fish populations. This issue will have to be addressed, if the tuna fisheries of the Indian Ocean are to remain sustainable.

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### ACP – EU Fisheries Research Report Number 5

#### Economic analyses of fisheries impacts on food webs: pricing down marine food webs

*Ussif Rashid Sumaila (Chr. Michelsen Institute, Norway)*

Marine fisheries are increasingly becoming one of the highly 'globalised' sectors of the world's economy as the value of world fish trade continues to increase. The value of international fish exports, which was only US\$17 billion in 1985, has more almost trebled to US\$ 47 billion in 1994 (FAO 1998). The increasing globalisation of fisheries products implies that prices should be similar throughout the world for similar fish products, and that price increases should reflect relative abundance or scarcity on the global market, rather than in local fisheries and markets (Asche et al. in press, and see Hanneson, this vol.).

The increase of fishing effort since the 1950s has led at first to rapid increases of global landings, which grew by an average of over 6% per year until the early 1970s, when the collapse of the Peruvian anchoveta (*Engraulis ringens*) occurred (see contributions in Pauly et al. 1989). This massive crash introduced two decades of slower overall average growth (below 2% per year), in spite of continued, rapid increase of fishing effort (Grainger and Garcia 1996). In the 1990s, the slow increase of landings turned into stagnation, though masked in global statistics by an increase of aquaculture production (Liao 1997).

The present, stagnating global landings of about 100 million t per year, to which 16-40 million t per year of discarded by-catch should be added (Alverson et al. 1994) have been misunderstood by several authors as indicating that some global 'maximum sustainable yield' may have been achieved, if only because this number roughly corresponds to earlier estimates of the 'potential yield' of the global ocean (see Pauly 1996). However, present fishing practices prevent, on most fishing grounds, yields from being sustained for more than a few years. 'Pulse fishing' of accumulated biomass of old, slow growing fish continues, as reflected, e.g., in the appearance of large amounts of Orange roughy (*Hoplostethus atlanticus*), or of Patagonian toothfish (*Dissostichus eleginoides*) on global markets. The net effect of this is the process described as 'fishing down marine food webs', wherein the fishing fleets, after depleting these

old-growth fish populations, turn to shorter lived, smaller fish and invertebrates of the former prey of the fish just depleted (see Pauly, this vol.).

Neo-classical economic theory predicts that the induced scarcity of these long-lived, usually large fish should lead to an increase in their price more rapidly than of those of their more abundant substitute (Gravelle and Rees 1981). Such increase, given functioning markets would then lead to rewards for conservative fishing practices, enabling continuous landing of the highly priced commodity. This would act as a break to fishing down marine food webs, thus contributing to conserving ecosystem integrity. The main question here is, does the empirical evidence support this assertion?

To test this, the database of world fisheries landings assembled and maintained by FAO, earlier used to detect the fishing down marine food web effect (Pauly, this vol.) was analysed. However, to render this analysis independent of the previous study, the fish categories were defined independently of the ecological categories used in that study. Thus, in Pauly et al. (1998a) the catch of various regions of the world was assigned to the trophic level corresponding to the different taxonomic groups reflecting their position in the food web of the ecosystem from which they were extracted. Here instead, the mean maximum size (in cm) of each taxonomic group was used, computed as the average maximum size of its constituent species. Overall, only three statistical groups were identified: 'large finfish' (>60 cm; this selected size is the median maximum size of all the relevant groups in the FAO database); small finfish (<60 cm); and invertebrates (mainly crustaceans, molluscs and echinoderms).

**Table 2.** Constant 1952 price change over time for the major fish groups.

Product type	1952 price [\$/t]	% increase (1952-1994)
Large finfish	218	20
Small finfish	120	150
Invertebrates	195	240

Table 2 presents average constant 1952 prices for large finfishes, small finfishes and invertebrates. The US market prices for 1952 and 1994 as reported by FAO are used as representative of global fish prices. Further, to reduce current prices to constant prices, the US consumer price index for the period 1950 to 1996 are applied. As might be seen, large finfishes produced the lowest increase in price over this period, followed by small finfishes and invertebrates, in that order. The main point to note is that the price of small fishes has grown by more than seven times those of large finfishes. In addition, when a plot of size against price for finfishes was drawn, the positive relationship between price and size prevailing in the 1950s ( $r=0.394$ , d.f.=10), had reversed its sign in the 1990s ( $r=-0.292$ , d. f.=10). See Sumaila (1998) for the corresponding graphs.

**Figure 5** shows global trends in value of landings, based on inflated 1952 and deflated 1994 (i.e., constant) US \$ prices, for (a)

invertebrates; (b) small finfishes and (c) large finfishes. Note correspondence between 1952 and 1994 value for large fish (c), and differences for small fish (b) and invertebrates (a), indicating price increase above inflation.

Figure 5a plots the landed value against time for invertebrates in both 1952 and 1994 constant prices, while figures 5b and 5c do the same for small and large finfishes, respectively. The aim is to investigate if there is any gap between the plots for inflated 1952 and deflated 1994 prices, for any of our three groups. The figures show that unlike in the case of large finfishes, where there is virtually no gap; large gaps occur for small finfishes and invertebrates. This implies that, unlike for large fish, the price development of small fish and invertebrates has not followed the general price trend for a basket of goods in the USA over the period of the analysis.

The above results show that despite enormous prices in some groups of large fish, of up to \$80 000 for a single sashimi-quality tuna, large fish do not command any more the high prices that once distinguished them from small fishes. Moreover, invertebrates, which tend to be small and short-lived, continue to command much higher prices than fishes. The result, thus, runs counter to what would be expected based on neo-classical economic theory. A possible explanation for this is that there is usually a change in taste, and hence in demand, when a massive effort is made to market previously unattractive species (as for example the deep-sea fish presented by Gordon, this vol.), following the demise of desirable species.

Combined, these various results imply that operations, which overfish populations of large, long-lived fishes feeding on small fishes and invertebrates, will find themselves rewarded by abundant high value substitutes. A typical example of this trend is the bottom fisheries around Newfoundland, Canada. This fishery now relies, at least in part, on the invertebrates previously consumed by the now defunct local cod population and its landings - in terms of gross dollar value - have never been as high. However, this high value does not account for the large transfer of federal (i.e., taxpayers') money to support the unemployment insurance of former cod fishers.

The key conclusion from this is that markets cannot be expected to halt, and even will accelerate the trend of fisheries toward fishing down marine food webs, with all that it implies for the extermination of populations of large fishes.

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### ACP – EU Fisheries Research Report Number 5

#### Globalisation of seafood prices: some examples

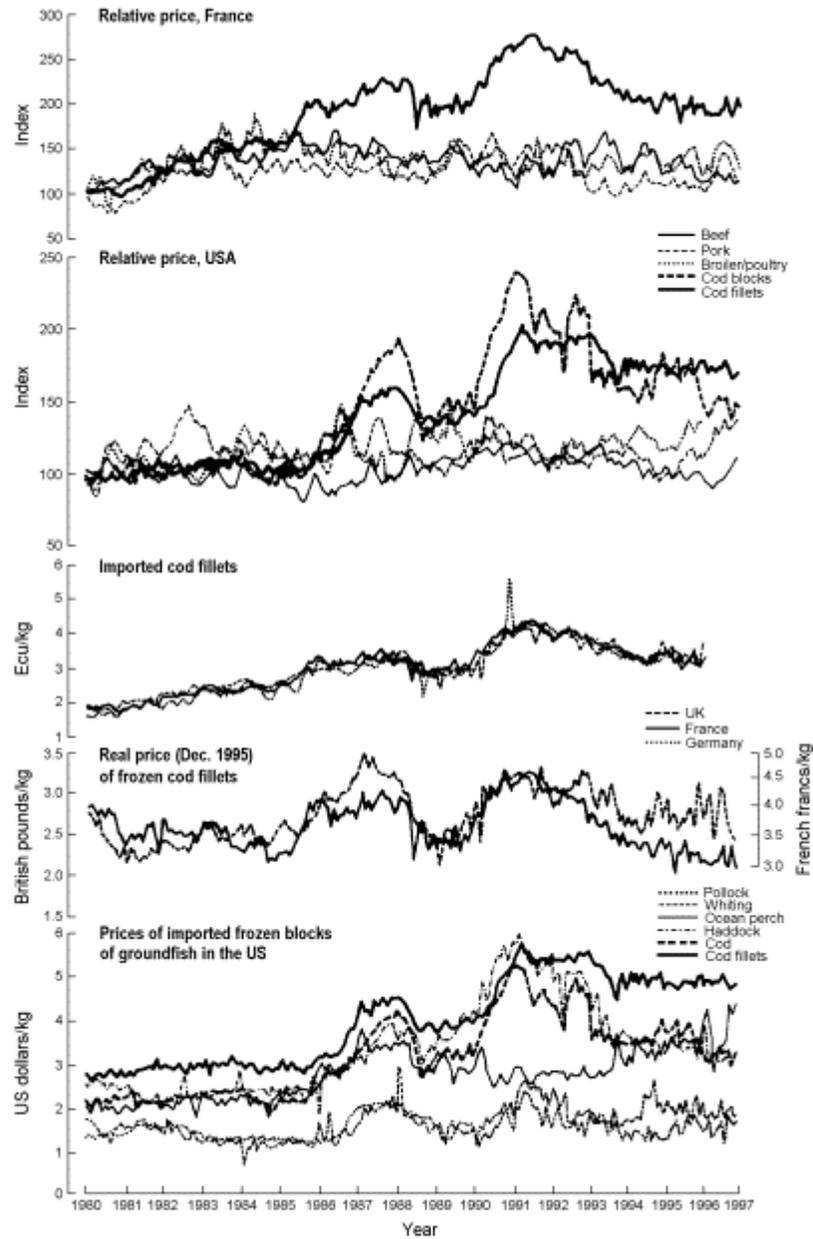
*Rögnvaldur Hannesson (Centre for Business Economics, Norway)*

The study by Sumaila reported above assumes that fish prices are globally integrated. This assumption can be shown to be realistic by detailed studies such as those we conducted, dealing with 'whitefish' products (i.e., cod and similar bottom fish).

Our key result is that the price of these products move closely together over time, across national markets, species of fish, and product types, from frozen cod (*Gadus morhua*) and haddock (*Melanogrammus aeglefinus*) blocks, imported to the USA, to similar products imported to the European Union (Figure 6). This also applies to salted fish imported to Southern Europe, and to fresh whitefish imported into France. In short, we have a global whitefish market.

Another key result of our studies is that prices in local currencies deviate from each other more than prices expressed in a common currency, indicating that shifting of suppliers by producers is the mechanism that keeps prices aligned.

Moreover, fish prices since the 1980s have changed in a manner distinctly different from wholesale prices of fishmeal and related products. Notably, distinct peaks occurred in 1987 and 1991, with prices much higher in 1996 than in the 1980s.



**Figure 6. Trends in fish product prices in various markets. Note overall correlation of prices, suggesting a globally integrated market.**

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### ACP – EU Fisheries Research Report Number 5

#### Bioeconomics of bluefin tuna in the Northern Atlantic

*Clara Costa Duarte (Universidade Nova de Lisboa, Portugal)*

The European Commission has supported a research project (FAIR CT96-1778) on the 'Management of High Seas Fisheries' since 1966, in order to support the United Nations in the process of negotiating possible regional arrangements for the management of highly migratory and straddling fish stocks. The bioeconomic modelling of the fisheries on Norwegian spring spawning herring (*Clupea harengus*) and North Atlantic bluefin tuna (*Thunnus thynnus*) are examples of this. Specifically, in the case of bluefin tuna, the study is devoted to:

1. estimating the optimal utilisation of the bluefin tuna population;
2. evaluating the biological and economic implications of alternative utilisation patterns;
3. simulating the outcome of cooperative and non-cooperative games under a variety of conditions;
4. analysing the impacts of new international arrangements, including the possibility of new entrants into the fishery.

Bluefin tuna are caught by different gear, each directed toward different size/age groups, occurring in different parts of their overall range. Thus, a model aiming to describe the dynamics of the fishery must be age-structured, account for different interacting gear and for their deployment in space.

The linkage between the economic and the biological components of the model was represented by;

- a. assuming constant catchability, i.e., a constant relationship between fishing effort and fishing mortality;
- b. assuming variable catchability, as a result of the schooling behaviour, and other mechanism concentrating the fish, and thus rendering them more susceptible to each unit of effort.

The approach in (a) leads to the conclusion that the Eastern and Western Atlantic bluefin tuna populations do not risk depletion, even under conditions of open access. However, major economic gains would be achieved by imposing catch and/or effort limits.

The approach in (b) was implemented using a Cobb-Douglas catch function with low stock elasticity. In this case, depletion of both populations is the most likely scenario under open access. Obviously, major economic gains would also be achieved by imposing catch and/or effort limits.

The lesson is obvious, and confirms other work on the presently much reduced populations of bluefin tuna. Our results are consistent with the effect of 'fishing down marine food webs' and other ecosystem effects discussed elsewhere in this document, as bluefin tuna, the most endangered of the pelagic fishes of the North Atlantic, is also the largest, and that with the highest trophic level.

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### ACP – EU Fisheries Research Report Number 5

#### Management issues in Namibian fisheries

*Peter Manning (London School of Economics, U.K.)*

Even when a fisheries management authority is committed to rebuilding stocks and then harvesting them at something approximating an optimal level, the capacity to do so is severely compromised by the failure to take adequate measures relating to the economics of the sector.

The Namibian's hake fishery may be used to illustrate the problem. There is considerable evidence demonstrating a readiness by the Namibian Government to limit catch when the biological state of a stock requires this to happen. When, at Independence in 1990, the Namibian Government found itself confronted with the reality of depleted stocks, the Total Allowable Catch (TAC) was dramatically reduced. Subsequently examples can be given, where the TAC was drastically reduced in response to scientific advice. Yet, when the economic pressure of overcapacity grew to become excessive, the scientific advice was compromised in favour of short-term economic gains.

Data for 1994-1996 inclusive for the fleet targeting hake (*Merluccius paradoxus* and *M. capensis*) in Namibian waters were used to calculate growth in fish harvesting capacity. Overall, the annual catch capacity in the hake fleet grew from 180,400 t to 259,900 t between 1994 and 1996, that is by 44%. The freezer-trawler fleet targeting hake increased its capacity by 52%, the wet fish fleet grew by 32%, while the capacity of the much smaller long-line fleet targeting hake grew by 50%. Processing capacity also grew very rapidly during this period, adding to the economic pressure on the fisheries authority to maintain a high TAC.

This period was characterized by a severe environmental perturbation off the Namibian coast. The productive upwelling system weakened, sea temperatures rose and low oxygen levels were recorded. The hake stocks suffered a high level of natural mortality, as did both the predators and prey of these populations. In this context, the scientists of the Ministry of Fisheries and Marine Resources recommended a reduced TAC, but this advice was not heeded.

The net result is that fleet capacity grew as biomass declined. There was an increasing gap between the TAC recommended by the Ministry's own scientists and the TAC set by the Ministry. The TAC tracked the growth in fleet capacity rather than the decline in biomass.

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### ACP – EU Fisheries Research Report Number 5

#### Information required by fishers to make sustainable economic decisions

*Sophie Des Clers (University of Warwick, U.K.)*

Research in collaboration with fishing communities in Great Britain and experience of West African fisheries, suggest that a lack of suitable information greatly contributes to small and medium scale fishers being unable to 'internalise' resource scarcity. Quite often, when information is made available to the smaller vessel owners by government agencies, it has been processed and aggregated to a national or regional spatial scale. As a result it often contradicts the fishers' intuitive and local knowledge of the fisheries, even though they are the main providers of primary data.

Another problem lies in the lack of coherence among the messages put forward by different information providers, public and private. For example, government fisheries development policy measures may still encourage investment that lead to increasing fishing mortality, even though the resource is already fully exploited. Similarly, banks may encourage investments even though government policy measures are reducing fishing opportunities.

Three categories of information are considered from the point of view of small-scale operators: information relating to:

1. the fisheries' ecosystem;
2. the fisheries economics; and
3. the government policy framework.

Small and medium scale operators have a limited autonomy. They have to stay close to shore, and exploit mostly continental shelf ecosystems, locally from coastal communities or seasonally migrating to distant fishing grounds along the coast.

#### Ecological data

Fishers collect and process quantities of ecological information while fishing. These range from the ocean climate (air and water temperature, wind speed and direction, tidal patterns, currents), the seabed habitat, depth and topography, to marine life above (seabirds, marine mammals) and under water (presence and abundance of unwanted and target species, as well as size and product quality). Information is collected at the fishing grounds level, for specific fish stock assemblages (pelagic, demersal, benthic), and on the time scale of the fishing trip, daily or weekly basis.

The overriding scale to collect, analyse and share ecological information is the fishery's ecosystem, which naturally regroups exploited and non-exploited fish and other species. Fishers also analyse signals from the physical environment and create their own 'expert systems' to explain local abundance and variation patterns (see also Le Fur and Bommel, this vol.). There are situations however, when smaller operators may not be able to obtain a full picture, for example when the range of fishing boat activity covers only part of the ecosystem. This is particularly true for migrating species in pelagic systems, which are often exploited by different fishing communities, fleet and gear during their life cycle.

Fisheries research concentrates on establishing yield and recruitment patterns for exploited species, usually one 'stock' at a time. Fish stocks are artificial units in ecosystems terms, in both space and time. Individual stocks (actually: populations) are delimited by fisheries assessment scientists, to regroup fish of one species sharing a common life history. Apart from shipping weather forecasts, government and fisheries management agencies provide little information on marine ecosystems back to fishers.

Recent years have however seen a growing interest in addressing fisheries management at the ecosystem level, and a promising approach in this context is represented by the Ecopath with Ecosim modelling approach, see Christensen (this vol.)

### **Economic data**

There are many types of economic data collected and produced at the level of a small fishing firm. They range from the costs of capital investments, the costs of inputs (fuel, ice, food, gear, foreign currency etc.), cost of labour and micro-financing of fishing trips, to revenues from sales of key species at different fish markets. The spatial scale of interest and level of information aggregation and processing are different from those for ecological information.

Fish caught by small and medium-sized operators are landed fresh and processed on shore (salted, dried, frozen, etc.), to be kept long enough to travel to large market places. Market data are made widely available to small-scale fishers, for example through private and government sponsored initiatives. However, shore-based local or travelling fishmongers have traditionally assumed marketing activities, while fishers went back fishing. Therefore, the link between production and marketing is indirect, and fishers may be slow to react to market preferences. Unfortunately, information on demand is not always forthcoming to small operators. Government or industry sponsored marketing campaigns may also backfire, to the extent that demand may

be satisfied through imports if local production is limited by seasonal variations.

Great progress is being made concerning the quality and hygiene of fisheries products on shore, and also on board the smaller vessels. However, it is difficult to foresee fishing activities being fine-tuned to consumers' tastes and budget in the immediate future for at least two reasons:

- fishers can mostly choose the fish that they land, but not the fish that they catch. Therefore, demand needs to be adjusted to supply, to some extent, rather than the more standard reverse process;
- markets currently ignore the scarcity and ecosystem value of wild caught marine species, and therefore market demand makes very little ecological sense.

Small-scale operators have an additional constraint in that they rarely produce enough fish to influence market prices. They have to be price takers. Government agencies may undertake regular costs and earnings surveys of fishing firms and collect statistics of prices and availability of key inputs, in a way similar to any other productive sectors. Some data are collated and published, but are little used by fisheries policy makers.

Data quality problems may arise from the sensitivity of earnings data, which fishers fear may be used to assess their tax liability. Small fishing firms often complain of the costs of regulations, which are rarely assessed by policy makers. Fuel tax exemptions, for example, may provide little benefits to small operators if they entail paperwork or lengthy trip to designated supply points. Finally, small-scale operators have little time to make use of published data, as they do not possess the institutional backup of larger firms.

### **Policy-related data**

Even in countries where a national Fisheries Policy explicitly means to support the artisanal sector, fishers have little input in the policy making process. In many cases, even actual numbers of fishers are not precisely known, and part-timers are ignored. The sheer number of small operators means that both information collection and dissemination bear high administrative costs. The small-scale sector may be constrained by resource access and conservation measures, but it evolves with little direct steering from the Fisheries Policy itself.

The question of access or resource use rights is crucial to the smaller scale, which does not have the operational range of larger operations. When use rights are ill defined the ensuing race for fish and its drive to over-capitalisation presents an immediate and direct threat to the survival of smaller operators. When use rights are well defined, such as for many shellfish beds, ecological and economic information appear to be more easily collected and analysed, often at the initiative of fishers themselves who design enhancement and conservation measures. Unfortunately, many coastal fisheries are effectively managed in quasi-open access, and fishers resent information demand from government as

yet another costly regulatory pressure, with no obvious benefit to them.

Conservation measures are usually designed to provide the greatest global benefit, estimated in tonnage of single-species fish stock escaping fishing mortality. Thus, they apply mainly to large-scale operators. The economic impacts of new regulations are rarely estimated and may be disproportionately high for small-scale operators.

Major incoherence often arises from conflicting objectives within the Fisheries Policy itself. For example, the encouragement of highly efficient large-scale fishing operations, through a Fisheries Structural Policy, are likely to be perceived as an immediate threat to the effective conservation of a resource jointly exploited by small-scale operators. Similarly, the development of global fish markets may encourage fishers to switch to species with higher environmental costs, (e.g., roe, shark fin and rays fisheries).

Finally, Fisheries Policy measures are nearly always modified by other government policies. Social Policy, Regional Development, Transport, Environmental Protection, National and International Trade policies all have great potentials to combine and produce incoherent measures at the level of small fishing operators. The interaction of local, regional and national policy levels add to the confusion. Historically, a high degree of local fisheries dependency even appears to aggravate the risk of mismanagement, rather than insure against it.

### **Fishers' decisions**

For vessel owners and skippers, fishing is obviously driven by a set of economic decisions just as for other primary production activities subject to environmental constraints. In situations, where fisheries are predominantly market-driven (as compared to subsistence purposes), catching and selling fish aim to maximise selling price, and buying and upgrading fishing vessels and gear are aimed to maximise profit and fishing power. Both decision sets are subject to financing constraints, and are framed by regulatory constraints. Ultimately, all activities are bound by the natural productivity of the fisheries ecosystem. However, resource scarcity is rarely recognised to be a key constraint to capital investment decisions. The detail, in time and space of information used by fishers depends very much on the decision to be made. It is a compromise between what is perceived as important, and what is available. Two types of decisions are examined:

- a capital investment such as buying a fishing vessel or new gear; and
- the routine planning of a fishing trip.

For each decision information types and scales are reviewed and ranked according to their importance perceived by smaller scale fishers.

### **Capital investment**

Capital investments are relatively rare for artisanal fishers, where skill and experience are the key assets. Resource abundance, or rather its perceived abundance, justifies the initial decision to invest, but does not

appear to be taken as a constraint at this stage. Two mechanisms (at least) may contribute to this oversight:

- investments are mostly guaranteed by the owner's personal wealth. Consequently, although vessel owners have to be aware of the risk involved if fishing seasons are unsuccessful, bankers need not be. The providers of private finances, even when public subsidies are available, usually feel they do not need information on the natural limits of the fisheries.
- business plans drawn to finance borrowings, whether from public or private sources, estimate future earnings as an average of past earnings in the on-going fisheries, or in comparable fisheries. The use of a new vessel or new gear is not assumed to reduce individual catches so far recorded in the fishery. In effect, vessel owners, the banks and public funding agencies most often ignore resource scarcity.

Economists argue that in fisheries managed through an Individual Transferable Quota (ITQ ) system, vessel owners take resource scarcity into account. However, this seems to apply mostly to larger-scale operators, who may harvest single-species aggregations which may be successfully managed through single species TACs, and who may harvest large enough quantities for both fish and ITQ market prices to reflect resource scarcity.

Overall, a striking feature is the lack of connection between the different information types used to guide the investment process. A limited-entry access policy, which would connect policy measures to resource abundance, for example, is rarely found at the small-scale level, except for shellfish beds. In Europe , the Common Fisheries Policy has been designed for larger scale operators, and is rarely effective at the local level.

### **Fishing trip planning**

The routine planning of the mostly day trips of small-scale fishers requires a complex set of information. Information types are essentially the same as for any commercial fisheries decision, but their time and space scales and dynamics are different. For small-scale fishers, local resource abundance is an obvious issue. The gathering of information and signs of local resource abundance are a priority, on a level similar to that of the trip's micro-financing and the policy measures allowing resource access. Unfortunately, a crucial part of the small-scale fisheries system, the fish market, appears to be disconnected from the rest. Successful fishing trips, in terms of species, sizes, numbers and weight of fish caught, may fail to secure high revenues because of an excess of fresh fish production at local level.

Information systems on supply and demand of fresh fish have been slow to develop, even in Europe where refrigerated road transport is fast and relatively cheap. Developments are less local than in response to a wider, even global market (see Hannesson this vol.), and the small-scale appears to have little say in the process.

### **Future directions**

From this brief review of information use and need, it appears that small-scale fishers gather and use a large variety of information, at various time and space scales. This, however, is not acknowledged by fisheries management agencies. At national level, fisheries managers concentrate on the larger-scale operators, and provide little information directly relevant to the local level. Notably, the widespread practice of single-species resource assessment captures little of the understanding at ecosystem level.

The current lack of shared understanding between government (regulators, managers, and scientists), fishers, and marine resource conservationists, could be reduced through the production of integrated information systems, incorporating an ecosystem -based concept of sustainability. Several important aspects of such ecosystem-based fisheries information system still need to be researched. This applies particularly to the articulation between coastal and offshore, and between pelagic and demersal components of the ecosystem, between different spatial scales of exploitation, and between seasonal, annual and longer time scales.

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### ACP – EU Fisheries Research Report Number 5

#### When do artisanal fishers switch targets? A case study from Senegal

*Jean Le Fur and Pierre Bommel (IRD/HEA, France)*

An individual-based computer model was developed which formalises the responses of the Senegalese artisanal fishery to changes in its environment. The problem of a fishery's response to change is first considered at a global system level. There, adaptive processes are defined as the major determinant of the fishery's response to change. The system's structure and function are then formalised at the most local, possible level (that of communities) and related, through successive embedded schemes, to the global level. Artificial intelligence formalism is used to generate this progression (**Figure 7**, a schematic representation of factors involved in decision-making by small-scale fishers, here in the context of the Senegalese artisanal fishery, modified from Le Fur 1998).

Our key result is that at a global level, a given change can produce unexpected effects as well as expected effects or no effect at all. In the first simulation example, the increase of communities' aversion to risk produced a large modification of the system's dynamics, whereas a drastic lowering of the yield of *Sardinella* spp. did not. Sensitivity analysis seems necessary, therefore, to better understand the results.

In a second simulation, an increase of fish consumption led to an increase of traders' earnings, but this monetary effect did not propagate all the way towards the fishers. A similar example was recently encountered in the Senegalese exploitation system: just after the currency devaluation at the beginning of 1994, artisanal fish exports increased. The fish traders interviewed at the Kayar landing place felt satisfied with the new situation, whereas the fishers were negatively affected by the change. It appeared that the fishers went on selling their fish at the same price, while fish traders were selling theirs at the new international price (without telling the fishers). The problem was finally partly solved by the fishers' 'syndicate', which ruled on the prices.

From the processes represented in the model, it appeared that the

agents' possibilities are too restricted to fully explore their environment. Indeed, given a fisher community that can get information about two possible tactics, if a drastic change occurs in the environment that greatly affect both of the tactics, the community will not have the means to adapt. This case occurred for the purse seine in the first simulation: when the catches of *Sardinella* spp. were lowered no change occurred, since the communities went on fishing for jack mackerels (*Trachurus* spp.). When these purse seine fishing communities were allowed to practice another fishing tactic, most of them changed to the new tactic, as if they were unsatisfied with their current earnings (poor catches of *Sardinella* spp).

Overall, our conclusion is that there is a multitude of mechanisms that may be used to describe target switching. Therefore, modelling approaches such as that presented here can only be used to describe fishers' behaviours, not to predict them. Further details may be found in Le Fur (1998) and the references cited therein.

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### ACP – EU Fisheries Research Report Number 5

#### Ecosystem modelling and the challenge of ecosystem-based management

*Villy Christensen (ICLARM, Philippines)*

The contributions above show that in general, the world's fish stocks are overexploited, and that the prospects for developing new fisheries are dwindling. Hence, we have to get the best out of the limited resources at our disposal, and/or rebuild the stocks that can be rebuilt. To address these issues, I will focus on the state of exploited marine ecosystems, paying special interest to what can be learned from trophic modelling that is of interest for increasing or at least sustaining global harvest levels.

As a measure of the state of exploitation of the world's aquatic ecosystems Pauly and Christensen (1995) estimated how much primary production was required to sustain the global fisheries in 1988-1991. As basis for the calculations, FAO catch statistics were split on six major aquatic resource ecosystem types, and aggregated into 39 major species groups for which information on trophic status was extracted from 48 published trophic ecosystem models. The results showed that, globally, some 8% of aquatic primary production was appropriated by the fisheries, and that there was considerable variation between resource system types: for open oceans fisheries, only 2% was required, while upwelling, shelves and freshwater systems required in the order of 25-35% of total primary production. When we add to this that a subsequent study (Trites et al. 1997) found the marine mammals in the Pacific to require an additional 20-25% of primary production, it may be concluded that the 'available' primary production of the oceans is about fully utilized by humans, since a good part of it (over half) can be expected to fall out to the sediment. We can only expect to use perhaps one third of the total primary production. For terrestrial systems (which in general are more fully exploitable and exploited) the global average is that 35-45% of the primary production is appropriated by humans, directly or indirectly (Vitousek et al. 1986).

#### The modelling basis

The study introduced above builds on information extracted from published trophic ecosystem models prepared using the Ecopath approach and software (freely available through [www.ecopath.org](http://www.ecopath.org)). Such models are designed to describe the trophic fluxes and state variables in ecosystems, and are constructed as follows:

1. Define an ecosystem in space and time;
2. Aggregate its components into a manageable number of compartments;
3. Enter available information on biomasses, consumption and production rates and diet compositions; and
4. Construct the model based on the diagnostic and tools built into the system.

The model itself, and its use are described in more detail in Christensen and Pauly (1992, 1993) and Pauly et al. (submitted). Ecopath models are constructed based on an assumption of mass-balance, i.e., that for any given time period the following expressions hold true:

- a.  $\text{Production} = \text{Predation} + \text{Catches} + \text{Migration} + \text{Biomass accumulation} + \text{Other mortality}$
- b.  $\text{Consumption} = \text{Production} + \text{Unassimilated food} + \text{Respiration}$

To parameterise the models, data collected during routine fisheries assessment work can be used. However, these have to be supplemented with information from ecological studies. Once a model has been constructed, the basic information required to evaluate the trophic structure of the ecosystem is available in a well-structured form, incorporating our best knowledge of the trophic interactions in the ecosystem – especially for the upper trophic levels, where human interest is the strongest. By their very nature, such models encourage comparisons within and between ecosystems. The last part of this contribution will exemplify this.

The Ecopath with Ecosim software system includes a large number of modules, e.g., for addressing uncertainty and data quality, for documenting models, for accessing built-in empirical relationships, for network analysis, etc. Two new, major additions are the Ecosim module for time-dynamic simulation (Walters et al. 1997) and the Ecospace module for spatial simulation (Walters et al. in press). The modules of Ecopath are closely linked, and indeed serve as diagnostics for each others (see **Figure 8**). Ecopath is distributed freely via [www.ecopath.org](http://www.ecopath.org), and more than 1600 persons in 94 countries have so far registered as users, and more than 300 have participated in training courses and workshops. In total, more than a hundred ecosystem models have been published based on Ecopath, and another fifty are in progress.

### **Avenues for increased, sustainable exploitation**

If, as discussed above, marine stocks in general are fully exploited, we cannot expect to get increased catches by simply increasing fishing effort. Can we instead increase the harvest by changing the exploitation pattern? At present the global fisheries are to quite a large extent based on fishing large, piscivorous fish – by weight, one third of the global catch consists of piscivorous fishes (Christensen 1996). Also, there is a

negative correlation between catch rates and the trophic level of the catch. It is therefore legitimate to ask if increased benefits can be obtained by 'fishing down the food web', i.e. by initially targeting the predators and subsequently fishing (an increasing amount of) the prey. Indeed, if trophic transfer efficiencies are around 10% by trophic level as studies indicate (Christensen and Pauly 1993, Pauly and Christensen 1995), considerable gains may be anticipated.

The present state of exploitation varies between systems, and we may gain an idea of how far 'fishing down the food web' can be taken, in practice, by examining a number of test cases. For this purpose I have compared 33 published trophic models of exploited ecosystems, including African lakes, coastal/shelf systems and upwelling ecosystems (Christensen 1996). The general conclusion was that even in the most heavily exploited coastal/shelf systems, fish predation on fish exceeded the catch – the only real exception was an intensively fished shallow gulf in the Philippines, where the catches were dominated by immature fish: usually an undesirable situation. Hence, one should not expect catches to amount to more than half the amount of predation. Indeed, pooling different estimates of finfish predation on finfish from various areas indicated that, on a global scale, predation outweighs catches by a factor of 2-3 (Christensen 1996).

Where the preliminary studies above pointed toward difficulties for humans to simply 'replace' predators, we might still ask whether it would be possible to increase yields intelligently 'fishing down the food web' as opposed to the blind, market-driven approach applied hitherto. Addressing such questions may provide leads to far more scientific and economic benefits than the massive, yet ultimately futile efforts devoted, in the past decades, to improving our stock assessment methodologies so as to be better able to 'count fish'.

Humans generally dislike competitors, especially when are taking what we want for ourselves. Thus, it is no wonder that the initial reaction to a fishery crisis is often to try to eliminate the competitors, often top-predators such as marine mammals, birds, and piscivorous fish, (the 'whale strategy' of Pauly 1979). In Antarctica, the exploitation of whales has thus given way to the exploitation of krill, at a level of 300 000 tonnes per year, not really a large figure.

For African lakes several scientists have over the years speculated whether removing the predators could increase catches. Even though exploitation levels may have increased, the results are, however, far from conclusive, and my overall conclusion is that predator removal in general is a problematic avenue which may have unwanted side-effects, not further discussed here (but see Christensen (1996). As expressed by Larkin (1979): "Do not expect long-term benefits to the prey from predator control."

Another simple step on the 'fishing down the food web' ladder is to target the prey populations directly. This may lead to considerably catch of often low-valued species. Economical considerations may be used to consider the degree to which such a situation is desirable, especially since the price of the prey may increase (see Sumaila, this vol.).

An anticipated result of the 'whale strategy' discussed above is that

environmental groups will protest – the same holds for the ‘Lilliput strategy’ (sensu Pauly 1979) discussed here. Prey exploitation will impact the top predators in a system, and as the Greenpeace action against industrial sandeel fishing on ‘Wee Bankie’ off the Scottish coast in the spring of 1996 showed there are strong opinions on prey exploitation. From a scientific point of view the Greenpeace action was interesting, as it showed that in spite of the North Sea being an area where species interactions have been studied for decades, it was not possible to give convincing scientific arguments about the impact of fishing on prey species. We need to be able to address such questions.

As a related example, the study of Trites et al. (1997) calculated for the seven FAO statistical areas in the Pacific Ocean how much primary production was required to sustain the catches and the marine mammal populations. The results indicated an inverse relationship. In the regions where the catches appropriated most of the primary production the marine mammals took less – or less was left to the marine mammals, the poorer competitor in this example of what may be “food web competition”.

Coexistence is a scientifically more challenging approach than elimination, and it is in the long run the only sustainable – environmental concerns will gain increased importance, fisheries may not. The now well-established procedure for managing predator/prey coexistence is the Multispecies Virtual Population Analysis, MSVPA, (Pope 1991). In the North Sea the forerunner of the MSVPA, the North Sea model of Andersen and Ursin (1977) was initially used to give ideas for how the catches could be doubled. The MSVPA has not been used for anything similar, mainly because such considerations need to involve economical and sociological factors, which neither of the models does. A new tool for studies of predator/prey coexistence, and the impact of different harvest strategies has recently emerged in the form of a generic, dynamic simulation model, Ecosim, developed as part of the Ecopath system (Walters et al. 1997). This model is now seeing widespread use, and may show useful for addressing questions as raised here.

A final form for management potentially leading toward increased harvest should be discussed: rebuilding stocks through closing areas for fishing or at least for destructive fishing. The idea is not new, it has been part of many traditional management schemes, and it has been part of fisheries science at least since Beverton and Holt (1957). Due to its importance in relation to biodiversity conservation, marine protected areas (MPAs) have gained renewed interest in recent years, but also other factors speaks for their inclusion in modern fisheries science (see the section on ‘Protected areas as strategic tool for ecosystem management’).

If we can rebuild stocks, we may be able to increase yields through better management. Christensen and Pauly (1998) tried to simulate how fish stocks may once have been. Once, before humans started exploiting the marine environment there must have been much higher populations of especially top-predators, and hence, also of the intermediate predators on which they relied. If we could re-establish such ecosystems, and if we were to manage them in a sustainable manner, how much more could we extract from them? The initial analysis indicate that the ecosystems studied may be able to accommodate 3-4 times as high fish biomasses before reaching ecosystem carrying capacity. This indeed gives reasons for seriously considering the possibility of managing with ‘increased

capital in the bank', instead of the present impoverished situation.

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### ACP – EU Fisheries Research Report Number 5

#### Fisheries impacts on marine ecosystems

*Konstantinos Stergiou (Aristotle University of Thessalonike, Greece)*

Fishing is one of the oldest human activities, and it developed gradually, when our ancestors moved from the collection of plants and animals they happened to find, to the extraction of organisms they actively sought, using tools and weapons shaped for the purpose, first of stone, later of wood, bone, ivory and horn. The oldest fishing implements so far identified are sophisticated harpoons, found in the territory of the Congo (ex-Zaire), and dated about 90,000 years (Stringer and McKie 1996). Interestingly, these harpoons were found associated with the bones of a species of now extinct giant catfish.

Well-preserved fishing tools from the Neolithic and Bronze Age (1700-800 BC) indicate further technical improvements. In the Alps region, these included dugout canoes, and fine, curved hook, later made of bronze and iron, and nets made of hemp and flax, with mesh sizes from 5 to 45 mm knot to knot. At about the same time, the dolphinfish *Coryphaena hippurus* was exploited in the Aegean Sea, as evidenced from a Minoic fresco ('the little fisher of Santorini') showing a young man with a catch of over 20 kg of dolphinfish, a species then probably more abundant than now. Homer (900-800 BC) as well described various fishing methods relying on hooks, nets and harpoon in both the Iliad and the Odyssey. The life and activities of fishers were also described in the 'Attic comedies' of Antiphanes (350 BC), and of Menander (about 300 BC), by Aristotle (384-322 BC) in his Natural History, and by Opianos (about 200 BC) in his Halieutika.

Important to the subject of this report is that, at this early stage of their development, fisheries tended to use highly selective gear. Moreover, their effect on ecosystems, being highly localised, probably resembled the effect of natural predation.

The fishing pressure exerted by modern industrial fleets differs radically from natural predation, due to the combination of direct and indirect effects. The direct fishing effect of reducing the abundance of various exploited populations is often enough for them to collapse. The recent closure of the Northern cod fishery off Newfoundland provides an excellent example of this. More cases could be mentioned from various areas of the world, ranging from the North Atlantic to the South China Sea (see also contributions on Marine Protected Areas, this vol.).

These various areas also exhibit strong reductions of mean size in the species landed, reflecting similar reductions of size in the ecosystems. These changes imply, as well, changes in the life history of the species concerned, though changes of their age at first maturity, and of their sex ratio, particularly important in hermaphroditic species (see Sadovy, this vol.).

Overall, strong fishing pressure tends to have detrimental effects mainly for long-lived, late maturing species (Parrish 1998), thus leading to the phenomenon now known as 'Fishing down marine food webs' (Pauly et al. 1998a; see also Pauly, this vol.). Fishing pressure also affect biodiversity, and this becomes particularly visible when MPAs are set up, as they tend to increase biodiversity, i.e., to reverse this effect of fishing (besides increasing biomass; see Roberts, this vol.; and Rijndorp, this vol.).

A strong indirect effect of fishing on ecosystem is through habitat alteration. Trawling and dredging are the main culprits as far as soft bottom are concerned, while explosives and poisons, increasingly used in countries with coral reefs, also destroy the very habitat that supports exploited species, or their preys.

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### ACP – EU Fisheries Research Report Number 5

#### Approaches to integrating trophic modelling with physical oceanography

*Coleen Moloney (Marine and Coastal Management, South Africa)*

The approach presented by Christensen (this vol.) for modelling marine, e.g., upwelling ecosystems solely in terms of their trophic flows has proven invaluable in generating insight on the functioning of these ecosystems (see, e.g., Jarre et al. 1991). However, given the dynamic nature of such ecosystems, further progress will be made only if explicit account is taken of the change in the underlying physical oceanography, and of its impacts on the configuration of their network of biomass flows. This requires the resolution of two issues:

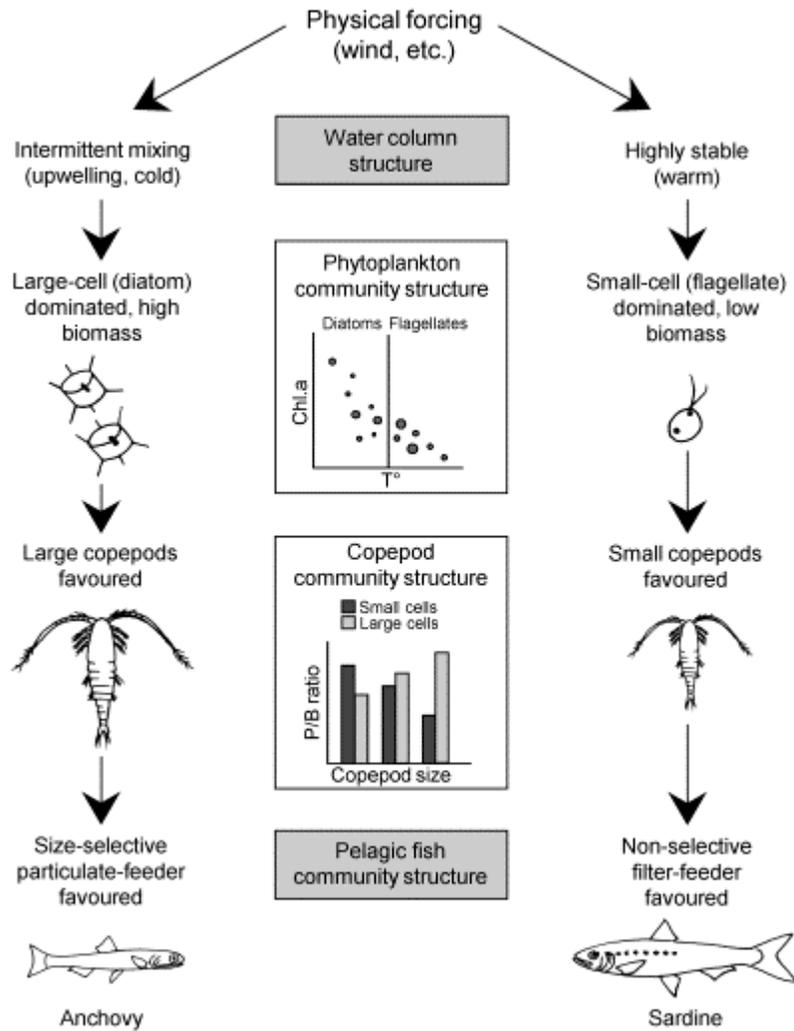
1. physical information is required (at appropriate scales) to derive indices of ecosystem state; and
2. the conceptual (and factual) simplicity of mass-balance trophic models must not be sacrificed in the process of accommodating physical variability.

Data such as required for (1) can nowadays be freely downloaded from the Internet, e.g., in the form of pre-processed satellite images at various temporal and spatial scales. Analysis of such data appears particularly worthwhile in developing countries, where ground-based information may be scarce. Such analyses are used to formulate quantitative hypotheses on the structure of the food webs that interface with, e.g., the primary production represented on satellite maps. An example of such analyses would be the identification, based on different types of information, of the alternative states that may be taken by a given ecosystem, both in terms of its physical parameters and in terms of its food web structure. This is particularly true as such descriptions of alternative states (or 'frames') can be used for resolving the issue in (2), within a modelling approach called 'frame-based modelling' (Starfield et al. 1993).

The basic idea behind this approach "is that it partitions the temporal dynamics of the system; only one simple model is operational at any time. When the assumptions underlying that model are violated, a

demon invokes rules for switching to a new frame and, hence, a new model. The approach provides a structure that simplifies the construction of a model. In particular, the introduction of qualitative variables, such as cool and hot [regimes], offers a functional approach that facilitates model construction. The example shows that a relatively simple model can lead to complex and realistic results, with unanticipated and interesting implications for management." (Starfield et al. 1993).

An application of this approach that immediately comes to mind is the Benguela Upwelling ecosystem, which alternates between physically driven 'cold' and 'warm' states, each with a specific food web structure (Figure 9). Ecopath models representing some sort of 'mean' state of this system exist (see [www.ecopath.org](http://www.ecopath.org)), and generating two variants, each representing one of the alternative states that the Benguela ecosystem can take, is straightforward, given the large amount of available data. It is therefore recommended that a study be made of the feasibility of using Ecopath models for frame-based modelling of the Benguela upwelling ecosystem, with switching rules to be based on existing knowledge of the physical oceanography of the Benguela Current region.



**Figure 9.** Alternative states of the Benguela upwelling ecosystem (after Verheye et al. 1993), as may be used to represent modelling 'frames' (see text).

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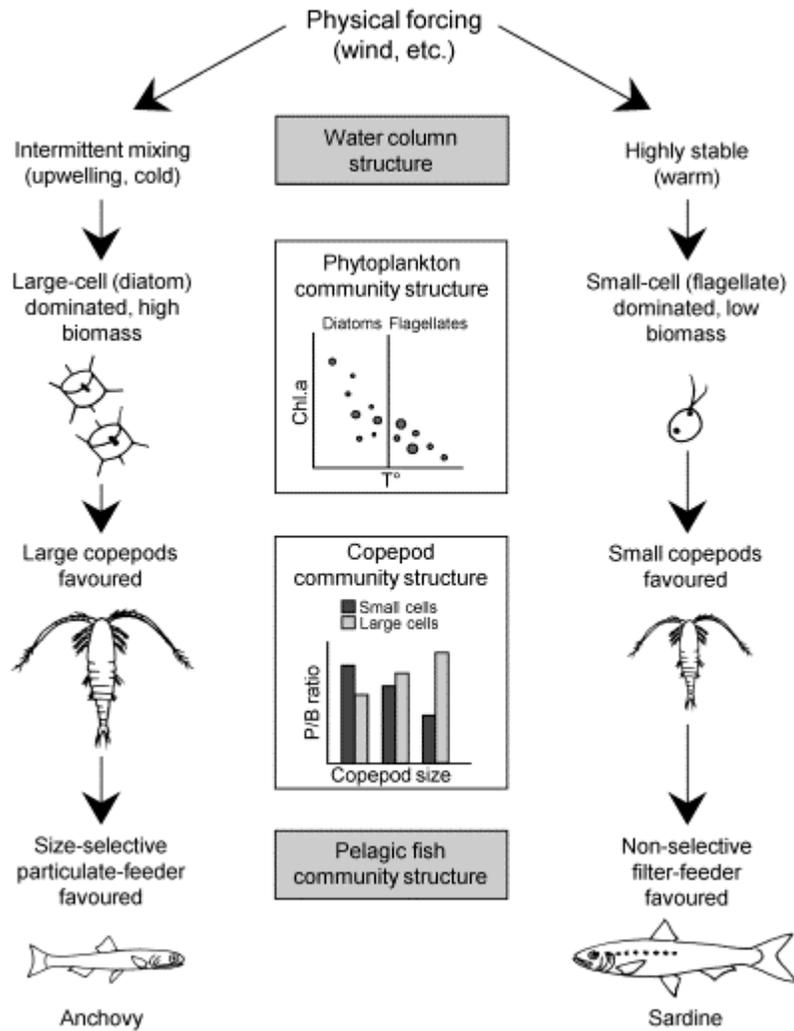
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### ACP – EU Fisheries Research Report Number 5

#### Incorporating ecosystem modelling into fisheries research: a case study from Colombia

*Camillo Garcia (Instituto de Investigaciones Marinas y Costeras, Colombia)*

In the Gulf of Salamanca, an area of about 900 km<sup>2</sup> in the Caribbean waters of Colombia, the fisheries exploit hundreds of species, and landings regularly include 60-100 species – though a few, sometimes only one, may contribute 50% of the catch, (e.g., the ‘anchoveta’ *Cetengraulis edentulus*). The problems of differentiating species in catch statistics is real, especially as common names (as also observed elsewhere, e.g., Berlin 1992, Palomares et al. in press), usually distinguish taxa at the level of the genus, or as groups of similar genera, while species distinctions are made only for a few extremely important, or striking species. One example of this is the term ‘pargo’, which in our region not only applies to six species of the genus *Lutjanus* (i.e., to ‘snappers’ in the narrow sense), but also to *Ocyurus chrysurus* (yellowtail snapper), to *Rhomboplites aurorubens* (vermillion snapper), and to species of the genus *Pristipomoides* (jobfishes). This is one reason for the apparent stability of the landings of various tropical countries mentioned above, due to overaggregated fisheries statistics, and which mask the changes in species composition implied in ‘fishing down marine food webs’ (see Pauly, this vol.).

We have therefore begun, in 1994, a new series of detailed catch statistics. When we examine this series at the aggregate level, it suggests that catches are stable, of the order of 1,400 t per year. However, examining the same data in terms of monthly values reveals a strong seasonality, with high catches occurring during the wet season, from January to May, and lower catches during the dry season, from June to December.

If we further disaggregate the statistics, and put them on a monthly basis, we find clear cycles. However, the peaks and valleys of abundance in a given species do not occur in the same month; rather they are often shifted by several months. This implies that interannual variability also impact on our series. Global phenomena such as El Niño events spring to

mind. Further, our statistical time series also shows that, in the case of the snappers, the years 1996-1997 saw a huge increase in catches, though we shall never know which species increased.

In summary, we can see in our short time series evidence for seasonal cycling, longer-term cycles, and for pulses of recruitment that led to increased catches.

Now, fisheries scientists working in such high diversity settings may ask themselves how to deal with series covering hundreds of exploited species:

1. Should they concentrate on a dominant species, and hope that the ecosystem will somehow adjust to management measures aiming to generate high catches of that species? After all *Cetengraulis edentulus* makes up more than 50% of the landings;
2. Or should they try to consider 'ecological redundancies', i.e., group the fishes into guild of similar species and try to manage the guilds as if they were single species? After all we know that, for example, diets are more influenced by size of predator and prey than by taxonomic categories;
3. Or is there hope of predicting general trends in fish communities and in the catches therefrom? After all, even the short time series mentioned above suggests that interpretable trends do occur;
4. How much monitoring and surveillance do tropical ecosystems (and the fisheries they support) require in order to be managed? Or, in other words, what is the cost-benefit relationship between scientific monitoring and revenues from the fisheries?
5. Do we in tropical developing countries have time to do all the science that is needed before we start 'fishing down marine food webs'?
6. What to do with politicians who want to report as a success of their administrations that landings have increased by this or that percentage? And what to do with our fishers, adverse to almost any form of self-organisation?

Overall, the question here may be whether ecology can help in managing fisheries, that is, in answering at least some of the questions above. Here I detect two basic answers:

1. ecology may help in finding out what is the carrying capacity of the ecosystem. This carrying capacity, perhaps measured as the sum of all the possible fluxes in the ecosystem, represents the available energy from which we may want to divert as much as possible toward us. It is also important to have some sort of a 'magic number' representing a limit of what one can get from an ecosystem. Without it, we cannot convince our politicians that limits do in fact exist.
2. ecology may help by characterising places and times where

valuable species should be protected. However, protection should not be extended only to a few species. Also, the suite of species that have an ecological impact on the valuable species should find protection in space and time, and ecology can tell us what those species are.

I believe that approaches such as that incorporated in the Ecopath with Ecosim software (see Christensen, this vol.) are very promising in this context, especially since Ecopath has grown beyond the simple deterministic representation of an ecosystem to include uncertainty and temporal and spatial simulations. In a way, Ecopath makes the ecosystem transparent and because the input parameters of the model can be estimated rather easily, Ecopath may represent the shortcut we need for making sense of the hundreds of populations exploited simultaneously by our fisheries.

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### ACP – EU Fisheries Research Report Number 5

#### The contribution of 'observatories' to the sustainable development of fisheries: the case of Guinea

*Pierre Chavance, Jean Le Fur and Abdoulaye Diallo (IRD/HEA, France and CNSHB, Guinea)*

Managing tropical coastal fisheries such as those of Guinea (West Africa) requires meeting a number of challenges, notably:

1. declining biomasses of the nearshore resources;
2. increasing effort by the artisanal fisheries; and
3. conflicts between the artisanal and industrial fisheries.

Meeting these challenges requires information (Chavance and Diallo, 1995). To be useful, this information must be reliable, timely and cost effective, and, as well, pertinent to the state of the fisheries, and their evolution (see also Des Clers, this vol.). This information must further

1. provide a basis to decision making;
2. contribute to the required dialogue among stakeholders;
3. contribute to making management more efficient; and
4. support fisheries research.

A fishery 'observatory' can be defined as a permanent institution, with appropriate staff and hardware, set up to meet the information need of the fisheries sector, as expressed by the members of that sector, and using transparent, state-of-the-art methods to ensure the functions of:

- a. gathering information;
- b. managing information;
- c. process information;
- d. analyse information; and
- e. generate products such as fisheries statistics, and status and scientific reports (e.g., Domain et al.1999), including, e.g., atlases (Chavance et al. 1998).

The observatory set up in Conakry , Guinea meets these various

functions, and details are available from the authors on its formal structure, and mode of interaction with the private sector. Important here is that its costs are modest relative to the value of the resource: about US\$ 1.5 per tonne landed, which represent only 0.32% of the sector added value.

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### ACP – EU Fisheries Research Report Number 5

#### International and regional cooperation in fisheries research: the case of Northwest Africa

*Moctar Bâ (Ministère des Pêches, Mauritanie)*

A number of institutions and agreements have been created in recent years of which it was hoped that they would halt, and perhaps reverse the nefarious trends presently affecting fisheries and their supporting ecosystems(1). Notable under these institutions and agreements are the Convention on the Law of the Sea, the agreement regulating the exploitation of highly migratory and straddling stocks (New York Agreement), FAO's Code of Conduct for Responsible Fisheries, the Convention on Biological Diversity and more. The Sub-Regional Fisheries Commission (SRFC) of the six north-western African countries Cape Verde, Gambia, Guinea, Guinea Bissau, Mauritania and Senegal established through an international convention as early as 1986 is a case in point for attempts to create a connection between international law and management principles and more local conditions.

Various studies by FAO, by the EC and the Study on International Fisheries Research (SIFR) all indicate that the failure of fisheries to operate in sustainable fashion is largely due to inadequate institution (see Vestergaard, this vol.). In developing countries, this problem is amplified by the fact that the agencies tasked with managing fisheries usually lack the means (human and material resource, supportive legislative and political action, etc.) to fulfil their mandate. What makes this a particularly serious issue is that, contrary to the situation prevailing in industrialised countries, fisheries – especially in Northwest Africa – contribute significantly to the national economies, either as foreign exchange earner, as supplier of affordable animal protein, or both.

For our countries, mismanagement of fisheries – excess fishing effort, costing annually millions of dollars in lost revenues, imply schools that are not built, and roads that are not maintained. Addressing some of these issues requires, among other things, that fisheries research institutions should collaborate more closely. Such collaboration may be seen as having two axes: North-South and South-South.

Since the 1960s, close collaboration between fisheries research institutions in the 'North', (mainly in Europe) and those in Northwest Africa has led to the emergence of a number of relatively strong national research institutions, e.g., the Centre National de Recherche Océanographiques et des Pêches (CNROP), in Nouadhibou, Mauritania, the Centre de Recherches Océanographiques de Dakar-Thiaroye (CRODT), Sénégal, or the Centre National des Sciences Halieutiques de Boussoura (CNSHB), in Conakry, Guinea.

The emergence of these centres and similar institutions in other countries of the region made it inevitable that a strong trend toward South-South collaborating would establish itself. This is apparent at least in the form of regional projects funded, and sometimes coordinated, from outside, notably by the FAO and, increasingly, by the European Community and its member states. Several projects of this sort now exist, covering areas ranging from fish processing to geographic information systems for fisheries.

Particularly relevant here is the ACP-EU Fisheries Research Initiative, which also sponsored the conference documented in this report. We can only hope that these activities will contribute to gradually overcome the limitations still hampering fisheries research in our region and strengthen the links between fisheries research and economic and political decision-making.

(1) *Editors' note:* A database of international treaties relevant to fisheries and aquatic biodiversity is available at the FishBase web site ([www.fishbase.org](http://www.fishbase.org))

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### ACP – EU Fisheries Research Report Number 5

#### Marine protected areas as strategic tools

*Callum Roberts (University of York, U.K.)*

There is much talk about marine protected areas (MPAs), but on the ground, things do not look so great. Less than 0.5% of the seas lie within 'marine protected areas', but a much smaller fraction of that is currently protected from fishing. Seventy-two of 110 'MPAs' in Canada offer no legal protection to species or habitats. Of the 104 'marine reserves' in California, less than one percent is closed to all forms of fishing (McArdle 1997). We have been extraordinarily slow to even begin thinking about protecting the marine environment. Instead, we are still gripped by the belief expressed by Hugo Grotius in his book of the early 1600s, where he stated that the seas could not be spoiled and therefore needed no protection. Surely, the sorry legacy of 20th century fishery collapses tells us that Grotius' philosophy was wrong; a philosophy which, incidentally, is enshrined in the principle of 'freedom of the seas', largely responsible for our appalling lack of action to protect. However, there are reasons to be optimistic. Although we have so far done little, we could achieve a lot. This contribution will briefly show some of the things we could achieve. We have in our grasp a most remarkable tool: that of marine reserves protected from all forms of fishing. It is a tool that terrestrial ecosystem managers and conservationists would love to have, and one we should now use widely.

The idea behind reserves is simple: if you protect fish from fishing they live longer, grow larger and produce an exponentially increasing number of eggs. A plethora of studies have convincingly demonstrated that creation of no-take reserves allows the rapid build-up of fish spawning stock biomass (see Sadovy, this volume, and Alcala, this volume, Roberts and Polunin 1991, Dugan and Davis 1993, Bohnsack 1996, Allison et al. 1998, Guénette et al. 1998). Overall (multi-species) levels of biomass per unit area can double or quadruple within two or ten years of closure. Biomass of some target species vulnerable to overexploitation can increase by more than an order of magnitude within reserves. These results are incidentally in agreement with modelling results (Christensen and Pauly 1998, Christensen, this vol.)

We can calculate the effects of protection on egg production using figures on differences in biomass and body size between stocks in exploited and unexploited areas. A few examples suffice to show the magnitude of reserve effects on reproduction. In Californian reserves, reproductive

output of two rockfish species was estimated to be two to three times as great as in fished areas, and these were small, recently established reserves (M. Paddock, pers. comm.) On the West Coast of the US, a reserve in Puget Sound has been protected for 27 years. The reproductive output of lingcod (*Ophiodon elongatus*) inside the reserve was estimated at 20 times greater than outside, and for the copper rockfish at 100 times greater (Palsson 1998).

Reserves then can be likened to money in the bank for the fishing industry: spawning stocks on deposit, spilling out interest into the surrounding fishing grounds. Interest is delivered year after year in the form of exported eggs and larvae, and also by spillover of adults and juveniles across reserve boundaries (see Alcalá, this vol.).

In parts of the world, where long-established reserves exist, fishers operate close to them to benefit from spillover. Bill Ballantine, one of the pioneers of marine reserves described to me how, when showing a visitor the Leigh Marine Reserve in northern New Zealand, they complemented him on the clear ring of buoys marking the reserve boundary. Bill replied to him that they were actually the buoys of lobster pots set just beyond the edge of the reserve.

So much for theory and data on population build-up: do reserves actually enhance catches in practice? Unfortunately, outside of the studies of A. Alcalá and G. Russ (see Alcalá, this vol., there have been very few studies which have measured actual yield enhancements from reserves. There is a desperate need for more studies measuring catch and effort in relation to reserve establishment. One reason for the shortage has been a lack of working reserves to study. A second reason is that ecologists like to study ecology while fishery scientists stick to fisheries. The two do not often cross their disciplinary boundaries.

How much will reserves benefit fisheries? I have recently been working on a bioeconomic model of marine reserves with two economists Jack Pezzey and Bjorn Urdal . We found that the amount by which catches would increase varied according to how overfished stocks were to begin with. Reserves were beneficial when the ratio of fished stock size to unfished stock size was less than 0.5 (Pezzey et al. in press). For most of the world's exploited stocks this level of depletion was reached long ago (Roberts 1997). As stocks become more overfished, the benefit to be had from reserves increases. For a heavily exploited stock, you can more than double yields by creating no-take reserves.

In Europe, along the corridors walked by fishery scientists I have heard a great deal of scepticism about reserves. One reason is that these colleagues usually have no direct experience of reserves: we have in Europe only a handful of tiny no-take areas, and none in regions subject to industrial fishing. A second reason is that these colleagues continually claim that reserves may work in the tropics, but the temperate seas are 'different'. The difference they usually point to is that coral reef fish species tend to be sedentary as adults, while dispersing widely as larvae. This means that adult stocks will be well protected from fishing by reserves while their larvae help replenish adjacent fisheries. Many people argue that fixed-location reserves will provide no benefit to migratory species. Thus, since many of Europe's key fish stocks are migratory, reserves will not work here, they say.

The argument does not hold (Roberts submitted). Those criticising reserves on these grounds are far too narrowly focused. They are still thinking 'single-species' when approaching fishery management. Reserves, above all, are ecosystem management tools:

- Firstly, there are numerous species around Europe which are not migratory as adults. For example, you do not see many shoals of migrating shellfish. Such species will benefit in just the same way as tropical species;
- Secondly, the reserve approach recognises that species do not exist in isolation from one another, and that fish habitat is important. Recovery of habitats used by migratory species will occur in reserves, and will benefit these species, for example by increasing food production and carrying capacity (Roberts in press a);
- Thirdly, reserves placed in nursery and spawning areas will protect migratory species during critical life stages. Almost all migratory species are much more vulnerable to capture at certain critical periods, for example when they gather on spawning grounds. Fisheries have taken advantage of such behaviour for centuries and there can be a huge difference in catch per effort between vulnerable areas and times compared to the rest of the year. A calculation you can do on the back of an envelope shows that you would not have to close very much of those vulnerable areas to create a major benefit in terms of stock protection (Roberts in press a). Such approaches have already been implemented on a limited basis for particular species. For example, spawning haddock are protected on Georges Bank. Spawning groupers are protected in the U.S. Virgin Islands - although only after a spawning aggregation was fished to extinction (see Sadovy, this vol. on the vulnerability of groupers to such events).

Is it heresy to suggest that we give up some of the places we find it easiest to catch fish? The consequences of not protecting species sufficiently during migration bottlenecks are eloquently shown by the recent salmon fishery closure in the Northwest Atlantic. The near extinction of a croaker species, the Totoaba, (*Totoaba macdonaldi*) in the upper Gulf of California is partly due to the annual slaughter, which occurred when the species aggregated to spawn at the mouth of the Colorado River (Roberts and Hawkins 1999). When Charles Gilbert first described the Totoaba in 1889, he wrote that the species congregated in great numbers, and could be easily approached and speared (Gilbert 1880, cited in Walford 1937). By the 1930s, 500 to 1000 t of Totoaba were landed every year. The destruction of this fish species is akin to the slaughter of buffalo or the great auk. It is depressing that we fail to learn from such obvious mistakes. In the Southern Ocean the 'gold rush' for Orange roughy (*Hoplostethus atlanticus*) of a few years ago, was based on fishing the spawning aggregations of this very long-lived, deep-sea species. Now, only 10% of the initial Orange roughy population are left in many areas.

No-take reserves will work well for migratory species – we just have to put them in the right places. (Roberts in press a).

## Marine reserves as a means of simplifying management

The most obvious way in which no-take reserves could simplify management is by substituting for some of the complex morass of rules surrounding what can and cannot be landed, when and where. They could also help minimise conflict between different fishery sectors, for example where a fishery for penaeid shrimps is causing heavy mortality of the juvenile snappers and groupers fished somewhere else. Closure of a nursery area could eliminate much of the juvenile mortality without hurting the shrimp fishery.

The way it is currently practised, fishery management is a high-risk endeavour with a track record of high profile failures (Roberts in press b). Such failures undermine fishery management as a profession. Current approaches to setting total allowable catches are subject to enormous political interference by politicians and stakeholders with little understanding of biological uncertainty and the risk they take with fishers' livelihoods. As a consequence of political risk taking, fisheries go belly-up and fishery scientists get the blame. Because fishery scientists are then perceived as 'failures' in political circles, their advice is less likely to be taken in future and their funding gets cut. This leads to a reduction in the quality of advice they can give. This self-reinforcing spiral ultimately hurts the fishing industry and the marine environment. Politicians do no good when they interfere with fishery management, and fishery scientists need to build safeguards against political interference into the management process. A system of no-take zones would provide such a safeguard, promoting sustainability and restoring the credibility of the management process.

Take for example the cod (*Gadus morhua*). Cods are vulnerable to capture at sizes smaller than the size at which they mature. Instead of the 15 or 20 reproductively active year classes present in an unexploited population, we have only two or three in the North Sea (Cook et al. 1997). Recently we have begun to appreciate that marine environments vary over long time scales and that conditions for survival of fish offspring may be poor for stretches of many years. Long-lived species such as cod evolved to overcome such poor periods by reproducing repeatedly. The mechanism whereby each female produces millions of highly dispersive eggs and larvae, year after year has evolved for a good reason – the sea is a highly uncertain world. Fishing reduces the ability of populations to see through lean years, and thus increases the risk of stock collapse. Reserves, by providing refuges for older, larger and highly fecund fish, increase the resilience of exploited populations, thereby promoting sustainability of the industry that depends on them.

The dynamics of populations at low sizes are risky dynamics. What fishing does, and politicians encourage is to reduce the biomass of populations to a small fraction of their unfished level. Against this we have a background of environmental variation, which over long time scales drives population fluctuation independently of fishing. At small population sizes there is greatly increased risk of population, and therefore fisheries collapse. Reserves, by shifting stock sizes upwards, reduce the risk of populations collapsing.

**Figure 10** is a schematic representation of how marine reserves, by increasing population size, protects exploited species against local

collapses. (Redrawn from an original by Jeremy Jackson, with thanks).

### **Habitat destruction**

In the 14th Century, history records the introduction of a curious new device into English fisheries. This device was so efficient and so damaging that there was an immediate call for it to be banned. The Parliament Roll of Edward III in 1376 reports:

*"The commons petition the King, complaining that where in creeks and havens of the sea there used to be plenteous fishing, to the profit of the Kingdom, certain fishermen for several years past have subtly contrived an instrument called 'wondyrechaun' made in the manner of an oyster dredge, but which is considerably longer, upon which instrument is attached a net so close meshed that no fish, be it ever so small, that enters therein can escape, but must stay and be taken. And that the great and long iron of the wondyrechaun runs so heavily and hardly over the ground when fishing that it destroys the flowers of the land below water there, and also spat of oysters, mussels and other fish upon which the great fish are accustomed to be fed and nourished."*

Today we know the wondyrechaun by its more familiar name of the 'trawl' (Alward 1932).

This early account provides as eloquent a statement of the damage done by trawling of any that I have read. It is obvious from the rapid adoption of the trawl over subsequent centuries that the commoners failed in their petition. The trawl is now one of the most widely used forms of industrial fishing gears. Since the wondyrechaun of the 14th Century, the weight and size of trawls has increased enormously, and they are now used to fish to depths of more than one kilometre (see Gordon, this vol.).

Just as people observed in the 14th century, the trawl transforms marine habitats from places rich and complex with invertebrate life, to muddy, or sandy wastelands good only for some flatfish (Watling and Norse 1998). Mostly, we have failed to notice this transformation take place because much of it happened so long ago. An indication of its happening can be gleaned from accounts of 19th century fishing on the Dogger Bank in the North Sea . Until the Dogger Bank began to be trawled it was not a good place for catching flatfish. But Alward, in his 1932 book on the Sea Fisheries of Great Britain explains that the trawls cleared the bottom of the 'old decayed vegetation' so creating the open sandy expanses suitable for flatfish. "Before long", he says, "some parts of the bank abounded with some of the finest plaice, and the supply soon exceeded demand" (Alward 1932).

This old, decayed vegetation partly came from forests submerged after the last ice age. But the bottom was also covered in rich biogenic habitats. In few places we have been able to glimpse the destruction done by trawls in new fishing grounds. For example, in the northern Australian prawn fishery and the deepwater fishery for Orange roughy off New Zealand (Dayton et al. 1995). In both cases trawls initially came up laden with a rich bottom fauna, but after only a few years this was destroyed. In the prawn fishery, species like bream and snappers, which lived among these rich bottom communities, disappeared from catches with the disappearance of their habitat.

Habitat destruction is only one aspect of the damage that fisheries can do. As the commoners petitioning their King observed, trawls are relatively indiscriminate in what they catch. So are many other kinds of fishing gear, be they traps, drift nets or long-lines. But the species they catch differ widely in their ability to withstand fishing mortality. Some are highly resilient, while others will disappear with only a relatively small amount of fishing. On the U.S. East Coast, they have brought the barndoor skate (*Raja laevis*) to the edge of extinction: it has not been seen in experimental trawls for 20 years and the handful of individuals that have been caught recently were from more than 1000 m deep, a last refuge perhaps (Casey and Myers 1998). In Europe, the so-called 'common' skate (*Raja batis*) has been eliminated from much of its range and survives only in the small pockets of very rough ground, which are still untrawled (S. Jennings pers. comm.) Historical catch records show that many other vulnerable species have been disappearing from European waters, just like the common skate (Roberts and Hawkins 1999).

However, it is not only industrial gear that can cause loss of species. Even artisanal methods, for example those used to catch coral reef fish cause loss of species. There are only a few places where we have seen losses occur in detail. For example, in the early decades of this century, monstrous fishes and lobsters could be caught in Californian kelp forests and on coral reefs of the Caribbean . California's kelp forests are almost empty now, their former inhabitants have disappeared among the shadows. Paul Dayton calls them 'ghost habitats' (see Dayton et al. 1998). In the Caribbean there are 'ghost coral reefs'. The corals are there, and there are small fish, the insects and mice of the reef. But the big fish, the eagles and the lions, have all gone (Roberts 1998b).

The North Sea, which today's fishery scientists grew up with, was very different from the North Sea before the trawl. The giant cod, halibut and turbot we used to land are gone, replaced by small flatfish and scavenging dogfish and rays. The large sharks are an even more distant memory.

We have an obligation to protect marine species just as we do terrestrial ones. The FAO Code of Conduct for Sustainable Fisheries rightly demands that we protect species but we have made no progress towards this goal. No-take reserves offer perhaps the only hope for survival of these species.

### **How much, how many and where?**

Establishing that reserves are a wonderfully promising strategic tool is only the beginning. We need to answer questions about how much of today's fishing grounds should be placed in reserves, how many do we need, and where should we put them. These are difficult questions and it would be misleading to say the answers were simple. However, there are some very straightforward principles:

1. The first is that we need a large area. Jack Pezzey, Bjorn Uldal and I recently used a bioeconomic model to calculate the reserve size that will produce maximum economic benefit in terms of catch. We found that the size is a function of how overfished stocks are to begin with – the more overfished the stock is the larger the reserve

has to be (Pezzey et al. in press). We calculated reserve areas needed for three Caribbean reef fisheries ranging from very over-exploited in Jamaica, through heavily exploited in St. Lucia to moderately exploited in Belize. Reserve areas varied from 20% of fishing grounds in Belize to 40% in Jamaica. The figure for St. Lucia was 36%. Happily, both Belize and St. Lucia have well-developed programmes for establishing no-take reserves and are likely to meet these targets (see Gillett, this vol. for the case of Belize); Both biological and economic models suggest that closures between around 20-40% of fishing grounds will provide maximum benefits. Recently, Jane Lubchenco, past president of the American Association for the Advancement of Science (AAAS), along with hundreds of other scientists called for 20% of the world's oceans to be declared no-take by the year 2020. Roberts (in press c) recently reviewed evidence for how much we need to protect and concluded that 20% represented sound advice based on current knowledge;

2. The second principle is that while we need a large total area being reserved we need to sub-divide the actual reserves. This is important both for conservation and fishery purposes. Some fishery benefits will be very local, for example spillover, so we do not want all the benefits in just one place. In conservation terms, we want to represent the full biogeographic and ecological diversity of marine habitats so we need to put reserves in many different places (Ballantine 1997). Some reserves will primarily benefit fisheries, some conservation, but most will benefit both simultaneously;
3. The third principle is that we do not want to place reserves where there are damaging activities such as gravel mining or drilling for oil.

## Conclusions

Many fisheries scientists in so-called 'developed countries' almost reflexively respond to the idea of no-take reserves with opposition. It is too alien to their notions of how fisheries should be managed. When challenged that their own prescriptions don't seem to be curing the patient they often counter by saying that they would work if politicians were to listen to them. But if a management scheme is failing now because of political interference, there is little likelihood of things suddenly getting better. A system of no-take reserves would, I believe, form hedge against interference by politicians willing to take a gamble with the recommendations of fishery scientists.

No-take marine reserves represent a rare and precious example of a tool which blends conservation benefits with commercial gain. Here there is no conflict of interest between those who exploit and those who wish to protect. Reserves could deliver very significant benefits. Model predictions are that coral reef fisheries alone would increase in value by over a billion US dollars annually if we set up no-take reserves world-wide (Pezzey et al. in press). Calculated across all fisheries the value would be massive. With no-take reserves, fishers will benefit from greater security of income and reassurance of sustainability of the species they fish. Fishery managers will benefit by taking the success or

failure of management out of the hands of politicians.

The value of reserves for conservation is also enormous. I would appeal to sceptical fishery scientists that even if you do not yet believe in reserves for fishery management, do not block them for conservation, (see also McNeely 1998). Yes, we should have the underwater equivalent of intensive agriculture – the muddy seabed ploughed by trawls, but give us wilderness too – the nature reserves and national parks. I think that getting reserves set up now is one of the most urgent priorities in marine conservation. We need to act fast to turn the tide of human impact in the oceans and no-take marine reserves offer simple and sound solution. We are a long way off declaring 20% of the seas as no-take but it is a target well worth reaching. Without them, the seas will become a sorry shadow of their former abundance and the giants that we once hauled from them creatures of imagination alone.

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### ACP – EU Fisheries Research Report Number 5

#### MPAs as a generic tool, with emphasis on the protection of long-lived fishes, such as groupers

*Yvonne Sadovy (University of Hong Kong, China)*

This contribution deals specifically with groupers (Fam. *Serranidae*, Subfamily *Epinephelinae*). However, the reader will understand that besides being very important in their own right, this group also stands in for the other long-lived, high-value bottom and especially reef fish species presently threatened by a process known as "fishing down marine food webs" (see Pauly, this vol.).

Groupers have low natural mortalities (Pauly and Binholan 1996) and high longevities, reaching up to 30-40 years or more in various species. Consequently, they also require many years to reach maturity, which leads to low population turnover rates. Moreover, groupers usually have short spawning seasons, usually a few weeks only, and mating, especially in large species - occurs in so-called, spawning aggregations. These occur at distinct sites, used by a large number of animals, which may migrate 100 km or more to reach their destination. Another feature of groupers is that most are protogynous hermaphrodites, i.e., first function as females, then turn into males as they get larger. Recent reviews of these features may be found in Arreguin-Sanchez et al. (1996).

Combined, these features render groupers extremely sensitive to overfishing. Thus, for example, even low rate of fishing leads to a female bias, likely to influence mating behaviour, not to mention the fact that fishing on spawning aggregations can remove a large fraction of a population even at a low level of fishing effort (Koenig et al. 1996).

Marine Protected Areas appear, therefore, as one of the tools most likely to help protecting groupers, given that account is taken of the above characteristics. Indeed, experience so far shows that MPAs confer protection that can lead to increases in density, biomass, mean size and abundance of groupers inside the MPAs (see Table 3 for a partial, but representative list of examples).

However, in many cases where positive effects of MPAs have been observed, the groupers involved either belonged to small species which do not migrate (i.e., they did not leave the MPA to reach a distant spawning aggregation site). Also, they were sexually immature (i.e., had not yet undertaken any spawning migration), or were already in close vicinity to a spawning site (e.g., *Epinephelus striatus* in Table 3).

**Table 3.** Examples of the positive effects of Marine Protected Areas on grouper populations.

Species	Location	Effects
<i>Cephalopholis miniata</i> , <i>C. hemistiktos</i> , <i>Variola louti</i>	Red Sea	About 30 to 300% increase in mean weight of species in un (der)fished relative to other areas (Roberts and Polunin 1993)
<i>Serranids</i> , mainly <i>Cephalopolis spp.</i>	Sumilon Island, Philippines	Average weight twice as large and density and biomass 3-30 times greater than controls (Russ 1985).
<i>Plectropomus leopardus</i>	Great Barrier Reef, Australia	Average lengths greater, and density higher on unfished than on fished reefs (Beinssen 1989, Craik 1981)
<i>Epinephelus fulvus</i>	Saba Marine Park, Belize	Unfished biomass, sizes and abundance greater in unfished than in fished zone (Polunin and Roberts 1993, Roberts 1995).
<i>Epinephelus striatus</i>	Marine Park, Bahamas	Eggs per area greater inside (due to greater parental sizes and abundance) than outside park (Sluka et al. 1997).
Serranids	Loe Key Reef, Florida, USA	Abundance increased after two years of protection from spearfishing (Bohnsack and Bannerot 1986).
Serranids, mainly young <i>Plectropomus leopardus</i>	New Caledonia	Significant increase of biomass and density in protected areas (Wantiez et al. 1997).

This suggests several possibilities:

1. Large migrating groupers benefit little from MPAs which do not include their spawning sites;
2. Larger grouper species need longer to recover from past exploitation, even when offered complete protection from fishing.

This leads to the identification of the following research requirements regarding MPAs:

1. the spawning and nursery areas of grouper populations must be known if MPAs are to protect them from the effects of exploitation;
2. the extent of fishing on spawning aggregation outside of MPAs must be known, so it can be sharply limited; and
3. monitoring regimes for grouper populations must be developed, which are sufficiently accurate and precise to detect, in MPAs, i.e., without fisheries-derived information - even small change in numbers and/or biomass.

Moreover, the continued existence of viable populations of high value species must be ensured outside MPAs as well, through responsible management of the fisheries, lest only the MPAs will end up containing individual of those species. The latter situation would put too much pressure (e.g. through poaching) on the MPAs. This emphasises, if needed, that MPAs cannot serve as replacement for classical fisheries management measures, but only as their necessary complement.

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### ACP – EU Fisheries Research Report Number 5

#### Fisheries enhancement effects of marine reserves

*Angel C. Alcala (Commission on Higher Education, Philippines)*

The concept of marine reserve (defined as an area of the marine environment protected from all forms of exploitation) is not new. In 1862, Henry David Thoreau, the American environmentalist, wrote that "in wildness is the preservation of the world" (see Bohnsack, 1993). However, it took almost a century for Thoreau's words to begin to be applied to oceans. It certainly took more than a century for scientists to realise and appreciate the use of marine reserves to enhance fisheries and protect fishery resources, the first modern marine reserves having been established for those purposes only in the mid-1970s (Alcala 1981; Alcala and Russ 1990; Bohnsack 1994, Roberts and Polunin 1993), even though Beverton and Holt (1957) had earlier discussed the potential of a sanctuary on the North Sea plaice fishery (see Pauly 1993, and Guénette et al. 1998). Marine reserves or sanctuaries are especially effective for fishes with restricted geographical movement, such as coral reef species (see Sadovy, this vol.). There are a number of reasons for the effectiveness of marine sanctuaries as a management strategy for coral reef fisheries and similar nearshore fisheries (Alcala and Russ 1990; Bohnsack 1994; Roberts and Polunin 1993; Russ and Alcala 1996). This is particularly true if marine sanctuaries are combined with an effective enforcement mechanisms, involving local fishers and their communities.

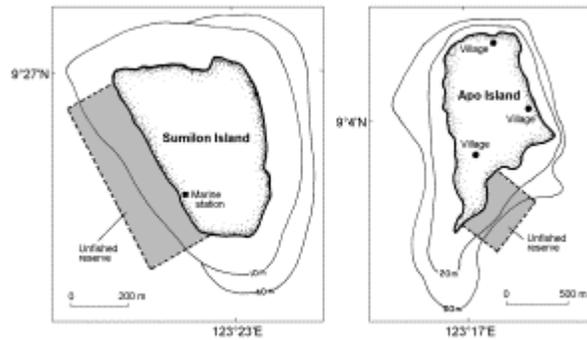
The fisheries-related objectives for the establishment of reserves or sanctuaries emphasised in this contributions are: (a) protecting a critical spawning biomass to ensure a supply recruitment to fished areas via larval dispersal, and (b) to enhance fish yields in areas adjacent to reserves through the spillover of adults. Two small coral reef islands in central Philippines, studied from 1974 to the present by Dr. Garry Russ of James Cook University, Australia and the author, then at Silliman University, Dumaguete City, Philippines (details in Alcala and Russ 1990, Russ et al. 1992, and Russ and Alcala 1996) are used as case study.

#### Sumilon and Apo Islands

Sumilon Island has a land area of 23 ha. It is a low coralline island, surrounded by a 50-ha fringing coral reef at the 40 m isobath (Figure 11). A marine reserve, comprising about 25% of the reef area was established in 1974 at the western portion and protected for 10 years by Silliman University. During that period, about 100 fishers from the

nearby larger island of Cebu exploited the non-reserve area. In April 1984, the reserve was invaded and fished down.

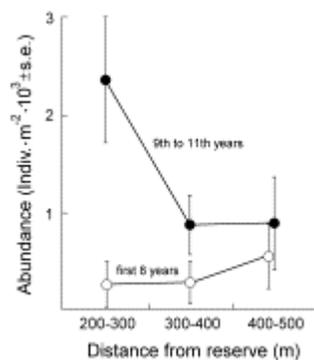
Apo Island has a land area of ca 70 ha. It is a high island, surrounded by a 106-ha fringing reef at the 60 m isobath (Figure 11). A marine reserve, comprising about 10% of reef area, was set up in 1982 and protected by the island community of about 500 residents. About 200 fishers, mostly residents, exploited the non-reserve.



**Figure 11.** Sumilon and Apo Islands, Philippines. Note large area of MPAs, relative to the fishing grounds

The fisheries of both islands were monitored in terms of catches by fisher per trip and by species groups (details in publications cited above). The key results were as follows:

1. The reserves had in both cases marked effects on fish population abundance within and outside of the reserves, and increased catches in the areas fished areas adjacent to the reserves;
2. Underwater visual surveys revealed a strong spillover of adults from the reserves to the adjacent areas (see Figure 12);
3. This spillover effect is also likely to be the reason for the high catches from the non-reserve area at Sumilon , during the 1974-1984 period of protection.



**Figure 12.** Spillover of fish from Apo Island Marine Protected area to the adjacent fishing grounds.

*Further details may be found in the literature cited above. Jointly, they justify the optimistic interpretation, by Alcala (1981), of the first results of this continuing study, which, at least in the Philippines , contributed to establishing reserves as bona fide instruments for fisheries management.*

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### ACP – EU Fisheries Research Report Number 5

#### The Ria de Aveiro Lagoon (Portugal): a case for protection

*José Eduardo Rebelo (Universidade de Aveiro, Portugal)*

It is well known that lagoons play an important, structuring role in shaping the ecology of coastal systems (reviews in Kjerfve 1994). Notably, they act as nurseries for important invertebrate and fish species (Yañez-Arancibia et al. 1994; Pauly and Yañez-Arancibia 1994).

The Ria de Aveiro Lagoon, on the west coast of Portugal is the only typical estuarine lagoon in the country, and appears to have been formed in the 10th Century, although its 470 m connection to the sea was artificially stabilised as late as 1808. This lagoon and its surroundings are of great economic importance due to its contributions to fisheries, agriculture, navigation and tourism. The lagoon proper has a depth of about 1 m, a length of 45 km and a width of 11 km, and serves (or served, see below) as temporary or permanent habitat for some 55 fish species, consisting of the following groups:

1. Estuarine species (especially silversides, Family *Atherinidae*), whose entire life cycle occurs within the lagoon (5 spp., contributing 54% of individuals recently sampled, and 25% of the biomass);
2. fresh water species, which migrate into the slightly brackish, interior part of the lagoon (4 spp.; 1.2%; 0.1%)
3. marine species (mainly grey mullets, Family *Mugilidae*), occurring in the lagoon only as juveniles (8 spp.; 25%; 52%);
4. marine species (mainly gobies, Family *Gobiidae*) are occasional visitors to the lagoon (35 spp.; 15%; 11%);
5. anadromous or catadromous species, which use the lagoon for only a small part of their life cycle (2 anadromous spp.; 0.1 %; 0.3 %; 1 catadromous sp. – *Anguilla anguilla*; 4%; 11%).

Only 42 of the 55 species reported from the Ria de Aveiro Lagoon at the beginning of the century were observed in recent samples. This suggests that the massive degradation of the lagoon ecosystem has led to a loss of biodiversity, mainly due to changes in land use patterns around the

lagoon, pollution from industrial and fishing ports, paper factories, urban sewage and cattle husbandry. It is clear that in coastal systems such as Ria de Aveiro Lagoon, excessive fishing effort is only one of a wide array of stress factors. Thus, fisheries management (including the setting up of marine protected areas) must be part of an integrated coastal zone strategy that attempts to make the Ria de Aveiro Lagoon ecosystem recover from the effects of these other stress factors as well, notably from pollution.

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### ACP – EU Fisheries Research Report Number 5

#### Marine protected areas: adaptations for use in temperate conditions

*Nicholas Polunin (University of Newcastle, U.K.)*

With the failure of fisheries stocks in many parts of the world, it is tempting to blame scientific approaches on fisheries management, but how rational is it to propose that MPAs could succeed where other measures have failed?

Specifically:

- Where and for what groups of target organisms is there evidence that MPAs help depleted species recover?
- What are the characteristics of these areas and organisms, and to what extent are MPAs a generic fishery management tool?
- How might MPAs actually benefit fisheries?
- Have MPAs helped actual management of any fisheries?

I will not consider whether fisheries are at all 'manageable', given in particular variability in recruitment and limited resources (Jennings and Kaiser 1998).

Fisheries impact their target species by:

- reducing mean ages, sizes, and abundance and biomass;
- reducing population fecundity, but not necessarily recruitment;
- probably reducing resilience vis-à-vis recruitment fluctuation (see Figure 10 in Roberts, this vol.); and
- possibly reducing genetic diversity (see also Stergiou, this vol.).

In the process, fisheries may also impact non-target species, either directly (though by-catch mortality) or indirectly, notably by reducing the food base of predators, or reducing predation mortality in some prey organisms, or by impacting . keystone. species. But in spite of their

prevalence in the literature, however, few cascades and keystone-type effects have been found, and top-down controls cannot be assumed, (e.g., Polunin and Jennings 1998). Also, impacts may be generated through disturbance of structural biota, and of physical habitat structure (notably by bottom trawling), which may have consequences for process such as recruitment, although physical effects of gears may be overridden in areas where natural disturbances are dominant (e.g., Jennings and Kaiser 1998, Figure 8).

MPAs are expected to help address these issues, and this is briefly reviewed, distinguishing tropical settings, for which much useful information is available (see Alcala, this vol., Sadovy this vol.), from temperate settings (Roberts, this vol., Rijnsdorp, this vol.).

It is well established that on tropical reefs, small MPAs will lead to increase of the individual size and/or abundance of many species within the areas so protected, but such changes are detected in only a small proportion of species (e.g. Polunin and Roberts 1993). This small proportional response is likely to be contributed to by the variability of abundance data and low statistical power of the sampling designs used, but other factors undoubtedly contribute, including spatial variation in recruitment and unknown sources of mortality such as poaching. In a few cases, size and abundance increases have not occurred at all, and this has been attributed to either faulty assessment methods, recruitment failures over limited areas, or unknown sources of mortality, but the latter processes cannot be dispelled as unimportant in the planning of MPAs and prediction of any benefits to be predicted therefrom. In any case, increases in abundance in closed areas do not equate to increases in yield. Other limitations have appeared even in otherwise successful cases. One such limitation is that the spillover effect (see Alcala, this vol.) tends to operate over very limited distances. This implies that networks of MPAs may be needed to cover larger fishing grounds, especially in areas where migratory species are important (see also Sadovy, this vol.).

In temperate waters, small MPAs can be expected to work well for sessile species, and in temperate waters these will be primarily target species with affinities to reefs or rocky areas (wrasse, lobster, rockfish). They may be of use when overlapping with nursery areas in some cases (but see Rijnsdorp, this vol.).

Small MPAs are unlikely to have much impact on the major commercial species, e.g., in Europe, plaice (*Pleuronectes platessa*), sole (*Solea solea*), herring (*Clupea harengus*), mackerel (*Scomber scombrus*) or dogfish (*Squalus acanthias*). Table 4 summarises the case made here.

**Table 4.** Tentative contrasts between tropical and temperate waters

Item	Tropical reefs	Temperate waters
Site-attached species	Typical	Rare
Commercial species	Many site attached	Nearly all migratory

Fishing-effects studies	Small-scale	Large-scale
Means of study	Visual and fishery	Fishery
'Indirect' (food-web) fishing effects	Most convincing, but little evidence	Evidence weak
Habitat recovery	Typically slow	May be fast

On the other hand, even small MPAs may contribute toward habitat recovery from the impact of fishing gear, where the habitat is not physically disturbed by processes other than fishing. They should provide control sites for studies aimed at certain fishing effects and may help increase awareness of the effects of fishing, particularly if such effects are demonstrated. These latter points help to build a polemical cases for setting up small MPAs at selected sites even in temperate areas, but it had to be stressed that large MPAs will probably be required to protect and rebuild commercial stocks in areas such as the North Sea , a fact substantiated by the consequences of large-scale involuntary fishing restrictions in the that region during both world wars (see also Gu nette et al. 1998).

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### ACP – EU Fisheries Research Report Number 5

#### The North Sea's "Plaice box" as a marine protected area

*Adriaan Rijnsdorp (RIVO, Netherlands)*

One of the many problems besetting the fishery for plaice (*Pleuronectes platessa*) in the North Sea is the large amount of discards, which reached 50% (in numbers) in the period from 1989-1991, mainly involving specimens from 15 to 30 cm. The distribution of plaice in the North Sea follows Heincke's Law (Heincke 1913; see also Gordon, this vol.), i.e. it is characterised by a strong gradient of size, increasing from the coastal areas of the South-eastern North Sea to the deeper grounds of the Central North Sea, while numbers decrease as sizes increase. As much of the discard problem is due to fishing in the coastal areas where undersized fish occur, the idea came up to close at least part of these areas to trawling ; hence the 'Plaice box'(Figure 13).

The emergence of the Plaice box as an MPA was a gradual affair, involving ICES since 1987, the EU since 1989, and gradual extensions of the restricted seasons, and restricted vessel classes (Piet and Rijnsdorp 1998, Pastoor et al. 1998).

The responses to this experiment cover the fisheries, the plaice and the ecosystems as a whole, viz.:

1. Fishing effort and landings inside the box declined;
2. The abundance of young plaice within the box was high at the start of the closure, but then declined;
3. Juvenile mortality increased in the 1990s;
4. The spawning stock outside of the box declined;
5. There was an increase in large-sized fish (including plaice) inside the box;
6. A multivariate analysis of catch data showed a marked shift in the structure of the species assemblages, and hence of the ecosystem as a whole.

The interpretation of these results is not straightforward. Clearly, the Plaice box succeeded in reducing fishing effort. As yield per recruit analyses have suggested yields would increase with a decrease of effort, yields should have increased as well. However, the growth rate of young plaice inside the box declined as a function of their high density at the beginning of the closure, a factor not considered in the model used for predicting the effect of the Plaice box. The changes in growth and

mortality coincided with changes in the North Sea ecosystem as well, due to changes in ocean climate and the level of beam trawl effort, which may have led to a decrease of the food supply for plaice.

Although effects of the closed areas in terms of the size structure of the fish assemblage can be shown, the expected positive effects on the fisheries is more difficult to demonstrate because it is impossible to disentangle the effects of the reduction in fishing effort from the effects of changes in the ecosystem due to environmental factors (ICES 1999). Here, focused research is still required, notably to monitor target species abundance and growth rate, as well as community and ecosystem effects and the effects of bottom trawling on the productivity of the benthic ecosystem.

**Figure 13** shows the location of the 'Plaice Box' and schematic representation of the distribution of plaice (*Pleuronectes platessa*) in the North Sea with mean sizes (total length, in cm) given for each depth range (modified after Garstang 1908).

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### ACP – EU Fisheries Research Report Number 5

#### Protecting the marine ecosystem around the Galapagos Islands

*Günther Reck (Universidad San Francisco de Quito, Ecuador)*

Little needs to be said to justify why the Galapagos Islands ecosystems – both terrestrial and marine - should be protected. Their high degree of endemism, highlighted by Charles Darwin, should suffice. Indeed, there is much international support for keeping the Galapagos as pristine as possible. This, however, conflicts with conventional views of 'development' and with the aspiration of fishers, colonists, and other citizens of Ecuador, eager to exploit the natural resources of the Galapagos directly, rather than through eco-tourism, here the key alternative to a conventional 'development' scheme.

This conflict became very acute in the 1980s, when shark finning (including a large 'by-catch' of sea lions and seabirds ) expanded around the Galapagos, soon followed by an equally destructive fishery for sea cucumbers.

One response was the creation, in 1986, of a 'Marine Resource Reserve' covering the waters within 15 nautical miles of the Galapagos Islands. However, this and accompanying measures, imposed from above, were not respected by the fishing industry. Particularly, these measures failed to prevent the development of the sea cucumber (bêche-de-mer) fishery, and the violent conflicts that followed in its wake.

It was only in the mid 1990s that participatory processes were initiated, which involved the various stakeholders, notably the tourism industry, and the local press, and through which the fisheries sector came to accept the need for resource conservation. This was facilitated by the distinction of the artisanal from the industrial subsector, which allowed the adoption of measures such as limiting the access to inshore resources to the artisanal subsector (see Fontenelle, this vol.)

However, serious problems remain. Notably, the idea of 'no-take' areas is still not accepted by the artisanal fishers, who continue to mistrust the conservation agenda they (rightly) attribute to most scientists. However, given the weak infrastructure for fisheries management in Ecuador, the consultative process that has been initiated among the Galapagos Island stakeholders must be considered a qualified success, upon which detailed zoning for multiple resource uses, and further-reaching governance -type arrangements (see, e.g., McConney, this vol.), may be based.

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### ACP – EU Fisheries Research Report Number 5

#### The Marine Stewardship Council: a market-based fisheries management approach

*Carl-Christian Schmidt (Marine Stewardship Council, U.K.)*

Fisheries management as performed to date has not worked, as proven by the crisis we have on hands. The reasons are many and do not need listing here. One of these reasons, though, is the fact that the general public has so far not been involved in decision about what are after all, public resources. As documented by existing eco-labelling schemes, notably that initiated by the Mexico-based Forestry Stewardship Council, market-based mechanisms do provide for public involvement in natural resources management. So far, however, comparable efforts in the area of marine fisheries have been scattered and ad hoc, mainly driven by single issues (or groups of organisms to be protected), such as through schemes to promote 'dolphin-free tuna', or 'turtle-free shrimps'.

Established in February 1997, the Marine Stewardship Council (MSC) is an independent, not for profit, international body, set up to promote sustainable and responsible fisheries and fishing practices world-wide, and to overcome the fragmentation alluded to above. The MSC started its existence as a joint initiative between the World Wide Fund for Nature (WWF) and Unilever, a large, Anglo-Dutch company involved in, among other things, the marketing of fish products. In creating the MSC, both organisations aimed for the same objective: to ensure the long-term viability of global fish populations, and the health of the marine ecosystems within which these populations are embedded.

The now independent MSC has established a broad set of principles and criteria, which will be implemented through a standardised certification scheme (**Figure 14**). Only fisheries meeting these standards will be eligible for certification by independent, accredited certification bodies.

Therefore, the Principles and Criteria (i.e., standard) for sustainable fishing of the MSC are central to its purpose. Certified fisheries and fisheries stakeholders are then eligible to use the MSC logo for their product, which will convey to consumers the assurance that the fish or fish product is from a well-managed and sustainable fishery and that it

has been fished responsibly.

The MSC 'Principles and Criteria' standards by which sustainable fishing is measured are applicable to commercial fisheries throughout the world. They are meant to ensure that the catch of marine resources are at a level compatible with long-term sustainable yield, while maintaining the marine ecosystems' biodiversity, productivity, and taking into account:

1. relevant local, national and international laws;
2. ecological sustainability and ecosystem integrity;
3. responsible and effective management systems;
4. benefits from the fishery; and
5. social considerations.

**Figure 14** is a schematic representation of requirements toward MSC certification.

During 1997, the MSC conducted a global series of workshops, in the USA, Germany, Canada, Australia and other countries in order (1) to refine the initial set of standards developed by a working group of international experts, (2) to develop standards for individual fisheries and (3) to facilitate international implementation of its accreditation scheme. Further consultation sessions were held in Chile, Argentina, Peru and Ecuador during 1998.

The process leading – or not – to the certification of a given fishery is outlined in Figure 14. Note that much of this process falls within the purview of the fisheries wishing to be accredited, and of independent certification bodies, but outside of the purview of the MSC. Also note that the MSC's certification process is confidential and all fisheries have access to the certification scheme, irrespective of size and location. Particularly, the MSC accreditation scheme is not meant to favour developed-country fisheries, or developing-country fisheries. Rather, it is hoped that it will contribute to sustainable fisheries in countries both of the North and of the South.

The MSC is actively seeking the widest possible involvement from individuals and organisations, committed to seeking new solutions to the decline of marine fisheries and securing the future of these important resources. The home page from which this brief contribution was adapted ([www.msc.org](http://www.msc.org)) contains supplementary information on all issues raised herein.

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### ACP – EU Fisheries Research Report Number 5

#### European fish imports: a multiple regression approach

*Rafael Lostado (Universitat de Valencia , Spain)*

A study was undertaken of the factors which determine imports to the European Union in the context of the EC Project FAIR (CT95 0892), on 'Foreign Trade and Seafood Prices'. One of our key results is a multiple regression model which is log-log specified so as to provide insights into the elasticities of the independent variables through the parameter estimates ( $b_1, b_2, \dots, b_n$ ).

Our model for prediction of annual fish import (Q) thus takes the form

$$\ln(Q_{i,j,t}) = a + b_1 \cdot \ln(Q_{i,j,t-1}) + b_2 \cdot \ln(\text{IMPP}_{i,j,t}) + b_3 \cdot \ln(\text{CONS}_{i,t}) + b_4 \cdot \ln(\text{PROD}_{i,t}) +$$

$$b_5 \cdot \ln(\text{PRICE}_{i,t}) + b_6 \cdot \ln(\text{TRADB}_{i,j,t}) + b_7 \cdot \ln(\text{DIST}_j) + b_8 \cdot \ln(\text{CHG}_{j,t}) + e_{i,j,t}$$

where

$Q_{i,j,t}$  is the quantity (tonnes·10<sup>3</sup>) of fish product i imported to country j in year t;

$\text{IMPP}_{i,j,t}$  is the import price of product i from country j in year t;

$\text{CONS}_{i,t}$  is the domestic consumption (tonnes·10<sup>3</sup>) of product i in year t;

$\text{PROD}_{i,t}$  is the domestic production (tonnes·10<sup>3</sup>) of product i in year t;

$\text{PRICE}_{i,t}$  is the domestic production price in year t, in national currency; (1993 = 100);

$\text{TRADB}_{i,j,t}$  is a measure of trade barriers (tariffs, etc.) of i, imported to country j in year t;

$\text{DIST}_j$  is the distance, in km, between the economic center of country j

and that of its supplier(s);

$CHG_{j,t}$  is the nominal currency exchange rate (1993 = 100) between the country of reference and country  $j$  in year  $t$ ; and  $e_{i,j,t}$  is the error term.

**Figure 15.** Schematic representation of flows of fish products within (left) and into (right) the European Union.

Figure 15 shows the fish product flows considered in, and explained by this model, for trade within the European Union (left panel), and between the European Union and its major fish suppliers (right panel). Note the important roles played by Norway, as exporter to the European Union and by Denmark as both importer and exporter.

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### ACP – EU Fisheries Research Report Number 5

#### The role of new actors in ensuring fish supplies: a case study from North-western Africa

*Cheikh Saad-Bouh Kamara (Université de Nouakchott, Mauritania)*

Mauritania has experienced large social changes in the last decades, most due to the sedentarisation of a large fraction, previously nomadic, of the population.

This process, wrenching in itself, was accompanied by

1. growth of the overall population, and increased poverty;
2. strong growth of the informal sector of the economy;
3. new social and economic roles for women, now often heading families due to an increase rate of divorce, or, frequently, long absence of their husbands;
4. increase of democratic practices, wherein citizenship determines rights and duties, as opposed to earlier practices, which emphasised patronage;
5. new attitudes resulting from the above processes, from the growing influence of the mass media, and from the local impacts of outside process (globalisation, structural adjustment programmes; 'food aid' programmes, etc.).

These changes have strongly impacted the fisheries sector, either directly, or through changes in eating habits of Mauritians, with fish consumption gradually replacing red meat as major source of animal proteins. The changes in the fisheries sector are manifest at several levels:

1. increase in the number and activity of the organisations representing small-scale, artisanal fishers;
2. increased resistance against the presence and activity of distant-water fleets operating along the Mauritanian coast (review in Bonfil et al. 1998);
3. increased surveillance of the operation of these fleets (incl. observer programmes);

4. imposition of a closed season ('biological rest');
5. widespread perception of the need to maintain a productive marine ecosystem, i.e., not to 'kill the goose that lays eggs of gold';
6. establishment of organisations representing consumers.

Traditional actors (government, the private sector, etc.) initiated some of these developments, but many are due to initiatives by new actors, or rather by actors newly involved in the artisanal fisheries, notably;

1. Women starting smaller and medium businesses;
2. Citizens returning from foreign contract work;
3. Retired public servants entering the private sector;
4. University graduates not finding work from traditional employers (i.e., the State and the formal sector of the economy);
5. Formerly rural, recently urbanised persons;
6. Businesses responding to difficult conditions by diversifying;
7. Religious or clan leaders newly entering the economic sector;
8. Organisations of artisanal fishers (small and medium scale operators);
9. Former stockholders in the industrial subsector, now investing into the artisanal fisheries.

The constraints these new recruits to the artisanal subsector encounter are the same as those encountered by the subsector as a whole, viz.: diminished stocks, insufficient surveillance leading to pirate fleets adding to the fishing effort of foreign industrial fleets (themselves coddled by the government); massive export of high quality fish and, increasingly, coastal pollution.

The requirements that can be formulated from this largely correspond to the demands of local groups, and include:

1. government support, rather than non-recognition of consumer organisations and other civic groups;
2. encouragement and support of activities involving traditional and non-traditional actors in the artisanal fisheries sector, at the national, regional and international levels;
3. establishment and implementation of national standards of quality, safety, etc. relevant to the fisheries sector, in agreement with international standards;
4. increased international cooperation at all level, including with international NGOs, especially with regard to maintaining a productive, diverse marine ecosystem.

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### ACP – EU Fisheries Research Report Number 5

#### Neo-liberal economic policies: impact on the fisheries of Chile, Mexico and Peru

*A. Thorpe, A.A. Ibarra and C. Reid (University of Portsmouth, U.K. and Instituto Nacional de Pesca, Mexico)*

Fisheries policy in the major Latin fishing nations has historically reflected prevailing macroeconomic development strategies. This is particularly notable with respect to neo-liberalism, the development doctrine that has been applied since 1973 in Chile, from 1982 in Mexico and from 1990 in Peru.

Trade liberalisation was adjudged to be essential if exports were to be stimulated, the competitiveness of domestic production against imports improved, and the debt overhang reduced. Standard policy recommendations can be decomposed into two elements. First, trade de-regulation (tariff – import and export – reduction, converting specific into ad valorem tariffs, eliminating non-tariff barriers). Second, through the liberalisation of foreign-exchange markets (exchange-rate unification, the elimination of preferential access to foreign currency). Less emphasised, though indisputably important, are the specific schemes introduced to promote exports.

The fisheries sector has benefited too: devaluation created opportunities to earn large (albeit temporary) profits in the export sectors. The renewed export drive in Peruvian pelagic fisheries and the modernisation of Mexican fisheries can also be ascribed to the trade-oriented neo-liberal model. The impact of the new trade arrangements is not uniform across fishing sub-sectors or countries, however, due to devaluation-induced movements in imported input. Thus, while the majority of inputs (over 99.9 %) are sourced domestically in Mexico, the shortage of fossil fuels in Chile ensures that industrial fleet operating costs rise as the Chilean peso falls against the dollar.

The fisheries sector has also been immune to privatisation pressures. In Chile, the historically important Northern pelagic fisheries which had been rescued by the state following the severe 1965 El Niño event, were privatised between 1974 and 1978. One consequence of privatisation

was rapid industrial concentration. The principal beneficiary was the Anacleto/Angelini Group. Incomes generated from the fishery enabled the Angelini Group to re-invest outside the sector, thereby strengthening its political influence – particularly as far as fisheries policy formulation was concerned. In Peru, restructuring of Pescaperu, the state-run fishmeal monopoly with exclusive access rights to anchovy stocks, had pre-dated neo-liberalism. However, industrial rationalisation quickened following the election of President Fujimori in 1990 and, by early 1998, over US\$130 million had been generated through the liquidation of Pescaperu's assets. The withdrawal of the state is also evident in Mexico where Propemex, the state enterprise entrusted with regulating Mexican domestic fish supplies and developing export markets, had accumulated a debt of US\$6.4 million by 1988. The neo-liberal response, set out in El Diario Oficial on 11 November 1988, was to privatise Propemex canneries, processing factories and vessels along with the para-statal marketing agency, Oceans Gardens.

Historically it must be said, Latin American fisheries development was always geared to the export market, in particular pelagic reduction into fishmeal. While greater emphasis was accorded to domestic consumption objectives by populist Presidents in the three countries during the 1970s and 1980s, this objective nevertheless remained subordinated to the export goal. Hence, while the region is the world's largest per capita fish producer, it also remains the world's second lowest per capita consumer of fish.

The 'New Neo-Liberal Arrangements' are unlikely to improve local food fish consumption levels on a number of counts. First, as a depreciated exchange rate offers improved export returns, there is every likelihood that a greater proportion of the national catch will now be directed to overseas markets. Second, devaluation also had effects on aggregate demand. Devaluation, in the absence of any compensating increase in money wages, will influence domestic food fish consumption patterns by reducing the real purchasing power of potential customers. Third, the administrative tendency to favour uniformity when determining value added tax (VAT) rates implies that these new taxation arrangements – despite the zero-rating of selected basic goods – are somewhat regressive in nature. Consequently, post-reform shifts in demand will not only be determined by local food fish income elasticities, but also by the differential impact of such taxation across the different income strata. Finally, there is a possibility that domestic price de-regulation may eliminate price controls over specified fish products, causing a rise in price and a corresponding decline in demand. Thus, it can be expected that domestic food fish consumption will suffer from the new neo-liberal arrangements, notwithstanding (i) the support offered to artisanal fishers – the principal historic suppliers of the domestic market and (ii) the favoured position of fish, in protein per peso terms, over competing goods.

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### ACP – EU Fisheries Research Report Number 5

For institutions that encourage meaningful debate

*Elisabeth Vestergaard (University of Aarhus, Denmark)*

Scientific and scholarly advice from a number of disciplines could undoubtedly contribute more to the development of new policies and new institutions. The institutions should be aimed at integrating marine resource conservation, technological expediency, economic efficiency, political necessity and the internal socio-cultural requirements of the industry. This ideal integration would then in turn contribute to resolving the crisis of fisheries, and the ecological threats to ocean productivity that emanates from it.

The social objectives have a key position in management, because for a management regime to work, it must hold legitimacy in the eyes of those subjected to it. If, however, a management regime challenges basic values in the social systems concerned, it loses its legitimacy, leading to either a collapse of the management regime or calls for expensive enforcement measures in the form of surveillance and various forms of intensive control.

First, however, we must clarify what we mean by institution, and, as well, state what to consider when drafting new institutional designs for the governance of resource exploitation systems.

What is an institution? Institutions create and structure order. According to Malinowski (1944), an institution is a group of people who are united for a purpose. This implies an organisation and the technological knowledge for carrying out the purpose, and a charter or a set of ideas which assures that the purpose is worth carrying out. Also, institutions imply a power structure. One may also say that institutions provide the frames and stipulates the rules for interaction in society. Actors then move within these frames, while adhering to their rules – or trying to expand them.

Some of the issues to consider when drafting governance systems may be identified by contrasting two visions of the world, including human societies, and their institutions (Table 5).

Table 5. Schematics difference between two views of the world, impacting on the institutions we design to manage fisheries.

<b>Item</b>	<b>The static view</b>	<b>The dynamic view</b>
How does the world work?	'Equilibrium'	'Chaos'
How can ecosystem be defined?	Closed, high predictability	Open, low predictability
How should target species be studied?	One at a time	Several at a time
With what models?	Static, deterministic models	Dynamic, stochastic models
With what goal function?	Short term maximization of output from a few species	Long-term optimization of benefits from entire system
With what underlying view of fishers?	Fishers as rational, profit-seeking Homo economicus	Fishers embedded in social and cultural webs of reciprocal ties
Through what institutions?	Centralized, rigid, top-down	Decentralized, flexible, networked

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### ACP – EU Fisheries Research Report Number 5

#### Managing pluralism of renewable resources: patrimonial mediation and subsidiarity

*Didier Babin (CIRAD, France)*

This contribution (based on Babin et al. in press) deals with some aspects of governance (see also McConney, this vol.) usually not covered when dealing with this concept.

Thus, limiting the operation of the State to functions of rule-making, guiding, piloting, controlling and maintaining order does not necessarily mean 'less State' but undoubtedly implies a 'better functioning State'. In many African countries the decentralisation process, if its is to succeed, must begin from a strengthening of the central authorities and, at the same time, a transfer of their responsibilities to the authorities at the more local level.

Any attempt to get to 'less-State = better-State' leads to the principle of subsidiarity, wherein responsibilities are taken up and decisions are made at the lowest feasible economic and operational levels. Above and beyond the mere decentralisation of the administration, the principle of subsidiarity, beginning with an effective decentralisation of powers, relies on civil society to accomplish tasks of common concern. There are advantages in this, but it is not without risks (Millon-Delsol 1993, Mors 1993).

People's participation may take on a variety of forms, some of them differing considerably from one another in what actually is meant – at one extreme, 'manipulative participation' and, at the other, 'self-mobilisation', i.e., effective participation, and one yet to be translated into fact. It is a question, then, of "empowering people to mobilise their own capacities, be social actors rather than passive subjects, manage their resources, make decisions, and control the activities that affect their lives" (Cernea 1986). Humans are an integral part of their ecosystems, and without them, any project is doomed to failure. Restoring local people to their central role means that they must be involved from the start in determining the objectives of management and in the decision-making process. Mediation is geared to securing exactly

this. It is somewhat far removed from the participatory approach because it is based on contracts, and goes beyond short- and medium-term consensual solutions. Within the group, the contract, once legitimated and ritualised, becomes its 'patrimony'. Thus, the actors appropriate the outcome of their negotiation.

In situations where powerful externalities are operating, economist would recommend a range of technical means in order to 'internalise the externalities'. This would include ownership rights, or instruments such as taxation, licensing, the polluter-pays principle or, again, normal contracts (Barde 1992). Such incentives are looked on as a transaction cost as a means of getting people to 'share' in the objectives pursued by the managing body. Environment questions are about the very long term, However, the longer-term the horizons of the problems needing to be dealt with, the less the economic (and, *a fortiori*, monetary) assessment has something pertinent to contribute. On the long term, what is more important than economics is the creation of institutions.

The choice of the right instruments for the internalisation process should be governed by the objectives assigned to the regulatory function (Faucheux and Noel 1995; Meuriot 1989). The primary problem therefore is to decide on the objectives. At the local level, the starting point for determining objectives cannot lie in the machinery for resolving conflicts. On the other hand it often is possible to have the actors themselves discuss their long-term future. Thus, within the time considered, there must be provision for resolving conflicts or for dealing with the problems at hand. The long term envisaged here is of the order of 25-30 years – a time span which, by definition, will force the actors to discuss the issues not in terms of their own benefits, but for their children's. This quest for agreement about the long term – in an attempt to get short- and medium-term undertakings into perspective – is what endows this approach with its community heritage dimension.

Where social actors with conflicting interests are negotiating in an attempt to solve a conflict, each one hopes to persuade the others as to the appropriateness of their past action. Thus, the emergence of a compromise is extremely difficult if it is to be reached via a direct assessment of that conflict and its underlying causes. Further, when a compromise is reached, it will be seen to be highly unstable. 'Free rider' behaviour will quickly be adopted by many of the actors. If the attempt to settle the conflict proves a failure, the actors will take an even stronger stand on what they see as their legitimate past behaviour. The conflict becomes even more acute as a result.

'Patrimonial mediation' starts from this, and seeks to turn the order of negotiation the other way round. The starting point, then, is getting the parties to agree on the very long term and work back from the future to the present. This relies on the assumption that the long term cannot be 'foreseen', but can to some extent be decided upon or agreed on, and that having some control over the long term calls for forward thinking.

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### ACP – EU Fisheries Research Report Number 5

#### Can traditional, community-based systems of fisheries management be used in a modern context?

*Kenneth Ruddle (Kwansei Gakuin University, Japan)*

The problems of fisheries management identified in the various contributions of this report may be classified under four groups:

1. difficulties in maintaining resource flows;
2. accounting for (economic) externalities;
3. dealing with technological impacts (gear externalities); and
4. accommodating allocation issues.

Traditional fisheries management arrangements, especially those in countries of the Pacific evolved over centuries in response to these problems, and the question posed here is whether these arrangements may provide answers for managers elsewhere. A subsidiary question is whether these systems will be able to cope with 'development' and modernity in the very areas where they evolved. The sources used here, though not cited in context, are mainly the author's own publications, notably Ruddle (1984, 1987, 1996a, 1996b, 1996c, 1996d, 1997, 1998a, 1998b, 1998c) and the contributions in Ruddle and Johannes (1990).

At the basis of traditional systems lies an emphasis on gear externalities and allocations issues. Use is defined by geographical areas and community control of a common property. The systems are based on local knowledge, and are enforced by local, moral and political authority.

The design principles of traditional systems involve authority (i.e., leadership), rights and rules, monitoring, accountability and enforcement, using different types of sanctions.

The authority is either secular, or religious, may be based on a specialisation such as fishing, or on rights, recognised by the community.

The rights themselves may be primary (e.g., hereditary), or secondary (e.g. acquired by marriage). They also may be nested, and involve both

temporary arrangements, such as loans and sharing arrangements.

The corresponding rules pertain to the definition of territories, and define the eligibility of members of a community, or of neighbours. They also sanction fisher behaviour, as pertaining to the use of gear, temporal access to certain resources species and fishing grounds, and the distribution/sharing of the catch. These rules also sometimes define areas set aside for conservation, either temporality or permanently.

Monitoring and enforcement are performed by the community, and sanctions for not adhering to rules range from the social and economic sphere, all the way down to the physical, and up to the supernatural.

Underlying all of this is a body of local knowledge, which while practical, is highly structured and dynamic. Its main components are:

1. the physical features of the marine environment;
2. fish behaviour, and their habitat; and
3. ecosystem concepts, e.g., pertaining to predation.

So, traditional, locally-based management can rely on a 'menu' of practical, time tested rules concerning the conservation of the resource base, 'stock assessment' and fish biology, environmental impacts assessment, local hydrography, seabed mapping and the fishing impacts of various fishing methods and technologies. These cover the same grounds as science does – when and where scientists and the support they require are available.

This is a strong claim. Yet it is obvious that on small Pacific Islands, for example, local groups unable to develop and maintain a sustainable system for managing their reef fisheries, rooted in sound local knowledge, would have starved centuries ago. Moreover, people within these same local groups had to get along, and hence the emphasis on rules for conflict resolution and avoidance, and various forms of taxation and tributes.

Rapid urban population growth in Pacific Island states has led, along other things, to destruction of mangrove and beach areas, pollution of lagoons and reefs, loss of marine species, and often of their supporting ecosystems as well. The primary mechanisms for this have been ill-managed coastal 'development' activities, leading to improper disposal of sewage and domestic solid waste, mismanagement of non-domestic waste, and increased sedimentation owing to residential construction. Also important are hillside farming, mining, and other changes in land use (see also Rebelo, this vol. for the similar case of a Portuguese lagoon).

The impacts of these practices exacerbate the effects, on the resources, of new, inherently unsustainable fishing practices. These include fishing with poisons and explosives; the deliberate destruction of corals to drive fish into nets (muro-ami fishing); and the removal of excessive numbers of live fish for export as luxury food or aquarium uses, and of shells for collectors and cottage industries.

This establishes that traditional, locally-based management systems cannot be expected to halt, by themselves, trends resulting from outside

development. On the other hand, no useful alternative models are likely to emanate from affluent Japan, legalistic U.S.A., volunteerist U.K or from free-enterprise developing countries. Thus, the traditional community-based approach of Pacific countries will have to be re-invented, within the specific cultural, social and economic constraints of these countries. Foremost among these is to the requirement to involve all stakeholders, as also pointed out in contributions dealing with other small island developing states (see e.g., Murray, this vol.).

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### ACP – EU Fisheries Research Report Number 5

#### Fisheries governance in the Caribbean

*Patrick McConney (Fisheries Division, Ministry of Agriculture and Rural Development, Barbados)*

The concept of governance or the more popular term 'good governance' has its origins in the field of political sciences, and is currently being promoted as a means of achieving the goal of sustainable utilisation of natural renewable resources such as fisheries resources. Good governance usually implies liberalisation, privatisation, deregulation, decentralisation, community participation and democratisation (government reform and community development). This contribution, adapted from Chakalall et al. (1997, 1998), and McConney (1997) briefly evaluates the usefulness of the concept of governance in the Caribbean context.

Clearly, the success of governance depends on the support of research to provide the necessary data and information in order to properly identify and prioritise management issues, and on effective communication between all stakeholders. This may often be achieved best through participatory pilot projects, i.e., through decentralisation. The main challenge facing Caribbean governments in this process is to ensure that decentralisation and civil service reform does not dilute accountability and weaken government functions in areas that need to remain centralised (see also Babin, this vol.). Such areas involve monitoring the fisheries resources and the environment, and the formulation of fisheries policies (see also Gillett, this vol.).

With the assistance of FAO, the majority of Caribbean states have revised their fisheries legislation in line with the 1982 UN Convention on the Law of the Sea and other international legal instruments (Mahon 1987). In doing this, several Caribbean states have harmonised their legislation, and declared their EEZs (**Figure 16**, a map of the Caribbean, with emphasis on the potential Exclusive Economic Zones of the various countries).

The harmonised legislation provides for the appointment of a Fisheries Advisory Committee to advise on the management and development of fisheries and, as well, for arrangements or agreements with other countries or organisations in the region. The legislation requires the

fisheries officer to prepare and keep under review a plan for the management and development of fisheries (McConney and Mahon 1998).

Although the present situation may create problems for implementing fisheries policy, the relative smallness of the Ministries in Caribbean countries can itself be an advantage in that it may allow for direct access by the Fisheries Officer to the Minister or other senior government officers such as the Permanent Secretary. However, no matter where the fisheries sector is located within government's administrative system, it is very important that the sector be given its appropriate share of development resources.

Governance often involves vesting some or all responsibility for management in the stakeholders through partnership arrangements, in particular, co-operative management (co-management) and community-based management (Nauen 1995). This requires that they be adequately organised to undertake the task (McConney et al. in press). Stakeholder NGOs may either comprise parties directly involved in the fishing industry or other stakeholders. Where the required level of organisation is absent, or for other reasons, responsibility may be vested in NGOs which would not otherwise normally have a stake in management.

In the Caribbean there are apparently no private sector institutions involved in fisheries management and development. However, private sector interests have functional linkages with fisheries. This may be because they compete for fishery resources, e.g., sport fisheries, or because they are more interested in use other than production, e.g., tourism industry. Moreover, given that governance also implies devolution of responsibilities one should expect more private sector involvement in the management of coastal and marine resources, including fisheries, in the future. In a few Caribbean countries, private sector entrepreneurs from the tourist sector have requested from governments lease of marine space to be managed as marine parks for tourism exclusively. The concept of private sector involvement is also contained in the harmonised legislation of the countries belonging to the Organisation of Eastern Caribbean States (OECS), which have made provision for the leasing of marine space (mainly for mariculture). However, no attempts have been made so far to implement this aspect of the legislation.

Monitoring, control and surveillance (MCS) and compliance with rules and regulations concerns governance at all levels, but can conveniently be examined in two parts: local and foreign fishing. Fishery officers, coast guards, and other officers of the peace usually effect the regulation of local fishing activities, often ashore. One of the common reasons for the failure of fishery controls to prevent overfishing is that it is not feasible to implement the monitoring requirements with the available human and material resources. Many countries lack the capability for extensive enforcement of fishery regulations. Widely scattered, small-scale rural fisheries are particularly difficult to monitor, and regulations are usually ignored. This has led to the recent upsurge of interest in co-management and community-based management discussed above, in which compliance is achieved through greater internalisation of the rules and regulations.

The success of governance in the fisheries sector rests particularly on the

legitimacy of the regulations as perceived by the stakeholders involved in the management of the fishery (Sen 1998, Sen and Nielsen 1998). One of the main purposes of fisheries research is to seek out information for management that can convey legitimacy to decision-making. In pursuit of good governance, Caribbean fisheries administrations have begun to tap into local knowledge and involve the fishing industry in research. They have also accepted the need to monitor and inform stakeholders about relevant research done in the region or elsewhere, and the effects management decisions have on fishing industries and fisheries resources (McConney and Mahon 1998). Widely disseminating research results and obtaining feedback is part of this process of information exchange, the first step in participatory forms of management. There are, however, serious constraints that Caribbean states share with other developing countries, and small island developing states (SIDS) in particular (see Murray, this vol. and Ruddle, this vol.).

In the Caribbean, most of the fisheries resources are thought to be either fully exploited or overexploited. So, a critical question is how much fisheries research should focus on the stock assessment, biology and ecology of the resource species, and how much on the socio-economic conditions of the fisher communities, co-operatives, and other factors that can be expected to influence unsustainable exploitation patterns. Currently, fishers play only a minor role in management or setting research priorities and in evaluating or using research results (see also Des Clers, this vol.). If greater emphasis is going to be placed on involving the stakeholders in the management of fisheries, then priority should be given to the organisational and socio-economic aspects of the primary stakeholders, the fishers. It is therefore recommended that research priorities be set on the basis of the information fisheries administrations and fishers require and must share in the exercise of good governance.

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### ACP – EU Fisheries Research Report Number 5

#### 'Good governance' for the Fisheries of OECS Member States

*Peter A. Murray (OECS Natural Resources Management Unit, St. Lucia)*

Given the apparent state of exploitation and the current economic importance of the marine fishery resources of the eastern Caribbean, it is timely to consider the development of a new approach to managing these resources. The basis of this management has to be good governance (see McConney, this vol.). Among the Members of the Organisation of Eastern Caribbean States (OECS), the concept of Island Systems Management (ISM: Nichols and Chase, 1995) is seen as the new paradigm for the management of the natural resources of Small Island Developing States (SIDS). This approach is structured around a participatory, multi-sectoral strategy within an appropriate institutional and legal framework for integrated resource management. Within this framework, management efforts are geared towards mitigating not only the deficiencies with regard to one specific management issue, but also combining the 'treatment' to combat all the symptoms of the 'disease' (Murray and Nichols, in press).

The fisheries industry has been described as being over-capitalised, and, while this is open for discussion with regard to the Eastern Caribbean, my personal opinion is that the fishing industry in the Caribbean has been 'badly capitalised' rather than 'over-capitalised'. There is, however, little doubt that the nearshore fisheries are over-exploited. Additionally, the fishery science practised in the region in general, and the OECS in particular, has, until recently, paid inadequate attention to the management and development of the industry within a holistic framework. The view is evolving in the Caribbean that while great emphasis has been placed on stock assessment, there has possibly been insufficient attention given to the industry itself (Chakalall et al. 1998; Mahon 1997). The need for a fisheries (the industry as a whole) assessment, as opposed to stock assessment, is predicated on the necessity to have a comprehensive view of the industry (Mahon 1997). Such a view in turn will better inform a development policy and management plan for the fisheries industry. The management and development of fisheries, especially of small island states, must be objective-driven rather than driven by simply the assessment of the fish stocks. The apparent overemphasis on stock assessment has unfortunately diverted attention away from fishery assessment, and the consequent implementation of a development, policy and strategic plan for the entire industry. The ISM approach should facilitate such a

comprehensive view of the industry, and directing attention towards the developmental objectives of the country and the role that the fisheries may play in attaining those objectives.

The ISM approach involves increasing the participation of fishery managers in the development control process, thereby ensuring that due consideration is given to the impacts of development projects on fisheries resources. Additionally, due regard must be given to the direct and indirect impacts that agricultural and construction practices can have on the near-shore marine habitats. Legal instruments also become important in this instance since there is a need to regulate the activities creating externalities. The mandatory requirement of Environment Impact Assessment (EIAs) and the inclusion of the fisheries department on the relevant development control authorities would be a step in the right direction.

The use of the legislative process, and the concomitant enforcement of regulations, is central as control mechanisms, to ensure compliance with the regulations governing practices, which cause physical damage to marine habitats. Rigorous enforcement of regulations needs to be coupled with the use of the consultative process primarily as a means of increasing the awareness of all stakeholders to the long-term impacts of destructive fishing methods (Murray and Nichols, in press). The participatory approach can lead to a change in attitudes reducing the need for enforcing regulations. Educating stakeholders, particularly fishers, and engaging them in discussion may make it possible to convince them to make the types of changes, to fishing gear or methods, that would lead to a reduction in the deleterious impacts of fishing. Consultation with and discussion among fishers would increase the chances of voluntary changes in fishing practice.

Within an ISM framework, and in the context of a participatory approach to resource management at the national level, the setting up of co-management arrangements is a means of encouraging good governance of specific fisheries. In the English-speaking Eastern Caribbean, there is acceptance among fisheries managers of 'co-management' as the sharing of power and responsibility in the exercise of resource management between a government and a community or organisation of stakeholders. With such a system in place, benefits will accrue to nearshore species, particularly the more sedentary and sessile organisms that, by virtue of their limited, or lack of, mobility, are much more susceptible to the ravages of destructive fishing gear, pollution, and other stresses. Involvement of stakeholders may also help facilitate the process of conflict resolution. The co-management of the sea urchin fishery, and the setting up of the Soufrière Marine Management Area, in St. Lucia are examples of such a use of co-management arrangements which augur well for the future of fisheries governance. However, it must be admitted that co-management and true stakeholder participation may be constrained by the existing structure of the public sector in the region. The view has been expressed that for co-management to really take root, public sector reform must take place parallel to, and in support of, the ISM framework with the devolution or sharing of power being accepted as a necessity for good governance, rather than a loss of 'turf'.

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### ACP – EU Fisheries Research Report Number 5

#### The Belize government and marine park designation

*Vincent Gillett (Belize Department of Fisheries, Belize)*

Belize, formerly British Honduras, is the second smallest country on the American continent covering an area of approximately 23 000 km<sup>2</sup>. Mexico borders Belize in the north, Guatemala to its west and south, while the Caribbean Sea lies to the east.

The Belize coast harbours a complex of ecosystems that includes mangrove forest, river deltas, estuaries, sea grass beds and coastal lagoons which support many important species including crocodiles, manatees, turtles and seabirds; at least 594 genera and 1040 species occur in coastal regions while at least 634 genera and 1304 species occur in marine areas. Nineteen rivers from the interior empty into the coastal system. Until recently, these rivers were most important avenues of communication in the country.

The coastal zone extends further eastward to include the continental shelf, which is delineated by the outer slope of the Belize Barrier Reef, and three offshore atolls. The reef complex is about 20-25 km offshore and about 250 km in length, extending from the southern tip of Yucatan Peninsula (Mexico) in the north, to the Gulf of Honduras in the south.

As in many other countries, high population growth has led to increased pressure on many coastal ecosystem resources, this being added to the 'normal' growth of the fisheries (Wells et al. 1992). Thus, overfishing of conch and lobster is already evident, though prices increases have tended to mask the effects of declining catches in weight (see also Sumaila, this vol.).

Moreover, the number of tourist arrivals increased from 142,000 in 1988 to 329,000 in 1994. Seventy-two percent of all tourists spend time snorkelling, and over 50% will participate in a SCUBA dive. Tourists compete for reef and fish resources.

The Belize Department of Fisheries and the other Government departments, tasked with managing the fisheries and other users of the marine resources, lack the human and material resources to do the job, notwithstanding an extensive arrays of legislative acts, and formal institutions. Thus, in Belize, there are 94 Acts pertaining to marine

resource conservation, administered by 18 Permitting Agencies and 10 Ministries. Belize is a member of 24 international conventions and treaties concerning marine life and coastal protection. What this amounts to, however, is that the Government cannot manage the fisheries and their resources, nor guarantee the health of the ecosystems upon which the fisheries and the resource depend.

This has led to a de facto acceptance, by the Government of Belize, of governance arrangements wherein power is shared between stakeholders. Thus, the Advisory Committee of the Bacalar Chico Reserve is composed of representatives of the following institutions:

- Fisheries Department
- Forestry Department
- Coastal Zone Management Project
- San Pedro Town Board
- North Ambergris Caye land-owners Association
- Caribena Fishermen Co-operative
- Sartaneja Village Council
- Hol Chan Marine Reserve
- Coral Caye Conservation
- International Tropical Conservation Foundation
- San Pedro Tour Guide Association
- University College of Belize

Such wide representation also occurs in the Boards or Advisory Committees of various marine protected areas, and Table 6 gives a non-exhaustive lists of groups involved therein.

It is ironical that some of the theoretical advances, (e.g., in Kooiman et al. 1999) concerning the manner in which natural resource management systems ought to operate should be tested first in developed countries such as Belize. Upon reflection, however, we can see that this only duplicates the experience with marine protected areas, where developing countries have a lead, (see Roberts, this vol.). If anything, this point illustrates the usefulness of information exchange and cooperation between researchers and managers from ACP and EU countries, another theme of this report.

**Table 6.** Some NGOs active in protected area management in Belize

Organization	Inputs	Area Protected	Support
Belize Audubon Society support	Education, funding, management	Half Moon Caye Natural Monument; Laughing Bird Caye reserve	Broad community
Belize Center for Environment Studies	Technical Education	Port Honduras; Ambergris Caye	Limited community support
Belize Enterprise	Training,	Manatee Special	Rural

for Sustainable Technology	education, management	Development Area	community support
Belize Tourism and Industry Association	Educational, & promotional	Country-wide	Special interest
University College of Belize	Technical, education, training	Turneffe Island, Belize City	Special interest
Coral Caye Conservation	Technical, research, funding	Bacalar Chico, Caye Caulker, South Water Caye	Special interest
International Tropical Conservation Foundation	Consultancies, funding	Bacalar Chico	Special interest
Wildlife Conservation Society	Consultancies, funding	Hol Chan, Pedro Glovers Reef	Special interest

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### ACP – EU Fisheries Research Report Number 5

#### Involving the other players

*Guy Fontenelle (Ecole Nationale Supérieure Agronomique de Rennes, France)*

The contributions previous to this, dealing with the social aspects of fisheries management, and ultimately all contributions in this report, assume the need to involve other stakeholders - or players - in the fisheries management game.

This is an appropriate assumption, since until they are caught, the resources exploited by fisheries are supposed to belong to the public. Ownership of marine resources must not be confused with access to them, which can be regulated by a State (public resource), by a private body (privatised resource), by a community (common property regime) or by no one (free access resource). The free access concept was for a long time assimilated to common resource and this was a fallacy (Bromley and Cernea 1989; Berkes 1989; McCay and Acheson 1990; Bromley 1992, among others). [The only exceptions to this are resources that have been privatised through Individual Transferable Quotas (ITQs). Interestingly the Icelandic Supreme Court has recently decided that the heavily ITQ -ed Icelandic fisheries management system is unconstitutional, because it denies resource access to most traditional fishers].

Thus, defining players requires determining who has (or traditionally had) access to the resources, who has a stake or interest in these resources or their supporting ecosystems, and/or who cares about their status. The sum of these players defines a 'virtual community', which may involve persons living in areas very remote from where the resource actually occurs (NRC 1999).

Here, the key point is that the fishers, until recently perceived as the only, or at least the privileged partner of management authorities (as is implicit in various 'co-management' schemes), become one of several partners, some of which may have interests very different from those of fishers. This extension of the number and types of players is particularly important in view of the growing realisation that the Earth and its oceans are not for this generation to trash, but a legacy to hand over to the next generations. However, achieving some sort of intergenerational equity is

difficult in view of globalise markets and a demand for goods – particularly fish products – that far exceeds supply (particularly in developing countries, though this may be masked by depressed incomes).

It is clear that solutions beyond arm-waving, and beyond calling for the operators of industrial fishing fleets to 'think of the future' are called for. Schmidt (this vol.) documented a procedure that involves fishers and the public at large in identifying sustainable fisheries, and in selectively purchasing products from such fisheries, respectively. Here, positive incentives are created within the private sector for fisheries to minimise the ecosystem impact of their operation.

Another approach is to follow up on the various implications of the concept of 'New Governance' as developed in Kooiman (1993). Particularly interesting is the suggestion that beleaguered governments may deliberately pit one group against the other. This approach is implicit in several contributions in this volume, (see e.g., Gillett, this vol., or Reck, this vol.). Here, the idea is to involve other players (e.g. conservation-orientated groups in Fisheries Management Councils, or in drafting legislation), not because they have some interest in the fisheries and/or the ecosystems in question, but because their interests are opposed to at least the short-term interests of the fishers. That this approach is realistic is proven by the fact that it increasingly occurs in practice, although few would admit so, given its decidedly Machiavellian nature (Dunsire 1993). Such proposals are being developed within the E.U. by incorporating representatives of environmental organizations into the Consultative Committee for Fisheries Common Policy. By looking at hundred examples throughout the world, other players can participate to manage fisheries resources and their related ecosystem with fishers to sustain long-term resources for both capture and/or non-extractive uses.

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