RECOVERING FISHERIES FROM CRISIS OR COLLAPSE
HOW TO SHORTEN IMPACT TIME OF INTERNATIONAL RESEARCH COOPERATION

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ABSTRACT

ICES – the International Council for the Exploration of the Sea – was founded more than a century ago out of concern for overfishing. However, today's global marine ecosystems are for the most part in a degraded state, many alarmingly so. Why is the science used so little to make decisions compatible with long-term sustainability of fisheries?

The paper argues that there is a large gap between the understanding of scientists and that of political and economic decision makers. Scientists investigate the fundamentals of nature and socio-economic systems. These approaches do not coincide with the perceptions, belief systems and experiences of most social actors, except in the long run. Communicating scientific results better and more pervasively to citizens is an avenue that holds great potential to shorten impact times – provided there is willingness to hear the message.

Since the media brought the overfishing message to the general public in the early 1990s, the international discourse has gradually shifted. From 'maximum sustainable yield' (MSY) of single species, the discourse started to put restoration of entire marine ecosystems by 2015 formally on the agenda through the Johannesburg Plan of Implementation adopted at the 2002 World Summit on Sustainable Development. But results are few and far between as fleet overcapacity driving the process shows little sign of alleviation.

It is desirable that international scientific cooperation engages more constructively with citizens, civil society movements, companies and government authorities to speed up adaptive learning. While not replacing political processes, research and research communication that are aware of the different mindsets, cultures and historically grown preferences in societies can help more effectively to bring about the conditions for recovery of lost ecosystem functions and productivity. Trust is a key condition for acceptance of the message. A few examples of the EC's international S&T cooperation projects are given to explore opportunities and challenges to recover fisheries in crisis.

Keywords: fisheries recovery, connecting science to citizens, shorten impact time of science, global public knowledge goods, international scientific cooperation

INTRODUCTION

ICES – the International Council for the Exploration of the Sea – was founded more than a century ago out of concern for overfishing. However, today's global marine ecosystems are for the most part in a more seriously degraded state than before, many alarmingly so. The relentless decrease of targeted fish stocks continues in most of the North Atlantic studied by ICES (www.ices.dk) [1]. This takes place despite semestrial advice on key stocks, more long-term advice produced annually by the ICES *ad hoc* Group on Long Term Advice (AGLTA) and the ICES Study Group on Management Strategies (SGMAS). Moreover, latest overviews of global trends contained in the State of Fisheries and Aquaculture 2004 produced by the FAO for its Committee on Fisheries [2], summarises that the proportion of stocks in depleted, overfished and fully fished state continues to be high (around 75%). It also shows the steady increase of deep-sea and oceanic fishing after many demersal fisheries on the most productive shelves have declined considerably. As this downward trend is systematic, it is unlikely to be an artefact of better statistics and is consistent with the science suggesting that long-lived species with few offspring per female reaching maturity can not sustain heavy fishing pressure.

Emblematic fishes of past healthy states of the oceans, such as cod and cod-like fishes are at their lowest level since 1967 levels recorded by FAO [2]. Within each fishery investigated over a longer time span, mean trophic level, especially of predators, declines, indicating that the fishery is altering ecosystem composition and functioning.

This pervasive trend of 'fishing down marine food webs' has been demonstrated initially by Pauly *et al.* [3]. It has been confirmed as much more serious than originally thought in that it has also been found in freshwaters and more pronounced in heavily fished parts of the sea, where trends are even more pervasive than global averages suggested [4]. Every region of the ocean that was examined in this respect showed the downward trend. The trend was sometimes weak, when accessible documentation was incomplete, but tended to be more visible, the better and more abundant the data. Historical overfishing and recent collapses of coastal ecosystems is driven by human demography, economic growth and global change and affects now all parts of the globe [5,6]. One of the regions, where data recovery of numerous dispersed surveys carried out over more than 50 years confirmed steep declines of biomasses and trophic levels of catches is West Africa. All three large marine ecosystems in NW and SW Africa as well as in the Gulf of Guinea are affected [7]. Hutchings [8] and Myers and Worms [9] have shown with the best available time series the extent to which valuable top predators have been reduced by the fishery and that signs of recovery are absent when biomasses get reduced to very low levels over extended times. Conover and Munch [10] also draw attention to the evolutionary pressure towards lower yields entailed by size selective fishing eliminating big specimens.

Independent research shows, moreover, that misreporting by countries with large fisheries, combined with the large and widely fluctuating catch of small pelagics such as the Peruvian anchoveta can cause spurious trends in global catch statistics kept and published by FAO. The authors suggest that such conveyance of a perception of upwards or stable trends, when the opposite is the case, influences unwise investment decisions of firms and banks running counter to effective management of international fisheries [11].

That begs the question: Why is the science used so little to make decisions compatible with long-term sustainability of fisheries and what can be done about it? To address this challenge, the paper is structured into the following sections: (1) The different perceptions of the social solidarities; (2) Shifting baselines affect the science; (3) From knowledge to action; (4) Conclusion and implications for future international research cooperation.

THE DIFFERENT PERCEPTIONS OF THE 'SOCIAL SOLIDARITIES'

Scientists investigate the fundamentals of nature and socio-economic systems. Much of the research about the resource system, particularly recent studies putting resources into their ecosystem context contribute 'mosaic stones' that accumulate towards the bigger picture of unsustainable use patterns. These have historically dominated the fisheries literature. Investigations of the socio-economic systems into which fisheries are embedded are less frequent and have for some time focused on bio-economic modeling. But economic concepts have also importantly shaped analytical approaches to understand fisheries [12,13].

These approaches generate an abundant scientific literature and advice to politicians and the industry, which however seems not, for the most part, to coincide with the perceptions, belief systems and experiences of most social actors, except in the long run. The bi-annual meetings of the FAO Fisheries Committee illustrate the point. Following the enforced break to fishing during World War II, many resources had recovered considerably and their abundance combined with demographic and economic developments sparked an expansion of fisheries research and fishing operations. During the 60s and well into the 80s the prevailing mindset was to mobilise research in search of production increase. The global resource assessments by Moiseev – though the then Soviet Union was not a member of FAO - and FAO were witness of this mindset [14,15]. The end of colonialism made many former colonies embrace the industrial expansion, though this economic model did not prove viable in their socio-economic and political setting as country after country along the West African coast and in other parts of the world experienced. Conversely, local and often increasingly mobile artisanal fisheries blossomed while industrial fishing was dominated by long-distance operations by industrialised countries and emerging economies from Europe, the former Soviet Union and Asia [16,17].

Since the mid 70s, few entirely 'new' resources were opened up to fisheries – the general picture changed towards full or over-exploitation according to FAO [18], except perhaps access to formerly inaccessible resources such as around deep sea mounts and in areas earlier protected by ice cover thanks largely to dual technologies, which have both civilian and military applications.

The 80s brought about rising attention by conservationists to an increasingly visible fisheries resources crisis. However, if number and tonnage of vessels are taken as an indication of the perceptions of operators and bankers about earning opportunities, these numbers were still influenced by the logic of the preceding period. FAO suggests that the number of all types of fishing vessels in the world more than doubled from almost 600,000 in 1970 to about 1,250,000 in the 25 years until 1995. Fishing vessels bigger than 10,000 tons (stable around 14,000 tons) had hovered between 20 and 40, while in 1995 an apparently new generation of such vessels boosted numbers to 141 and tonnage to more than 2 million tons, 7% of the world's total. Fishing vessels of just under 100 tons accounted to about 97% in numbers and 38% in tonnage throughout the period. The tonnage of smaller vessels up to 50 tons rose from 31% of the total in 1970 to 38% in 1995.

Table I sums up the broad upwards trend in fishing capacity and the relative change of capacity composition of trawlers, which grew less steeply in numbers compared to total numbers of fishing vessels during the period under consideration, but increased their relative average size from 62 to 76 tons. In terms of tonnage, they represented about half in 1970, but only 38% in 1995.

Table I Development between 1970 and 1995 of the global fishing fleet by total number and tonnage and the trawler segment according to data provided by the Fisheries Global Information System (FIGIS) of FAO

Year	Total number of vessels and % increase [1970 = 100]	Total tonnage and % increase [1970 = 100]	Total number of trawlers	Total tonnage of trawlers
1970	595,099 [100%]	13,363,168 [100%]	109,417	6,806,579
1980	824,128 [138%]	18,698,129 [140%]	128,267	9,623,311
1985	984,547 [165%]	21,202,947 [159%]	112,678	9,923,454
1990	1,207,147 [203%]	24,791,179 [186%]	129,416	11,087,585
1995	1,258,162 [211%]	27,987,941 [209%]	139,183	10,586,302

According to the last FAO 2004 State of world fisheries and aquaculture [2], the number of decked vessels remained approximately stable around 1.3 million since the late 90s, 84.8% based in Asia, 8.9% in Europe, 4.5% in North and Central America and the remaining 1.8% in Africa, South America and Oceania. Undecked vessels were in the order of 2.8 million worldwide, 68% of these were not powered and 83% in Asia. The aggregate gross tonnage of large fishing vessels (about 100 gross tons) reached its peak of 15.6 million gross tons in 1992 and has since declined to about 12.5 million gross tons though numbers of vessels were almost stable around 24,000.

Looking at the age structure of fishing fleets around the world, the percentage of large vessels more than 30 years old increased from 6% in 1992 to 28% in 2003. Among the biggest fleets (>200,000 gross tons), South Korea's fleet is the oldest (average age 29 years), Japan's the youngest (average age 16 years) [2]. Based on data from Lloyds database presented by Smith [19], shipbuilding was much lower through the 90s. Reflagging between countries, including to flags of convenience, became the major factor in the dynamics of the fleets of large vessels [2,19]. At the same time, provision and reliability of data has become a major problem [2], though various authors affirm a continuing serious overcapacity of global fisheries, much of which is driven by ill-placed subsidies [2,20,21].

Some 10 years after the peak of nominal fishing capacity, Tietze *et al*. [22] suggest on the basis of country level analyses on the economic and financial performance of marine fishing fleets in 13 South American, Caribbean, European, African and Asian countries in 2002 and 2003 that many of the 94 fleets studied had positive cash flows even when considering depreciation and interest. The analysed fleets in some countries, such as the Republic of Korea, Germany and Argentina, fared better than a few years earlier. This is attributed to a large degree to capacity reductions and was achieved despite increases in fuel prices of about 9% (before the bigger price increases of the last two years) and a decrease in fish landing prices of up to 5%.

But others did worse than in the past. And particularly small-scale fisheries tend to be selectively affected by direct competition from industrial operations, often targeting the same dwindling resources. A classical case has been reliably illustrated back in 1990 [23]. It shows on the basis of the detailed Indian fisheries statistics for the entire country and five of its states how total catches stagnated overall between 1969 and 1977, but were increasingly transferred to the 'mechanised' sector at the expense of small-scale fisherfolk. While the artisanal fisheries have since engaged in their own mechanisation efforts, often helped by development projects, this has only increased the overall pressure on marine ecosystems.

Indeed, the combination of human demography, lack of alternative employment in agriculture, industry or services and sense of opportunity carried over from past years of abundance, has swelled the global ranks of fishermen. According to FAO [2], the number of fishers has increased by about 30% from an estimated 27.8 million in 1990 to 37.8 million in 2002, Asia accounting for the lion's share. In many places, this leads to what Pauly termed Malthusian overfishing [23]. It may be assumed that these are at best 'guestimates', given the patchy coverage particularly of small-scale operations in national accounting systems feeding FAO statistics. Developments are, moreover, unevenly spread across localities, countries and regions depending on the specific situation. In the wake of collapses of fisheries e.g. in Canada and Europe, many fishermen have lost their livelihoods. As a result, e.g. young Europeans with access to alternatives, enabled through education, vocational training, access to credit, employment opportunities in other sectors etc. have opted out to the point where particularly European long-range industrial vessels are massively relying on crew from outside Europe [24]. Conversely, Senegalese artisanal fishermen, faced with an increasingly acute crisis back home without the buffering mechanisms afforded by a functioning social support system [25], are taking their place together with other nationalities going through similar resource and economic hardship.

Women tend to be at the bottom part of the receiving end. Case studies from different countries and continents show a common pattern of women being denied legal and social recognition, payment and status in their roles e.g. as family business managers in the artisanal fishing and post-harvest sectors. As a result, they inadvertedly contribute to unsustainable fishing practices by keeping their menfolk in the profession despite deteriorating conditions. This is in stark contrast to their traditional roles in many societies, where they have been historically associated with cultural practices amounting to conservation, though more in practice than in terms of terminology [26].

These few points serve to illustrate that perceptions of social actors, shaped by their historically grown economic, social and institutional context, are not the same as those of scientists' insights into the fundamentals of ecosystems and fisheries economics. This was aptly shown by a recent research collaboration sponsored under the International Scientific Cooperation Programme (INCO: ICA4-CT-2001-10033, KNOWFISH) originally pitched on the assumption that there would be significant overlap between ecological knowledge of fishermen and scientists and that fishermen's eco-knowledge would serve as a foundation for more cost-effective conservation management relying less on external enforcement [27]. In reality, perceptions of social actors are different from the way science expresses its findings and are also different from one another, depending on the social solidarity the actor belongs to or what his or her social status is. An industrial boat owner is bound to give a different perspective from a small-scale fisher, if not on the resource situation, then on possible ways out of the crisis. Women will typically give a different account of what matters than men, because they pursue different, albeit often complementary, strategies in making a living out of fishing.

We recognise that such perceptions are more powerful in making decisions about the strategies of social actors than scientific accounts, at least in the short and medium run. Simple indicators for the status of a fishery, of its need to rebuild the productivity of its ecological base and particularly of how to repartition access and benefits, derived from access and use of the resource, either directly or indirectly pose a real challenge. It is therefore hard, if not impossible, to detect generally viable indicators in socio-economic terms, because indicators have different currency within the major social groups and do not 'indicate' the same thing to each [28]. Most importantly, allocation issues are intensely political and not simply technical issues solvable by producing more or better research, though it is argued that more integrated and socially engaged interdisciplinary research can make significant contributions to the social dialogue, negotiation and allocation processes.

Finally, from a political perspective, the Rio and Johannesburg summits (1992 and 2002 respectively) show the slow development of perceptions of nature and, more specifically, of the marine environment. It has remained primarily anthropocentric, not yet establishing a link between this utilitarian and a non-anthropocentric vision of nature [29]. However, by adding time-bound objectives for rebuilding degraded ecosystems, the Johannesburg Plan of Implementation took an important step forward in the political discourse. For an historical perspective of the representation of nature, ocean and marine ecosystems, see Failler [30].

SHIFTING BASELINES AFFECT THE SCIENCE

For much of its first hundred years of 'fisheries science', scientific approaches to fisheries have been firmly grounded in disciplinary reasoning. The early focus in the first half of the 20th century was on effects of fishing on the target species and early warnings of stock declines [31,32]. In the second half, economic concepts also became applied to the sector and gained more currency [12, 33], though many adopted a bio-economical perspective focused on single fisheries or micro-scales unsuitable to discern broader trends. Social analyses were mostly addressed in anthropological work in tropical developing countries or remnants of traditional fisheries in the high north, though they tended not to connect explicitly to biological and economic studies [34]. Upwards of 30,000 publications in marine science get registered every year in the Aquatic Science and Fisheries Abstracts (ASFA) since 1971, more than 1 million titles as of June 2006 [35]. A large number of these are dedicated to fisheries, resource questions and conservation, though the coverage has incessantly expanded into other areas from aquaculture, marine technology, pollution to policy and legislation. But, as the European Environment Agency documented in its report aptly entitled

'Late lessons from early warnings', which also contains a fisheries case study, impact times of disciplinary scientific research in societies typically take decades to materialise, sometimes more than 100 years [36].

Pauly argued [37] that shifting baselines were to blame. This important and pervasive phenomenon consists of one generation of fisheries scientists taking their own professional life as a reference and trying to conserve the status of stock(s) or resource systems as they have known them at the beginning of their career. Without going back over longer periods though, the creeping erosion of ecosystems that have started well before their time goes largely unnoticed. The extent and scale of degradation and transformation of ecosystems under human influence does not become apparent. Neither do indirect effects, such as decreased resilience of degraded ecosystems to environmental stressors, such as those arising from climate change, which itself is driven largely through human activities, and pollution from point and non-point sources, including persistent organochlorine pesticides (POPs). This can lead and often has led to 'rear-guard' battles with science inadvertedly presiding over progressive phases of gross-degradation and change, without the tools to even identify the issue, when working in that mode.

Once identified as a problem, every study going back to reconstruct biomasses of key resources over longer periods has produced evidence about the degree of change in every ocean, inland water and land resources [1,3,5,6,7,8,9,25]. Equally important, over the last 20 or so years, formerly separated fields of enquiry on exploited stocks of individual species and ecological research are being brought together by putting back fisheries resources into their ecosystem context. This continues to require major attention as many organisations entrusted with fisheries management and associated scientific advice are still firmly wedded to single species concepts, particularly because they provide seemingly simple outcomes with 'maximum sustainable yield' (MSY) as a communicable target. Conversely, ecosystem approaches that integrate species interactions reveal much greater complexity and the trade-offs that any exploitation strategy entails, making also the uncertainty associated with decision making much more obvious – and unpalatable [38].

The difficulties associated with such a major paradigm change are visible in the time-consuming and difficult journey from stock-based management towards recognition of the need for ecosystem-based management. It can be traced in the decade between the fisheries-specific conferences in the run-up to the 1992 Rio Earth Summit (e.g. Cancún, Mexico) and through several sessions of the FAO Committee on Fisheries (COFI), through the Reykjavik Conference in 2001 to the Johannesburg Plan of Implementation adopted at the 2002 World Summit on Sustainable Development. Despite 10 years of labouring over the evidence, there is still a gulf between the formal acknowledgement of the need and the ability to put it in practice. The difficult coexistence between single species and ecosystem approaches is even manifest in the Johannesburg Plan for Implementation. While making the paradigm shift from generic species conservation demands to concrete timebound rebuilding of ecosystems by 2015 it still refers to the technically incompatible MSY concept [39].

Recognition that mono-disciplinary work can tackle only a small part of the multi-dimensional problems encountered in real-life fisheries led to a growing number of attempts over the last approximately 20 years to bring different disciplinary lines of work 'under one roof'. The most comprehensive study at a local scale to date was the analysis of the San Miguel Bay fisheries in the Philippines [40]. Some international efforts to bring ecological, social and economic lines of research together to ask more policy-relevant questions and develop answers that were receivable by a larger public were, among others, undertaken at a series of conferences convened under the ACP-EU Fisheries Research Initiative on the high-visibility platform of the EXPO 98 in Lisbon [41,42].

A systematic, large-scale effort to document and analyse the effects of world fisheries on marine ecosystems and lay open the economic drivers and explore alternatives to enable rebuilding and more sustainable strategies has started and is still underway through the 'Sea Around Us' Project and its wide-ranging research collaborations and communications work [43].

Going beyond this, the Millennium Ecosystem Assessment (MEA) has been the most comprehensive effort yet to piece the wider picture together for terrestrial and aquatic ecosystems over larger scales and longer historical periods through integrated analysis of innumerable specific studies [44]. It also considers economic drivers and implications of the wholesale degradation. Most importantly, it does not stop at the diagnostic part, but pays specific attention to innovative scenario development and possible courses of action targeting tailor-made publications and publicity events at different types of audiences as well as civil society in general. It conveys an antidote to put a stp to shifting baseline syndrome. The results of the MEA open a very disquieting perspective on the sheer scale of human-induced erosion and transformation of aquatic and terrestrial ecosystems and, indeed, the overall natural environment on earth, including its climate change effects.

FROM KNOWLEDGE TO ACTION

From the trajectory of fisheries science and the object of its research sketched out above, we draw the following lessons from the perspective of making the science more directly relevant to policy and action and the related concern of shortening its impact time:

- Mono-disciplinary work in isolation is insufficient and needs to be replaced systematically by interdisciplinary analyses pulling together the major dimensions of real-life problems, social, environmental and economic. This is the main research pre-requisit for a return to sustainability.
- The other pre-requisit is the change from mechanistic to heuristic research approaches, where nature and fish stock, for instance, cease being assimilated to variables and parameters for the purpose of the modelling, for being considered as entities characterised by a natural propensity of change over the time with all side effects involved. Likewise fishermen's behaviour would shift in perspective from a simple profit maximizer to a human being characterised by economic activities and strategies, influenced also by family, social and political life.
- These changes in research will be most effective if concomitant with changes in the appreciation of management and enforcement tools by policy makers and other types of public. The illusion of <u>controlling</u> fisheries only by sophisticated management tools (such as individual transferable quotas (ITQ) and others) and high-tech monitoring and surveillance still exists despite past failures of such tools to countervail ecosystem degradation.
- None of these dimensions alone will ensure sustainability. Rather sustainability may be achievable through a combination of or compromise between social, environmental and economic considerations following Latour's advice "we have to change our manner of changing things" [45].
- The process of negotiating such a compromise is mediated through existing (and emerging) institutions, law and the political process, as resource allocation processes are by their nature political.
- That means solutions will not be the technically best e.g. from an environmental or economic perspective. Rather, solutions will be second or third best on any type of technical score, but be politically feasible and socially acceptable (see Fig. 1).
- Moreover, we have seen that the perspectives of major social groups in a society are more influential in this political process than a mono-disciplinary scientific point of view.
- However, such negotiation processes are amenable to suitably communicated information and to being themselves researched.
- Receptivity to research results depends on many factors and is not automatically ensured. In some situations, undesirable scientific information which might have unacceptable social, economic or political implications, may simply be ignored or even actively rejected.
- Conversely, scientific information may be avidly taken up if presented in a language and format that can be accessed, understood and appropriated easily by social actors for constructing arguments in the negotiation process.
- Whether this information gains wider currency among different, and often opposing, social groups, is influenced by the credibility of the messenger, the pertinence of the message and the way it is communicated [46].
- The time between appropriation of a message and action also depends on the relative ease or difficulty of making any change, on in other words, the distribution of cost and benefits and social acceptability.

If this is so, modern fisheries science in support of rebuilding healthy ecosystems and restoring fisheries to socially and economically sustainable activities needs to develop its own *modus operandi* towards interdisciplinarity, constructive engagement with all relevant social actors and should be paying particular attention to communication inside and outside the science community.

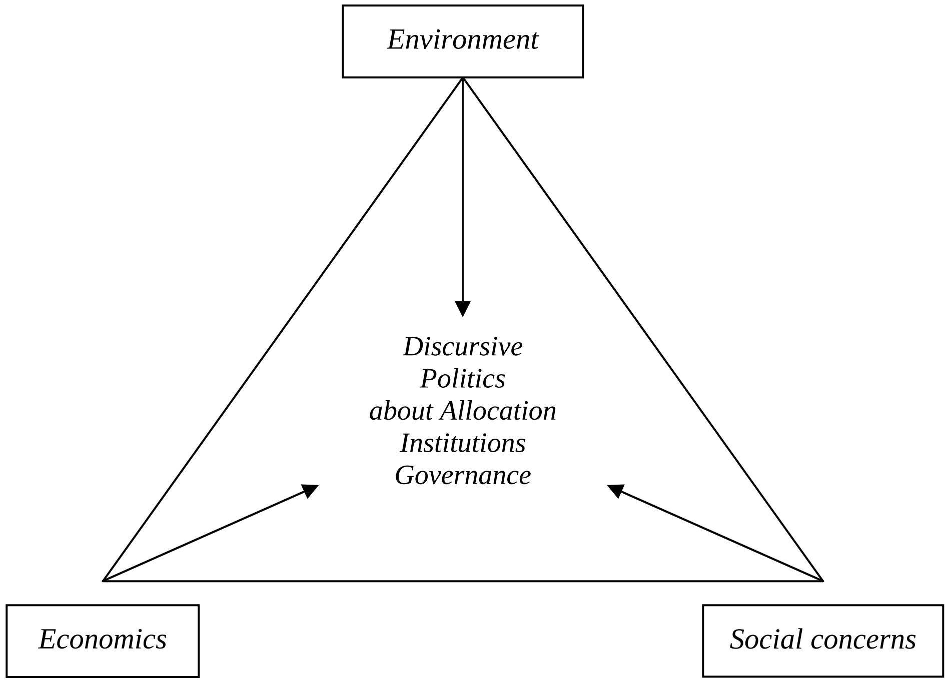

Fig. 1 Sustainability is a dynamic process involving negotiated compromise between social, environmental and economic dimensions mediated through institutions, governance and discursive politics about resource allocation among major groups in society (modified from Gyawali, Allan *et al*. [47]).

Are there examples showing that scientific research is (a) developing in that direction, is (b) being utilised for such purposes and (c) can we detect signs that some recovery of fisheries from crisis or collapse is happening? We discuss the three questions in turn.

(a) Fisheries research is becoming more interdisciplinary and accessible

System approaches to fisheries have certainly increased signficantly over the last decades. A now widely utilised research tool to analyse marine ecosystems, the Ecopath suite of analytical tools has achieved the amazingly rapid penetration of the scientific world through systematic investment in training combined with modest support to the >4000 registered users of the free software (www.ecopath.org).

Integration between environmental and economic aspects beyond simple bio-economic modelling remains a challenge, but has made much progress as scientists try to develop now a new generation of models that are holistic and not simply an extension of economic model toward ecology. For instance, ecologists use what are termed ecology-cum-economic models and rely on the use of system dynamics to formulate and solve their models. They are primarily interested in investigating how the ecological system behaves under a specified set of policy instruments. Economists, on the other hands, use economic-cum-ecology models, and are interested in deriving optimal policy responses to a specific system. They have been diligent in modeling robust dynamic economic systems, but have been as guilty as the ecologists in being less attentive to capturing the dynamics of the “other” system [48].

An integrated and multi-disciplinary system approach to the coastal ecosystems and fisheries resources of Pacific South America is subject of the ongoing INCO project CENSOR (www.censor.name). CENSOR explores the effects of overfishing in one of the most productive marine ecosystems, the Humboldt Current upwelling system, and puts particular emphasis on the coastal artisanal fishers and their activities in the area. The problem of highly fluctuating stocks due to natural climate oscillation (El Niño Southern Oscillation) requires a multi-disciplinary approach that combines marine and terrestrial scientific disciplines, especially in climate modeling approaches. Unraveling the combined effect of overexploitation of marine resources from the effect of climate oscillation is a particularly difficult task in an upwelling region. An equal challenge is to present such results in ways that enable fisherfolk and managers to integrate this information with their knowledge and devise more sustainable resource use strategies. The focus on likely climate change effects on people and their ecosystems, including the effectiveness and fate of MPAs, adds a particular difficulty through combining different geographical and time scales, which mean different things to different people and components in the system.

Another effort at integration or at least synergistic combinations of best available disciplinary science for reconciling multiple demands on coastal zones is made through the INCOFISH collaboration (www.incofish.org) which spans four continents. Among others, it connects ecological knowledge about coastal ecosystems to legal frameworks and economics to investigate to which extent internationally agreed reconstruction agendas (e.g. JPoI) get acted upon at regional, national and local levels.

Social and ethical dimensions have been most elusive, but are getting tackled in an on-going international research collaboration [ECOST]. More specifically, this project has an objective of equipping public decision-makers and society with the appropriate tools and methods needed to take into account the costs engendered by fishing activities and fishing policies which relate as much to ecosystems as to societies (www.ecostproject.org).

Accessibility in the public domain has been a red thread throughout these efforts. Much attention is being paid to create a level playing field by connecting a wide range of disciplinary knowledge about fish biodiversity, ecosystems and the institutional context of their use, including bridges to traditional knowledge. By way of example: The www.fishbase.org website offers multi-lingual access at different degrees of simplicity and thus serves currently several million people per month. Based on the success of FishBase (see also Table II), the need to expand public access to well-structured, scientifically validated knowledge has been recently taken on by CENSOR (www.censor.name), mainly dealing with invertebrate and near-shore fisheries resources and ecosystems along Pacific South America. Heterogeneity of data is a challenge to this database systems. Data networking is one result to reduce transaction costs to research teams by helping do avoid duplication of efforts in terms of both limited public funds and infrastructure available. Specific efforts are also made to bring the science to citizens through exhibitions, other outreach and links with education efforts.

(b) The results of fisheries research are being used to help develop the new political agenda of rebuilding and restoration

A recent analysis of FishBase internet use confirmed its potential to support to the Johannesburg restoration agenda [49]. The citations of FishBase recorded on the website itself were 1,125 on 18 April 2006. We found 519 publications citing FishBase since 2003, a very high citation record by any standard. The references relate mostly to technical research and show that it is a champion of biodiversity and environmental work, in line with the agenda set by the Johannesburg Plan of Implementation. The low number of citations focused on economic and institutional aspects (Table II) suggests that FishBase has not yet become a major instrument of policy makers, though there are recent indications that this may be changing as a result of uptake of simple indicators by consumer protection interests.

Table II Citations of FishBase one year and two to four years after the 2002 World Summit on Sustainable Development which has adopted the Johannesburg Plan of Implementation with timebound objectives to restore degraded marine ecosystems, to the extent possible, by 2015 and doing so, among others, by establishing networks of marine protected areas (MPAs) by 2012

Type of research/argument	Citing FishBase in 2003	Citing FishBase between 01/01/2003 and 18/04/2006
Individual species research, including taxonomic group revision etc.	39	43
Biodiversity research: species introductions, field guides, checklists, incl. distribution maps	22	202
MPAs, protection, ecosystems	21	27
Climate change, fisheries	23	18
Conceptual analyses	11	21
Normative, legal studies	3	2

It may also be argued that increasing levels of usefulness may be assessed by numbers of citations (Stergiou, *pers.comm.*)

- in the primary scientific literature showing importance within the scientific community,
- in reviews showing influence in forming leading ideas or concepts,
- in textbooks being passed on as a matter of course to the next generation, and finally
- in generic publications signalling a more generic appropriation of an idea or concept.

FishBase and the research it makes available to a wide public has certainly appeared in all four categories and is in heavy use. Recently, the simple indicator provided for almost all species to identify the size at which 90% of a yearclass has reached sexual maturity (and can therefore ensure reproduction and maintenance of the population) [50] has been taken up by the German consumer protection agency in Hamburg with what they call 'fisch-o-meter', enabling consumers to reject buying baby fish and promoting the marketing of fully grown fish [51].

In Northwest Africa, the extent of the resource degradation and threats to coastal people's livelihoods and government income has created a new receptiveness for the work of successive research and development projects. The results of many of these were epitomised by the 2002 conference on 50 years of change in ecosystems, fisheries and societies [25]. Mediated through active work of governmental and non-governmental organisations and amplified by unprecedented local media coverage, arguments about remedial actions and debate about fisheries policy in the coastal countries and their international trading and cooperation partners abound. Research results are used to construct these arguments, though being a social and political process, citations are only given in the rarest of cases. Many examples of such use arose in the electronic discussion forum 'acp-fisheries' that ran for some time on the DGroups Forum (Development through Dialogue), a joint initiative of Bellanet, DFID, Hivos, ICA, ICCO, IICD, OneWorld, UNAIDS and World Bank.

(c) Signs of recovery of fisheries and ecosystems are still scarce

The very well-researched book by Clover 'The end of the line' [52] digests decades of scientific and journalistic research in a compelling story about the extent of overfishing, how it changes what we eat, but also what can be done to revert the trend, including some encouraging examples about how industrial demand helps introduce environmental standards under pressure from civil society movements and well-understood longer-term self-interest.

Chile is among the relatively early examples for bringing science into management practice. In the last 30 years, considerable effort has been undertaken to establish a novel resource management by integrating studies of the ecosystem and the use of coastal marine resources [53]. Against the backdrop of neoliberal market opening, but also articulate trade unions in the coastal fishing sector, the country has been a pioneering element in the development of MPAs by involving private organisations in management and funding or in natural reserves monitored and co-managed by research projects. Although in practice many of the current management approaches of small-scale fishing communities along the coast might not be sufficient to prevent overfishing of valuable resources, such as for *Concholepas concholepas* [54], the incorporation of traditional small-scale fisheries should be key to improved coastal ecosystem management in developing countries [55]. Inclusiveness is also critical for countering their still prevailing social marginalisation, despite important contribution to production, value creation and income distribution [56,34].

CONCLUSION AND IMPLICATIONS FOR FUTURE INTERNATIONAL RESEARCH COOPERATION

Communicating scientific results better and more pervasively to citizens is an avenue that holds great potential to shorten impact times – provided there is willingness to hear the message. An example of international research cooperation which is particularly active in bringing scientific results to the public in a format that suits many different people's needs are the INCOFISH (www.incofish.org) and CENSOR (www.censor.name) projects relying heavily on experience from a global collaboration on fish biodiversity, which develops a public archive that attracts several million visitors/month (www.fishbase.org).

A now widely utilised research tool to analyse marine ecosystems, the Ecopath suite of analytical tools has achieved the amazingly rapid penetration of the scientific world through systematic investment in training combined with modest support to the >4000 registered users of the free software (www.ecopath.org). But finding ways to respond more directly to the needs of fisheries managers and other decision makers tends to be an even bigger challenge that the ECOST project is trying to achieve (www.ecostproject.org), by making specific efforts to integrate social and ethical dimensions as a prerequisite for sustainability.

The paper concludes that it is desirable for international scientific cooperation to engage more constructively with citizens, civil society movements, companies and government authorities to speed up adaptive learning. While not replacing political processes, research and research communication that are aware of the different mindsets, cultures and historically grown preferences in societies can help more effectively to bring about the conditions for recovery of lost ecosystem functions and productivity. Trust is a key condition for acceptance of the message.

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