Ecosystems and fisheries management

GLOBEC is one of the leading global science programmes focusing on understanding the functioning of marine ecosystems, with special reference to harvestable resources and the impacts of climate change and fishing. The international investment in GLOBEC should be realised as a major contribution to the task of implementing an ecosystem approach to fisheries management. The societal relevance of GLOBEC science will be one of the measures of its success. Our working group did not develop any specific plans to address this issue but proposed that this activity be viewed as an ongoing, long-term activity of GLOBEC, sustained through GLOBEC involvement and representation in international fora concerned with ecosystem issues. We see this activity as a broad issue that could be addressed by different groups within the GLOBEC program. No particular plans were developed for this activity at this time.

Comparative ecosystem analysis

At a previous meeting, the working group supported the synthesis of generic, simplified conceptual models of marine ecosystem function, with the zooplankton community as a core element. Over the past decade, we have developed new understanding of marine ecosystems, yet that knowledge has not yet reached the broader marine science community nor the public at large. We propose that a small group should write a review of ocean ecosystem function that draws on current theory and also highlights some of the new insights derived from GLOBEC studies. It was suggested to use structure and metabolic indexes to classify the systems and explore if it is possible to describe general key physical and biological factors that drive the structure and function of the system. The exponent of the size-abundance relationship was proposed as a structure index and ratios like respiration/biomass or new production/carbon sequestration as metabolic indexes. The ratio new production/carbon sequestration will give an idea of the relative importance of recycling and therefore the relative importance of certain pathways of carbon and nutrient fluxes. This could be an exciting activity that would be of broad interest to the marine science community. Eugene Murphy has expressed an interest to take the lead for our working group although no specific work plan has yet been developed.

GLOBEC Focus 4 Workshop on the human dimensions of marine ecosystem changes: understanding the linkages through comparative case studies.

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Assessing the human dimensions of, and their interactions with, marine ecosystem changes is a new initiative of GLOBEC, without analog in other Regional or National GLOBEC programs. It has the potential for strong interaction with other global change programs, such as the International Human Dimensions Program (IHDP). Two preparatory meetings of GLOBEC Focus 4, with unofficial membership, were held (in Sidney, Canada, June 2002 and Banff, Canada, June 2003) to scope out the issues and problems related to the linkages between fishing-dependent human communities and marine ecosystem changes, and to establish working relationships among natural and social scientists. Reports of these workshops have been published in previous issues of the GLOBEC Newsletter. The Focus 4 Working Group has now been formally constituted (see the GLOBEC International Newsletter 11(1): 38-39) and its first meeting was held at Dunsmuir Lodge, Sidney, BC, Canada, from 31 August to 2 September 2005.

The objectives of this workshop were to:

1) develop an "appraisal" paper on 'inter-dependent changes in marine ecosystems and fishing-dependent human communities';
2) develop plans for a major symposium on coupled marine ecosystem-human community interactions in the face of global changes; and
3) develop contacts among members of the Focus 4 Working Group, hopefully leading to collaborative proposals and activities.

All of these objectives also serve as important contributions to GLOBEC's Integration and Synthesis activities.

Most of the meeting focused on the first objective; case studies were presented on a number of examples worldwide of inter-related marine ecosystem and human coastal community changes. Two of these examples discussed North Atlantic cold-water ecosystems. Svein Jentoft (University of Tromsø, Norway) described the Barents Sea ecosystem. Its high latitude, large seasonal and inter-annual variability and position near the Arctic Ocean makes it an extreme environment. The marine ecosystem is dominated by a few key species and experiences marked fluctuations of commercially-important species. The economy and human population are connected with the marine ecosystem through three main activities: fishing, oil and gas extraction, and sea transportation – with fishing the most important activity for the northernmost county of Finnmark. Severely reduced Atlantic cod stocks in the 1990s affected this county particularly harshly, hitting coastal communities harder then those in the interior. Consequences included a fishing industry near bankruptcy, unemployment and out-migration of much of the younger population. Those people who remained survived largely on other employment opportunities (such as with the public sector), welfare, fishing "harder" and for other species (such as shrimp) and skills-upgrading through education. Fortunately, this crisis disappeared in the later 1990s with the return of healthy cod stocks, although permanent changes remain. Barbara Neis (Memorial University, St. John's, Canada) and Rosemary Ommer (University of Victoria, Canada) presented a similar example from the other side of the North

Atlantic, off Newfoundland, Canada. This is also a large cold-water ecosystem with strong seasonal and inter-annual variability. Fish biomass now is lower than historically and the region has a relatively low human population density which is declining in most fishing-dependent areas. The early 1990s saw a major shift in species dominance from demersal fish to shellfish, small pelagic species and seals. This collapse of bottom fish caused a decrease of 50% in the fish processing labour force. However, by 2003 the number of fish harvesters had almost recovered to pre-collapse levels; their distributions among boat sectors and species harvested, however, were quite different. Small-scale fisheries of the past were household-based; family connections still matter today but are now less important. Low incomes and overall outmigration of younger families are contributing to aging labour forces in fishing and fish processing and potential future labour shortages. Harvesters have developed a variety of fishing and non-fishing livelihood strategies to deal with variations in their social, economic, political and natural environments. These include fishing "harder", multiple income sources which include other sectors and employment insurance. Industrial and environmental restructuring in Newfoundland interacted with policy changes and outmigration to sustain fishing effort in the short-term, drive up fishing costs and pressure to harvest, thereby contributing to ongoing problems with stock abundance and scientific uncertainty. In addition, rapid environmental and industrial restructuring influenced occupational health risks in fishing and fish processing, including increased search and rescue events, and serious occupational health problems such as asthma and allergy to shellfish.

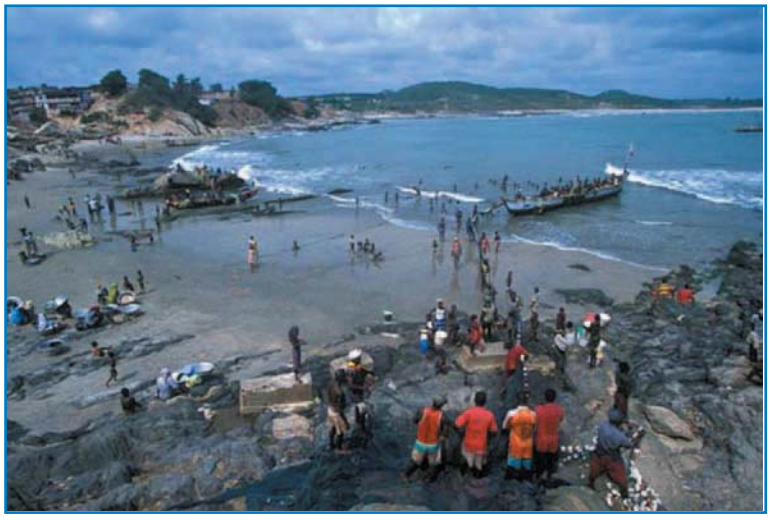
Ian Perry (Fisheries and Oceans Canada, Nanaimo, Canada) presented an example from the Northeast Pacific, dealing with Pacific salmon. Although not as severe as the North Atlantic, this region also experiences significant natural variability on seasonal, inter-annual and longer time scales. The 1990s were a time of warm sea temperatures and a shift towards warm-water species of more southern origin. These conditions ended abruptly following the large 1997–98 *El Niño* and the 1998/99 *La Niña* events. Warm ocean conditions are generally not favourable for the growth and survival of Pacific salmon which originate from British Columbia and many of these stocks declined significantly over this period so that several major salmon fisheries were closed. These declines and closures caused unemployment and outmigration from coastal communities, leading to stress, family breakdowns and deterioration in individual and community health. Alternative employment in the other major industry in this region - forestry - was reduced because of declining jobs in that sector at the same time. Human responses to these changes were to move into other fisheries and marine-related activities such as aquaculture and tourism, reliance on government support programs, or outmigration.

Focus 4 Working Group members participating in the Sidney workshop. From L to R: top row: Ian Perry, Rosemary Ommer, Barbara Neis, Kevin Stephanus, Renato Quiñones, Kenny Broad; bottom row: Jiehua Lu, Carrie Holcapek, Rashid Sumaila, Svein Jentoft.

A variety of examples were presented focusing on upwelling systems, which inherently experience strong variability on a variety of temporal scales and to which one might expect fishing communities to have adapted at least to seasonal and inter-annual variability. Jiehua Lu (Institute of Population Research, Beijing, People's Republic of China) presented the situation of upwelling areas of China, in which most key fish species such as larger yellow croaker and small yellow croaker are declining and being replaced in catches with small pelagic species characterised by small size, low value, young age and early maturation. In addition, coastal lagoons are facing pressure from water quality, habitat degradation and overfishing issues. The past two decades have seen an almost 10% per year growth in fishing, driven by large increases in fishing effort; however, marine catches still account for only 36% of total Chinese fishery production. The remainder is made up by enormous mariculture production. This latter activity has been a major strategy of fisherfolk to adapt to fluctuations in availability of their key fishery species. Other strategies have included prey switching, migrations to distant fishing grounds and risk-spreading using social security measures. However, the effects of those strategies on the changes in upwelling systems needs to be evaluated and measured taking a long-term perspective. Ian Perry also presented the example of Ghana, West Africa, which is part of a tropical upwelling system with strong seasonal and inter-annual variability. Inter-annual variability appears to be driven at large spatial scales by *El Niño* events which influence sea surface temperatures and subsequent pelagic fish landings off Ghana. At decadal scales, Ghanaian marine waters experienced cool sea temperatures and low fishery landings during the 1960s, rapid warming and increases in fishery landings during the late 1970s and 1980s and variable temperatures and fishery landings during the 1990s. Added to this natural variability is intensive fishing which has reduced the biomass of several important harvested species. As expected, artisanal fishers and fishing communities in Ghana have devised strategies to deal with this natural variability, including exploiting marine and terrestrial resources more intensively, ensuring multiple and diversified income sources; investing in social relationships and communities for support; and undertaking seasonal or permanent migrations.

The more "traditional" major upwelling systems off Africa and South America were examined in three

presentations. Rashid Sumaila (University of British Columbia, Vancouver, Canada) and Kevin Stephanus (University of Namibia, Windhoek, Namibia) described the situation of the Southwest African pilchard stock (off Namibia) and the interactions with human communities. The annual catch of Namibian pilchard declined from a peak of about 1.4 million tons in 1968 to the current annual catch of less than 20,000 tons. Two key reasons have been advanced for this decline: overfishing and an adverse environment. They concluded that the pilchard biomass collapses in 1971 and 1977/78 were largely attributable to overfishing. However, the collapse of the 1990s is blamed principally on environmental changes and in particular on the interaction between an unfavourable environment and unsustainable fishing practices. A number of coping strategies were used by both the pilchard harvesting and processing sectors in Namibia to mitigate the sharp declines in catches. These included movement of (largely foreign-owned) vessels to other parts of the world, targeting other species such as horse mackerel and shifting processing of pilchard to higher-valued products such as canning. This latter action both improved the total economic returns to the fishery and, because it is more labour-intensive, also contributed to softening the impact of the declines to workers in the processing sector.



Bringing in the catch in Moree, Ghana. Photo courtesy of FAO Sustainable Fisheries Livelihood Program.

In general, it appears that seasonal workers from the north of Namibia probably paid the highest price for the collapse of pilchard. Kenneth Broad (University of Miami, USA) explored the working hypothesis that vulnerability in Peru to the societal impacts of climate variability could be significantly reduced if strategies for improving socioeconomic development - particularly with respect to health, infrastructure, industrial fleet structure and small scale market exchanges - were strategically coordinated with knowledge of climate variability and change. Strong *El Niño* events cause spatial and temporal changes in ecosystems and also cause increased damage to ports, homes and roads resulting in health problems and increased spoilage of the catch. As there is not a culture of eating 'oily' fish (i.e., anchovy, sardine, mackerel) in Peru, these species, which make up 95% of the total catch, are largely converted to fishmeal for export. Considering the high degree of natural variability in this system, the artisanal fishery is challenged by economic and resource availability issues. They have developed a variety of fishing and non-fishing strategies to deal with variations in their social, economic, political and natural environments, including: use of multiple gears; occasional migration, especially during strong *El Niño* events; and occupational multiplicity (e.g. taxi driving, small household businesses). Renato Quiñones (Universidad de Concepción, Chile) described the jack mackerel crisis in central-southern Chile and the roles of environmental variability and scientific uncertainty as factors which increased the intensity of the resulting social conflicts.

The jack mackerel off Chile is one of the most important world fisheries in terms of landings (up to 4.5 million tons per year). It occurs in the Humboldt Current System, which experiences strong variability in a wide range of temporal and spatial scales. The crisis increased because of scientific and therefore management, uncertainty about changes in fish size: whether the apparent increase in abundance of juveniles and the reduced number of individuals belonging to older classes in the fishing zones represented fishery-induced declines in adult abundance or environmentally-induced (related to *El Niño*) changes in the spatial distributions of adults and juveniles. A management response was required and so the quota was cut drastically, which caused significant unemployment in the fishing industrial sector. Due to the complex web of ecological, oceanographic, economic, social and political factors acting in a system such as this, a major crisis in a key industrial fishery has a high probability of significantly affecting other economic activities (e.g. artisanal fisheries) and industrial associations, especially if they are located in the same geographical area. In this case, the effect was to increase employment in the artisanal sardine/anchovy fleet by 380% (person/trip equivalent units) over the period 1997-2001. Eventually, after much discussion, consensus was reached among government, industry, unions and artisanal fishermen about an appropriate allowable jack mackerel catch and its associated risk levels, which diffused the crisis. Long-term government responses included:

- awareness of the lack of instruments in Chile to confront major fisheries crises;
- the need to stop the "gold-rush" and establish new forms of property rights;
- the need to invest more money in fisheries research; and
- the need to advance towards decentralisation of decision making regarding quota definition and its allocation.

Ultimately, it was recognised that the challenge imposed by climate global change on fisheries management and its social consequences remains far beyond our present capabilities.

Several important concepts can be drawn out of these case studies. Diversity is an inherent feature of marine ecosystems and highly diverse systems are believed to be more resilient. However, human interactions with marine ecosystems tend to reduce their diversity by changing benthic environments,

truncating life spans and age structures within populations, contributing to range contraction and to the elimination of subpopulations and species. These changes can decrease the "strategies" or options available to such populations when responding to environmental variability and can increase the risk of threshold shifts at multiple spatial and temporal scales. Longer lived and larger species appear to be particularly vulnerable to collapses which are linked to overfishing. Climatic changes can either exacerbate or mitigate the impacts of fishing, but rapid climatic changes are likely to be detrimental to local populations. Since longer-lived species, species diversity and reasonable levels of abundance of key species give a certain stability to the structure of ecosystems, the result is greater variability and greater scientific and management uncertainty.

On the human side, harvesters tend to respond to ecosystem change in the short term by diversifying their fishing strategies through spatial, temporal and ecological intensification and expansion. Coping strategies that were apparent in the case studies presented included "riding out the storm", "fishing harder", diversifying, innovating, relying on social networks, attempts to even out boom-and-bust cycles and political action. Thus, in the short term, fisheries can become more diverse and variable. In the longer term, however, in the absence of focused and sustained recovery strategies, matters change. The combination of environmental degradation and crisis management associated with large scale collapses has tended to generate responses which can result in the consolidation of fisheries in the hands of fewer, larger enterprises. Globalisation and the rapid spread of new technologies, standardised organisational systems and standardised approaches to fisheries science and management are tending to erode the diversity of technologies, cultural diversity, local social networks and the resilience of local communities.

Consequently, humans are building increasing vulnerability for ourselves, our communities and also the marine ecosystems upon which we depend. The paper that is being prepared from this Focus 4 workshop will consider trends in diversity at the levels of the fish stock and fishery-dependent human communities when confronted with a rapidly-changing marine ecosystem. It will also identify ways in which current developing trends may result in declining diversity in both marine ecosystems and human communities on longer time scales. Implications of these trends for scientific and management uncertainty, social conflict and for our capacity to reverse these trends will also be considered.

The new China GLOBEC III / IMBER I programme takes off

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The third phase of China GLOBEC has been launched as the first combined GLOBEC/IMBER national programme, with the title of "***Key Processes and Mechanisms of Sustainable Food Production of Marine Ecosystems in China***". A kick-off symposium was held at the Equatorial hotel and at the Yellow Sea Fisheries Research Institute in Qingdao, China, 23–25 January 2006. The symposium was attended by Drs Sylvie Roy (Director, IMBER IPO) and Manuel Barange (Director, GLOBEC IPO) to provide international context to the occasion. Programme MOST 973–2, as it is known in China, is headed by Prof Dr Qisheng Tang (Chief Scientist) and Prof Dr Jilan Su (Scientific Consultant) and includes researchers from the Yellow Sea Fisheries Research Institute (YSFRI), the Second Institute of Oceanography (SOA), the East China Normal University, the Ocean University of China and the Institute of Oceanology (CAS). The Symposium built on a number of key stepping stones: the formation of an IGBP GLOBEC-IMBER National Committee in 2004 and the results of the 228th Xiangshan Science Meeting (2004), attended by the chairs of the GLOBEC and IMBER scientific steering committees. By creating the first combined IMBER-GLOBEC national programme China shows its leadership in implementing the wishes of the co-sponsors of GLOBEC and IMBER, to promote combined activities between both programmes (see Editorial). GLOBEC looks forward to the results of programme 973–2 and wishes China great success in its implementation.

Prof Qisheng Tang opening the GLOBEC/IMBER symposium