

Theme Session on Ecosystem Approach to Fisheries Management Worked Examples (BB)

ICES CM 2005/BB:01

A case history of ecosystem considerations for science supporting fishery management in the Northeast US

Jason Link, Michael Fogarty, Jon Brodziak, William Overholtz, Thomas Noji, Steven Murawski, and Fredric Serchuk

Fisheries in the Northeast US (NEUS) Large Marine Ecosystem (LME) have had a long and varied history. As targeted stocks have variously declined or recovered, as protected species have been increasingly listed, as habitat considerations have become increasingly important, as sequential targeting has been observed, and as conflicts among the different fishing sectors have escalated, fisheries management in the NEUS has had to adapt, to the point of becoming highly complex. As a result, the science supporting fisheries management has had to develop and research novel approaches while also supporting existing legislative mandates and their requisite demands. Work done at the National Marine Fisheries Service, Northeast Fisheries Science Center has in some respects had elements of an ecosystem approach to fisheries management (EAF) over the past several decades. For instance, in the 1970s under the ICNAF system there was a two-tier quota scheme that accounted for total production of the system in addition to single-stock production. Current research efforts to evaluate multi-species production, energy budgets, guild/functional group-based management, and total allowable catch are underway, in some sense revisiting this multi-tier scheme. Additionally, the closed areas for much of Georges Bank and the Gulf of Maine established in the 1990s, while not originally developed from an ecosystem perspective, have provided numerous insights into habitat issues, gear effects, and enhanced fishery production. These closed areas have spawned additional research efforts that evaluate both how to address habitat concerns in fisheries management and the more explicit use of one management tool, marine protected areas. Additionally, some stock assessments now have or are developing single-species "add-ons" to incorporate into the assessment, most typically to account for predation mortality. How these translate into modified biological reference points is fairly clear; how they will be accepted as a modified management tool is not. Further, technical interactions have often been addressed quite explicitly in the NEUS LME, with the management tool of bycatch quotas or protected species take-reductions often closing a fishery before target species limits have been reached. Other research developing and validating multi-species and ecosystem models, including MSVPA, multispecies aggregate production, multispecies bioeconomic models, network models, energy budgets, and a NEUS version of the Atlantis model, are extant. Additionally, research into the vetting, culling, and translating of ecological indicators into ecosystem decision criteria is ongoing. Yet despite the NEUS LME being one of the most well-studied and data-rich marine fishery ecosystems on the planet and despite all of the efforts just described, EAF are not

yet operational for this region. The items described above are some steps we are taking to enable EAF to become an operational reality in the NEUS, most particularly to address the fundamental issue of exploring trade-offs.

Keywords: ecosystem-based fishery management, ecosystem approaches to fisheries, Georges Bank, Southern New England, Gulf of Maine, biomass tradeoffs, management tools.

Jason Link: National Marine Fisheries Service, Northeast Fisheries Science Center, 166 Water St., Woods Hole, MA 02543, USA [tel: +1-508-495-2340, fax: +1-508-495-2258, e-mail: jlink@whsun1.wh.who.edu].

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Ecosystem-based fisheries management for *Lophelia* Reef HAPC at the northern-most "Agassiz Coral Hills" at bathyal depths off Cape Lookout, North Carolina

Robert Y. George

Magnusson Fisheries Conservation and Management Act was the fundamental guide-line for protecting single-species fisheries within Exclusive Economic Zones in the U. S. for more than two decades. However, the recommendations of the U. S. Ocean Commission in 2004 emphasized the need for a holistic approach, which includes:

1. Accountability for excessive bycatch,
2. Scientific justification for designation of Marine Protected Areas (MPAs) as Habitat Areas of Particular Concern (HAPC), and
3. Discussion of life history strategies of commercially important fish species.

The third criterion focuses on the identification of Essential Fisheries Habitats (EFH). This paper describes these three criteria for a bathyal *Lophelia* reef bioherm, located bathymetrically between 300–700 m and situated topographically between the Haterras-Florida slope and the northern tip of the Blake Plateau. Fisheries potentials of three deep-sea fish species of the genera Polyprion (wreckfish), *Beryx (alfonsino)* and *Coryphaenoides* (rattail fish) in this study-site are discussed from otter-trawl data. Biodiversity of associated megafaunal and macrofaunal invertebrate species on the *Lophelia* reefs and in adjacent *Bathypssamia* hard-coral and pteropod ooze habitats is defined with specific details on the species composition of *Munnupsidid* isopod Crustacea. Oceanographic parameters in this reef site are briefly reviewed with apparent implications of climate change and possible influence on the Gulf Stream-induced episodic upwellings. The final part of this paper deals with the importance of baseline information on ecosystem values, including apparent food chain and benthopelagic couplings (who eats who). This paper advises the South At-

Atlantic Fisheries Management Council (SAFMC) in the US for creation of fisheries management laws that give importance to the merit of vast contiguous bathyal zones as a network of deep-sea MPAs over the Blake Plateau such as the "Agassiz Coral Hills" off Southeastern United States. Lessons learned from the over-fishing and illegal fishing activities over the *Oculina* reefs off Florida are discussed. The recent Aleutian Islands model of banning bottom trawling, as recommended by the North-eastern Pacific Fisheries Management Council, is proposed for the *Lophelia* reef complex of bioherms and lithoherms on the Blake Plateau.

Keywords: *Lophelia* reef, Habitat Area of Particular Concern, *Oculina* reef model, wreckfish, *Alfonsino*, rat-tail fish, fisheries bycatch, *Munnopsididid* Isopods, bioherms, lithoherms, Gulf Stream, episodic upwellings and climate change.

Robert Y. George: *George Institute for Biodiversity and Sustainability, 305 Yorkshire Lane, Wilmington, North Carolina 28409, USA [tel: +1 910-799-4722, fax: +1 910-799-4722, e-mail: georgeryt@cs.com].*

ICES CM 2005/BB:03

A whole ecosystem approach to marine restoration: Optimal strategies for northern British Columbia

C. H. Ainsworth and T. J. Pitcher

Marine ecosystem models (Ecopath with Ecosim) are used to evaluate potential restoration goals for Northern British Columbia based on historic ecosystems (1750, 1900, 1950, and 2000), and a new methodology is developed to achieve those goals. We introduce a new conceptual ecosystem restoration target – the Optimal Restorable Biomass (ORB), which is based on historic ecosystems. It is an ecosystem analogy to BMSY that maximizes stock production rates while trading off the relative biomass of interacting ecosystem components in order to satisfy specific harvest objectives. Having defined the candidate goals for restoration, we then use a non-linear search procedure to draft restoration plans. The plans prescribe specific fleet-effort configurations that would use fishing as a tool to selectively manipulate the present-day ecosystem into one resembling the ORB target. Candidate restoration plans are evaluated in market terms using cost-benefit analysis, and in non-market terms using new indices developed for this approach (e.g. biodiversity, species extinction risk). A convex relationship between fishery profit and ecosystem biodiversity suggests that there may be an optimal rate of restoration. Under some conditions, the return on the resource investment is comparable to bank interest. This work offers a new methodology to guide strategic ecosystem restoration, first in evaluating restoration goals and then in developing optimal long-term fishing strategies to achieve those goals.

Keywords: ecosystem restoration, British Columbia, Ecopath with Ecosim, Optimal Restorable Biomass.

Cameron H. Ainsworth: University of British Columbia Fisheries Centre, 2259 Lower Mall, Vancouver, BC, Canada V6T 1Z4 [tel: work: +1 (604) 822-1639, home: +1 (604) 267-1799, e-mail: c.ainsworth@fisheries.ubc.ca].

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An Ecosim model for the Faroe Islands ecosystem

Luis Ridao Cruz

The fisheries management system in the Faroe Islands is characterised as a spatial- and effort-based scheme. The fisheries in the Faroe area (ICES Area Vb) can be typified as multigear and multispecies, targeting demersal, deep-water, and pelagic species. Cod (*Gadus morhua*), haddock (*Melanogrammus aeglefinus*) and saithe (*Pollachius virens*) form the three most important demersal species. Blue whiting (*Micromesistius poutassou*), Norwegian spring-spawning herring (*Clupea harengus*), and mackerel (*Scomber scombrus*) comprise the main component of the pelagic fisheries while the deep-water units are made up mostly of Greenland halibut (*Reinhardtius hippoglossoides*), redfish (*Sebastes* spp.), silver smelt (*Argentina* spp.), and blue ling (*Molva dypterygia dypterygia*). The Ecosim component of the Ecopath with Ecosim (EwE) suite is used for predicting temporal change in population parameters. EwE is a mass-balanced trophic model widely used in terrestrial and aquatic systems. Based on an Ecopath model for 1997 different simulations were carried out to project catch, biomass, and fishing mortality rates forward in time. Population estimates derived from single-species stock assessment models are also presented and compared with EwE results.

Keywords: Ecopath with Ecosim, ecosystem model, mass-balanced, temporal simulations.

Luis Ridao Cruz: Faroese Fisheries Laboratory, PO-Box 3051, Nóatún 1, FO-110 Tórshavn, Faroe Islands [tel: +298 353900, fax: +298 353901, e-mail: luisr@frs.fo].

ICES CM 2005/BB:05

Review of management plan conservation strategies for Canadian fisheries on Georges Bank

S. Gavaris, J. M. Porter, and R. L. Stephenson

The word "based" in Ecosystem-Based Management (EBM) explicitly acknowledges that ecosystems are not managed. Rather, human use activities that impact those ecosystems are managed. Making EBM operational involves converting broad conservation objectives for productivity, biodiversity, and habitat into explicit strategies, whose performance can be measured by indicators, for regulating those human use activities. The fisheries management plan strategies used to achieve the conservation objectives for EBM of Canadian fisheries on Georges Bank were reviewed to a) determine the degree to which existing management plans address the conser-

vation objectives, b) evaluate how the plans have performed with respect to these strategies, and c) provide a synthesis of aggregate results and consideration of cumulative effects across management plans for an area. Four fisheries management plans govern Canadian fishing activity on Georges Bank: those for groundfish, herring, offshore scallop, and offshore lobster. The plans focus on strategies aimed at sustaining population productivity for the utilized resources. Community productivity is considered to be adequately addressed by moderating exploitation on the utilized species. Biodiversity concerns are addressed through by-catch limitations for incidental mortality and through restricted fishing zones. Habitat considerations, other than those related to preserving biotopes, have not featured prominently. The plans reflect the historical emphasis by fisheries science on the broad conservation themes, with population productivity studies dominating through most of the 20th century, incidental mortality receiving attention in the latter decades and habitat considerations emerging as the most recent concern.

Keywords: conservation strategies, Ecosystem Based Management, fisheries management, productivity, biodiversity, habitat.

Stratis Gavaris: St. Andrews Biological Station, 531 Brandy Cove Road, St. Andrews, N.B. E5B 2L9, Canada [tel: +1 506 529 5912, fax: +1 506 529 5862, e-mail: GavarisS@mar.dfo-mpo.gc.ca].

ICES CM 2005/BB:06

A North Sea fisheries ecosystem plan: delivering an ecosystem-based approach?

Chris Frid, Odette Paramor, and Catherine Scott

Fisheries ecosystem plans were first proposed in the US as a means of embedding fisheries management regimes into a wider ecosystem context. Over the last 3 years a European Community funded study has developed a proposal for a fisheries ecosystem plan (FEP) for the North Sea. The North Sea FEP carried out a systematic review of the ecology of the North Sea to identify key ecosystem elements, consulted stakeholders for their views of the health of the system, the management issues and current management regimes. The threats to the key ecosystem components were then assessed and the effectiveness of various fisheries management tools to deliver management objectives determined. Simulation modelling of the response of the system components to various management scenarios and qualitative assessments when models were not available were then used to select a limited combination of management tools that would deliver fisheries management in an ecosystem context. Stakeholders views on this toolbox were solicited in a second round of consultation before the Fisheries Ecosystem Plan proposal was published. This paper documents this process, the lessons learned from it and discusses how the plan could now be made into an operational tool for ecosystem based fisheries management.

Keywords: North Sea, stakeholder consultation, modelling management regimes, toolbox.

Chris Frid: Dove Marine Laboratory, University of Newcastle, Cullercoats, North Shields NE30 4PZ, UK [tel: +44 191 252 4850, fax: +44 191 252 1054, e-mail: c.l.j.frid@ncl.ac.uk].

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ICES CM 2005/BB:08

Understanding the ocean in order to support decision-making: An introduction to NOAA's 5-year research plan and 20-year research vision

Robert J. Brock

The US National Oceanic and Atmospheric Administration (NOAA) is entrusted with responsibly managing the living marine resources and habitats of the world's largest Exclusive Economic Zone (EEZ). Americans depend on healthy ecosystems and the living marine resources they support for food, jobs, recreation, tourism, medicine, and energy. To achieve the delicate balance of sustainable use through wise conservation and protection measures of coastal and marine resources, NOAA will focus on conducting and sponsoring research that will improve our understanding of the complexity and interconnectedness of the world's marine ecosystems to allow policy and decision-makers to make more science-based predictions and decisions. To advance our knowledge of ocean processes and identify the goods and services required in the 21st century, NOAA has developed a short-term 5-year research plan and a longer-term 20-year research vision that seeks partnerships, both domestically as well as internationally, to take full advantage of the available expertise throughout the world's research community. NOAA's plans identify research milestones within a larger program structure: Ecosystems, Climate, Weather and Water, and Commerce and Transportation. Whether it be rebuilding depleted fish stocks and protecting endangered species to assessing climate variation and primary productivity, NOAA must invest in research to improve environmental forecasts that affect the quality of people's lives and those of future generations. This poster will present some of NOAA's important research milestones and encourage international collaboration from the world's research community.

Keywords: NOAA, research milestones, 5-year research plan, 20-year research vision, partnerships, ecosystems.

Robert J. Brock: NOAA National Marine Fisheries Service, Office of Science and Technology, 1315 East-West Highway, Silver Spring, Maryland 20910-3282, USA [tel: +1 301-713-2363, fax: +1 301-713-1875, e-mail: Robert.Brock@noaa.gov].

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Application of MSE methods at “whole of fishery” level to evaluate alternative EBFM strategies for a large complex fishery in Australia

Tony Smith, David Smith, Jeremy Prince, Ian Knuckey, Margot Sachse, Sonia Talman, Pascale Baelde, Terry Walker, Gerry Geen, and Peter Franklin

Australia’s Southern and Eastern Scalefish and Shark Fishery is a multi-species, multi-sector fishery managed primarily by ITQs. The fishery is perceived to be in a poor ecological and economic state. There is clear requirement for a more integrated approach to management and a need to simultaneously meet the requirements of fishery and environmental legislation that involves moving towards a more ecosystem based approach. In response to this, a project using an MSE approach was established with the aim of focusing on integrated management solutions with impacts on the ecology and all aspects of the fishery being considered. This paper reports the results of stage 1; a qualitative MSE. Four management scenarios were identified comprising a different mixture of four basic management measures: the quota management system (QMS), spatial management arrangements, gear controls, and effort controls. The scenarios range from “business as usual” to more radical changes to current arrangements. The future consequences of each scenario were evaluated by predicting how performance indicators (ecological, economic, social, and governance) would vary over a 5- to 20-year timeframe. *Status quo* scenarios indicated continued deterioration of almost all performance indicators for the fishery. Extensive changes to the QMS produced some long-term economic improvement, but most ecological indicators continued to decline. Scenario 4 involved the most radical changes to current management arrangements, particularly in spatial management and effort controls, but also changes to the QMS. This scenario provided the best ecological outcomes of any of the scenarios considered, and also the best long-term economic outcomes. However, the short-term economic impacts of adopting this scenario would be severe. A quantitative evaluation is underway using the Atlantis model, modified to include economics.

David C. Smith: IMERSD, (Integrated Marine Ecosystem Research for Sustainable Development), CSIRO Marine Research, Castray Esplanade (GPO Box 1538), Hobart TAS 7000, Australia [tel: +613 6232 5491, fax: +613 6232 5053].

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Comparison between trophic models of protected and fishing areas for an ecosystem approach to fisheries in the Adriatic Sea

Simone Libralato, Marta Coll, Alberto Santojanni, Cosimo Solidoro, Enrico Arneri, and Isabel Palomera

The Adriatic Sea is one of the most exploited basins of the Mediterranean and management of fisheries is particularly challenging. In order to account for the effects of environmental factors and fishing, along with their indirect and cascading effects on the trophic web, an ecosystem approach is therefore necessary. The mass-balance model, although a static picture of the ecosystem, can be a valuable tool in giving information on structure and functioning of the ecosystem, in evidencing effects of fishing and in allowing inference on management options at the ecosystem scale. These results can also be achieved through the comparison between models of exploited and non-exploited sub-systems. For the first time in the Mediterranean Sea, and for the same ecosystem i.e., the Adriatic Sea, ecological models describing a protected and a non-protected area are available. The former represents the MPA of Miramare (Gulf of Trieste, Italy). The latter represents the fished North and Central Adriatic for the 1990s. Standardized models were compared on the basis of biomass and flows of production and consumptions aggregated into integer trophic levels and analyzed in terms of their trophic spectra. The comparison evidenced the different functional roles of analogous trophic groups and ecosystem structure differences, thus indicating the functional changes that fisheries might have induced. Analyses applied to the exploited ecosystem model evidenced the effects of fishing on target and non-target species, and results are discussed in relation to the observations on the MPA model. The model of the exploited area was used for producing future scenarios of alternative management options.

Keywords: ecosystem approach to fisheries, fisheries impact, fisheries management, ecological models, marine protected area, Adriatic Sea.

Simone Libralato: Dept. Oceanography, Istituto Nazionale di Oceanografia e di Geofisica Sperimentale - OGS, Borgo Grotta Gigante 42/, 34010 Sgonico (TS), Italy [tel: +39 040 214 0376, fax: +39 040 214 0266, e-mail: slibralato@ogs.trieste.it].

ICES CM 2005/BB:12

EAF in South Africa

Lynne Shannon

South Africa is committed to moving towards an Ecosystem Approach to Fisheries. Through a project under the Benguela Current Large Marine Ecosystem (EAF Feasibility Study), a dedicated scientific working group established by Marine and Coastal Management, and collabo-

rative scientific and modelling studies within the joint French-South African Programme "Upwelling Ecosystems", foundations are being laid for a South African EAF. This contribution will provide an overview of the progress made in South Africa, both on the scientific front in terms of improved understanding of the functioning of the Benguela ecosystem and the ways in which its ecosystem components interact, and regarding the practical ways being explored to enable scientific advice to feed in to South African fisheries management whilst taking into account broad stakeholder concerns.

Lynne Shannon: Marine and Coastal Management, Department of Environmental Affairs and Tourism, South Africa, Private Bag X2, Rogge Bay 8012, South Africa [e-mails: lshannon4@yahoo.co.uk, lshannon@deat.gov.za].

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Promotion, implementation and communication of the EAMR (Ecosystem Approach to Marine Resources): the Eur-Oceans approach

Philippe Cury and Manuel Barange

The objective of the recently-launched European network of excellence, EUR-OCEANS, is to achieve long-lasting integration of European research organisations on global change and marine ecosystems. With 68 Member Organisations, located in 25 countries, one of the objectives of the network is to promote a cohesive and integrated view to implement the EAMR across Europe. This vision involves the development of partnerships with user communities, policy makers and conservation bodies to deliver effective, European-wide, ecosystem-based management solutions. It also requires communication and dissemination strategies with the public, users, policy makers and scientists, to promote co-management arrangements based on credible, interdisciplinary, and ecosystem-wide scientific advice. We present here plans for the activities of the network, the challenges that it faces in the development of integrated ecosystem knowledge, and the need to implement a unified Ecosystem Approach to Marine Resources with full stakeholder participation.

Philippe Cury: Centre de Recherche Halieutique Méditerranéenne et Tropicale, IRD - IFREMER & Université Montpellier II, Avenue Jean Monnet, BP 171, FR-34203 Sète Cedex, France [tel: +33 0 4 99 57 32 33, e-mail: philippe.cury@ird.fr].

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Ecosystem approach to fisheries management: The Moroccan upwelling resources case

Souad Kifani, A. Faraj, and H. Masski

The Canary current ecosystem represents one of the four major eastern boundary upwelling systems of the world

oceans. The Moroccan Atlantic continental shelf is part of the Canary current ecosystem, and constitutes an area of high biological productivity and intensive fisheries activity. Like most fisheries worldwide, Moroccan marine fisheries are presently managed following a mono-species approach. The research and stock assessment effort has mainly focused on the commercially targeted species. However, the mono-species approach has gradually revealed its limits: it is inadequate to address ecosystem-fisheries interactions, whereas fisheries operate within a complex array of species interactions and commercial fish stocks are only part of the complex web of life in the oceans. Catches and distribution of numerous species have undergone decadal changes since the exploitation begun. Huge fluctuations of abundance have been observed for sardines, sardinellas, and other pelagic and bottom fishes during the last five decades. Time-series of catches show signs of replacement of longer-lived bottom fish species by short-lived ones (small pelagics and cephalopods) in the commercial fisheries. The central scientific question that these observations raise is whether the (top down) effects of harvesting or (bottom up) changes in the physical environment are responsible for those changes. The challenge is to understand the critical factors that impact the ecosystem and its resources, and then use this understanding to assist in the management of Moroccan fish stocks.

Keywords: Canary current ecosystem, catches fluctuation, Moroccan fisheries.

Souad Kifani: INRH, 2 Rue Tiznit, Casablanca, Morocco [tel: +212 22 02 45, fax: +212 22 26 69 67, e-mail: kifani@inrh.org.ma].

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The Combined Indicator Trends method to translate indicators into a diagnostic on fishing impact useful for fisheries management

Marie-Joëlle Rochet, Verena Trenkel, Jean-Charles Poulard, and Jacques Bertrand

While studies about indicators designed for an ecosystem approach to fisheries management are accumulating, integrating them into diagnostics usable by fisheries managers seems more difficult. This is because several indicators have to be monitored for an ecosystem, hence much information has to be synthesised. In addition, determining reference points to trigger management decisions for each of these indicators is difficult, on both theoretical and practical grounds.

Finally, indicators are sensitive to many confusing factors. We propose a method for assessing whether a system is moving towards a desirable direction, based on combined trends in indicators. First, the initial state of the community is assessed using published information. Second, this initial state is the basis for establishing desirable combinations of trends in a set of simple indicators of fishing impacts on fish populations and communities (population abundance and average length, com-

munity total biomass and number, average length and weight, and size spectrum). Third, these indicators are estimated from time-series data of scientific surveys. Fourth, linear temporal trends in these indicators are tested. Finally, the test results are combined within the predefined framework, providing a diagnostic on the dynamics of fishing impacts in populations and communities. The method is demonstrated for nine coastal and shelf sea fish communities monitored by French surveys.

Keywords: indicators, ecosystem approach, fisheries management, diagnostic, trends.

Marie-Joëlle Rochet: Département EMH (Ecologie et Modèles pour l'Halieutique), IFREMER, B.P. 21105, 44311 Nantes Cedex 03, France [tel: +33 2 40 37 41 21, fax: +33 2 40 37 40 75, e-mail: mjrochet@ifremer.fr].

ICES CM 2005/BB:16

Predation on common hake (*Merluccius gayi*) by jumbo squid (*Dosidicus gigas*) in central Chile (33°–39°S)

Hugo Arancibia and Sergio Neira

The dramatic drop in hake biomass, the main demersal resource in central Chile, in recent years resulted in a TAQ of 70 thousand tonnes in 2005, which is about half of the TAQ in 2004. No agreement exists about the hypothesis that could explain this situation, i.e., overfishing vs. predation by jumbo squid. Traditional single-species models are insufficient to answer this question, and then a more holistic (ecosystem) approach is required. We quantify predation of hake by jumbo squid using a multi-species model including 31 functional groups for year 2000. We estimate the biomass of jumbo squid (B_{squid}) at 300 thousand tonnes. B_{squid} is combined with data on diet composition and consumption to calculate the biomass of hake removed by jumbo squid. Then, we simulate the effect of predation by jumbo squid on hake biomass (years 2003 to 2005), increasing M_2 in hake caused by jumbo squid in steps of 50% and 100% per year compared to the same parameter in 2002, maintaining a constant fishing mortality (F) on hake. Removed biomass of hake by jumbo squid resulted in about 150 mil tonnes year⁻¹, which is similar to hake landings in 2004. Simulations indicate that predation by jumbo squid cannot by itself explain the decrease in hake biomass, which would be then explained by overfishing (years 2002 to 2004). The Chilean fishing authority is increasingly considering the ecosystem-based approach for fisheries management to understand the effects of fishing and predation on the dynamics of Chilean hake.

Keywords: predation mortality, jumbo squid, common hake, multi-species modelling, ecosystem approach to fisheries, central Chile.

Hugo Arancibia: Departamento de Oceanografía, Universidad de Concepción, P.O. Box 160-C, Concepción, Chile [e-mail: harancib@udec.cl].

ICES CM 2005/BB:17

Role of predation in the collapse and recovery of two *Galatheid* crustaceans in central Chile (33°S–39°S)

Sergio Neira and Hugo Arancibia

The assessment of predation on target species is important when placing fisheries in their ecosystem context. We estimate coefficients of predation mortality (M_2) for red squat lobster (*Pleuroncodes monodon*) and yellow squat lobster (*Cervimunida johni*), based on four multi-species models (31 functional groups) describing the central Chile marine ecosystem (33–39°S) in years 1992, 1998, 2000, and 2002. Besides, we simulate the trend in biomass of these stocks under the following levels in fishing mortality (F ; year⁻¹) from 2003 onwards: $F = 0.0$; 0.05; 0.10; 0.15; and 0.20, using the same models and the Ecopath with Ecosim software. Each fishing scenario is evaluated considering the following increases in M_2 compared to M_2 in year 2002: 5%, 10%, 20%, 30%, and 50%. Results indicate that M_2 is the main source of mortality in both stocks, mainly due to predation by common hake (*Merluccius gayi*), and that F represents only a small part of the total mortality. Simulations indicate that in all fishing scenarios the biomass of red squat lobster decreases without showing recovery in the medium term, while the biomass of yellow squat lobster could recover only under a combination of both moderate fishing scenarios ($F < 0.1$) and low M_2 . Therefore, M_2 , more than fishing, plays a main role in the dynamic and recovery of these resources. This analysis allowed the understanding of the reasons biomass of red squat lobster has not recovered in last years, even in the absence of fishing. The advice is to keep the fishery closed, at least for another 5 years.

Keywords: predation mortality, red squat lobster, yellow squat lobster, hake, trophic interactions, ecosystem approach to fisheries, central Chile.

Sergio Neira: Zoology Department, University of Cape Town, Rondebosh 7701, Cape Town, Republic of South Africa [e-mail: sneira@botzoo.uct.ac.za].

ICES CM 2005/BB:18

The management of human impacts on the benthic communities of the Scotian Shelf: A case study on ecosystem-based management

M. Sinclair and R. O'Boyle

Proclamation of Canada's Ocean Act in 1997 represented the start of a new management paradigm of the country's three oceans. Soon thereafter, a number of Integrated Management (IM) projects were initiated by the Department of Fisheries and Oceans (DFO) to investigate how best to turn the policy within the Oceans Act into operational reality. Since then, the national approach to IM has started to emerge, including the development of a suite of nationally defined conservation objectives and a planning hierarchy which first puts these into a regional con-

text and then links these to specific ocean industry activities through operational objectives (indicators and reference points) and management actions. The Integrated Management project on the Eastern Scotian Shelf (ES-SIM) has developed a suite of regional objectives based on the national model and is currently considering operational objectives for all ocean activities. The three objectives on the conservation of benthic community diversity are a subset of the entire framework that are used to illustrate how national, conceptual, conservation objectives are made operational. The process whereby the regional objectives are developed is first described. Next, for each objective, the issues and impacted ecosystem components are considered and indicators, reference points and management actions outlined. A number of issues relating to how best to characterise the sensitivity of benthic communities to human impacts are discussed as are strengths and weaknesses of the approach. Of particular interest will be how cumulative impacts are addressed in a risk management setting as well as options being considered for management actions. The lessons being learned will be of general interest to those involved in integrated management.

Keywords: conservation objectives, Integrated Management, benthic community diversity, cumulative impacts, decision rules.

M. Sinclair: Bedford Institute of Oceanography, P.O. Box 1006, Dartmouth, Nova Scotia, Canada B2Y 4A2 [tel: +1 902 426 3490, fax: +1 902 426 5435, e-mail: sinclairm@mar.dfo-mpo.dfo.gc.ca].

ICES CM 2005/BB:19 – Poster

Including ecosystem consideration into ICES advice

Chris Frid, Paddy Walker, Stuart Rogers, and Jake Rice

Various international agreements include the Bergen declaration and the revised CFP for an ecosystem approach to fisheries. This is often interpreted as a need to consider the impacts of fishing on other ecosystem components – birds, marine mammals. Recent analysis of the performance of ICES fisheries predictions have shown a good track record for single-stock models, but one area that has been highlighted where improvements could be made is in the consideration of the external, environmental drivers on recruitment, growth, and survivorship. This paper considers how these various ecosystem issues might be incorporated into the ICES advisory framework and briefly comments on the changes in data needs that this implies.

Keywords: ACFM, ecosystem drivers, critical components, ecosystem properties, integrated management.

Chris Frid: Dove Marine Laboratory, University of Newcastle, Cullercoats, North Shields NE30 4PZ, UK [tel: +44 191 252 4850, fax: +44 191 252 1054, e-mail: c.l.j.frid@ncl.ac.uk].

ICES CM 2005/BB:20

Evolution of an ecosystem-based management approach in the British Columbia groundfish fishery

A. Sinclair, J. Fargo, R. Stanley, and B. Turris

The management regime for groundfish fisheries in British Columbia, Canada, has undergone a significant evolution in the past 15 years. The fishery is supported by an extremely diverse array of species with a wide range of life history characteristics and habitat preferences. The fishing fleets use bottom trawls, midwater trawls, longlines, handlines, and traps. When catch quota management was initially introduced, individual fishers competed for aggregate quotas. There was considerable acrimony among fishers, fishing fleets, and with the central authority. This led to data quality issues, hindered effective management decision making, and put considerable stress on the fish resources. Fundamental changes were introduced in the mid-1990s. These included industry-funded dockside monitoring of landings and 100% observer coverage of the bottom trawl fleet. An individual transferable quota (ITQ) system was established for the bottom trawl fleet in 1997. Industry-funded associations were established to support resource conservation and by funding research and monitoring. Recently a commercial industry caucus has been tasked with implementation of groundfish ITQs and limited entry for all species including new allocation formulas for species taken primarily by hook and line gears. These discussions are being led by respected fishers and significant progress is being made. The upshot of this evolution is that acrimony has been replaced by collaboration, central management has been replaced by co-management, data quality has improved immensely, and research programs have been established where they were not affordable before. Together these lay the foundation for ecosystem based management.

Keywords: groundfish, co-management, ecosystem based management.

Alan Sinclair: Pacific Biological Station, Fisheries and Oceans Canada, 3190 Hammond Bay Road, Nanaimo, B.C., Canada, V9T 6N7 [tel: +1 250 756 4569, fax: +1 250 756 7305, e-mail sinclairal@dfo-mpo.gc.ca].