Symposium on

Rebuilding Depleted Fish Stocks– Biology, Ecology, Social Science And Management Strategies

Book of Abstracts

3–6 November 2009
Yachthafenresidenz Hohe Düne
Warnemünde, Germany

Contents

Welcome...

Dear colleagues and friends,

The three inviting institutions of the ICES, PICES and UNCOVER Symposium on Rebuilding Depleted Fish Stocks dearly welcome you to Warnemünde.

From the full title and the programme you have surely already learnt that we intend to make a comprehensive Tour de Table of recovery and rebuilding depleted fish stocks, spanning the bridge from biology over ecology to social sciences with nearly 50 oral presentations and over 30 posters. We were by far not able to accept all excellent presentations and unfortunately had to disappoint a number of colleagues who submitted abstracts. Sorry for this! This however sheds some light on the upcoming presentations. These will by far not only be results of the UNCOVER project but will give insight into rebuilding of fish stocks from non-European, non-ICES waters.

In a final panel discussion we will take ample time to discuss the messages of the presentation with the stakeholders and the European Commission.

And after all, when work is done, we will have a fine party.

We hope that you have a fruitful and memorable time in Warnemünde and enjoy the Baltic coast.

Cornelius Hammer
Symposium convener, UNCOVER project leader, Director of the Institute of Baltic Sea Fisheries in the Johann Heinrich von Thünen-Institut of Rural Areas, Forestry and Fisheries

Welcome...

Today, rebuilding depleted fish stocks ranks high on scientific and marine management agendas everywhere. In 2002, at the World Summit on Sustainable Development (WSSD) in Johannesburg, governments committed themselves to restoring fish stocks to levels that can provide a Maximum Sustainable Yield by no later than 2015. To achieve this goal, we need functioning strategies for rebuilding overfished stocks. These strategies must be built on sound science and scientific advice that can be communicated to marine managers through the ICES network. To help focus the work of marine scientists from around the North Atlantic and beyond focus on this important goal, the UNCOVER project has gathered information and knowledge on Biology, Ecology, Social Science, and Management Strategies that will provide state of the art scientific backing for the development of approaches that support this process.

ICES is pleased to co-convene this important symposium with PICES and the EU 6 FP, which is the main funder of the UNCOVER project. We look forward to hearing about the interesting science and new approaches to practical management of depleted fish stocks that will certainly be presented here.

Gerd Hubold
General Secretary, International Council for the Exploration of the Sea (ICES)

Welcome...

On behalf of the North Pacific Marine Science Organization (PICES; www.pices.int), I extend a warm welcome to all participants in this Symposium on *"Rebuilding Depleted Fish Stocks"*. PICES is extremely pleased to be able to co-convene this symposium with our ICES and UNCOVER colleagues. PICES is keenly interested in this topic as evidenced by a 2009 special issue of *Fisheries Research* (Vol. 100, Iss. 1) on this topic, based on papers presented at a session held during the PICES 2007 Annual Meeting. Given the mixed success to attain rebuilding goals in fisheries worldwide, we look forward to your findings and advice concerning alternative approaches presented at this symposium.

Gordon H. Kruse
Vice-Chairman, North Pacific Marine Science Organization (PICES) Fishery Science Committee

Introduction and background of the ICES/ PICES/ UNCOVER symposium

Some fish stocks recover according to predictions, others do not, and some recover more slowly than predicted. At the World Summit on Sustainable Development in Johannesburg in 2002, governments committed themselves to restore fish stocks to levels that can provide a Maximum Sustainable Yield no later than 2015. To achieve these goals, functioning strategies for rebuilding overfished stocks are necessary. For some depleted stocks recovery measures have been successful, many others however, have not shown any sign of recovery so far.

The principle objectives of the EU 6th Framework Programme (FP6) SSP-4-FISH Specific Targeted Research Project (STREP) "Understanding the Mechanisms of Stock Recovery" (UNCOVER, contract No. 022717) were to understand mechanisms in fish stock recovery and to provide recommendations for recovery strategies to the European Community in a multi-species, ecosystem and socio-economic context, recognizing the biological (within a stock e.g. genetics and demography) and ecosystem changes (trophic controls) experienced during the stock decline. This was achieved by analyzing existing data and utilizing available information from all sources, including finished and ongoing research projects and specific targeted studies to be performed inside UNCOVER. The result will be a comprehensive evaluation of the success and failure of management measures to restore marine fish stocks and the underlying mechanisms, which is as yet still largely missing.

Since it began in 2006, UNCOVER has engaged more than one hundred scientists from twenty-six institutes in fifteen countries in developing recommendations for the recovery of European fish stocks. The amount of collective research expertise involved illustrates the complexity of this endeavor, as does the diversity of approaches.

The fish stocks investigated in four case studies were: Arctic cod, Norwegian spring-spawning herring, and capelin in the Barents Sea; cod, herring, and plaice in the North Sea; eastern cod and sprat in the Baltic Sea; and hake and anchovy in the Bay of Biscay. In each of the four regional seas, operational models based on established time-series and process models were run to summarize the impact of stock collapse on the migration and distribution of the target species and on their potential to successfully reproduce and, finally, to recover. Together with aspects of reproduction and spatial distribution, historical variations in recruitment have also been related to abiotic and biotic conditions during periods of high and low stock productivity. Of course, the modelling tools developed in UNCOVER cannot forecast the future precisely. What they can do is provide quantitative scenarios that have a good chance of becoming reality.

UNCOVER's closing date is rapidly approaching and almost four years of hard work within the project are culminating in this symposium, where the insights gained and the recommendations developed will be presented. The symposium should also serve as a forum to exchange ideas and views across disciplines and stakeholders. The upcoming presentations will not exclusively be results of the UNCOVER project but will also give insight into rebuilding of fish stocks from non-European, non-ICES waters. The presentations and subsequent discussions will hopefully contribute to tackling probably the hardest, but nevertheless the most important, task: the synthesis of all project results and their eventual translation into clear-cut management advice.

The conference will be opened in the morning of Tuesday Nov. 3rd with a symposium keynote. All scientific sessions will be held in plenary with no parallel sessions, to encourage interaction among participants and different disciplines. Each session will open with a keynote address by invited keynote speakers.

Conveners

Cornelius Hammer
Johann Heinrich von Thünen-Institut, Institute of Baltic Sea Fisheries
Rostock, Germany
Olav Sigurd Kjesbu
Institute of Marine Research
Bergen, Norway
Gordon H. Kruse
University of Alaska Fairbanks, School of Fisheries and Ocean Sciences
Juneau, USA
Peter Shelton
Fisheries and Oceans Canada
St. Johns, Canada

Scientific steering committee

Denis Bailly
Institut Francais de Recherche pour l'Exploitation de la Mer (IFREMER)
Brest, France
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Rostock, Germany
Toyomitsu Horii
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Madrid, Spain
Fritz W. Köster
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Copenhagen, Denmark
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University of Aberdeen, School of Biological Sciences
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Woods Hole, MA, USA
Axel Temming
University of Hamburg, Institute of Hydrobiology and Fisheries Science
Hamburg, Germany
Douglas C. Wilson
Aalborg University, Research Centre Innovative Fisheries Management
Aalborg, Denmark

Notes for Guidance

Registration

The registration desk is located in the foyer of the hall where the conference will be take place, and opens Mon 1500 hrs.

Internet access

There will be free internet access via WLAN in the whole conference building.

Smoking

Smoking is not allowed anywhere in the conference building.

Meetings

A meeting room will be available on the first floor of the conference building.

Oral presentations

To ensure the smooth running of the sessions and maximize the time for discussion, all presentations will need to be pre-loaded onto the computer.

Please check the schedule for oral presentations to confirm timing for your presentation. The programme guide can be found in the conference programme starting on page 11 of this volume.

Please submit your presentation on either a memory stick or CD to a member of the conference team at the conference registration desk for uploading. This should be undertaken preferably upon your arrival at the venue, but no later than 1600 on the day before you present your paper. It will be loaded onto our conference PC and checked if it is working properly. For reasons of fairness towards other speakers please adhere strictly to the time allocated (20 minutes, including questions and discussion).

A laptop computer and projector will be provided for your presentation using PowerPoint software. Slides are not acceptable. A cordless slide advancer with built-in laser pointer will be provided.

Please be at the meeting room before the session begins and contact the session chairs for last-minute instructions or changes in the schedule.

- During your presentation, state the purpose/objectives of the paper, the main concepts and results, and the conclusions.
- Avoid going into detail.
- Do not read your paper, but instead talk to the audience. Speak slowly and audibly.
- Do not exceed the allocated time for your presentation.
- **State clearly how your work relates to the topic of stock recovery.**

Posters

Poster authors are kindly asked to please contact the registration desk, where further instructions will be provided, e. g. about where to hang your poster. Please note that presenters of posters should be available to discuss their contributions at the Poster Session. Posters will be on display for the duration of the Symposium, with a special poster session on Wednesday Nov. 4th. It starts at 1900 and will end at 2200. There will be free drinks and snacks, and authors will be happy to present and discuss their research.

Refreshments and lunch

Coffee and tea will be served during morning and afternoon breaks in the foyer of the conference hall. Lunch will be served during the lunch breaks on Tuesday, Wednesday and Thursday. Coffee breaks and lunch are covered by the conference fee.

Conference dinner

On Thursday, November 5th 2009, the conference dinner will take place between 1930 and 2230 hrs in the Bootshalle at the venue. The conference dinner is covered by the conference fee.

Panel discussion

The conference will be opened in the morning of Tuesday Nov. 3rd with a keynote. All scientific sessions will be held in plenary with no parallel sessions, to encourage interaction among participants and different disciplines. Each session will open with a keynote address by invited keynote speakers. Posters will be on display for the duration of the Symposium, with a special poster session on Wednesday Nov. 4th.

On Friday, November 6th the symposium will be concluded around mid-day with an inter-disciplinary panel discussion on lessons learned and a final wrap-up to provide conclusions.

The panel will be made up of eight international experts representing science, fishers, conservation and politics. The panel discussion will have a moderator to ensure to adhere to the fairly strict schedule and the thematic balance. It will be divided into five blocks, each being opened by a brief summary of the theme session chairs, followed by discussions within the panel and with the audience. For a final wrap-up, the symposium keynote speaker Steven Murawski will share his take-home messages with us.

On the panel:

Michael Andersen
> Baltic Fishermen's Association

Kevern Cochrane
> United Nations, Food and Agricultural Organization (FAO)

Poul Degnbol
> EU Commission, DG MARE

Gordon H. Kruse
> University of Alaska Fairbanks, School of Fisheries and Ocean Sciences

Philippe Moguedet
> EU Commission, DG Research

Karoline Schacht
> World Wide Fund for Nature, Germany

Peter Shelton
> Fisheries and Oceans Canada/Ministère des Pêches et des Océans

Ralf Röchert (Moderator)
> Alfred Wegener Institute Bremerhaven, Department of public relations, Germany

Conference Proceedings

Selected papers from the Symposium will be published in the *ICES Journal of Marine Science*, subject to a full peer-review process. The Scientific Steering Committee and the four conveners will decide upon the papers to be accepted for review. However, the guest-editor Niels Daan remains responsible for the review process and the ultimate decision about papers accepted for publication.

Manuscripts for the proceedings have to be submitted to a member of the Symposium Secretariat upon arrival in Warnemünde. For the manuscript text, electronic copy is always required; a hard copy is not usually required. Text and figures should be in separate files: A text file including the main body of the paper, references, tables and figure captions and a separate figures file. Preferably, manuscript texts should be submitted in MS Word format, other formats may be accepted on prior agreement, but **do not submit manuscript texts in PDF format**. Figures may be submitted either in one file or in separate files preferably an editable file, such as MS Excel. Authors will be informed within one week after the Symposium whether their manuscript is selected for entering the review process.

Because of a strict page limit of 250 pages for the proceedings issue, manuscripts must be restricted to a maximum of 7 pages in print, so that about 30-40 papers can be included covering the full range of topics addressed. This means that the main text of a manuscript must not exceed 4000 words.

Because it is the aim of the IJMS to publish proceedings within one year after a Symposium, strict deadlines will have to be adhered to. Authors will be informed about the decision whether their manuscript is accepted and with associated requests for revision within 4 months after the symposium, and they will have 3 months to revise their contributions. To speed up the whole process, all file transfer will be exchanged by e-mail.

ICES/PICES/UNCOVER Symposium on Rebuilding Depleted Fish Stocks – Biology, Ecology, Social Science and Management Strategies

3–6 November 2009 in Warnemünde/Rostock, Germany
Yachthafenresidenz Hohe Düne, Am Yachthafen 1, 18119 Rostock Warnemünde

Monday, November 2ⁿᵈ 2009

1500   **Opening registration**

1900-2100   **Symposium reception**

Tuesday, November 3ʳᵈ 2009

0830   **Opening addresses**

Cornelius Hammer, UNCOVER project coordinator and symposium convener
Gerd Hubold, General Secretary of the International Council for the Exploration of the Sea (ICES)
Gordon H. Kruse, delegate North Pacific Marine Science Organization (PICES) and symposium convener

0900   **Main symposium keynote**

Steven Murawski, Director of Scientific Programs and Chief Science Advisor for NOAA Fisheries (USA)
"Rebuilding depleted fish stocks: The good, the bad and the mostly ugly"

1000   **Coffee break**

Theme Session 1: Impact of Fisheries and Environmental Impacts on Stock Structure, Reproductive Potential and Recruitment Dynamics
Chaired by Toyomitsu Horii (Japan) and C. Tara Marshall (Scotland)

1030-1100   **Session keynote**
Horii, T. and Akihiko Yatsu
"Impacts of fisheries and regime shift on fluctuations of finfish and shellfish stocks in Japan"

1100-1120   **Mantzouni, I.** and MacKenzie, B. R.
"Productivity patterns and abundance-area relationships in 3 marine fish species (cod, herring and haddock): Meta-analyses on the effects of temperature, life-history and habitat size across the N Atlantic"

1120-1140   **Payne, M. R.**, Christensen, A., Munk, P., Nash, R. D. M., and Dickey-Collas, M.
"The role of spatial processes in North Sea herring larval survival and recruitment"

Tuesday, November 3rd 2009 continued

1140-1200 **Dingsør, G. E.,** Huse, G., and Llope, M.
"Spatial distribution and population dynamics of herring and cod in the North Sea"

1200-1220 **Rijnsdorp, A. D.,** van Damme, C. M. and Witthames, P. R.
"Implications of fisheries-induced impacts on the stock structure and reproductive potential on stock-recovery of a sexual dimorphic species, North Sea plaice"

1230-1330 **Lunch**

Theme session 1 continued

1330-1350 **Lambert, Y.**
"Variations in the life history traits and intrinsic rate of population growth of cod in the northern Gulf of St. Lawrence and their impact on the rebuilding capacity of the population"

1350-1410 Opdal, A. F. and **Vikebø, F.**
"Disentangling the cost-benefit hypothesis of long distance spawning migrations in the Northeast Arctic cod"

1410-1430 **Krysov, A.**
"Reproductive capacity of the Norwegian spring spawning herring in the period of global stock change"

1430-1450 **Voss, R.,** Köster, F. W., Schmidt, J. O., Peck, M. A., Möllmann, C., Kraus, G., Stepputtis, D., and Hinrichsen, H.-H.
"Yes, we can – the successful recovery of the Baltic sprat stock"

1500-1530 **Coffee break**

Theme session 1 continued

1530-1550 **Brunel, T.**
"Influence on the age composition of the spawning stock on recruitment: a meta-analysis"

1550-1610 **Huret, M.,** Petitgas, P., Grellier, P., and Bourriau, P.
"The space-time variability of anchovy larval survival in the Bay of Biscay using a biophysical model"

1610-1630 **Petitgas, P.,** Secor, D., McQuinn, I., Huse, G., and Lo, N.
"What is a collapsed stock? Mechanisms that sustain life cycle closure in space and time"

1630-1650 Enberg, K. S., Jørgensen, C., Dunlop, E. S., **Heino, M.,** and Dieckmann, U.
"Implications of fisheries-induced evolution for stock rebuilding and recovery"

Wednesday, November 4th 2009

Theme Session 2: Trophic controls on stock recovery
Chaired by Axel Temming (Germany) and Bjarte Bogstad (Norway)

0830-0900 **Session keynote**
Temming, A., Kempf, A., Flöter, J., and Vinther, M.
"Recovering stocks of predators: what can managers learn from multi-species models?"

0900-0920 **Andersen, K. H.** and Rice, J.
"Indirect effects of recovery strategies"

0920-0940 **Andonegi, E.,** Quincoces, I., Howell, D., and Stefansson, G.
"A multi-species model in the Bay of Biscay using Gadget: implementing European hake and anchovy relationships"

0940-1000 **Cerviño, S.,** Howell, D., Velasco, F., Preciado, I., Olaso, I., Punzón, A., Jardim, E., and Cardador, F.
"Assessing the importance of cannibalism for recovery plan in Southern hake using age-length structured model"

1000-1020 **Filin,** A.
"Simulation of capelin impact on cod stock recovery rate in the Barents Sea"

1030-1100 **Coffee break**

Theme session 2 continued

1100-1120 **Kempf, A.,** Huse, G., Dingsør, G., Floeter, J., Temming, A., and Vinther, M.
"The importance of overlap – predicting North Sea cod recovery with a multi-species fisheries assessment model"

1120-1140 **Neuenfeldt, S.** and Köster, F. W.
"Baltic cod cannibalism: Differing consequences at stock recovery versus the historic situation of cod decline?"

1140-1200 Schweigert, J. F., Flostrand, L., and **Cleary, J. S.**
"Factors affecting recovery of Pacific herring stocks in Canada"

1200-1220 **O'Boyle, B.** and Sinclair, M.
"Cod-Seal interactions on Eastern Scotian Shelf: Consideration of modelling assumptions"

1220-1240 **Dolgov, A. V.**
"Influence of intraspecific and interspecific food competition on ability of the Barents Sea cod stock to recover"

1245-1345 **Lunch**

Wednesday, November 4th 2009 continued

Theme Session 3: Methods for analysing and modelling stock recovery
Chaired by Ana M. Parma (Argentina) and Laurence T. Kell (Spain)

1345-1415   **Session keynote**
Parma, A. M.
"The design of a rebuilding strategy for Southern Bluefin Tuna: from theory to practice"

1415-1435   **Eero, M.**, Jarre, A., Ojaveer, H., Tomczak, M. T., Lindegren, M., and Köster, F. W.
"An ecosystem-based framework for tracking performance of fish stocks and related forcings using fuzzy-logic approach"

1435-1455   **Cleary, J. S.** and Schweigert, J. F.
"Harvest control rules for Pacific herring management: business as usual or in need of repair?"

1455-1515   **Gårdmark, A.,** Möllmann, C., Neuenfeldt, S., Blenckner, T., Lindegren, M., Aro, E., Bastardie, F., Heikinheimo, O., Müller-Karulis, B., Niiranen, S., Tomczak, M. A., van Leeuwen, A., and Wikström, A.
"Biological Ensemble Modeling of the Eastern Baltic cod future"

1515-1535   **Hinrichsen, H.-H.**, Dickey-Collas, M., Huret, M., Peck, M. A., and Vikebø, F.
"Evaluating the suitability of coupled bio-physical models for the development of recovery plans of collapsed fish populations"

1545-1615   **Coffee break**

Theme Session 3 continued

1615-1635   **Howell, D**. and Bogstad, B.
"Assessing the likely consequences of differing management rules and environmental factors in the Barents Sea using a multispecies Gadget operational model"

1635-1655   **Hurtado-Ferro, F.** and Shirakihara, K.
"Could a different management approach recover the Japanese sardine stock from depletion?"

1655-1715   **Juan-Jorda, M. J.,** Mosqueira, I., and Freire, J.
"Fishing impacts on biomass and mean body size of Scombrid populations on a global scale"

1715-1735   **Kraus, G.,** Karasiova, E. M., Voss, R., Köster, F. W., Bleil, M., and Oeberst, R.
"Egg production methods as a fishery independent alternative to assess the Eastern Baltic cod stock"

1735-1755   Vermard, Y., **Lehuta, S.**, Mahévas, S., Thébaud, O., Marchal, P., and Gascuel, D.
"Combining fleet dynamics and population dynamics for a volatile fishery: the example of the anchovy fishery of the Bay of Biscay"

1900-2200   **Poster session**

Thursday, November 5th 2009

Theme Session 4: Social and economic aspects of fisheries management and governance
Chaired by Denis Bailly (France) and Douglas C. Wilson (Denmark)

0830-0900   **Session keynote**
Bailly, D.
"Pathways for a knowledge based governance in fisheries"

0900-0920   **Delaney, A. E.**
"Who would have thought it would come to this? Social impact assessments and community sustainability in North Sea fishing communities"

0920-0940   Järvik, A., **Raid, T.,** Järv, L., and Sadul, J.-V.
"The social aspects of overexploitation of fish resources on small-scale fishery: ways of mitigation the effects on coastal communities"

0940-1000   **Da-Rocha, J.-M.**, Cerviño, S., Fernandez, C. and Gutierrez, M. J.
"The Economic Assessment of the Southern hake recovery plan"

1030-1100   **Coffee break**

Theme session 4 continued

1100-1120   **Dankel, D. J.,** Heino, M., and Dieckmann, U.
"Can integrated assessments reconcile stakeholder conflicts of interest in marine fisheries management?"

1120-1140   **Strehlow, H. V.**
"What's Next? One Year after the Implementation of the Cod Recovery Plan in the Baltic Sea"

1140-1200   **Garcia, D.** and Prellezo, R.
"Fleet reaction to management advice, a key process for success of management plans"

1200-1220   Cox, A. and **Khwaja, S.**
"Rebuilding fisheries: An overview of policy approaches in the OECD"

1220-1240   **Wilson, D. C.** and Becker Jacobsen, R.
"Governance Issues around Recovery plans in a Mixed Fisheries Context"

1250-1350   **Lunch**

Thursday, November 5th 2009 continued

Theme Session 5: Management & Recovery strategies
Chaired by Joseph E. Powers (USA) and Fritz W. Köster (Denmark)

1350-1420 Session keynote
Powers, J. E. and Hedges Monk, M.
"Recovery strategies: science, enforcement and allocation"

1420-1440 Dankel, D. J., Jacobson, N., Georgianna, D., and Cadrin, S. X.
"Facilitating policy analysis of different gear types: Can we increase haddock yield within the constraints of the Magnuson-Stevens Act?"

1440-1500 Holt, C.
"Will depleted populations recovery under Canada's Wild Salmon Policy? An evaluation of benchmarks for assessing biological status"

1500-1520 Brodie, W. B. and Walsh, S. J.
"Evaluation of the Recovery of theYellowtail Flounder Stock on the Grand Bank"

1520-1540 DiCosimo, J. and Methot, R. A.
"Use of Annual Catch Limits to Avoid Depleting Fish Stocks in U.S. Fisheries"

1545-1615 Coffee break

Theme session 5 continued

1615-1635 Dickey-Collas, M., Nash, R. D. M., Brunel, T., van Damme, C. J. G., Marshall, C. T., Payne, M. R., Corten, A., Geffen, A. J., Peck, M. A., Hatfield, E. M. C, Hintzen, N., Enberg, K., Kell, L., and Simmonds, J.
"What can we learn from the stock collapse and recovery of North Sea herring? A review"

1635-1655 Aps, R. and Lassen, H.
"Three decades of the Baltic fisheries management – lessons learned"

1655-1715 Kruse, G. H., Zheng, J., and Stram, D. L.
"Recovery of the Bristol Bay Stock of Red King Crabs under a Rebuilding Plan"

1715-1735 Bastardie, F., Vinther, M., Nielsen, J. R., Ulrich, C., and Storr Paulsen, M.
"Evaluation of the multiannual plan for the cod stocks in the Baltic Sea"

1735-1755 Hammer, C., von Dorrien, C., Hopkins, C. C. E., Köster, F. W., Neuenfeldt, S., St. John, M. A., and Wilson, D. C.
"UNCOVER: Fish Stock Recovery Strategies – Lessons learned in the Baltic Sea"

1930-2230 Symposium dinner at Bootshalle

Friday, November 6th 2009

0830-1300   Panel discussion

0830-0845   Introduction of panelists

0845-0855   Summary theme session 1 by Toyomitsu Horii
0855-0920   Discussion panel
0920-0930   Comments & questions audience

0930-0935   Summary theme session 2 by Axel Temming
0935-1000   Discussion panel
1000-1010   Comments & questions audience

1010-1015   Summary theme session 3 by Ana M. Parma
1015-1140   Discussion panel
1040-1050   Comments & questions audience

1050-1115   Coffee break

Panel discussion continued

1115-1120   Summary theme session 4 by Denis Bailly
1120-1145   Discussion panel
1145-1155   Comments & questions audience

1155-1200   Summary theme session 5 by Joseph E. Powers
1200-1225   Discussion panel
1225-1235   Comments & questions audience

1235-1250   Key take home messages from the symposium, by Steven Murawski

1300   Closing of the symposium

Abstracts of keynote talks

(*Corresponding author,* **presenting author**)

Main symposium keynote

 "Rebuilding depleted fish stocks: The good, the bad and the mostly ugly"

Steven Murawski

National Marine Fisheries Service
1315 East West Highway, Silver Spring, Maryland, 20910 USA
Steve.Murawski@noaa.gov

Tuesday, November 3rd 2009, 0900-1000

Recovery of depleted fishery populations, world-wide, has been only partially successful. At the World Summit on Sustainable Development (WSSD) in 2002, governments committed to restore fish stocks to levels providing Maximum Sustainable Yield by 2015. Nevertheless, consistent standards for defining sustainable fishing, recovery goals, triggers for the adoption of rebuilding plans and, in fact, for when a stock has been "rebuilt" remain elusive. Recent history in fishery stock recovery provides a rich source of examples of rebuilding plans across a spectrum of execution. Those plans considered successful in meeting their stated objectives (the "good"), those that remain "paper plans" despite assertions to the contrary (the "bad"), and plans that have been partially to completely unsuccessful, despite significant management interventions (the "ugly"). A fourth category of plans is those for which it is too early to categorize them (the "incomplete").

Successful rebuilding plans share critical attributes of a consistent definition of plan objectives, determined in an open and transparent process, occurring over finite time scales, and supported by the industries, political leadership and the public. They incorporate credible and consistent scientific monitoring of progress. Many incorporate fishers into the science process.

"Bad" recovery plans often allow stocks to continue to decline; in extreme cases resulting in calls for the use of non-fishery control statutes, such as protected resource agreements and legislation and international trade control agreements, when traditional fishery management mechanisms are ineffective in stock rebuilding.

By far the most enigmatic rebuilding programs are those for which management interventions have occurred (e.g., significant reductions in fishing mortality and therefore *should* represent the "good"), but for which the stocks have either not responded or are tracking up at rates lower than projected at the onset of rebuilding programs.   Many explanations have been offered for the delayed or non-existent recovery of these stocks, including depensatory natural mortality rates, predator "pits", conspiratorial climate effects, loss of evolutionary resilience, multispecies effects, and the inability to quickly recover complex life-cycles determined by species co-evolution, migration patterns and demography. When science is ambiguous (e.g., in cases where sampling variability is high or where retrospective biases occur) it is difficult to link incremental rebuilding progress to management measures, eroding the credibility of the recovery plan process. Stakeholders

have come to expect virtually instantaneous positive feedback in stock rebuilding, often encouraged by optimistic scientific projections of stock rebuilding that do not take appropriate time lags into account.

Management measures incorporated into recovery plans include, in the extreme, complete or significant moratoria on fishing. Lesser rebuilding mechanisms can include lower overall total allowable catches (TACs), reduced effort, closed areas, and introduction of gear mitigation. Most successful rebuilding programs incorporate significant, measurable reductions in fishing mortality at the onset of the program, rather than relying on incremental small reductions over time, which can be compensated for by "technology creep". Unsuccessful plans often rely on back-loaded "balloon payments" or larger reductions in fishing mortality rates later in the rebuilding schedule. Property rights schemes (e.g., "catch share" programs) have shown promise in helping to attain biological stock rebuilding goals and provide a pathway to assure that the cycle of stock decline does not repeat once stocks are rebuilt. Social and economic considerations are not usually incorporated directly into rebuilding schemes, but these issues will take on added importance as society addresses the large number of stocks requiring rebuilding, with the obvious short-term dislocations in favor of long term sustainability.

A particularly vexing issue in rebuilding is the differential pace of stock recovery among productive and relatively unproductive components of mixed species fisheries. If "weak stock" management and recovery schemes are used this may leave recovered components underfished while less productive ones recover, due to bycatch concerns. These situations may undermine the validity of the recovery program with stakeholders.

Many of the prominent examples of "good" plans are for essentially single-species fisheries. However, it is clear that if we are to recover the majority of stocks classified world-wide as "overfished", it will take a more holistic, adaptive and ecosystem-based approach to fishery recovery that incorporates trophodynamics, habitat restoration, and climate effects, and is sensitive to life history and previous impacts of fisheries on stock resilience. A new, more consistent, effective and politically supported recovery paradigm is necessary if society is to meet its articulated sustainability goals for fisheries.

Keynote talk Theme Session 1: Impact of Fisheries and Environmental Impacts on Stock Structure, Reproductive Potential and Recruitment Dynamics

"Impacts of fisheries and regime shift on fluctuations of finfish and shellfish stocks in Japan"

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Tuesday, November 3rd 2009, 1030-1100

The Kuroshio/Oyashio current system provides rich habitats for many marine animals and fishing grounds around the northern Pacific Ocean off Japan. This system is greatly affected by climatic regime shifts. Two examples will be presented in order to highlight the importance of the "regime concept" and adaptive management. The first example shows how the 1988/89 climatic regime shift affected the Japanese sardine *Sardinops melanostictus*, and subsequently prevented recovery of chub mackerel *Scomber japonicus* through the growth of excess fishing capacity due to extremely reduced sardine productivity. The "regime concept" of fishery management includes 1) regime-dependent fishing rates with a time-lag after the year of regime shift, 2) target switching, 3) conservation of biodiversity and 4) precautionary approach. The second example is for a local stock of abalone *Haliotis spp.* The stock enhancement projects on abalone by means of reseeding have been implemented in the last 30 years. However, the catches have decreased rapidly since 1970s, and not started increasing. The causes of the steep decline were assumed to be the both of over-exploitation and changes in marine environmental conditions. These examples suggested that the precautionary approach is essential to prevent fishery resources from being depleted.

Keywords: Regime shift, Japanese sardine, chub mackerel, abalone

"Recovering stocks of predators: what can managers learn from multi-species models?"

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Wednesday, November 4th 2009, 0830-0900

The study summarises the current understanding of multi-species interactions based on the multi-decadal runs with multi-species models describing the historic changes in fished predator prey systems in different UNCOVER case study areas. This analysis serves as foundation to our expectations of the effects of recovering predator stocks. The analysis will focus on the effects of improvements and extensions of the North Sea data base that were introduced over time to illustrate the sensitivity of model predictions to limitations in the underlying data and concepts. The recent addition of new predator species, for which no analytical assessments are conducted, has substantially changed our perception of the food web changes that followed the decline of traditional predator species. Instead of a simple fishing down the food web, a partial refilling of ecological niches has been observed with new predators such as grey gurnard and horse mackerel.

An analysis of diet selection and size preference of predators reveals that in spite of a clear preference for larger prey the dominant prey of most predator size groups is small 0-group fish. This leads to a situation where two predator levels rely partly on the same small prey and in case of a recovery of the top predator the effects on the lowest trophic level are less dramatic. This can be contrasted with the Baltic Sea, with essentially only two trophic levels, the effects of a predator recovery are more pronounced and direct, as well as in Iberian waters were hake cannibalism is a key process influencing recovery.

The study concludes with an outlook into the applicability of the MSY approach in a multi species context.

Keynote talk Theme Session 3: Methods for analysing and modelling stock recovery

"The design of a rebuilding strategy for southern bluefin tuna: from theory to practice"

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Wednesday, November 4th 2009, 1345-1415

Although the severe depletion of the southern bluefin tuna stock was long recognized and a rebuilding target was established by the Commission for the Conservation of Southern Bluefin Tuna in 1994, no agreement about quotas could be reached for many years. A plan to design a management procedure was finally initiated in 2002, which involved scientists from member countries proposing and simulation-testing decision rules using software developed by the Scientific Committee. The process shifted attention away from inconclusive arguments about abundance estimates towards discussion of testing protocols, uncertainty axes to explore in stock projections, plausibility of alternative hypotheses, and trade-offs between robustness and optimality in the selection process. Candidate decision rules were tuned to achieve a range of rebuilding levels to facilitate comparisons. The philosophy was that the Scientific Committee would evaluate consequences of alternative rules, and the Commission would define the operational goals to be achieved. In practice, several iterations were needed to present management choices in terms of attainable goals and trade-offs. A consensus recommendation was made in 2005 which called for an immediate reduction of catches followed by adoption of a management procedure with an associated high probability of stock rebuilding. The first substantial quota cut in many years was taken, but the management procedure was not implemented because substantial underreporting of historical catches became apparent, which warranted reexamination of the models. Lessons learned should facilitate the next round of simulation-testing, which is about to start. The main difficulties remain in the need to have reliable indicators of stock trends to drive decision rules.

Keywords: management procedures, management strategy evaluation, bluefin tuna

Keynote talk Theme Session 4: Social and economic aspects of fisheries management and governance

"Pathways for a knowledge based governance in fisheries"

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Thursday, November 5th 2009, 0830-0900

Fisheries will forever be a text book case for the commons. Whatever degree of administered management or individual tradable rights is developed, complex interdependencies calls for building up deliberative scenes. Forcing in fisheries management environmental concerns, dealing with logics in human decisions as different as they are in commercial and recreational fisheries, will even add more to already complex interactions between social and ecological components of fisheries systems.

Though avoiding change is often considered as highly desirable in the society, evolution is induced at different scales by strong external forcing or by difficult to predict outcomes of internal interactions. Events like collapse of stocks or more complex phase shifts in ecosystems are preferably to be addressed in an adaptive manner either as anticipatory or ex-post adaptation. But due consideration should also be given to the unlikelyness of social and ecological system to come back to past state when economic opportunities and social constructs have been harshly shocked. So when collectively exploring the future, the associated social process must be very inclusive and allow for a very open exploratory state of mind.

Getting collective decision made and implemented requires a great deal of human intelligence gathering. And ensuring high quality and efficient communication among the players of fisheries "drama of the commons" is an important goal. Present state of highly unbalanced and segmented organization of research contribution, the confusion between scientific production and delivery of management support service, the often lacking mutual trust between fishermen, their organization, the fisheries administration and the research is not at the level of the challenges in the fisheries. This is despite the fact that consultative and advisory forums have multiplied and that efforts to produce information and time spent in meetings is at the point of exhausting available resources. Pathways to better harness all sources of knowledge to policy process are discussed here.

"Recovery strategies: science, enforcement and allocation"

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Thursday, November 5th 2009, 1350-1420

Reversing the spiral of overfishing requires management strategies that are robust to scientific uncertainties, to imprecision in implementing and monitoring those strategies and to the institutional dynamics of the management process. Experience suggests that success or failure of recovery is contingent upon each of these factors and the interactions between them. Heretofore, emphasis has centered on development of management strategy evaluations (MSEs), control rules and adaptive management procedures, focusing on the assessment, scientific advice and data uncertainty. However, compliance issues, allocation and management structures are often as important, or more so. We examine specific case histories of both successful and unsuccessful recoveries with respect to science, enforcement and allocation to provide a perspective on the design of recovery strategies. Additionally, simple game-theoretic simulations are presented depicting negotiation of allocation shares between sectors (e.g. gears, nations, recreational versus commercial) and imprecise compliance and monitoring for specified control rules and their effect on recovery trajectories. Results of the model and of the case histories suggest that an important requirement for successful recovery is stable allocations. Guidelines for addressing successful recoveries are suggested.

Keywords: allocation, game theory, recovery strategies, management strategy evaluation

Abstracts oral presentations

(*Corresponding author, **presenting author**)

"Indirect effects of recovery strategies"

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Wednesday, November 4th 2009, 0900-0920 in theme session 2

For a higher organism to grow another organism has to die. This obvious and fundamental relation means that if one species group increases in abundance, the prey species will suffer increased mortality. One the other hand, the predators of said species will have a more abundant food supply. Size-based models of fish communities indicate that these relationships have lawful dynamics that continue to be expressed, even when individual species become rarer - as predators or as prey. An ecosystem based management recovery strategies of a given species or group of species should therefore not be seen in isolation, but the expected consequences for the rest of the ecosystem must be analyzed. We use a general size- and trait-based model to calculate the ecosystem effects of fishing and recovery. We present a general analysis of a recovery strategies targeting either large fishes (consumer fishery), small fishes (forage fish fishery), or the ecosystem as a whole. We calculate expected recovery time and demonstrate indirect effects on prey, predators and beyond, and provide some insight into the relative difficulty of selective rebuilding of populations of large or small fish.

"A multi-species model in the Bay of Biscay using Gadget: implementing European hake and anchovy relationships"

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Wednesday, November 4th 2009, 0920-0940 in theme session 2

In this study, an age-length-based statistical multi-species model is presented for European hake (*Merluccius merluccius,* L.) eating on European anchovy (*Engraulis encrasicolus,* L.) in the Bay of Biscay. The model is based on a well known modelling toolbox, Gadget (the Globally applicable Area Dissaggregated General Ecosystem Toolbox), and it covers ICES Divisions VIIIabd. The goal of this study is to test how the implementation of the predator

prey interactions between the cited species can contribute to the better knowledge of the stock dynamics of each one in this area. Predictions simulating the current control rules are implemented for both species and the results are compared with those obtained by the corresponding Assessment Working Groups (ICES WGHMM and WGANC respectively). This study could be considered as one of the first steps to the introduction of the Ecosystem Approach to Fisheries in the area. The components of this particular ecosystem have been chosen following new studies of hake diet in the Bay of Biscay and the relevance of both species in the economics and the cultures of the countries fishing in the area.

Keywords: Gadget, hake, anchovy, multi-species, length-based, statistical model, Bay of Biscay.

"Three decades of the Baltic fisheries management – lessons learned"

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Thursday, November 5th 2009, 1635-1655 in theme session 5

This paper reviews the development of the Baltic fisheries management framework (IBSFC, BS RAC, EC–Russia agreements) and the measures aimed at the sustainable use and conservation of the Baltic shared fishery resources for the period of 1974-2008. The paper relates stock status for herring, sprat, cod and salmon over the period to the management initiatives and to the scientific advice. Special attention is paid to the development and implementation of the 1) Baltic Salmon Action Plan, Long-Term Objectives, Medium and Short-Term Strategies for the Baltic Salmon (1997), 2) Long-Term Management Strategy for Cod Stocks in the Baltic Sea (1999) and the Recovery Plan for Baltic cod (2001), and EC initiative in more recent years 3) Long-Term Management Strategy for the Sprat Stock in the Baltic Sea (2000), and 4) Long-term objectives and strategies for the management of Baltic herring (2000-2002). Management after 2004 is based on bilateral negotiations between EC and Russia with EC being the dominating partner taking 85 - 95 % of the total catch. Management is therefore dominated by EU initiatives and the paper reflects on the EC proposals for in particular cod management plans that have been put forward in recent years and their implementation.

Key words: Baltic Sea, long-term fisheries management strategy, fisheries management plan, stock recovery plan

"Evaluation of the multiannual plan for the cod stocks in the Baltic Sea"

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Thursday, November 5th 2009, 1715-1755 in theme session 5

The recently agreed EU multi-annual plan for the Baltic cod stock recovery is evaluated. This plan combines harvest control rules with direct effort reduction. Performance and robustness of the plan are tested with a Management Strategy Evaluation tool (MSE) using the FLR library. Stochastic simulations were carried out under different scenarios of recruitment and sources of uncertainties. The results demonstrated that the plan is likely to reach its targets for both the Eastern and the Western cod stocks in its current design and under the magnitude of errors investigated as long as (i) the current settings of the assessment model are maintained, (ii) the effort reduction is fully complied with, and (iii) biological parameters are assumed stationary. The plan is however more sensitive to the implementation error and bias than to the observation error. For the Eastern stock, uncertainties from fishery adaptation to the plan are further tested using a fleet-based and spatially explicit version of the model in parallel. These additional sources of uncertainties led to a slower reduction in F, but did not significantly affect the robustness of the plan. Simulations without the TAC system demonstrated that the effort control is more efficient when supplemented by the TAC avoiding side effects from fishery response. The medium-term economic evaluation of the fishery revealed that, if the profit was initially reduced along the effort and quota reductions, all the main fleet segments were still able to meet their costs

Keywords: Baltic, Bio-economic model, cod, Fishery Library in R (FLR); Harvest Control Rules (HCR); Management Strategy Evaluation (MSE)

"Evaluation of the Recovery of the Yellowtail Flounder Stock on the Grand Bank"

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Thursday, November 5th 2009, 1500-1520 in theme session 5

In 1994, biomass of yellowtail flounder (*Limanda ferruginea*) on the Grand Bank had declined to 20% of B_{MSY}, diminished by overfishing in the 1980's. Canada stopped its directed fisheries, and a fishery moratorium for this stock and several others in the area, was declared by the NAFO Fisheries Commission.
After 4 years of moratorium, biomass had quadrupled. The fishery re-opened in August, 1998 and biomass continued to increase, to presently about 8 times the 1994 value, well above B_{MSY}. TACs set by NAFO increased steadily from 4,000 tons in 1998, to 17,000 tons for 2009.   NAFO Scientific Council has provided recent advice using a precautionary

approach framework, and Fisheries Commission has set TACs corresponding to fishing mortality at $2/3F_{MSY}$.

When the fishery reopened, Canada, within its 200-mile Exclusive Economic Zone, and NAFO, outside the Canadian EEZ (NAFO Regulatory Area - NRA), introduced several measures to ensure continued stock recovery. These included several technical measures to reduce fishing mortality. New scientific studies were also initiated.

Yellowtail is the only collapsed Grand Bank stock which has fully recovered to date. This paper provides evaluation of some measures used to promote the recovery of this stock, and compares yellowtail to some Grand Bank stocks which have not recovered. Key measures include elimination of non-NAFO fishing in the NRA, protection of strong year classes recruited in the 1990's, and maintenance of fishing mortality around $2/3F_{MSY}$.

Keywords: biomass, evaluation, Grand Bank, moratorium, recovery, yellowtail flounder

"Influence on the age composition of the spawning stock on recruitment: a meta-analysis"

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Tuesday, November 3rd 2009, 1530-1550 in theme session 1

In exploited fish stocks, particularly those that went through collapse and recovery events, changes in the age structure take place along with the variations in stock size. Though spawning stock age structure is determinant for recruitment in some stocks, evidence also suggests that it is not an universal rule. This study investigated how common age structure effects on recruitment are among 39 Northeast Atlantic stocks. I tested whether decreasing spawners mean age or age diversity 1) reduces recruits number, 2) increases the sensitivity of recruitment to environment, 3) increases recruitment variability. The expected relationships were observed for some stocks, but not for the majority and in some cases the opposite relationship was found. Meta-analyses combining the stock-level tests indicated that none of the three effects was significant overall. There were however some species specific cases (for cod, haddock and plaice) where these effects were significant. I conclude that the effects of age structure on recruitment are not wide-spread, even if they are observed in a minority of cases for which they should be taken into account when studying the stocks dynamics.

Keywords: recruitment, stock demographic structure, variability, temperature effect, maternal effects, reproductive potential

"Assessing the importance of cannibalism for recovery plan in Southern hake using age-length structured model"

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Wednesday, November 4th 2009, 0940-1000 in theme session 2

Available stomach data suggests that cannibalism in Southern hake averages 5% of the diet. This, combined with the hake's high energetic requirements, make cannibalism a significant source of mortality on younger hake. It is therefore important that the impact of cannibalism on the outcome of current management plans be evaluated. This study presents an analysis of a Southern hake "Gadget" model with cannibalism. Southern hake is a depleted stock which has been managed with a recovery plan since 2006. The plan implements an annual 10% F reduction aiming to get 35 000 tonnes of SSB by 2015. This work aims to understand how the inclusion of cannibalism into the model changes our perception about the consequences of different management options. Uncertainty about hake growth is also taken into account. An initial model without cannibalism was developed for comparative purposes. This was extended to incorporate cannibalism and was fit estimating abundances and mortalities able to satisfy hake predation requirements. Model results show that cannibalism is an important source of natural mortality for young age classes (ages 0 and 1). Total hake consumed varies during the model time series (1990-2007) representing an important proportion of total catches. The incorporation of cannibalism into the assessment model gives a more pessimistic view about the SSB recovery possibilities and future yield of Southern hake in the medium and long term.

Keywords: age-length assessment models, cannibalism, recovery plans, Southern hake

"Harvest control rules for Pacific herring management: business as usual, or in need of repair?"

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Wednesday, November 4th 2009, 1435-1455 in theme session 3

Despite consistent application of a harvest control rule since 1986, abundance of three of the five Pacific herring (*Clupea pallasi*) stocks in Canada are currently below levels considered adequate for exploitation. Commercial fisheries have been closed on two of these stocks in 7 of the past 10 years as abundances are below commercial fishing thresholds defined at $0.25B_0$. An alternative harvest control rule was developed by Canada's precautionary fisheries management policy, which includes limit and upper stock reference points at $0.4B_{MSY}$ and $0.8B_{MSY}$. We developed a closed-loop simulation of the existing Pacific herring fishery management system to compare performance of the current harvest control rule to that developed by Canada's precautionary fisheries management policy in achieving

fishing and conservation objectives. Specifically, our simulations examine whether (a) realized fishery performance over the past 10 years should be expected, based on natural variation in herring biology, stock assessment, and fishing operations, or (b) such performance is unexpected and potentially indicates a failure of the current management system, and (c) if performance could be improved by adopting a harvest control rule based on limit reference points.

Keywords: closed-loop simulation, harvest control rule, Pacific herring, precautionary approach, reference points, stock recovery

"Rebuilding fisheries: An overview of policy approaches in the OECD"

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Fisheries Policy Division, OECD

Thursday, November 5th 2009, 1200-1220 in theme session 4

Pressure to take strong action to rebuild depleted fish stocks has been increasing over the past couple of decades at the international, regional and national policy levels. At the World Summit on Sustainable Development in 2002, governments around the world committed to an ambitious goal of rebuilding fish stocks. The Johannesburg Plan of Implementation specifically requires countries to "maintain or restore stocks to levels that can produce the maximum sustainable yield with the aim of achieving these goals for depleted stocks on an urgent basis and where possible not later than 2015."

However, convincing policy makers and fisheries stakeholders that it would be wise to undertake stock rebuilding is only a first step. Policy makers also need to know how to go about it in a cost efficient and effective way. Once a stock rebuilding target is determined on a biological basis, there are multiple potential paths: stock rebuilding can be achieved over different time periods, using different tools (quotas, time/area closures, gear restrictions, etc.), and under different institutional arrangements. Each path has a unique set of economic and social costs and benefits that need to be weighed in the historical, cultural and political context and fisheries settings of individual countries.

This paper provides an overview of some of the economic and institutional issues associated with stock rebuilding and provides an inventory of national policies and approaches to fisheries rebuilding programs in OECD countries and RFMOs to which OECD countries are parties. Specifically, the inventory includes information on the policy and legal framework that is used in each country to provide the institutional structure within which stock rebuilding programs are designed and implemented, as well as how countries conduct and then integrate economic information into planning and decision making processes.

"Can integrated assessments reconcile stakeholder conflicts of interest in marine fisheries management?"

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Thursday, November 5th 2009, 1100-1120 in theme session 4

The inherent conflicts between objectives in fisheries management (e.g. yield maximization vs. conservation interests) often create problems for managers, scientists and stakeholders. However, some seemingly contrasting objectives may be compatible (e.g. economic yield and ecosystem preservation) and could promote stakeholder consensus. The purpose of this study is to outline a quantitative approach to defining fisheries management objectives through stakeholder-specific utility functions. To achieve this, we link a biological model with a socio-economic model, both calibrated for a capelin fishery and a cod fishery. Second, we define multiple objectives in a quantified utility function for each stakeholder group. Finally, we conduct simulations that calculated the resulting stakeholder groups' utility for different levels of harvest and minimum sizes. Our different stock models allow us to examine the robustness of our results with the two contrasting fish life histories and fisheries. Our results illustrate that low harvest rates and minimum-size regulations that select for bigger fish represent a management consensus zone among five modeled stakeholders. We suggest a new route towards deriving appropriate management regimes with focus on compatible management goals to promote a new paradigm of stakeholder consensus in fishery management.

Keywords: fisheries management, stakeholders, stakeholder integration, utility functions, stakeholder preferences, population modeling, stakeholder consensus, management objectives, consensus building, ecosystem preservation

"Facilitating policy analysis of different gear types: Can we increase haddock yield within the constraints of the Magnuson-Stevens Act?"

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Thursday, November 5th 2009, 1420-1440 in theme session 5

Georges Bank haddock is a recently recovered fish stock in the New England groundfish fishery in the United States. Due to federal constraints under the Magnuson-Stevens Act, however, this stock cannot be optimally exploited due to the by-catch of other critical species in the New England groundfishery such as cod and yellowtail flounder which are overfished. The Ruhle trawl and Separator trawl are examples of recent advances in gear technology that have been shown to significantly increase haddock to by-catch ratios. This study models the groundfish fishery through a mixed stock yield model which incorporates technological interactions. We also develop a socio-economic model that quantifies the amount of employment and profit associated with three trawl types. Our results explore policy situations regarding the use of the new trawls. By bridging the biological and socio-economic models, we are able to view the fishery as a system that more accurately represents stakeholder views. Our model can aid policy makers in examining fishery gear trade-offs and the resulting biological and socio-economic consequences of different management actions within the constraints of the Magnuson-Stevens Act.

Keywords: multi-species, Georges Bank, groundfish, technological interactions, Ruhle trawl, Separator trawl, fisheries policy options, stakeholder views

"The Economic Assessment of the Southern hake recovery plan"

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Thursday, November 5th 2009, 0940-1000 in theme session 4

In this work we evaluate the economic consequences of the southern hake recovery plan. Economic projections performed follow stochastic age structured dynamics taking discards into account. Two projection periods were considered: from the present time to the recovery plan deadline (2015) and after 2015. Optimal control techniques were used to estimate fishing mortality (or fishing effort) paths in order to reach the recovery plan goals by 2015. We compare four different performance measures which correspond to maximizing: i) the net present landings, ii) the net present value of landings, iii) the net present added value and iv) the net present profits. After 2015, we compare these 4 performance measures if fishing were to continue at the mortality rates reached in 2015. Our preliminary results suggest that: (i) there is a high probability of achieving the recovery plan goals; (ii) fishing mortality economic reference points are sensitive to the performance measure chosen; (iii) whereas continuing fishing at F=0.27 (recovery plan target) after 2015 maximizes the net present value of landings, maximization of net present profits is achieved with a lower F value.

Keywords: Southern Hake recovery plan, economic assessment, control in age-structured models, fishery management optimization

"Who would have thought it would come to this?" Social impact assessments and community sustainability in North Sea fishing communities

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Thursday, November 5th 2009, 0900-0920 in theme session 4

European fishing communities have witnessed dramatic changes in the last several decades: the restructuring of European commercial fishing has expanded to the point that many small communities and ports are no long viable.   The implementation of stock recovery plans and expanded restructuring plans have compounded the challenges these communities face. These management plans have been made in an attempt to improve the sustainability of commercial fishery stocks.   In Europe, decision-making of fisheries resources are taken through the directive of Common Fisheries Policy (CFP).   This policy does call for the sustainable exploitation of stocks. Yet, the CFP mandates not only an obligation to ensure the exploitation of living aquatic resources that provides sustainable environmental conditions, but also sustainable economic and social conditions, as well.

This paper presents data on how North Sea individuals and communities have been affected by the limitations imposed by stock recovery plans and management measures.   This includes focusing on the social connectedness of individuals in fishing communities and a community-oriented perspective on resource rights and governance of fisheries in the North Sea.

"What can we learn from the stock collapse and recovery of North Sea herring?
A review"

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Thursday, November 5th 2009, 1615-1635 in theme session 5

The collapse and recovery of North Sea herring in the latter half of the twentieth century has been well documented. With hindsight and the benefit of almost 40 years of extra data and studies, we can now obtain a clear view of the impact of the collapse and the recovery on the stock, the fishery, and the North Sea system. The study will review the changes in

productivity in terms of growth, maturity, natural mortality and recruitment and the changes in distribution and demography of the stock associated with the collapse and recovery. It will also comment on the impact on the genetic makeup of the stock and potential consequences for fisheries induced change. This will then be considered in the context of the ecosystem as a whole and how the fisheries were affected. A final synthesis section first will look at how we can take these issues into management of North Sea herring, via projections and advice and secondly highlight the relevant lessons for the management of other fish stocks and other marine shelf ecosystems.

Keywords: herring, North Sea, collapse, recovery strategies, management, productivity, distribution

"Use of Annual Catch Limits to Avoid Depleting Fish Stocks in U.S. Fisheries"

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Regional fishery management councils have taken significant steps toward ending overfishing and rebuilding stocks. Seven fish stocks were removed from the overfishing list in 2007. However, 41 fish stocks in U.S. ocean waters continue to be fished at unsustainable levels. In 2007 the U.S. Congress required that all fishery management plans set annual catch limits so that overfishing no longer occurs in federal fisheries. Within two years of when it is notified that an "overfished" or "approaching overfished" stock status is determined, a council must prepare and implement management measures to immediately end overfishing and rebuild affected stocks. Annual catch limits must be implemented in 2010 for fisheries subject to overfishing and 2011 for all other fisheries. Each council may not set an annual catch limit above the recommendation of its scientific and statistical committee.
More than fifty managed fish stocks and assemblages in the Northeast Pacific have been sustainably managed through the use of annual catch limits. The North Pacific Fishery Management Council is considering new approaches to: 1) control rules on setting Allowable Biological Catch levels that are responsive to the degree of uncertainty in its stock assessments and 2) placing low vulnerable stocks in an ecosystem component.

Keywords: Alaska federal fisheries, catch limits, overfishing

"Spatial distribution and population dynamics of herring and cod in the North Sea"

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The spatial and population dynamics of fish populations are typically linked. We here show how the spatial distribution and migrations of North Sea herring and cod vary with different abundance levels. In addition to center of mass and distribution ranges, we have constructed geostatistical aggregation curves that give additional information about the relationships between distribution, abundance, and aggregation. For both stocks we found strong correlation between abundance and area occupied. For cod there was also a strong correlation between area occupied and recruitment, and a similar relationship was seen between cod abundance and recruitment. Due to the dependence between area occupied and abundance, we tried to disentangle these effects on recruitment, but were unable to do so. It therefore seems likely that the correlation between spatial distribution and recruitment is mainly an effect of abundance. This is an important result with regards to rebuilding these fish stocks, as it suggests that it will be sufficient to focus on abundance rather than spatial distribution when designing recovery plans.

Keywords: Gadus morhua, Clupea harengus, spatial distribution, geostatistics

"Influence of intraspecific and interspecific food competition on ability of the Barents Sea cod stock to recover"

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Influence of diet and fish community structure on ability of the Barents Sea cod stock to recover is considered. Data on food composition of the Barents Sea cod and some other most abundant fish species (haddock, saithe, Greenland halibut etc.) during of 1984-2007 and data on distribution and catches of various fish species during 1998-2007 were used for such analysis. It is shown that intraspecific food competition is more important then interspecific competition for the Barents Sea cod. As a result, the structure of the Barents Sea fish community provides more comfortable conditions for fast and safe recovery for cod stock recovery even after its possible depletion compared to other areas of North Atlantic.

Keywords: Barents Sea, cod, food competition, stock recovery, fish community

"An ecosystem-based framework for tracking performance of fish stocks and related forcings using fuzzy-logic approach"

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Wednesday, November 4th 2009, 1415-1435 in theme session 3

Marine fish stock dynamics are influenced by combinations of ecological interactions, environment-driven processes, and exploitation. Designing an effective rebuilding strategy for depleted fish stocks requires that the multiple factors responsible for a given state of fish stocks are generally understood and agreed between decision-makers and stakeholders. Indicators related to ecosystem state and the pressures affecting it can support the decision making process by tracking progress towards meeting fisheries management objectives and by communicating trends in complex impacts to stakeholders.

In this paper, we develop an ecosystem-based framework for integrating information from ecological/biological, environmental and fisheries indicators, relevant for the development of the three main commercial fish species in the central Baltic Sea, i. e. cod, herring and sprat. The framework is based on fuzzy logic approach and provides an intuitive way to monitor and illustrate the long-term development of fish stocks in relation to the agreed management objectives, i.e. the desired state of the stocks. Most importantly, it visualizes which natural or fisheries related factors have prevented the desired developments in the stocks or promoted it at different time periods, and allows the potential impact of future management actions on fish stocks to be easily communicated to a wider group of stakeholders.

Keywords: indicators, fuzzy-logic approach, management, Baltic Sea

"Implications of fisheries-induced evolution for stock rebuilding and recovery"

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The worldwide depletion of fish stocks has led fisheries managers to become increasingly concerned about stock rebuilding and recovery planning. To succeed, it is crucial to understand the factors affecting recovery dynamics, including the role of evolutionary changes resulting from harvesting. We use an individual-based evolutionary model parameterized for Atlantic cod *Gadus morhua* from its northern range, representative of long-lived, late-maturing species. The model allows for evolution of key life-history processes including maturation, reproduction, and growth. It also incorporates environmental variability, phenotypic plasticity, and density-dependent feedbacks. Our model analyses show that fisheries-induced evolution affects recovery in many ways. The first few decades of recovery were dominated by demographic and density-dependent processes, and biomass rebuilding was only lightly influenced by fisheries-induced evolution. In contrast, stock characteristics such as maturation age, spawning stock biomass, and recruitment were substantially affected, recovering to new demographic equilibria below their pre-harvest levels. This is because genetic traits took thousands of years to evolve back to pre-harvest levels, indicating that natural selection driving recovery of these traits is much weaker than fisheries-induced selection driving their deterioration. Our results strengthen the case for proactive management of fisheries-induced evolution, as the restoration of genetic traits altered by fishing is slow and may even be impractical.

Keywords: fisheries-induced evolution, recovery, rebuilding, probabilistic maturation reaction norm, maturation, reproductive investment, eco-genetic model, Gadus morhua

"Simulation of capelin impact on cod stock recovery rate in the Barents Sea"

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Capelin as the main prey for cod in the Barents Sea greatly affects cod stock dynamics through changes in its growth rate, cannibalism and maturity rate. However this is not

reflected in the harvest control rules for cod used currently. The evaluations of cod management strategies under different sceneries of capelin abundance in the Barents Sea are carried out using STOCOBAR model. This model is capable of modeling cod from age 1, and incorporating the effects of capelin on the cod stock dynamics. The work on the development of this model was part of the Barents Sea Case Study within the UNCOVER project.

The STOCOBAR simulations show that when capelin stock size is large, the cod population can sustain a more heavy fishing pressure. According to the model projections fishing mortality rate for cod, which corresponds to a maximum long-term yield, varies according to the scenario of capelin stock dynamics. Simulations also demonstrate that a depleted cod stock recovers more rapidly if capelin stock is large. Results of simulations analysis show that development of alternative management and recovery strategies for cod, which are sensitive to changes in capelin stock size, is needed.

Keywords: cod, capelin, model, cannibalism, management, recovery, Barents Sea

"Fleet reaction to management advice, a key process for success of management plans"

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Thursday, November 5th 2009, 1140-1200 in theme session 4

The results of Management Strategy Evaluation depend critically on the specification of the simulation model. To obtain realistic results the key processes, parameters and uncertainties of the system must be incorporated into the simulation. The implementation of the management advice is a key factor in the system. As little is known about the reaction of the fishery to the management advice, perfect implementation is usually assumed. This was the case in the Evaluation of Northern Hake Long Term management Plan carried out in 2007.

In this work the algorithm used in 2007 has been extended and the implementation of the advice is now explicitly simulated. Assuming that the fishery behaviour is driven by the maximization of the benefits, a private benefit function has been defined which incorporates the revenue, the variable and fixed costs and the fines. In each step the effort of the fishery corresponds with the effort that maximizes the private benefit function. The tool presented here can be used for the evaluation of Management Plans but also for the design of enforcement strategies. Different scenarios have been run to analyze the effect of enforcement in the fleet behaviour and hence in the recovery of the stock.

Keywords: Northern European Hake, management strategy evaluation, simulation, fleet behaviour, enforcement

"Biological Ensemble Modelling of the Eastern Baltic cod future"

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Wednesday, November 4th 2009, 1455-1515 in theme session 3

Predicting fish stock recovery fundamentally relies on mathematical models of population dynamics. The ecosystem-based approach to fisheries management further requires that management accounts for interactions among species and other ecosystem processes. Thus, diversity and complexity of models used for predicting fish stock responses to management have increased. Yet, the uncertainty associated with alternative model structures is rarely accounted for. Here we present the biological ensemble modelling approach (BEMA) to deal with such model uncertainty. Four single-species models, four multi-species models and one food-web model were used to investigate the response of Eastern Baltic cod (*Gadus morhua callarias*) to five alternative fisheries management scenarios. To test the robustness of these fishing levels, the nine models were further forced with the same climatic scenarios, assuming no climate change or a warmer and less saline future Baltic Sea. Although predictions differed also qualitatively between the models, the BEMA provided a means to (i) present the full range of projected stock responses, (ii) assess whether these also result in different conclusions on management, and (iii) draw general conclusions valid across all models used. Based on this example we will discuss how the BEMA can be used to further both fisheries management and fisheries science.

Keywords: ensemble modelling, food-web models, Baltic cod, stock recovery, fisheries management, climate change

"UNCOVER: Fish Stock Recovery Strategies – Lessons learned in the Baltic Sea"

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Many of the world's fisheries catches are in substantial decline due to overfishing, threatening not only the sustainability of the stocks and their associated ecosystems but also the social and economic sustainability of fishing communities, as well as the contribution of fisheries to human food supply. The European Commission recently recognized that 88% of European Union (EU) stocks are being fished beyond maximum sustainable yield (MSY), and 30% of these stocks are outside safe biological limits (SBL).

The UNCOVER project (2006-2010), funded under the EU's 6th research framework programme (FP6), aims to develop a rational scientific basis for developing recovery strategies for EU fish stocks that are outside SBL. The principle objectives of UNCOVER are to: 1) Identify various changes experienced during stock decline in order to understand the prospects of their recovery; 2) Enhance the scientific understanding of the mechanisms of fish stock recovery; and 3) Formulate recommendations for fisheries managers how best to implement successful stock recovery plans.

The recovery strategies developed in UNCOVER will be specific to four particular 'case study' areas (Barents Sea, North Sea, Baltic Sea, and Bay of Biscay), each with its own ecosystem, important fish species, and ways of fishing. The cases study areas represent ecosystems that vary significantly in structure and productivity due to differences in climatic influences, physical properties, species composition and species interactions. They encompass a wide range of physiological and population limiting conditions and processes, and they are subject to differing harvesting intensity and strategy and represent a broad array of socio-economic conditions.

In the current paper, we highlight and synthesize emerging UNCOVER results from the Baltic Sea, as a case study example, focusing particularly on the Eastern Baltic cod and sprat stocks.

Keywords: stock decline; recovery strategies; management strategies; Baltic Sea; cod, herring; sprat

"Evaluating the suitability of coupled bio-physical models for the development of recovery plans of collapsed fish populations"

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The development of recovery plans for collapsed stocks draws extensively from the "traditional" practices of stock assessments and projections that tend to assume that the past reflects what will happen in the future. However, the dynamics of collapsed and healthy stocks are likely different and climate-driven changes in the environment may influence the productivity of stocks and hence their ability to recover. Here, we assess the potential role of biophysical-models to aid management and projections of stock recovery. Particular attention has been paid to models that target European anchovy, Atlantic cod, herring and sprat. We first review knowledge gained from bio-physical models on processes impacting fish early life stage survival and recruitment. The strengths of current modeling approaches include the ability to estimate both spatial and temporal differences in the recruitment potential of larval cohorts. Our results demonstrate the applicability of coupled bio-physical models for predicting circulation patterns, temperature and prey fields within marine ecosystems and consequently, variability in early life stage drift, survival, settlement probability of juveniles as well as the connectivity within stocks. These are all factors that are not adequately addressed in standard projections of stock recovery. The influence of environmental variability on potential recruitment success can be discerned from model hind-casts. One of the main weaknesses of current modeling approaches is that future environmental variability remains unpredictable. Based on specific case study examples, we identify key products that operational models could provide managers who are charged with establishing viable stock recovery plans and adaptive management strategies.

Keywords: collapsed fish stocks, applicability of bio-physical models, early life stage survival, environmental variability, adaptive management strategies

"Will depleted populations recovery under Canada's Wild Salmon Policy? An evaluation of benchmarks for assessing biological status"

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The goal of Canada's Wild Salmon Policy (WSP) is to restore and maintain healthy and diverse salmon populations and their habitats. To achieve that goal, the WSP requires that biological status be assessed for all geographically, ecologically, and genetically distinct populations, or Conservation Units (CUs). Benchmarks delineate three zones of status (green, amber, and red), which reflect increasing probability of extinction and reduced biological production. The recovery of depleted populations (i.e., red zone) will depend on both the choice of the lower benchmark and the management action taken once it is crossed. At a minimum, that benchmark should be at a level high enough to allow recovery in an acceptable time frame in the absence of targeted fishing. Here, we compare the performance of limit reference points identified in Canada's Decision-Making Framework Incorporating the Precautionary Approach to benchmarks identified in the scientific literature in terms of achieving conservation objectives. We use a simulation modeling approach that incorporates uncertainties in all major components of the fisheries system and evaluates probabilities of recovery to a target within three generations. We found that the relative performance of benchmarks was highly sensitive to future trends in stock productivity. We suggest that benchmarks be selected in collaboration with stakeholders according to acceptable risk tolerances.

Keywords: Pacific salmon, biological status, Canada's Wild Salmon Policy, benchmarks, limit reference point, precautionary approach

"Assessing the likely consequences of differing management rules and environmental factors in the Barents Sea using a multispecies Gadget operational model"

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A biologically-realistic age-length structured multispecies Gadget model (incorporating minke whales, cod, herring, and capelin) has been developed for the Barents Sea. An operating model-assessment model cycle has been set up, with Gadget acting as the operating model and FLR running assessments. Such assessments may be XSA based, survey based, or take the stock numbers directly from the modeled stock. Annual fishing quotas (TACs) are based on the assessment and the currently agreed management rules. This cycle allows for errors on the data used for assessment and for errors on the implementation of the management advice. The model structure and the linkages with FLR

will be described, and the historical fit to the data will be presented. The likely outcomes of the existing and agreed management rules have been forecast for various species under a range of possible environmental conditions. Results are presented indicating the likely stock and catch levels over the medium term from the existing and alternative management strategies.

"The space-time variability of anchovy larval survival in the Bay of Biscay using a biophysical model"

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In the context of recovery of depleted fish stocks, investigating the processes of survival through early life stages, as well as determining which spawning habitats are successful for recruitment, are part of a necessary step towards a spatial or adaptive management, particularly for short lived species. Survival is tightly linked to transport and growth that show a high spatial and temporal variability. Using a biophysical model of anchovy larval transport and growth in the Bay of Biscay, we studied the seasonal and interannual variability of the survival. The transport model is made of a Lagrangian particle tracking module, accounting for larval advection and vertical behaviour, embedded in a 3-D hydrodynamic model, itself coupled to a biogeochemical model. The growth model was built by relating otolith growth rate to age and environment indices from the coupled model. The survival is based on differential growth rate between survivors and younger individuals of the same cohorts, giving a minimum necessary growth rate at age which varies seasonally. By confronting a spatially explicit spawning curve from survey data and spatially explicit survival from the model, we are able to provide space-time successful spawning windows.

Keywords: larval survival, recruitment, biophysical modelling, anchovy, Bay of Biscay

"Could a different management approach recover the Japanese sardine stock from depletion?"

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The Japanese sardine (*Sardinops melanostictus*) is a valuable marine resource of Japan and a highly variable one. Record catches were registered during the late 80's, but a four-years recruitment failure coupled with overfishing led to severe stock depletion, resulting in biomass levels falling one order of magnitude between 1987 and 1992. A TAC based management was introduced in 1997 but it has done little to reverse this trend, as biomass has kept falling steadily to current levels, two orders of magnitude below those of 1987.

It is widely recognized that strong correlation exists between the sea surface temperature of the Kuroshio Extension (SST) in winter and recruitment, thus a management strategy that maintains the same strategy along different conditions may be flawed, resulting in high risk conditions during bad conditions and difficult recovery when good conditions return.

Using an operating model we evaluate the performance, potential for stock recovering and robustness to uncertainties of three different management strategies: the currently used future-projection based management, Japanese ABC Guidelines strategy and an environmental based management strategy that uses SST as a proxy to switch between alternative catch rules. All three strategies are readily applicable or already being applied to Japanese sardine management.

Keywords: Japanese sardine, Management strategy evaluation, Environmental based management

"The social aspects of overexploitation of fish resources on small-scale fishery: ways of mitigation the effects on coastal communities"

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Thursday, November 5th 2009, 0920-0940 in theme session 4

The paper describes the outcome of an Estonian-Finnish INTERREG IIIA project (2006-2008), carried out using the bottom-up strategy with aim to find the conceptual strategy for the development of coastal fishery in West-Estonian Archipelago Sea region within the context of decreasing of main economically valuable local fish stocks.

The re-opening of West-European fish market for Estonian fish trading and relatively a high price offered for pikeperch (*Stizostedion lucioperca* L.) and perch (*Perca fluviatilis* L.) was incentive to increase the fishing effort directed at those species in all Estonian coastal sea at the beginning of 1990s. During some years, the initially sharp increase in landings observed, but it turned into slump already in mid- 1990s, because overexploitation.

As result, the income and social well-being of coastal fishermen in West-Estonian Archipelago Sea region suffered substantially. It generated acute social problems like high proportion of part-time employees; decrease of local population and in overall survival capabilities of coastal communities. The ways of mitigation of those, proposed by project are discussed.

Keywords: fish stocks, overexploitation, survival of coastal communities

"Fishing Impacts on Biomass and Mean-Body Size of Scombrid Populations on a Global Scale"

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Wednesday, November 4th 2009, 1655-1715 in theme session 3

Scombrids, commonly known as tunas, mackerels, Spanish mackerels and bonitos, have been subject to large removals of biomass in their populations since the 1950s. The global status of tuna species has been intensively debated over the last few years. There are signs that overfishing is threatening the future of many large tuna species. On the contrary, the global status of other scombrids remains mostly uncertain. This study quantifies trends in biomass and mean-body size of scombrid stocks on a global scale to provide estimates of fisheries impacts using hierarchical models. We have been able to collect fisheries data for 30 stocks belonging to 12 species with a good global coverage. The biomass of tuna stocks has been reduced on average by 40% in the last 50 years of exploitation and only the mean body size in the catches for the Atlantic tuna stocks showed significant declines. Mackerel stocks biomass has also been reduced on average by 22% and only stocks in the Pacific Ocean showed significant declines in their mean body size. The links between life history and responses to fishing can be used to better develop indicators of stock status for data-poor stocks and to validate alternative indicators of overexploitation.

Keywords: fisheries impacts, life histories, fisheries indicators, hierarchical models, conservation

"The importance of overlap – predicting North Sea cod recovery with a multi-species fisheries assessment model"

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Wednesday, November 4th 2009, 1100-1120 in theme session 2

The overlap between predator and prey is known as one of the most sensitive parameters in multispecies fisheries assessment models; and its parameterization is notoriously difficult. Different overlap indices were derived from the large scale International North Sea Bottom Trawl survey and used to parameterize the North Sea Stochastic Multi Species Model (SMS). The impact of different levels of detail in the overlap implementation (i.e., constant, seasonal, or year and quarter specific) on the historic (1991-2007) and predicted trophic interactions as well as the development of predator and prey stocks was investigated. The focus was set on the sensitivity of the North Sea cod recovery plan towards different overlap implementations. The spatial-temporal overlap between cod and its predators was found to increase with temperature. Further, small cod year classes were found to have a higher overlap with potential predators, indicating that food web processes will slow down recovery especially in warm periods.

"Egg production methods as a fishery independent alternative to assess the Eastern Baltic cod stock"

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Wednesday, November 4th 2009, 1715-1735 in theme session 3

At present several cod stocks are outside safe biological limits and are managed under recovery plans. These stocks are mostly assessed by VPA-type models based on commercial catch data. However, under recovery plans TAC's are normally low and quotas are accompanied by a broad variety of technical measures, e.g. closed areas and seasons. Consequently, the quality of input data to stock assessments is potentially biased and the perception of stock status derived from VPA may be incorrect. Egg production (EP) methods may provide a fishery independent alternative. Additionally, these methods provide better estimates of stock reproductive potential (SRP).

Here, we present an application of annual egg production method (AEPM) and daily egg production method (DEPM) to the eastern Baltic cod stock, using different sets of reproductive parameters as input. Egg surveys covering the spawning season have regularly been carried out on all spawning grounds since 1957. Therefore, egg production methods not only provided alternatives to the VPA-based ICES assessments, but also prolonged the available time series of stock abundance and SRP by almost a decade. A comparison of cod egg production dynamics with dates of major inflows evidenced that these events exerted the major positive effect upon cod egg production and subsequent reproductive success, especially on the eastern spawning grounds. Inter-annual variability in egg survival may also

explain deviations in output between the two assessment approaches. Generally, however, stock size estimates from the different approaches agreed reasonably well, suggesting that both EP methods are valuable alternatives to the VPA for Eastern Baltic cod.

"Recovery of the Bristol Bay Stock of Red King Crabs under a Rebuilding Plan"

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Thursday, November 5th 2009, 1655-1715 in theme session 5

Red king crab *(Paralithodes camtschaticus)* in Bristol Bay, Alaska, once supported one of the most valuable commercial fisheries in the United States. Landings peaked at 59,000 t in 1980, followed by stock collapse and fishery closure in 1983. Poor success at maintaining a healthy stock in the subsequent decade prompted a reexamination of the harvest strategy. In 1996, a stock rebuilding plan was implemented by the Alaska Board of Fisheries with a rebuilding target of 25,000 t of effective spawning biomass, the biomass of mature females estimated to have been mated in a given year. Key elements of the rebuilding plan include a fishery threshold (6,600 t) – a level of effective spawning biomass (15% of estimated pristine level) below which no fishing is allowed – and a conservative stair-step harvest strategy that established a 10% to 15% exploitation rate of mature males, depending on stock abundance. Concurrent ecosystem-based management approaches by the North Pacific Fishery Management Council included a prohibited species catch limit that constrains king crab bycatch by groundfish trawl and scallop dredge fisheries and a ban of mobile bottom-contact gear from two habitat areas – the Nearshore Bristol Bay Closure Area that protects juvenile crabs and their rearing habitat and an offshore Red King Crab Savings Area that protects adult crabs. Following implementation of these measures, effective spawning biomass doubled from an average of 10.9 t during 1986-1995 to 20.6 t during 1996-2005. The rebuilding target of 25,000 t of effective spawning biomass was attained in 2005.

"Reproductive capacity of the Norwegian spring spawning herring in the period of global stock change"

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Tuesday, November 3rd 2009, 1410-1430 in theme session 1

The paper analyses the data on herring fecundity collected in PINRO in 1954-2007. The impact of variations in population abundance and structure on its reproductivity and recruitment has been studied.

Absolute individual fecundity (AIF) of herring year-classes, which are various in abundance, is different. Differences in AIF are caused by the fact that poor year-classes are mainly represented by individuals of the southern and northern components with relatively high growth rate and early maturation, and, hence, with greater AIF, than in the abundant year-classes primarily represented by the Barents Sea component.

The study has showed that after the collapse, of the middle of the XXth century, with equal or even greater number of females, reproductivity of population was lower than in the 1950s-1960s. The reason is that in the multiage structure of the stock the recruitment by individuals from strong year-classes with low individual fecundity has a minor negative effect on population fecundity (PF) while when the structure is multiage and the PF-value depends on abundance of only one or two strong year-classes the populational mechanism of the fecundity reduction does not work.

Keywords: herring, population, fecundity, reproductivity, population structure, population abundance, recruitment

"Variations in the life history traits and intrinsic rate of population growth of cod in the northern Gulf of St. Lawrence and their impact on the rebuilding capacity of the population"

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Tuesday, November 3rd 2009, 1330-1350 in theme session 1

Time series of life history traits determining the productivity of cod in the northern Gulf of St. Lawrence were obtained for the period covering the collapse and the failure of the stock to recover. Growth, maturity, fecundity, stock egg production, and age-specific survival were used to obtain annual estimates of reproductive rate, intrinsic rate of population growth (r), and doubling time of population abundance. Estimates of r used as a proxy of stock productivity were negative in the 1986-1995 period indicating that the biomass of the stock would have decreased even without fishing during that time. In the recent period, r would have been positive (0.04 to 0.14) in the absence of fishing. However, considering fishing mortality (F), r varied between -0.09 and 0.09 with a declining trend since 2003. Population projection using age-specific survival and fecundity for the 2003-2008 period suggests a

potential increase in population size of 9% per year with a doubling time of 8.3 years in the absence of fishing and a near 0% rate with current F indicating that present harvesting does not allow any rebuilding of the stock. The results demonstrate the usefulness of *r* in assessing resilience of fish stocks and defining rebuilding strategies.

Keywords: cod, reproductive potential, intrinsic rate of increase, population recovery

"Productivity patterns and abundance-area relationships in 3 marine fish species (cod, herring and haddock); meta-analyses on the effects of temperature, life-history and habitat size across the N Atlantic"

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Tuesday, November 3rd 2009, 1100-1120 in theme session 1

Stock status evaluation and recovery policies in fisheries management rely largely on reference points derived from spawner-recruit (SR) models. The key-parameters of these models, representing productivity and carrying capacity, have been shown to be sensitive to environmental forcing and to depend on the biological and ecological characteristics of the stocks. Our aim was to identify the patterns of the temperature, habitat size and life-history effects on the SR dynamics across the N Atlantic range of 3 species; cod (21 stocks), herring (16 stocks) and haddock (7 stocks). Using hierarchical, Bayesian SR models, we combined the data across the distribution of the species in order (i) to determine the functional forms of the SR parameters dependence on these factors among and within stocks and (ii) to borrow strength and provide estimates of increased precision. Temperature during the spawning season was found to have significant effects on the productivities of all species, while carrying capacity was shown to depend also on the available habitat size. Using the derived relationships, it was possible to predict the expected changes in population-specific dynamics resulting from temperature increases. Synthesizing these patterns can improve our understanding of environmental impacts on key population parameters, which is required for an ecosystem approach to management.

Keywords: carrying capacity, cod, climate change, habitat size, haddock, herring, hierarchical models, life-history, productivity, temperature

"Baltic cod cannibalism: Differing consequences at stock recovery versus the historic situation of cod decline?"

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Wednesday, November 4th 2009, 1120-1140 in theme session 2

Cod cannibalism in the Eastern Baltic Sea was most intense in 1978-1984, a period with high juvenile abundance and large adult stock size. Subsequently, cod recruitment and adult stock decreased, while especially sprat, the main fish prey for cod, became significantly more abundant. We investigated, if cod cannibalism rate is under-proportional at low juvenile and adult abundances, indicating non-linear density dependence caused by density-dependent spatial overlap between juveniles and adults. Historically, about 30% to 40 % of the initial cohort was eaten before reaching age 2. When recruitment started to decrease due unfavorable environmental conditions at high adult abundance, cannibalism probably accelerated the decline in stock size. Since 2006 cod recruitment is increasing at a low but slowly increasing spawning stock biomass and restricted spatial overlap to sprat as prey. Using the stochastic multispecies model (SMS), we addressed the question, if cannibalism in the present situation of stock recovery has a different impact on stock dynamics than cannibalism in the historic situation of stock decline.

Keywords: Cod population dynamics, recovery, cannibalism, density dependent predation

"Cod-Seal Interactions on Eastern Scotian Shelf: Consideration of Modelling Assumptions"

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Wednesday, November 4th 2009, 1200-1220 in theme session 2

Subsequent to the closure of the cod fishery on the Eastern Scotian Shelf in 1993, it is estimated that natural mortality of cod has remained high, both for juveniles (ages 2-4) and adults (ages 5 and older). The purpose of this paper is to explore the implications of two assumptions that have been used in modelling the potential impacts of Grey seals on cod stocks on the Scotian Shelf - (1) the proportion of cod in the diet of Grey seals, and (2) the age/size composition of cod in the Grey seal diets. Based on consideration of these two assumptions, the role of grey seals in the lack of cod stock recovery since the closure are re-evaluated.

The modelling approach used to explore the implications of changes to the two assumptions (percent and size composition of cod in seal diet) employed an ADAPT formulation, modified to include cod – seal predation dynamics. In the earlier modelling, the size composition of cod in the diet was based upon the scat method from samples taken on Sable Island. In this paper, the cod age composition in seal diet was modelled using two approaches. The first used the summer survey data as a proxy for the cod age composition

(RV). In effect, it constructed a seal 'fleet' catch at age based upon the survey data. This assumes that seals encounter cod in the same proportion as observed by the summer survey. The second approach estimated cod age composition as a consequence of an assumed selection pattern of the seal 'fleet'. In this latter approach, three assumed selection patterns were input – one assuming that seals eat cod in proportion to their abundance (Flat), one assuming a modest decline in selection with cod age (Dome) and one assuming a selection pattern which would produce the percent cod age composition as observed by the scat method (Scat). In all four models, the seal 'fleet' consumed an annual 'quota', which was estimated based upon an assumed percent cod in the diet and the total consumption of fish by Grey seals in 4VsW (the eastern Scotian Shelf) during 1970 – 2000, this based upon seal energetics as described in earlier 4VsW models. Here, it was assumed that Grey seals consume 13.5% by weight of total diet as cod for 1970 to 2000 (close to the median in the literature and the value used in the earlier models). Cod catch at age from the fishery for this period was the same as used in earlier models.

All models estimate comparable trends in cod recruitment and adult abundance, the latter being marginally greater than estimated previously. Contrary to previous models, seal predation mortality represents an increasing proportion of total mortality across all cod age groups since the fishery closure in 1993. Assuming a residual natural mortality of 0.2, the trends in total mortality of both young cod (ages 2 to 4) and older cod (ages 5-7) produced by these models are consistent with estimates from the summer survey.

The literature on cod consumption by seals suggests that cod can be an important component of the diet even at low cod abundance. This literature also suggests that seals can consume a broad age/size range of cod. Application of these assumptions in a 4VsW cod – seal model for 1970 – 2000 produces a temporal pattern in cod total mortality across the full range of ages that is consistent with patterns observed in the surveys. Recognizing that these are initial explorations, if these conclusions are robust to further examination, they imply that seals are an important source of current cod mortality and are inhibiting stock recovery subsequent to closure of the fishery in 1993.

"Disentangling the cost-benefit hypothesis of long distance spawning migrations in the Northeast Arctic cod"

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Tuesday, November 3rd 2009, 1350-1410 in theme session 1

The Northeast Arctic cod, renowned for extensive migrations from their feeding and nursery areas in the Barents Sea to their spawning areas off the Norwegian coast, have during the last 150 years undergone striking fluctuations in abundance and substantial reduction in spawning ground distribution. While fluctuating stock abundance have received massive scientific attention, the long-term truncation of spawning ground distribution, by up to 1000 kilometres, appears to have been passed over in silence. Prior to the 1930's, Northeast Arctic cod where caught at spawning grounds ranging from the southernmost to the

northernmost parts of the Norwegian coast, but have for the last 50 years mainly been caught around the Lofoten archipelago and northwards. We ask why certain parts of the stock would undertake spawning migrations up to 3000 km longer than their conspecifics, and what circumstances may have caused this distribution to change with time. Using an ocean circulation model coupled to individual based models, together with a 104 year long time series of commercial catch data, we seek to investigate the trade-off between spawning migration and offspring fitness. We hypothesize that there exist a gradient for offspring success, suggesting faster growth and increasing survival with decreasing spawning ground latitude.

Keywords: Northeast Arctic cod, Arcto-Norwegian cod, spawning migration, general circulation model, larval fish

"The role of spatial processes in North Sea herring larval survival and recruitment"

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Tuesday, November 3rd 2009, 1120-1140 in theme session 1

The North Sea autumn spawning herring stock consists of several sub-stock components distributed along the east coast of Great Britain. This gives the opportunity to investigate the role of within-stock dynamics in stock-recovery. Year class strength in this stock is determined during the larval over-wintering period, between the end of the yolk-sack phase and metamorphosis. We reanalyse 25 years of extensive larval surveys through the use of an individual-based hydrographic advection model. The model is run in a back-tracking mode to identify the most likely spatial and temporal origin of a particular larval observation, and then use this information to assign it to a spawning component of the stock. By performing this exercise for every single larva observed in surveys performed both prior to and after the key over-winter period, it is possible to build up a picture of the annual larval survival rates of each component, and thereby identify any potential spatial differentiation in the recruitment processes. Insight is therefore obtained into the relative recruitment contributions to the whole stock from each component and the relative importance of diversity in spawning sites in a recovering fish stock. This understanding of within stock dynamics allows us to comment on the paradigm that spawning diversity is an important management target and should be addressed within recovery programmes.

Keywords: North Sea herring, recruitment, individual-based modelling, survival

"What is a collapsed stock? Mechanisms that sustain life cycle closure in space and time"

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Tuesday, November 3rd 2009, 1610-1630 in theme session 1

Experience has shown that the recovery of collapsed fish stocks takes place over longer periods of time than can be expected from traditional fishery population models. It is hypothesized that a collapse is associated with the disruption of biological mechanisms that sustain life cycle closure. Based on a review of case studies, we argue that stock collapses not only entail loss of biomass but key structural elements related to life cycle diversity (e.g., stock components, contingents) that contribute to stability and resilience. A list of mechanisms is identified that are necessary for these structural elements to recover. A dashboard of indicators is suggested to assess whether a stock is in a collapsed status or not. It is argued that models of depleted populations need to be spatially-explicit and incorporate the diversity of population components and behavioral interactions. Case studies considered are populations of herring (Norway, Gulf of Maine) and sardine (California), which recovered after more than a decade and stripped-bass (Chesapeake) and Capelin (Barents), which recovered after a short period of time. Finally, the case of anchovy in the Bay of Biscay is discussed as this collapsed stock is not recovering as quickly as could be expected.

Keywords: Collapse, Recovery, Behavior, Life cycle diversity

"Implications of fisheries-induced impacts on the stock structure and reproductive potential on stock-recovery of a sexual dimorphic species, North Sea plaice"

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Tuesday, November 3rd 2009, 1200-1220 in theme session 1

A key assumption in stock assessment and predicting stock recovery trajectories from historical populations is that spawning stock biomass and egg production are proportional and independent of stock structure (age composition and sex ratio). In this paper we examine the evidence for this assumption by analysing a time series of population structure and reproductive potential derived from maturity and fecundity at length and age using North Sea plaice as a case study. Fishing mortality on North Sea plaice has doubled since the 1950s and spawning stock biomass reached an all time low in the early 2000s. Based on commercial and research vessel survey samples the reproductive potential of the population

is estimated taking account of the observed changes in stock structure, maturation and fecundity-size relationships. Particular attention will be paid to the changes in the proportion of recruit and repeat spawners and the impact on reproductive potential and recruitment.

"Factors affecting recovery of Pacific herring stocks in Canada"

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Wednesday, November 4th 2009, 1140-1200 in theme session 2

The Pacific herring resource has supported one of the most important fisheries on Canada's west coast for most of the past century. Abundance of the five migratory stocks fluctuated cyclically throughout this period. An intensive reduction fishery began in the early 1930s culminating in a collapse of all five stocks in the late 1960s. After a coastwide fishery closure of three years the populations all recovered rapidly and a roe fishery was initiated in 1972. A precautionary management policy with a 20% harvest rate and fishing threshold was initiated in 1986. Despite the conservative harvest policy two of the five major stocks declined below the fishing threshold in the late 1990s and have not been fished for almost a decade yet there has been little or no recovery. In this study we estimate the contribution of various fish and mammal predators to natural mortality and top-down forcing versus plankton abundance to bottom-up forcing during the two periods of population decline and the earlier recovery. In contrasting the forcing factors during the collapses and the recovery we identify and predict conditions that will promote recovery from the recent collapse. We also speculate on some general conditions that will be critical to the recovery of depleted fish populations.

"What's Next? One Year After the Implementation of the Cod Recovery Plan in the Baltic Sea

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Thursday, November 5th 2009, 1120-1140 in theme session 4

Fishing regulations affect fishing operations in many different ways. Next to biological-technical effects, e.g. rebuilding of stocks and changes in fishing gear, are socioeconomic effects, e.g. employment structure or income. One year after the implementation of the cod recovery plan in the Baltic Sea, a follow-up visit was carried out visiting two fishing communities on the German Baltic Coast to understand the likely impacts of the plan. This information is also a prerequisite for policy makers to mitigate possible negative consequences on fishing communities. During semi-structured interviews, observations and group discussions information of the two fishing communities was collected. The survey revealed that the coastal fishery sector in particular the fishery segment fishing with passive fishing gear has no lobby in Germany and is among the most vulnerable affected by fisheries management measures. It is also the interest group with the lowest income and little resilience to cope with political change.

Keywords: multiannual cod management plan, small-scale fishing communities, social impact assessment, qualitative social research

"Combining fleet dynamics and population dynamics for a volatile fishery: the example of the anchovy fishery of the Bay of Biscay"

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Wednesday, November 4th 2009, 1735-1755 in theme session 3

It is increasingly recognized that fisher's behavior should be taken into account to understand and predict fishery dynamics, in particular in response to management. ISIS-Fish is a spatially and seasonally explicit modeling framework especially designed to couple populations and fleets dynamics and explore the impact of various management measures on mixed fisheries. It has already been set up using a static fishing effort allocation (corresponding to an average historical pattern) between the various métiers to simulate the pelagic fishery in the Bay of Biscay. We present here the integration of a fleet dynamics

model. This model is derived from a Random Utility Model simulating métiers choice using as explanatory variables the past value per unit effort of the main species caught and the past percentage of effort spent in the different métiers. We assess the contribution of the fleet dynamics module in the evaluation of management strategies building on TAC and Marine Protected Area, in the case of the Bay of Biscay pelagic fishery. Simulation results while applying the mean observed pattern or the dynamic effort allocation are compared with observations over the period 2000-2004. The simulated effort allocation fits observations for some métiers, but not for the most variable ones. Simulated anchovy biomass and catches fit observations reasonably well using either mean observed or dynamic effort allocation. More than the implemented MPA, we show that fisher's behavior and spatial fish distribution have a strong impact on the performances of management scenarios.

"Yes, we can – the successful recovery of the Baltic sprat stock"

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Tuesday, November 3rd 2009, 1430-1450 in theme session 1

The Baltic sprat stock successfully recovered from low spawning stock biomass (SSB) levels in the early 1980s (250 $*10^3$ tons) to peak values of 1.800 $*10^3$ tons in 1996. Despite a rapidly evolving, heavy fishing pressure, the stock is currently stabilized at 1.000$*10^3$ tons SSB, a level comparable to what was recorded in 1974, the beginning of available time series data. Higher mean sprat recruitment success (early life stage dynamics) and low cod predation pressure (adult life stage dynamics) have been discussed as the main mechanisms responsible for the stabilization in recent years. However, high inter-annual variability in recruitment success as well as seasonal variability in the survival of age-0 sprat cohorts have been documented. Large-scale, collaborative European research programs (e.g., STORE, GLOBEC Germany) have amassed a large body of knowledge regarding processes impacting the vital rates of various Baltic sprat life stages. This unique database includes information on both direct and indirect impacts of climate on early life stage dynamics as well as the consequences of fishing and predation pressure on adult life stages. The goal of this presentation is to review and synthesize our understanding of the key processes impacting the survival of different life stages and to examine the importance to stock development of factors operating on early versus adult life. Identifying the factors 1) that were responsible for the successful recovery of the sprat stock, 2) causing fluctuations in recruitment success and 3) contributing to the trophodynamic role of this species will ultimately be necessary for effective management Baltic fishery resources.

"Governance Issues around Recovery plans in a Mixed Fisheries Context"

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Thursday, November 5th 2009, 1220-1240 in theme session 4

Recovery plans provide an opportunity to partially "reboot" the governance system and to directly address its failures. They are opportunities for real change such as ending subsidies, increasing monitoring, and building long-term management plans. When these recovery plans are required for a sub-set of species in a mixed-fishery context the political strains of the management system become especially evident. Recovery plans involve a great deal of uncertainty. In the early stages stock dynamics are complicated when stocks are at very low levels. At later stages what "recovery" means must be defined. Political strains on science extend from fleet definitions, to complex and politically-driven modelling, to crafting balanced advice. The management system is also under strain as recovery plans involve increased attention from many stakeholder group at a time when a number of complex changes are called for. This paper reports the results of interviews with fishers, industry representatives, scientists and managers where the problems and possibilities of recovery plans in mixed-fishery contexts were discussed. Particular attention is paid to the implications for fishing fleets, the role of uncertainty in decision making and the response of members of the Regional Advisory Councils to recovery plans.

Keywords: mixed fisheries, recovery plans, fleet definitions, governance, regional advisory councils

"Expected rate of fisheries-induced evolution is slow"

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Commercial fisheries exert high mortalities on the stocks they exploit and the consequent selection pressure leads to fisheries induced evolution of growth rate, size at maturation, and reproductive output. Productivity and yields may decline as a result, but little is known about the rate at which such changes are likely to occur. Fisheries-induced evolution of exploited populations has recently become a subject of concern for policy makers, fisheries managers and the general public, with prominent calls for mitigating management action. We make a general evolutionary impact assessment of fisheries by calculating the expected rate of fisheries induced evolution and the consequent changes in yield. Rates of evolution are expected to be on the order of 0.1--0.4 % per year. Resulting relative changes in fisheries yield are less than 0.5 % per year. These rates are much lower than published values based on experiments and analysis of population time series and we explain why published values may have overestimated the rates. Dealing with evolutionary effects of fishing is less urgent than reducing the direct detrimental effects of overfishing on exploited stocks and on their marine ecosystems.

"Robust approaches to machine learning techniques for recruitment prediction in fisheries"

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There are many studies regarding the environmental and climatic factors that influence recruitment of different species. The interactions are complex often non-linear and frequently the different factors are difficult to disentangle. Machine learning techniques have been proposed as useful tools to overcome such difficulties. However, the accuracy of the prediction has important consequence and to be useful the manager need to know the risk is taking. In this study a robust supervised learning framework is proposed for early

recruitment prediction using environmental and climatic data. The underlying methodology consists in supervised pre-processing (discretization and feature selection) and a Bayesian network classifier. Bayesian networks not only outputs predictions, but also their probabilities. In addition, robustness of results at all steps is addressed to ensure overall robustness and to reduce prediction uncertainty. A short lived species (anchovy) and medium lifespan species (hake) are used as application examples.

Keywords: anchovy, hake, recruitment, climate, Bayesian networks, probabilistic reasoning, prediction, feature selection, discretization, stability, class selection, supervised classification

"The clupeoid stocks size and distribution in the southern and eastern Baltic (autumn 2005-2007), determined by the acoustic method"

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The paper describes herring and sprat stocks biomass and abundance changes in the southern and eastern Baltic in September-October 2005-2007. Materials were collected during the Polish, Latvian-Polish and Finnish-Estonian-Polish BIAS surveys on the Polish RV "Baltica". The studies were based on acoustic data recorded with the EY-500 echosounder at 38 kHz, control-catches with the herring pelagic fine-meshes trawl, and hydrological sampling with the Neil-Brown CTD-probe. Inter-annual and geographical variations in the mean biomass density of clupeoid stocks were evident, and, for example, in 2006 for sprat from the southern and eastern Baltic it was 13.2 and 127.7 t nmi^{-2}, respectively. The maximum biomass density of sprat and herring per ICES rectangle at that time was 857.1 and 161.4 t nmi^{-2}, respectively. In 2005-2007, herring distribution was characterized by a few concentration zones, which were more stable in the warmer southern Baltic waters; temperature in the zone of 0-40 m depth varied from 14 to 18°C. Sprat was concentrated mostly in the northern part, with variable southern limit range (temperature in the above-mentioned zone changed from 10 to 14°C). The clupeoid stocks distribution peculiarities and differentiated abundance of recruiting year-classes created problems in the local commercial fishery in given season.

Keywords: acoustic surveys, Baltic Sea, biomass, clupeoid, environment, geographical and inter-annual changes

"Spatial and temporal variation in Baltic sprat (*Sprattus sprattus balticus* S.) batch fecundity"

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Over the last decade the size of the Baltic sprat spawning stock declined from a record high of over 1.7 million tonnes in 1996 to 910.000 tonnes in 2008. From the perspective of stock recovery it is of central interest how reproductive parameters have changed over this period of strongly changing stock size. Batch fecundity of Baltic sprat (*Sprattus sprattus balticus* S.) during peak spawning time was investigated in relation to fish length and weight applying the hydrated oocyte method. A series of ten years was established covering important spawning areas in the Central Baltic Sea, i. e., the Bornholm Basin, the Gdansk Deep and for some years the Gotland Basin. Analysis of Covariance (ANCOVA) showed significant differences in batch fecundity of Baltic sprat between areas and years. To detect possible causes for this variation in batch fecundity environmental factors such as water temperature, salinity, oxygen content as well as fish and stock size were tested as explanatory variables. The data obtained in this investigation were used to develop a predictive model of Baltic sprat batch fecundity. Coupling these results with existing ichthyoplankton survey and stock structure data will allow applying the daily egg production method.

Keywords: Baltic sprat, hydrated oocyte method, batch fecundity, daily egg production method

"Uncertainty due to fisheries model formulation; a comparison of Gadget and STOCOBAR models for Northeast Arctic cod"

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Producing estimates of the uncertainties involved in fisheries models is important for effective fisheries management and scientific understanding. It is critical however that such estimates take account of the full range of uncertainties. Estimates which only consider some of the causes of uncertainties are likely to underestimate total uncertainty and could be misleading if taken at face value. Once source of uncertainty which is often overlooked is that caused by the selection of model formulation and structure. A comparison has been conducted between two different modeling approaches to Northeast Arctic cod, Gadget and STOCOBAR. The presentation will examine differences in both hindcast and forecast modeling results, and examine the differences in projected stock and catch structure under several alternative management rules.

"Fisheries impact on stock reproductive potential and recruitment of Japanese flounder *Paralichthys olivaceus* off the Pacific coast of northern Japan"

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Japanese flounder is an indeterminate multiple batch spawner. Most of females start spawning at age 3. Age at the first capture is 1.2 year old and average F 0.85. In this study, we estimated monthly and inter-annual changes in the survival rate from egg stage to juveniles by comparing monthly stock reproductive potential (SRP) and hatch date distribution of 50 mm juveniles for 2001 – 2006. Then, the effects of fisheries impact through low SSB and skewed age structure on recruitment were evaluated. Monthly changes in SRP were estimated with abundance, spawning fraction, spawning season, spawning frequency, and batch fecundity by age. Spawning occurred during May – September, with peak June – August. Relative annual fecundity of age-3 females was about a half of older fish, and spawning occurred only in the late spawning season. In contrast to the long spawning season, hatch dates of survivors were distributed within 1 – 2 months, and the month of this survival window varied year by year. As a result, inter-annual averaged survival rate was almost the same for May – August. Very low %SPR < 5% induced by the present high F, rather than slightly skewed monthly distribution of SRP, appeared to seriously impact on recruitment.

Keywords: Japanese flounder, stock reproductive potential, survival rate, age structure, %SPR

"Modelling the spatial dynamics of the Anchovy fishery in the Bay of Biscay with the simulation model ISIS-Fish : integration of information, calibration and validation"

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Understanding and predicting fisheries' dynamics suppose to model as realistically as possible the mechanisms that underlie their functioning. Unfortunately, fisheries are structurally complex as they result from multiple interactions between environment, populations, fishing dynamics and management decisions. Moreover few observations are available to characterize these interactions. Consequently models that enable to integrate processes involved and experiment on their interactions are helpful, particularly to advice on fishery's management. The anchovy population of the Bay of Biscay has suffered dramatic decrease in biomass since 2002 that led to fishery closure in 2005. This fishery involves

complex processes due to high environmental influence, spatial and seasonal structures and mixed features (multi-gear and multi-species). To assess management scenarios for stock rebuilding, the fishery was modelled using the ISIS-Fish simulation framework. We present here the generic methodology used to perform this modelling exercise. It is based on the following steps : (i) gather and analyse information available in literature about fishery's characteristics, (ii) estimate non available parameters using data at disposal and identify alternative or contradictory hypotheses regarding parameter values or process modelling, (iii) calibrate unknown parameters and (iv) valid the resulting fishery dynamics and choose between alternative hypotheses by confronting outputs to observations. This procedure enabled to integrate major processes of the pelagic fishery such as growth, reproduction, survival, fishing effort allocation, at a fine spatial scale and to choose between hypotheses regarding natural mortality and reproduction pattern. The fishery dynamics obtained is realistic and could be used for management scenarios evaluation.

"Accounting for differential growth patterns in a population - the GTG model"

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Most methods used to estimate population parameters in fisheries with catch-at-age data assume that all individuals follow the same growth pattern. Models that involve reconstruction of age structure from length frequencies, fitting to length composition data as a surrogate for age, and/or predict selectivity schedules based on size distributions at age, typically assume instantaneous renewal of the size structure at age at each time step. This assumption is seriously violated in size-selective fisheries where the faster growing individuals of an age-class suffer cumulatively greater fishing mortality. The "growth type group" (GTG) model accounts for individuals of the same age growing at different rates, thus explicitly considering distortions to the population size structure. Accounting for this distortion results in different estimates of fishing mortality from size-structure data. Using retrospective analysis on data for the shrimp fishery in the Gulf of Mexico (US EEZ), as well as simulated data, we compared VPA reconstructions using age compositions estimated from length data to GTG estimates based on fitting to total catch and effort data. We show here that different fishing mortality rates can be estimated and the GTG can therefore be a useful tool in the management and rebuilding of fish stocks.

"Assessing the robustness of management measures to fishermen reactions within uncertainty context"

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Fisheries management requires quantitative diagnostic of the impact of management measures. It has been largely argued that not taking into account fishermen reaction to management measures could lead to unreliable predictions of management impact on the fisheries. ISIS-Fish is a flexible simulation tool of fisheries dynamics to assess the impact of management scenarios on the dynamic of the fishery. This fishery model is time discrete, spatially-explicit and fishermen behaviour is described within its fleet dynamics model. As soon as ISIS-Fish is parameterised, running simulations is rather easy and following, without any rigorous approach that takes into account parameters and processes uncertainty, it could lead to wrong interpretation of management impacts. We proposed a statistical framework to perform an uncertainty analysis of the comparison of the impact of several management scenarios: 1) using a hierarchical statistical models, we analysed two metrics (simulations outputs) provided by a set of simulations designed according to the statistical model formula (simulation design); 2) we classified the management scenarios with respect to risk levels.
We applied this approach to the Anchovy fishery of the Bay of Biscay and assessed the impact of several hypotheses of fishermen reaction to two marine protected areas. We derived conclusions on the robustness of management measures to fishermen reactions and parameters uncertainty.

Keywords: Simulation tool, uncertainty, simulation designs, ISIS-Fish, diagnostic, decision-making

"Satisficing and trade-offs: Evaluating rebuilding strategies for Greenland halibut off the east coast of Canada"

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To be effective Management Strategy Evaluation (MSE) requires a well defined procedure for comparing the merits of candidate management strategies (MSs). Optimization requires a probabilistic evaluation of all possible outcomes and is beyond the scope of most fisheries management solutions. "Satisficing", a portmanteau of "satisfy" and "suffice", is a decision-making procedure that attempts to meet criteria for adequacy, rather than identify an optimal solution. We propose a two step process of satisficing followed by trade-off analysis for the selection of a suitable rebuilding strategy. Firstly, we apply satisficing to determine which rebuilding strategies achieve pre-specified thresholds set for imperative performance statistics relating to resource conservation/rebuilding, yield and stability of the fishery. Next,

trade-offs among important, but not necessarily imperative, performance statistics are evaluated for those strategies that passed the adequacy test. We consider a comprehensive reference set of operating models conditioned on the current XSA assessment for the NAFO subarea 2 and Divisions 3KLMNO Greenland halibut stock and a broad range of both model- and index-based MSs incorporating feedback and non-feedback harvest control rules (HCRs). Management by precautionary approach reference points and risk is beset with estimation difficulties. Rather than basing HCRs on estimated reference points and perceived risk, we argue that it is more appropriate to evaluate the "true" simulated risk in the form of performance statistics that can be included in MSE. An MS containing a simple feedback HCR based on the previous TAC and the change in observed index values was found to be the most robust for rebuilding this stock.

Keywords: satisficing, trade-off, rebuilding, management strategy evaluation, precautionary approach, reference points, risk, harvest control rule

"Moving towards an ecosystem approach to fisheries: a management strategy to rebuild the Namibian sardine resource?"

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Sardine, *Sardinops sagax*, historically the most abundant of the commercial resources in the Northern Benguela upwelling ecosystem played a central role as a wasp-waist species and in the Namibian economy. However, decades of overexploitation have led to a collapse of this stock in the 1970s and subsequent closure of most of the dependent industries. Since Namibian independence attempts to rebuild this stock to sustainable levels were impeded by short-term management decisions driven by socio-economic needs in conflict with scientific objectives and single species oriented assessments. Furthermore, the continuous fishing, albeit at low levels, had wider detrimental ecosystem impacts, which negatively affected other important commercial species such as hake and threatened species such as penguins. The recovery of the sardine stock seems to be a prerequisite for the rehabilitation of the northern Benguela ecosystem. Namibia, being committed to an Ecosystem Approach to Fisheries, and having agreed to rebuild its overexploited fisheries by 2015, needs to re-evaluate its policies and take ecosystem-effects into consideration in the management of its fisheries. However, short-term sacrifices to the currently marginal sardine fishery might be outweighed by the long-term benefits to the whole ecosystem. The historic and current management strategies of the Namibian sardine fishery are evaluated.

Keywords: Ecosystem Approach to Fisheries, stock recovery, sardine, management, overexploitation, northern Benguela ecosystem

"Norwegian Spring-Spawning Herring (*Clupea harengus*): The links between stock productivity, stock reproductive potential and recruitment"

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Productivity (surplus production) differs between cod stocks and varies annually. Here, we investigate the long-term productivity of the Norwegian spring-spawning herring stock, along with the reproductive potential (total egg production) and its links with recruitment. Fish less than 3 gain their production in the Barents Sea nursery grounds and fish older than three gain their production from the Norwegian Sea. The annual net and surplus production (per unit stock biomass to remove the influence of stock size) of the whole stock, pre-recruits and adult stock were estimated. The surplus production differs between the nursery (Barents Sea) and adult (Norwegian Sea) areas and in both has varied considerably on an annual basis. The changes in productivity of the stock can have consequences for the recovery of the stock from a depleted state. Interestingly, the relative surplus production during the period when the stock was in a collapsed state was relatively high, suggesting that the lack of numbers of fish was a major reason for the delayed recovery. How this relates to the stock productivity and subsequent recruitment is explored along with other contributory factors such as shifts in migration pattern, and growth rates and variability in early life history stage survival.

Keywords: Norwegian, herring, surplus production, collapse, recovery, reproductive potential

"Long-term spatial patterns of potential individual fecundity of cod in the Baltic Sea"

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Fish stock identification is the basis of forecasting recruitment which, in turn, requires estimates of a stock's reproductive potential, traditionally approximated by the spawning stock biomass (SSB). The SSB-approach relies on the two largely unsupported assumptions that SSB is proportional to a stock's reproductive potential and that spawning stocks are spatially and temporally discrete and, consequently, reproductively distinct.

Reproductive biology and stock identification are interdependent in that reproductive isolation and spatial variation in reproductive processes are critical aspects of defining stocks. In turn, population structure is an essential consideration for researching and monitoring reproductive biology. To date, fecundity information has not been used to discern stock structure of cod in the Baltic Sea.

We used data obtained between 1994 and 2008 to test if the current separation into a western and an eastern spawning stock is supported by the spatial variation of absolute and

relative individual fecundity and oocyte dry weight of cod caught during the main spawning season in the main spawning grounds in the Baltic Sea.

The spatial variation of cod reproduction metrics suggested three groups of spawners and did thus not agree with the current separation of cod in the Baltic into western spring spawners and eastern summer spawners. The results indicate that the criteria that have earlier been used for the stock separation are not necessarily reflected in all life-history characteristics alike and that different approaches to identifying stocks offer unique sensitivities and perspectives on population structure

Keywords: fecundity, egg weight, cod, Gadus morhua, Baltic Sea, spawning stock, reproductive potential

"Variation of fish frequency in the wetlands of Alma-Gol, Adji-Gol and Ala-Gol"

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During last 10 years observations (1995 -2005), range distribution of non-indigenous fish species have been developed in the wetlands with high frequency, coupled with decline of indigenous fishes suggesting limited area for the distribution of native species. Previously reported native species *Silurus galnis* (in Alma-Gol and Ala-Gol) and *Neogobius* sp. (in Alma-Gol) were not observed recently in the wetlands. Furthermore, another native species the *B. capito*, which belongs to the "Least Concern" category of IUCN with the widest distribution range in the Caspian basin, was recorded only occasionally and in small number in the ecosystems of the basin. It seems that variation in abundance of native species in the ecosystems is clearly associated with abundance of non-indigenous species. Therefore, the domination of none-indigenous species can be used as an indicator of decline of native fish stocks and a combination based on presence, abundance and biomass of none-indigenous species could be a good indicator of ecosystem health and function because of its practical and conceptual simplicity.

"Ongoing gene flow between fisheries of the Southern hake stock (*Merluccius merluccius*)"

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Previous population studies have reported the existence of a genetic split between Atlantic and Mediterranean populations of hake around Gibraltar Strait. In this study we have used the internal transcribed spacer ITS1-rDNA to better understand the population genetic scenario of the Southern hake stock. We aimed to assess whether the reported divergence between Atlantic and Mediterranean populations consists of a minor regional divergence between populations or a significant genetic barrier. A qualitative analysis of the 27 ITS1 variable haplotypes sequenced indicates that 18 of them are specifically found in the Iberian Atlantic fishery and 9 in the western Mediterranean fishery. However, one haplotype (MmITS1.2) is occasionally present from the Bay of Biscay to the Mediterranean Sea at very low frequencies. The existence of basin-specific haplotypes and across-basins rare haplotypes indicate a restricted but ongoing gene flow between all Southern hake fisheries. This pattern of diversity corresponds to a model expansive casual, i.e. the pattern of dispersion of this species depends on annual oceanic fluctuations affecting, passive dispersal of larvae and recruits, as well as adult migration between fisheries.

Keywords: Southern hake stock, genetic structuring, gene flow, fishery management

"Mangement implications of gene flow estimates between fisheries of the Northern hake Stock (*Merluccius merluccius*)"

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The overexploited status of the Northern hake stock makes advisable to incorporate population genetic data into management strategies. We provide molecular data of microsatellites scored on 22 populations from the Northern hake stock, aiming at testing the interannual genetic stability of these fisheries and the migration pattern between them. Our dataset indicates a limited migration between the population group of Rockall fishery and the North Sea (Termed here Rockall-North) and the population group of Porcupine, South Brittany and Biscay Bay (Termed here Porcupine-South). While high gene flow seems to occur across years within Rockall-North, migration among Porcupine-South populations seems to be yearly dependent. Porcupine fishery would expand southwards either to South Brittany (Year 2000) or reaching the southernmost fishery of the Biscay Bay (Year 2001). Present genetic data highlight the importance of Porcupine fishery in terms of global hake biomass and in terms of focal reproductive area feeding southern fisheries. Such key role makes advisable its special protection to ensure sustainability of most fisheries from the Northern hake stock.

Keywords: Northern hake stock, inter-annual genetic structuring, migration, fishery assessment, fishery management

"Changes in European hake diet as a result of the depletion of its main prey"

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The depletion of blue whiting *Micromesistius poutassou* in 2008 in the Cantabrian Sea (southern Bay of Biscay) triggered changes in European hake feeding habits. Data come from annual bottom trawl surveys carried out each autumn since 1983. Mean abundance of blue whiting, both in number and biomass, decreased significantly in 2008. This decline was consistent in the whole geographic area. Blue whiting size distribution displayed modes around 13-14 cm and 17-18 cm. However, in 2008 larger specimens were found with modes at 19-20 cm and 24-25 cm. All these changes in blue whiting abundance had 3 main consequences in hake feeding habits: 1) changes in diet composition, 2) increase of cannibalism and 3) significant decrease in feeding intensity. Analysing global diet composition two preys dominate the diet in the historical series, blue-whiting and mackerel. This pattern changed markedly in 2008 where hake, sardine and horse-mackerel replaced the former. Analysing these data by size range (< 17 cm, 18-34 cm, 35-69 cm), it was in medium sizes (18-34 cm) where the real change took place. An increase of cannibalism also took place in 2008 reaching values of 35 % in medium sizes. The third consequence on hake diet was a significant decrease in feeding intensity (volume as percentage of body weight, V%BW) in 2008. A significant correlation between hake feeding intensity (for specimens between 18 and 34 cm) and blue whiting abundance in the surveys was also detected.

Keywords: hake diet, feeding intensity, blue whiting depletion, Bay of Biscay

"Economic optimization of the Baltic cod fishery using an age-structured model"

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Suitable management measures to recover the Baltic cod stock are continuously under debate. One option is the combined regulation by fishing quotas and mesh-sizes. Despite the huge literature on optimal fishery management, no bio-economic analysis of mesh size regulations has been conducted so far. A likely reason is that, to study this instrument, an age-structured model of the fish stock has to be employed, which is difficult to analyze analytically. In this analysis we use a simplified age-structured model of Baltic cod to analyze the economic rationale behind the combination of two instruments – quotas and mesh sizes – in the management of a fish stock. The model consists of 4 age-classes, 2 of which can be harvested independently (young, immature and older, spawning fish). Under open access, every age class is harvested more heavily than under optimal management. In other words, with selective fishing gear, overfishing is not just a one-dimensional problem, but has as many dimensions as age classes can be selected by the fishing gear. First-best optimal fishery would not harvest immature fish, but harvest the older age-classes only. As optimal fishing mortality for the young fish is zero, first-best optimal fishery management can be

implemented by combining a quota management scheme for the older age class (the spawning stock) in combination with a mesh size regulation.

Keywords: optimal management, economy, mesh size, age-structured model

"Introduction of natural biological variability into Northern hake Management Strategy Evaluation framework to investigate different stock-recruitment relationship and its relation with stock recovery"

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The biological parameters as the weight at age, sex-ratio, and maturity at age of Northern Hake the population are fixed constant for the whole time series in the assessment. Thus, the natural variability which can be used in the assessment is removed. The main objective of this work is to use the Management Strategy Evaluation approach to analyze the robustness of northern hake management strategy to natural variability in the inputs parameters, such as weight at age, sex ratio and maturity, of Northern hake stock assessment. For that purpose, annual biological data collected in the Bay of Biscay has been analyzed in order to parameterize the natural variability in weight at age, maturity at age and sex ratio at age of the Northern stock of Hake. Different SSB indices including increasing biological complexity, adding variation in weight, sex ratio, and maturation in a stepwise process, were in order to investigate the potential effect on population productivity. In other words, different estimates of SSB were used to fit Ricker Stock Recruitment relationship and the resulted best fit was obtained when using both variable and constant female ogive give the better fit.
In summary, this paper provides an overview of natural variation in biological characteristics in European hake which can be used to estimate different indices of SSB and, hence, stock-recruitment relationships.

Keywords: Operating Model, hake, Biological variability, statistical model, Bay of Biscay, Assessment

Sexual maturation of cod (*Gadus morhua callarias L.*) in the southern Baltic (1990-2006)

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The poster summarises the results of long-term (1990-2006) investigations on cod sexual maturation and the sex ratio at age groups and length classes in the Polish parts of the

Bornholm and Gdansk basins. In total, 76 284 and 9 486 specimens, which were collected during the BITS surveys in February-March and measured for length and subjected to biological analysis, respectively, constituted the study input data. The results of the analyses indicated essential variation of the sex ratio at age groups and length classes and little inter-annual or spatial change. The numerical share of females increased with cod age and length. The length at which 50% of females are mature was higher than that for males in each running year throughout the period studied; however, no distinct trend in this parameter between ICES Sub-divisions 25 and 26 was noted. In comparison with females, cod males reached sexual maturity first (by age and length), and their mean numerical share was higher regardless of the calendar year examined. The results obtained indicted that proportion of mature cod within age groups 1-4 was lower in the Polish EEZ comparing with the ICES data, suggesting every year's verification of that parameter.

"Preventing Overfishing of Non-Target Species by Using Annual Catch Limits in the North Pacific Groundfish Fisheries"

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Worldwide, fishery managers face the difficult question of how to manage species that are not targeted by commercial fisheries, but are caught as bycatch in sufficient amounts to raise potential conservation concerns. Historically, U.S. federal fishery managers have prioritized the protection and sustainability of economically important target species due to legal requirements to reduce risks of overfishing, as well as the need for pragmatism under budget constraints. Data limitations pose challenges to stock assessment scientists charged to determine acceptable catch limits for many bycatch species. Yet, if a bycatch species experiences overfishing or declines to overfished levels, the consequences may include drastic reductions in fisheries for target species as part of a rebuilding plan for the depressed bycatch species. Off Alaska, new, innovative approaches for assessing data-poor, non-target groundfish species are being investigated, while managers continue to use traditional management strategies designed for target species (such as annual catch limits). Lessons learned in the Northeast Pacific illustrate challenges in assessing data-poor species in a management system designed for the most valuable species targeted by commercial fisheries.

"Seasonal lipid dynamics of herring and sprat in the Baltic Sea and possible implications for cod reproduction"

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The Baltic Sea experienced a regime shift in the 1980ies with major changes in food web dynamics. These ecosystem alterations were related to climatic driven changes in hydrographic conditions affecting phyto- and zooplankton assemblage and hence the food availability for clupeids. Sprat abundance increased dramatically in the early 1990ies. The changes in plankton communities in combination with increased competition resulted in declined condition of clupeids. Polyunsaturated fatty acids originate from phytoplankton and are transmitted through the food web. The present study investigates if the seasonal variation in lipid composition of herring and sprat reflects the changes in plankton. Fish were sampled five times over a year and the lipid composition of different size groups was analyzed. Significant seasonal variation in average lipid content in sprat was found: 14.00% in November, 11.26% in January, 7.47% in March and 9.60% in June. The lipid content in herring also varied within season but was lower than sprat: 7.42% in November, 6.71% in January and 4.70% in March. The seasonal lipid dynamic was reflected in variation of specific fatty acids. Clupeids are the major prey of Baltic cod so deficiencies of essential fatty acids could be a limiting factor for cod reproduction.

Keywords: Sprattus sprattus, Clupea harengus, Clupeids, Lipid dynamics, Fatty Acid Composition, Reproduction, Baltic Sea

"Management strategy evaluation for the anchovy stock (*Engraulis encrasicolus*) in the Bay of Biscay"

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In the past, the Bay of Biscay anchovy has been managed with a fixed TAC around 33,000 tons. However, in 2005 the stock collapsed and consequently the fishery was closed. This raised the need to establish a long term management plan as soon as the stock is recovered. In this paper we present the management strategy evaluation approach followed to help managers deciding on a strategy that would lead to a sustainable exploitation of the stock while being robust to different sources of uncertainties. First, using a seasonal age-structured operating model within the FLR framework, we test two harvest control rules: a) exploit a proportion of biomass where the proportionality factor is reduced continuously when the biomass is between B_{lim} (21,000t) and B_{pa} (33,000t) and b) exploit a proportion of biomass but fixing a minimum economically viable TAC when the biomass is between 24,000t and B_{pa}. The performance of the different rules is presented in terms of biological

risks, average catches and probability of fishery closure. Then, the robustness to the uncertainty on recruitment models and scenarios and to fishing patterns is tested. Finally, other sources of uncertainties and additional modules to be included in the management strategy evaluation are discussed and briefly outlined.

"Revisiting Stock-Recruitment-Environment relationships for the Bay of Biscay anchovy (*Engraulis encrasicolus*)"

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A review of the recent and potential use of the relationship between environmental indexes and anchovy recruitment in the Bay of Biscay for modelling stock-recruitment relationships is presented. Additionally we apply quantile regression modelling to analyse the previous environment-recruitment relationships to study the limiting mature of the relationships. We have analysed the environmental indexes that classically have been associated to anchovy recruitment, such as Eastern Atlantic pattern, Borja's upwelling index, mean annual turbulence in the Bay of Biscay and total annual run off in the Gironde estuary, total run off over February to April and March to July and some others related to the eggs spatial distribution at survey times.
SSB has been found to be statistically significant, although with a huge dispersion in the Stock-Recruitment relationship, which is the variable used while testing harvest control rules for the long term management. Regarding the quantile regression models on environmental and spatial covariates, despite some marginal statistical signification no convincing results were obtained.

"How ambient habitat traits determine seasonal and spatial distribution patterns of cod *Gadus morhua* L. in the central Baltic Sea"

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Highly stratified marine ecosystems challenge an individual's ability to select suitable living conditions. Ultimately, environmental heterogeneity organizes the spatial distributions of populations and hence the spatial structure of the ecosystem. We present an analysis of the small-scale vertical and meso-scale horizontal distribution on an individual level, as needed

for the behaviorally-based prediction of habitat choice and limits. We focused on the spatial distribution of cod *Gadus morhua* L. in the Bornholm Basin, central Baltic Sea, during several years with different vertical thermohaline and oxygen stratifications. Individual cod were identified by echotracking of real-time *in situ* hydroacoustic distribution data. In order to resolve and identify habitat preferences and limits, ambient hydrographic parameters temperature, salinity and oxygen concentration were individually allocated to each fish. Results showed a clear influence of ambient salinity and oxygen concentration on the vertical distribution of cod. Based on identified limits of vertical distribution, spatial distribution patterns of cod were analyzed on a seasonal scale along three hydroacoustic transects covering the basin. Consequently, various aggregation patterns in different areas of the basin could be identified for the years investigated and related to ambient hydrography.

"Testing the influence of variations in migration and recruitment on Baltic cod recovery"

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Although fishery modeling has made substantial progress over the last years, there is still a heavy deficit in addressing spatial aspects of resource and fishery dynamics. Spatial models will become essential in the process of marine spatial planning as well as for the evaluation of marine protected areas. Simultaneously, there is an increasing awareness of a need for reliable bio-economic models, recognizing the economic dimension of fisheries management.
Both aspects have led to the development of coupled model systems – one current example being the ISIS-Fish model. ISIS-Fish is a spatially resolving model framework, including multi-species, multi-population sub-models, a dynamic multi-fleet, multi-gear model with an optional economic component, as well as a rule based management model. The Baltic ISIS-Fish model is currently parameterized to describe the eastern Baltic cod fishery drawing back on the huge amount of available biological and fishery data. Previous applications of the model have shown that simulation results substantially depend on the type of stock-recruitment relationship used, as well as on adult behavior (e.g. migration). In this study we explore systematically different assumptions about stock-recruitment relationships and migrations patterns on recovery of the Eastern Baltic cod stock. The choice of parameters is based on best existing data and process-understanding gained in recent EU-funded research, i.e. the UNCOVER project.

"Rebuilding analysis of the eastern Bering Sea Tanner crab stock: Consideration of new overfishing definitions and bitter crab disease"

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The eastern Bering Sea Tanner crab (*Chionoecetes bairdi) stock* was declared overfished and closed to commercial fishing between 1997 and 2004. This stock is being rebuilt under a rebuilding plan with criteria set under the old US federal fisheries management plan (FMP). With the implementation of the new FMP in 2008, the reference points for spawning biomass index (total mature biomass under the old FMP vs. mature male biomass under the new FMP) and overfishing (retained catch estimated at the overfishing level fishing mortality, F_{OFL} vs. total catch estimated at F_{OFL}) have changed resulting in different rebuilding criteria. We performed a rebuilding analysis using length-based simulations considering recent changes in overfishing definitions and scenarios incorporating additional mortality due to bitter crab disease, a fatal disease caused by a parasitic dinoflagellate of the genus *Hematodinium*.

Keywords: Bering Sea, Tanner crab, rebuilding, length-based method, bitter crab disease

"Fecundity, atresia and maturation in North Sea plaice"

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North Sea plaice *Pleuronectes platessa* is an extreme capital spawner, which stops feeding during the spawning period. The onset of the maturation in plaice is in April or May, when the oocytes begin the maturation process. The number of vitellogenic oocytes is down-regulated through atresia during the maturation cycle. The oocyte development and down-regulation of fecundity is regulated by the energy content of the females. Females feed on the summer feeding grounds but stop food intake when on the spawning grounds. The down-regulation of the fecundity is thus dependent on the food intake in summer. Down-regulation through atresia continues to just prior to spawning.
In this study we describe the maturation cycle and the relationship between energy content and down-regulation of fecundity in plaice. We show the importance of atresia and down-regulation for the determination of fecundity for the use in SSB estimates based on egg

production methods. Understanding the maturation cycle and mechanism of down-regulation of fecundity enhances the understanding of the stock reproductive potential, and is therefore important for the management and recovery of the intensively fished plaice stock.

Keywords: atresia, down-regulation, fecundity, plaice, Pleuronectes platessa, reproductive potential

"A review of the implications of fisheries during the spawning season for the recovery of depleted fish stocks"

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Fishing during the spawning season may negatively affects the reproductive potential and reproductive dynamics of exploited fish stocks due to a variety of mechanisms such as the disturbance of the natural spawning behaviour, effects on the age, size and sex composition of the spawning population and effects on the population genetics. The effect may differ between species in relation to the spawning strategy and population dynamic characteristics. Based on first principles of reproductive biology, population biology and fishing methods, a theoretical framework is developed on the effects of fishing during the spawning period. This framework is used to structure a review of the available scientific evidence. Implications for the management and recovery strategies of depleted fish stocks will be discussed and illustrated for a selection of North Sea fish stocks (flatfish, roundfish and pelagic).

Keywords: seasonal management, spawning fisheries, spawning behaviour, reproductive potential

"Fishermen versus cormorants: stock collapse of Väinameri fish in West-Estonia"

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During the 1970-80's the fishery in the West-Estonian Väinameri area employed several hundred full-time fishermen. After the re-establishment of Estonian national independence, at the beginning of 1990's, fishing effort increased and caused collapse of stocks of some most targeted and valuable species during the second half of 1990's. Naturally, decrease of importance of the fishery followed, and number of active fishermen and their fishing effort declined nearly ten-fold. The stock recovery which was expected to take place in 2000's, however, didn't happen. One or even the main reason behind this is the exploding population of cormorants.

Historically the Estonian fisheries administration has followed „strong hand policy"– fishing restrictions are based just on the scientific advice and are usually not much negotiated with

the fishing community. In beating overfishing this policy has been quite successful. However, during the last years cormorants impose higher mortality than fishermen. So, the fishery has reached the dead end. Stocks are still worse than they were during the „golden period"of 1970-1980's. Fishing effort is much below the seemingly sustainable level of these decades. Further fishing restrictions are neither possible nor sensible. The only way seems to be to decrease the number of permanently increasing cormorants. However, this idea is not popular due to the prevailing environmental sentiment.

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