Environmental and Ecosystem Histories in the Northwest Atlantic—

What Influences Living Marine Resources

Hosted by the Scientific Council of the Northwest Atlantic Fisheries Organization (NAFO)

13-15 September 2006

Dartmouth, Nova Scotia, Canada

I. INTRODUCTION

The Scientific Council of NAFO is pleased to announce this Symposium to be held in conjunction with the NAFO 28th Annual Meeting, at the Holiday Inn, Harbourview, in Dartmouth, Nova Scotia, Canada. The Symposium will be co-convened by:

Bill Brodie (Canada), Jason Link (USA), Helle Siegstad (Denmark/Greenland), and Manfred Stein (EU-Germany), and organized by the NAFO Secretariat.

The Ecosytems to be considered cover all the NAFO Subareas and comprise the Ecosytems of Greenland (East/West), Labrador Shelf/Grand Banks, Scotian Shelf Banks and Gulf of Maine/Georges Bank. The scope of the Symposium is to describe and compare these ecosystems, considering their environmental and marine resources.

Theme Sessions:

- *Large-scale climatic forcing on the physical oceanography of the Northwest Atlantic seas*
- *Physical and biological factors structuring ecosystems in the Northwest Atlantic (e.g., nutreint availability, sea ice, low temperatures, low species diversity, etc.)*
- *The transfer of energy and material through food webs, from primary producers through zooplanton and benthic fauna to fish, seabirds, marine mammals, and fisheries*
- *Recent changes in NW Atlantic ecosystems, time scales of variation, and possible cause, including fishery effects*
- *Inter-comparisons between marine ecosystems (e.g. between those in the NW Atlantic, and between NW Atlantic and other areas)*
- *Economic, social impacts of ecosytem changes in NW Atlantic*

Invited key-note speakers will be sought for some of these sessions. Oral presentations and posters are welcome to be submitted for consideration.

Paper titles are still being accepted and should be submitted with an abstract by **30 June 2006**. Papers will be selected on the basis of their relevance to the topic and scientific suitability. It is anticipated that the proceedings of the Symposium will be published in the *Journal of Northwest Atlantic Fishery Science*, following normal peer-review process of the Journal.

II. SESSIONS

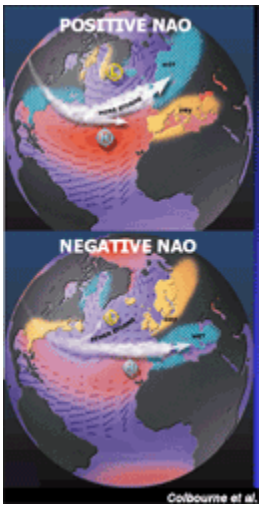
The Symposium on was held in Holiday Inn Harbourview in Dartmouth, Nova Scotia during 13-15 September 2006. The purpose of this Symposium was to better understand the ecosystems in the Northwest Atlantic and what influences them. The co-convenors were: W. Brodie (Canada), Jason Link (USA), Helle Siegstad (Denmark/Greenland), and Manfred Stein (EU-Germany).

The Vice-Chair of Scientific Council opened the meeting by welcoming participants and explaining the role of Scientific Council. The Vice-Chair also introduced the work plan and objectives. Co-convenor Bill Brodie also welcomed participants and gave a brief overview of logistics and meeting arrangements.

Three theme sessions were held: 1) Climatic, Physical and Biological Factors Affecting NW Atlantic Ecosystems; 2) Dynamics of NW Atlantic Ecosystems (including a mini-session on capelin); and 3) Comparison of Ecosystems, and Social and Economic Consequences of Changes in the NW Atlantic. Summaries of each session, as well as the overall discussion, are contained below. A total of XX people from XX countries attended, and 26 papers were presented orally, and 6 as posters. Presenters were invited to submit their papers for publication, by 31 October 2006, in a special issue of the Journal of Northwest Atlantic Fisheries Science (scheduled print date December 2007).

SESSION 1: CLIMATIC, PHYSICAL AND BIOLOGICAL FACTORS AFFECTING NW ATLANTIC ECOSYSTEMS

Session Chair: Manfred Stein



Ten lectures were given in Session 1. After a presentation on climate change impacts on NW Atlantic storm, wind and wave estimates, the second contribution dealt with a comparison of two large marine systems, the Northwest Atlantic and the Barents and Nordic Seas. This was followed by a presentation on remote forcing of marine ecosystem dynamics in the Gulf of Maine. Impacts of hydrographic fronts on the variation of abundance in some commercial stocks were considered in the fourth contribution of Session 1. A lecture on warming periods off Greenland during 1800-2005 and their possible influences on the abundance of cod and haddock was presented thereafter.

The afternoon lectures started with two presentations on phytoplankton in the Labrador Sea and on the Northwest Atlantic continental shelf, followed by a presentation on variations in over-wintering depth distributions of Calanus finmarchicus in the slope waters of the NW Atlantic continental shelf and the Labrador Sea.

A pan-North Atlantic wide study on the influence of the spring phytoplankton bloom on the life history and population dynamics of shrimp (Pandalus borealis), and a lecture on a near-universal metric for displaying the growth of fishes, formed the end of the afternoon oral presentations.

After the session discussion, six posters were presented in the lobby area.

SESSION 2 – DYNAMICS OF NW ATLANTIC ECOSYSTEMS - OVERVIEW/SUMMARY

Chair: W. B. Brodie

Six presentations were made in the first part of Session 2. Energy modeling of George's Bank noted that despite changes to this ecosystem, many fundamental features of the ecological network have remained remarkably consistent. A paper examining the effects of fishing exclusion on groundfish in the western Gulf of Maine revealed few differences in biodiversity, abundance, biomass or size distribution in areas inside and immediately outside the closed area, although sample sizes were small. At West Greenland, stock size indices for shrimp and cod do not indicate significant negative correlations, suggesting that bottom-up mechanisms in the ecosystem may have been responsible for increased shrimp abundance, rather than a release from cod predation. Another study of the West Greenland groundfish assemblages concluded that climate, ocean productivity, and fisheries are the main structuring forces in the groundfish assemblage. A study of the fish community in NAFO Divisions 2J3KLNO noted that major changes in this ecosystem occurred in the last 30 years, and that collapses of main commercial species were accompanied, and sometimes preceded by, collapses in non-commercial species, noticeably large demersals. A presentation on marine sponge and coral by-catch in the NW Atlantic noted that the trend toward fishing deeper resulted in increased sponge by-catch, and that some of these species take decades to form large scale patches.

In the discussion, the similarities of cod and shrimp dynamics in the west Greenland and Newfoundland/Labrador areas was noted. However, this cod/shrimp switch did not appear to occur in the more southern areas. Other discussion focused on ecsosytem dynamics, primarily on George's Bank, and how they may have changed over time.

MINI-SESSION ON CAPELIN (PART OF SESSION 2)

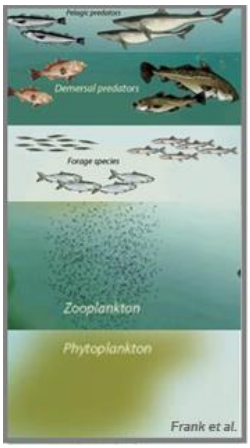
Chair: Helle Siegstad

At this session six different subjects related to capelin were presented. The first presentation showed preliminary results from a combined survey for capelin, polar cod, krill, marine mammals and birds over the West Greenland plateau from 73°N to about 60°N, including some fjords. The survey represents a first attempt to apply an "ecosystem approach" to pelagic survey work in Greenland waters. The next presentation discussed several reasons why capelin didn't have spawning success on Flemish Cap.

Biology and behaviour of capelin in Atlantic Canada have changed dramatically in recent years, and a collaborative, multidisciplinary initiative among university, government and commercial fishermen has investigated bio-physical mechanisms to understand reasons for the observed changes. The group presented one poster and four talks: 1) Acoustic seabed mapping for identification on capelin spawning sites. 2) Comparison between two reproductive tactics 3) Seabirds as sensitive indicators of large capelin density. 4) A models assessing the consequences of density shifts for top predators.

The symposium participants had a general discussion on the role of capelin in the Northwest Atlantic ecosystem. The discussion included the role as the energy transfer: preying on invertebrates and in turn being preyed on by most large predators, including cod, seals, whales and birds. All changes in capelin biomass and distribution will have serious effects on the ecosystem – most pronounced in northern regions. The basis of the observed changes in capelin and climates is still not well understood and every piece of new information is therefore of great importance.

SESSION 3: COMPARISON OF ECOSYSTEMS, AND SOCIAL AND ECONOMIC CONSEQUENCES OF CHANGES IN THE NW ATLANTIC ECOSYSTEMS



Chair: Jason Link

A key talk in this session noted latitudinal gradients among North Atlantic ecosystems. All have both bottom-up and top-down processes operating, but some apparently are dominated more by one or another. Key considerations were temperature (as influencing vital rates) and food web complexity. The session discussion highlighted that there may be more to the story than solely species interactions, with some influence of environmental processes also worth examining. One recommendation would be to explore a multi-variate approach that simultaneously examines a wide range of processes as they might influence the major biological groups.

Other talks in the session emphasized socio-economic considerations, particularly landing time series from a wide range of NAFO areas and countries. The discussion noted that a systems, or operations research, approach is useful. Additionally, it was noted that some further consideration might be given to combining the fleet dynamics and fishing community dynamics with the standard biological trophic levels (PP, ZP, Forage Fish, Larger Fish) as additional trophic levels, all as part of the same model system.

Another talk noted the importance of data and databases as the basis for fisheries science and management. The discussion then led to a suggestion that as one way forward for EAF, we begin to incorporate a broad range of ecosystem considerations into standard single species assessments (e.g., more delineated natural mortality terms in a VPA, environmental factors in a stock-recruitment model, etc.).

III. PARTICIPANTS

William B. Brodie
Science Branch
Dept. of Fisheries & Oceans
Northwest Atlantic Fisheries Centre
P.O. Box 5667, St. John's, NL A1C 5X1
Canada

Tel: +709 772 3288

E-mail: ***brodieb@dfo-mpo.gc.ca***

Jason Link
National Marine Fisheries Service
Northeast Fisheries Science Center
166 Water St., Woods Hole, MA, 02543
USA

Tel: +508 495-2340

E-mail: jlink@noaa.gov

Helle Siegstad
Afdelingschef, Grønlands Naturinstitut
P.O. Box 570
DK-3900 Nuuk
Greenland

Tel: +299 361200 (Direkte: 361220)

Email: helle@natur.gl

Manfred Stein
Institut für Seefischerei
Palmaille 9
D-22767 Hamburg
Federal Republic of Germany

Tel: +49 40 38905 174

E-mail: manfred.stein@ ish.bfa-fisch.de

CANADA

Chris Allen	Fish. Environment & Biodiversity Sci. Secretariat, DFO,200 Kent St., 12th floor, Ottawa, K1A 0E6 Tel: +613 990 0105 – E-mail: allenc@dfo-mpo.gc.ca
David Brickman	Dept. of Fisheries and Oceans, BIO, P. O. Box 1006, Dartmouth, NS B2Y 4A2 Tel: + 902 426-5722 – E-mail: brickmand@mar.dfo-mpo.gc.ca
Robert M. Branton	Dept. of Fisheries and Oceans, BIO, P. O. Box 1006, Dartmouth, NS B2Y 4A2 E-mail: brantonB@mar.dfo-mpo.gc.ca
Jason Bryan	Biology Dept., Acadia University, Wolfville, NS, B4P2R6 E-mail: jason.bryan@acadiau.ca
Alejandro D. Buren	Cognitive & Behavioural Ecology Programme, Dept. of Biology & Psychology, Memorial University of Newfoundland, St. John's, NL, A1B 3X9 E-mail: aburen@mun.ca
Chantelle M. Burke	Cognitive and Behavioural Ecology Programme, Departments of Biology and Psychology, Memorial University of Newfoundland, St. John's, NL, A1B 3X9 E-mail: chantelb@mun.ca
Andrea Carew	Senior Manager, Marine Conservation, WWF Canada, Atlantic Region, 5251 Duke Street, Suite 1202, Halifax, NS B3J 1P3 Tel: +902 482 1105 (ext 24) – E-mail: acarew@wwfcanada.org
Abdelhafid Chalabi	Advisor, Ocean Policy and Planning Branch, DFO, 200 Kent 12E241,Ottawa, Ontario K1A 0E6 Tel: +613 991-6984 – E-mail: ChalabiA@dfo-mpo.gc.ca
Stephen Cole	31A Heritage Dr., Antigonish, NS B2G 2T6 Tel: +902 690-3768 – E-mail: swbcole@gmail.com
Eugene B. Colbourne	Dept. of Fisheries and Oceans, P. O. Box 5667, St. John's, NL A1C 5X1 Tel: +709 772-6106 – E-mail: colbourn@dfo-mpo.gc.ca
Christopher J. Corkett	Senior Instructor, Depart.of Biology, Dalhousie University, 1355 Oxford Street, Halifax, NS B3H 4J1 Tel: +902 494-7016 – E-mail: chris.corkett@dal.ca
Earl Dawe	Science Br., DFO Newfoundland & Labrador, P.O. Box 5667, St. John's, NL A1C 5X1 Tel: +709 772-2076 – E-mail: dawee@dfo-mpo.gc.ca
Lindsay Eckersley	Saint Francis Xavier University, Biology Department, Antigonish, NSB2G 2W5 Tel: +902-867-5289 – E-mail: leckerslay@stfx.ca
Amanda Facey	MAARS Oceans & Aquat. Resour. Biol., 172 Truro Heights Road, Box 8, RR#1, Truro, NS B2N 5A9 Tel: +902 895-2982 – E-mail: afacey@mapcorg.ca
César Fuentes-Yaco	Dept. of Fisheries and Oceans, BIO, P. O. Box 1006, Dartmouth, NS B2Y 4A2 Tel: +902 426- 4681 - Email: Fuentes-YacoC@mar.dfo-mpo.gc.ca
Susanna Fuller	Dalhousie University, Halifax Nova Scotia E-mail: susannadfuller@gmail.com
Brett Gilchrist	Resource Management Officer, Resource Management Branch – Licensing Policy and Special Projects, DFO, 200 Kent Street, 13th floor West, Ottawa, Ontario K1A 0E6 Tel: +613 990-0192 – E-mail: gilchristb@dfo-mpo.gc.ca
W. Glen Harrison	Biological Oceanography Section, Ecosystem Research Division, DFO, BIO, P. O. Box 1006, Dartmouth,

	NS B2Y 4A2 E-mail: HarrisonG@mar.dfo-mpo.gc.ca
Christine Heaven	Saint Francis Xavier University, Biology Department, Antigonish, NS B2G 2W5 Tel: +902-867-5289 – E-mail: cheaven@stfx.ca
Roger Hunka	Director of the Maritime Aboriginal Aquatic Resources Secretariat, 172 Truro Heights Road, Box 8, RR#1, Truro, NS B2N 5A9 Tel: +902 895-2982 – E-mail: rhunka@mapcorg.ca
Erica J.H. Head	Biological Oceanography Section, Ecosystem Research Division, DFO, BIO, P. O. Box 1006, Dartmouth, NS B2Y 4A2 E-mail: HeadE@mar.dfo-mpo.gc.ca
Mary Kennedy	Biological Oceanography, DFO, BIO, P. O. Box 1006, Dartmouth, NS B2Y 4A2 Tel: +902 463-8537 – E:mail: kennedym@dfo-mpo.gc.ca
Franz Kesick	MAARS Community Aquatic Resources Development Advisor, 172 Truro Heights Road, Box 8, RR#1, Truro, NS B4N 5A9 Tel: +902 895-2982 E-mail: fkesick@mapcorg.ca
Mariano Koen-Alonso	Fisheries and Oceans, Canada, P. O. Box 5667, St. John's, NL A1C 5X1 E-mail: Koen-AlonsoM@dfo-mpo.gc.ca
Dan Lane	School of Management University of Ottawa, 136 Jean-Jacques Lussier Privé, Ottawa, ON K1N 6N5 Tel: +613 562-5800 x4795 - E-mail: dlane@uOttawa.ca
William K.W.Li	Biological Oceanography Section, Ecosystem Research Division, DFO, BIO, P. O. Box 1006, Dartmouth, NS B2Y 4A2 E-mail: LiB@mar.dfo-mpo.gc.ca
Caroline Longtin	3 Crockett Court, Antigonish, NS B2G 2Y2 Tel: +902 971-0603 – E-mail: x2006oyy@stfx.ca
Peter Koeller	Research Scientist, DFO, BIO, P.O. Box 1006, Dartmouth, NS B2Y 4A2 E-mail: KoellerP@mar.dfo-mpo.gc.ca
M. Kurtis Trzcinski	Post-doctoral Fellow, Atlantic Service Centre, Parks Canada, 1869 Upper Water St., Halifax, NS B3J 1S9 Email: kurtis.trzcinski@pc.gc.ca
Gary Maillet	Biological Oceanographer, Radiation Safety Officer, Environmental Science, Science Branch, DFO, P.O. Box 5667, St. John's NL A1C 5X1 Tel: +709 772-7675 – E-mail: ***mailletg@dfo-mpo.gc.ca***
Kyle McKenzie	Environment Canada, 45 Alderney Landing, Dartmouth, NS B2Y 2N6 Tel: +902 426-6312 – E-mail: kyle.mckenzie@ec.gc.ca
Joshua McNeely	Ikanawtiket, 172 Truro Heights Road, Box 8, RR#1, Truro, NS B2N 5A9 Tel: +902 895-2982 – E-mail: atitus@mapcorg.ca
Anna B. Neuheimer	Department of Oceanography, Dalhousie University, Halifax, NS Tel: +902 494-2830 - E-mail: anna.neuheimer@phys.ocean.dal.ca
Henri Motte	FAMP, School of Management, University of Ottawa, 136 Jean-Jacques Lussier Privé, Ottawa, Ontario K1N 6N5 E-mail: enremote@yahoo.com, enremote@gmail.com
Ransom Myers	Dalhousie University, Halifax, NS Tel: +902 494-1755 – E-mail: Ransom.Myers@Dal.Ca
Dave Orr	Science Br., DFO Newfoundland & Labrador, P.O. Box 5667, St. John's, NL A1C 5X1 Tel: +709-772-4935 – E-mail: orrd@dfo-mpo.gc.ca
Paulette Penton	Department of Zoology, University of Manitoba, Winnipeg, MB, R3T 2N2 E-mail: umpenton@cc.umanitoba.ca
Will Perrie	Dept. of Fisheries and Oceans, BIO, 1 Challenger Dr., Dartmouth, NS B2Y 4A2 E-mail: perriew@mar.dfo-mpo.gc.ca
Don Power	Science Br., DFO Newfoundland & Labrador, P.O. Box 5667, St. John's, NL A1C 5X1 Tel: +709-772-4935 – E-mail: powerd@dfo-mpo.gc.ca
Daniel Ricard	6164 Charles St., Apt. B, Halifax, NS Tel: +902 494-2146 – E-mail: ricardd@mathstat.dal.ca
Candace Rose-Taylor	Dept. of Geography, Memorial University of Newfoundland, St. John's, NL A1B 3X1 E-mail: ocianaca@yahoo.ca
Richard Sanders	Ph.D., Resource Manage, Inc., Box 25149, Halifax, NS Tel: +902 443-6796 – E-mail: resourcemanage@eastlink.ca
Ricardo Scrosati	Saint Francis Xavier University, Biology Department, Antigonish, NSB2G 2W5 E-mail: rscrosat@stfx.ca
Nancy Shackell	Ocean Sciences Division, DFO, BIO, P. O. Box 1006, Dartmouth, NSB2Y 4A2 E-mail: shackelln@mar.dfo-mpo.gc.ca
Angelica Silva	BIO, PO Box 1006, Dartmouth, NSB2Y 4A2 E:mail: SilvaA@mar.dfo-mpo.gc.ca
Don Stansbury	Science Br., DFO Newfoundland & Labrador, P.O. Box 5667, St. John's, NL A1C 5X1 Tel: +709-772-0559 – E-mail: stansburyd@dfo-mpo.gc.ca

Jamie Tam	31 Indian Garden, Antigonish, NS Tel: +902 872-0887 – E-mail: x2006onw@stfx.ca
Matthew J. S. Windle	Candidate, Fisheries Conservation Chair, Marine Institute, Memorial University of Newfoundland, P.O. Box 4920, St. John's, NL, A1N 5R3 Canada Tel: +709 778-0504 – E-mail: matt.windle@mi.mun.ca
PORTUGAL	
Ricardo Alpoim	Instituto Nacional de Investigacao Agrária e das Pescas (INIAP/IPIMAR), Av. de Brasilia, 1449-006 Lisbon, Portugal Tel: +351 21 302 7000 – E-mail: ralpoim@ipimar.pt
Antonio Avila de Melo	Inst Instituto Nacional de Investigacao Agrária e das Pescas (INIAP/IPIMAR), Av. de Brasilia, 1449-006, Lisbon, Portugal Tel: +351 21 302 7000 – E-mail: amelo@ipimar.pt
SPAIN	
Fernando Gonzalez-Costas	Instituto Español de Oceanografia, Aptdo 1552, E-36280 Vigo (Pontevedra), Spain Tel: +34 9 86 49 2111 – E-mail: fernando.gonzalez@vi.ieo.es
RUSSIA	
Vladimir Babayan	Russian Federal Research Institute of Fisheries & Oceanography (VNIRO), 17, V. Krasnoselskaya, Moscow, 107140 Tel: +70 95 264 8974 – E-mail: vbabayan@vniro.ru
Konstantin V. Gorchinsky	Knipovich Polar Research Institute of Marine Fisheries and Oceanography (PINRO), 6 Knipovich St., Murmansk 183763 Tel: +7 (8152) 47 2532 – E-mail: gorch@pinro..ru
UKRAINE	
Sergiy Rebyk	Senior Scientist, Southern Scientific Research Institute of Marine Fisheries and Oceanography (YugNIRO), Svezdlova 2, Kerch, Crimea, Ukraine 98306 Tel: +38 (06561) 21012 (Kerch); +38 (044) 4820984 (Kiev) – E-mail: zebikst@mail.zu
UNITED KINGDOM	
Phil A. Large	Centre for Fisheries & Aquaculture Science (CEFAS), Lowestoft Laboratory, Pakefield Rd., Lowestoft (Suffolk), England NR33 OHT, United Kingdom Tel: +44 502 525591 – E-mail: p.a.large@cefas.co.uk
USA	
Charles H. Greene	Director, Ocean Resources and Ecosystems Program, Department of Earth & Atmospheric Sciences, 2130 Snee Hall, Cornell University, Ithaca, NY 14853-2701 Tel: +607 255-5449 – E-mail: chg2@cornell.edu
Sirpa Hakkinen	NASA Goddard Space Flight Center, Code 614.2, Greenbelt, Maryland 20771, USA Tel: +301 614-5712 – E:-mail: sirpa.hakkinen@nasa.gov
Andrew Pershing	Dept. of Earth and Atmospheric Sciences, 1115 Bradfield Hall, Cornell University, Ithaca, NY 14853 E-mail: ajp9@cornell.edu

IV. PROGRAM/ABSTRACTS

Wednesday, 13 September

Welcome and Introduction (Scientific Council Chair, Convenors)

Session 1. Climatic, physical and biological factors affecting NW Atlantic Ecosystems

Climate change impacts on NW Atlantic storm, wind and wave estimates

Will Perrie, Jing Jiang, Zhenxia Long, Yonghong Yao, Weiqing Zhang, Bash Toulany

This is a study of the possible impacts of climate variability on marine storms, winds and ocean waves. Global climate models (GCMs) provide simulations of the present climate conditions, as well as possible conditions that may occur under future global scenarios, and tend to show an increase in the number of deep low pressure systems in the Northern Hemisphere, while the number of weak storms tends to decrease. Several recent studies have used GCM outputs to drive wave models and estimate the impacts on the wave climate resulting under these climate change scenarios. We consider this problem from the point of view of downscaling the GCM outputs by using finer-resolution regional models. Simulations are conducted for autumn storms (December – February) for present (1975-1994) and climate future scenario (2041-2060). We nest a mesoscale atmospheric model (the Canadian Mesoscale Community Compressible model MC2) on 0.25o resolution, within the CGCM2 simulations. This follows the approach of Knutson et al. (1998, Science). Simulations for 51 storm cases for the present climate and 47 storm cases for the climate change scenario years were completed. We suggest that, for the cases considered, strong storms become more intense, with higher waves. Some change occurs to storm tracks and regions of maximum wave heights.

Ocean Climate Variability - Comparisons of the Northwest Atlantic to the Barents and Nordic Seas

E. B. Colbourne, H. Loeng, K.F. Drinkwater and V. Ozhigin

The extent, magnitude and causes of ocean climate changes in Newfoundland and Labrador waters of the Northwest Atlantic with those on the Norwegian Shelf and the Barents Sea in the Northeast Atlantic are investigated. Analysis of oceanographic data from the Bonavista and Seal Island sections of Newfoundland and Labrador with the Svinøy, Gimsøy and Sørkapp Sections on the Norwegian Shelf and the Fugløya-Bjørnøya, Vardø-N and Kola Sections in the Barents Sea indicate a remarkable out-of-phase temperature relationship prior to the mid-1990s. When warm conditions dominated the Newfoundland and Labrador region, indicated by the lower-than-normal cold-intermediate-layer areas (CIL), conditions on the Norwegian Shelf and in the Barents Sea were generally colder-than-normal. However, since the mid-1990s the relationship between the two regions has shifted to a pan-Atlantic ocean warming response. The out-of-phase relationship in ocean temperatures between the two regions historically, and the recent departure of this relationship indicate that oceanographic processes operating in both regions are most likely connected in part to links through the large-scale atmospheric forcing.

Remote Forcing of Marine Ecosystem Dynamics in the Gulf of Maine

A. Pershing

In the Gulf of Maine, a significant reorganization of the zooplankton assemblage occurred in the 1990s, with an increase in small copepods and a decline in Calanus finmarchicus abundance. The strongest changes in the zooplankton occurred in late autumn/early winter, coinciding with intensified autumn phytoplankton blooms. These changes in plankton were associated with enhanced stratification precipitated by a negative salinity anomaly, part of a broader pattern of freshening extending upstream to the Labrador Sea. The impacts of these stratification-associated changes at the base of the food chain on higher tropic levels were complex, with herring stocks increasing in abundance and North Atlantic right whales producing fewer calves. The link between salinity anomalies derived from higher latitudes and food chain reorganizations downstream provides new insights into the future responses of marine ecosystems to remote hydrographic forcing associated with climate change.

Interannual variations of hydrological fronts in Northwest Atlantic and tendencies in the year-class abundance of some commercial stocks

I. K. Sigaev

Advective processes are assumed to play a significant role in formation of environmental conditions in the areas subject to Labrador Current and Gulf Stream impact, especially on the Northwest Atlantic shelf. Peculiarities of these processes may exert a considerable influence on formation of commercial fish species and invertebrate year class abundance. Interlattitudinal movements of hydrological fronts can serve as one of the indicies of warm and cold water advection to the shelf.

To estimate such movements, the interannual dynamics of surface fronts for the period of 1962 to 2005 was studied in the area between 55°W and 70°W. Movements of three boundaries – northern boundary of cold shelf water (CSW), north boundary of Slope water (SL) and northern Gulf Stream boundary (ST) were monitored. Canadian maps "Ocean feature analysis" and "Sea surface temperature", issued on a regular basis by fax were used as initial material.

A distance on the map in miles along the meridian from 37°N to the point of boundary intersection with this meridian was accepted as indices of boundaries localization. Periods of strengthening and weakening of warm and cold water advection to the shelf were revealed from the analysis of time series of these indices. It was shown that phase changes in interannual dynamics of hydrological fronts had occurred during 1979-1983. It was also noted that change of phases in advective processes resulted in tendencies of fluctuations of some commercial fish species and invertebrate abundance. Following 1979-1983, the abundance of pollock, yellowtail flounder, winter flounder and Witch fllounder, of illex on Georges Bank decreased, while a rapid growth was observed in spiny dogfish and white hake abundance on Georges Bank, and that of mackerel and herring on the Nova Scotia shelf. A correlation between year-class abundance and indices of water boarder localization was observed. Availability of correlation was also noted between indices of front localization and indices of atmospheric circulation over Northwest Atlantic. The purpose of the research was to accentuate the importance of environmental factors for assessment of stock condition and forecast of commercial species abundance.

Warming Periods off Greenland during the 19th , 20th and 21st century – Their Potential Influence on the Abundance of Cod (Gadus morhua) and Haddock (Melanogrammus aeglefinus) in Greenlandic Waters

M. Stein

Recent observations on the sea surface temperature anomalies in the North Atlantic Subpolar Gyre indicate cold conditions in the 1980s and warming from the mid-1990s onwards, with maximum temperatures observed during October 2003. This is consistent with air temperatures at Nuuk, Greenland, which document that 2003 was the warmest year since 1950. Ocean temperatures off West Greenland show a significant upward trend, which is considerably higher than that for the North Atlantic Basin. Ocean properties off West Greenland at recent times were more saline and up to 2°C warmer-than-normal. Sub-surface oceanographic observations on the advection of warm Irminger Mode water masses indicate that during the 20th century and the early-2000s pulses of this water arrived at depths of 400m - 800m off West Greenland. Long-term climate "proxy" data which cover the period 1800 – 1982 were taken for comparison with instrumental records of atmospheric data (Nuuk mean annual air temperatures), and of sea surface temperature data as annual mean data of area A1 (West Greenland). These data are compared to historic reports on the existence of cod in Greenland waters during the pre-1920s, and during the times of the Greenland cod fishery of the 1930s-1960s. Similar to the data on biomass and abundance of cod (*Gadus morhua*) and haddock (*Melanogrammus aeglefinus*), as obtained during German bottom trawl surveys between 1982 and 2005, these data suggest coupling of warming periods with the abundance of gadoids in Greenland waters. By means of sea surface temperature anomalies for the North Atlantic Ocean it is shown that the regional extent of warm water masses within the North Atlantic Subpolar Gyre varies significantly during the 1850s to early-2000s. Greenland and its adjacent waters are located at the northern boundary of the Subpolar Gyre and thus subject to climatic variations within this gyre. It is suggested that periods characterized by regional shrinkage

of warm water masses within the Gyre are adverse for the propagation of gadids from upstream Icelandic waters to Greenlandic waters, and periods of regional dilatation of warm water masses within the Gyre are favourable for developing gadid stocks in Greenlandic waters.

Phytoplankton growth and regulation in the Labrador Sea – light and nutrient limitation

W. Glen Harrison

Since 1994, research scientists at the Bedford Institute of Oceanography (BIO) have conducted annual oceanographic observations along a transect extending from Hamilton Bank on the south Labrador shelf to Cape Desolation off southwestern Greenland. These observations form part of a larger observation/modeling study of climate-ecosystem variability and change in a region of strong winter convective mixing. Although most missions were carried out during the spring/summer months, limited fall/winter sampling and regional satellite data (SeaWiFS ocean colour) provide information on the major season cycles of primary producers (phytoplankton) on the Labrador and Greenland Shelves and the central Labrador Sea basin.

Field and satellite data show maximum phytoplankton growth in spring, after ice retreat, at the continental margins and later (summer) at the shelf edge and in the central basin. A notable exception is the intense growth seen in April/May off the central Greenland coast, extending well into the central basin.

Because of geography of this region, the growth dynamics of phytoplankton are strongly influenced by the solar radiation cycle and the presence of sea-ice, the latter particularly along the Labrador and Greenland coasts. At this latitude (53°N-60°N) light levels in the surface ocean are limiting to phytoplankton growth for most of the ice-free growing season based on observations of ocean optical properties and phytoplankton physiology. Superimposed on this is the late spring to fall depletion of essential nutrients (nitrate, silicate) in the highly stratified surface mixed-layer that further constrains phytoplankton growth. Nitrogen appears to limit phytoplankton growth on the shallow shelves and silicon in the central basin.

Analyses of the long-term (decadal) trends in the physical oceanographic properties have revealed significant ocean warming and ice reduction in the region. In addition, changes in nutrient availability (more nitrate - less silicate) and in phytoplankton community structure (more small forms - fewer large forms) have also been observed over the last decade. These results suggest that the “first-order” effects of climate variability/change on the physical environment may already be inducing changes, “second-order” effects, in structure and function of the base of the foodweb.

Multiyear change in the phytoplankton community of the Northwest Atlantic continental shelf and the Labrador Sea

Li, William K.W.

Sea surface temperatures remotely recorded from the Advanced Very High Resolution Radiometer (AVHRR) indicate that the Scotian Shelf has been cooling whilst the Labrador Sea has been warming in the spring since the mid 1990s. Concomitant changes in the biomass and size structure of the phytoplankton communities have been detected from annual springtime cruises over this period. The change in phytoplankton biomass, indicated by the concentration of chlorophyll a, is inverse to the change in temperature: increasing on the Scotian Shelf and decreasing in the Labrador Sea. On the Scotian Shelf, there is an increasing prevalence of fucoxanthin and peridinin: namely those pigments predominantly ascribed to microphytoplankton associated with new production. Conversely, in the Labrador Sea (excepting the Greenland Shelf), there is an increasing prevalence of alloxanthin, chlorophyll b, 19’ butanoyloxyfucoxanthin, 19’ hexanoyloxyfucoxanthin and zeaxanthin: namely those pigments predominantly ascribed to nanophytoplankton and picophytoplankton associated with regenerated production. These multiyear springtime trends point to the possibility of greater export of production on the Scotian Shelf and lesser export in the Labrador Sea over the long term.

Variations in overwintering depth distributions of Calanus finmarchicus in the slope waters of the NW Atlantic continental shelf and the Labrador Sea

Erica J.H. Head

The copepod *Calanus finmarchicus* provides an important food source for larval groundfish and pelagic fish on the NW Atlantic continental shelf. Its life-history includes a dormant non-feeding phase, which includes part of the winter and which individuals spend at depth as pre-adult CV copepodites. This behaviour means that the shelves must be re-populated each spring from nearby deep waters. The NW Atlantic continental shelf is an advective system, with equatorward flow over the shelf and in the slope waters. Thus, C. finmarchicus overwintering in the slope waters can be transported from more northerly to more southerly areas. In order to elucidate the relationships between overwintering populations in different regions, vertically stratified tows were made in slope waters from the Labrador Shelf in the north to the entrance to the NE Channel in the south, and in the Labrador Sea. Along the shelf-break east of the central Scotian Shelf (CSS) and in the western and central Labrador Sea (WCLS) although most CVs were at depth in October/November (fall, 2001 or 2003) or December (winter, 2002 or 2003), there were still appreciable numbers (1,000s m-2) in the near-surface layers, suggesting that the seasonal descent was not complete. By contrast, C. finmarchicus were rare in the near-surface layers in fall or winter in the Greenland slope waters, along the shelf-break of the western Scotian Shelf (WSS) and offshore west of the Tail of the Grand Bank (TGB). The depth range of overwintering CVs was deepest in the Greenland slope waters (>1000 m), along the WSS and offshore west of the TGB (>500 m), and shallowest in Cabot Strait (200-300 m) and the WCLS (200-400 m). Total water column CV abundances in offshore regions were relatively consistent (10-15K m-2, WCLS; 2-3K m-2, west of the TGB), the highest concentrations were near the shelf at the TGB (30-50K m-2) and in Cabot Strait (59K m-2). Vertical distributions in the slope waters in December 2003 suggest that transport around the TGB was not important, that populations between the NW Grand Bank and the eastern Scotian Shelf had local sources, and that there was no appreciable southwesterly transport of overwintering CV C. finmarchicus along the shelf-break. Sequential observations in 2003 suggest that there was actually northeasterly transport of overwintering CVs from the WSS to the CSS slope waters between October and December. Current meter measurements at a station on the CSS slope were consistent with this idea.

Influence of the spring phytoplankton bloom on the life history and population dynamics of shrimp (Pandalus borealis) in the North Atlantic

C. Fuentes-Yaco, P. Koeller, K. Wieland, , U. Skúladóttir, and M. Aschan, T. Platt, S. Sathyendranath

Previous work conducted on the Newfoundland shelf demonstrated that shrimp growth in this area can be related to food availability as determined by remotely-sensed ocean colour data. In this paper we follow up on the previous results by exploring the relationship between shrimp growth/survival and environmental parameters including bottom temperatures and spring phytoplankton bloom characteristics for other stocks in the North Atlantic (West Greenland, Scotian Shelf, Flemish Cap, Barents Sea). Shrimp life history stage lengths were significantly correlated with the environmental parameters at all spatial and temporal levels of data summarisations tested, including sub-areas within stocks, stock areas, all stocks combined, and annual or long-term averages. Biological mechanisms behind the best models determined by step-wise multiple regression were difficult to determine at the lowest level (annual data within sub-areas) because of inconsistencies in the environmental parameters included and the signs of their coefficients, although R-squares were relatively high. Within stock analyses resulted in lower R-squares but more consistent inclusions of parameters in model choices. Across-stock comparisons, R-squares improved considerably when long-term (8 year) averages of all model components were used for individual sub-areas, possibly because lag-effects were reduced. At this level, the growth indicator with the most available data (length at sex change, L_{50}) produced a best model which included temperature and 3 of the four bloom characteristics (R-square 0.8358 df = 10) . Recruitment was significantly related to several bloom characteristics for both stocks where this data was available (West Greenland and Scotian Shelf) with R-squares of about 0.36.

Growth in fishes – a near-universal metric

Neuheimer, A.B., and C.T. Taggart

Using a different means to address growth in fishes, we can explain 92 to 99% of variation in fish length-at-day among 41 datasets representing 10 fish species drawn from marine and freshwater environments, temperate and tropical climes, and laboratory control and field studies. When it comes to gadoids, among others, we are able to explain 93% of the growth variation (length-at-day) among 17 North Atlantic cod (Gadus morhua) stocks, ages 2- to 4, over their entire range using a single parameterization. In haddock (Melanogrammus aeglefinus) we use our approach to tease apart the effects of temperature, food limitation and size-selective fishing on growth among years and year-classes over 3 decades. When it comes to climate change issues we demonstrate that subtle changes in climate can have a great effect on fish size-at-age, something that is not easily predicted using the various extant fish-growth models.

Poster presentations

Toward Ecosystem-based Fisheries Management in the NAFO Regulatory Area

WWF-Canada

Sustainable fisheries and the recovery of depleted fish stocks depend on a healthy ecosystem. Overfishing and depletion of once dominant predatory groundfish species, such as Atlantic cod (Gadus morhua), and declines in important forage species, such as capelin (Mallotus villosus), have contributed to changes in the Northwest Atlantic ecosystem, including the NAFO Regulatory Area (NRA). The removal of functionally important species from an ecosystem can lead to trophic shifts, biodiversity loss and a range of other effects. Ecosystem-based fisheries management (EBFM) is becoming increasingly recognized as an effective approach for preventing or reversing ecosystem changes brought about by fishing. In 2005, NAFO made a commitment to make the transition to EBFM as part of its reform process. WWF commissioned the report "High Seas Reform: Actions to reduce bycatch and implement ecosystem-based management for the Northwest Atlantic Fisheries Organization" to inform this transition. The report identifies the four following objectives that NAFO can use as a practical framework for making the shift to EBFM: (1) prevent or reverse overfishing, (2) minimize bycatch, (3) identify and protect essential fish habitat, and (3) maintain species diversity and key ecological interactions. This poster presents a suite of management measures under these four objectives and the associated science needs for implementing EBFM in the NRA.

Why an ecosystem approach is the wrong paradigm for the next stage of fisheries management

Christopher J. Corkett

Scientific advice based on scientific fact is one of the important inputs a fisheries commission seeks in order to make the decisions needed to manage a fishery. Scientists from the Department of Fisheries (DFO) collect data that is used to form a model that is, in turn, used to provide scientific advice. Clearly, if the database is uncertain or incomplete the scientific advice will be uncertain and incomplete. Better decisions must come from finding better databases, databases that are more certain (by removing uncertainty?) or more complete (by taking an ecosystem approach?). The reason this kind of data based approach is so damaging is that it puts the emphasis in entirely the wrong direction; instead of understanding that all decisions have to be taken we are now led to believe that decisions can be reduced to facts. Find the better facts and we will have the better decisions. However, it is a matter of elementary logic that policy decisions together with goals (such as sustainability) and standards (such as the precautionary principle) cannot be produced from, or be reduced to, facts or data; decisions have to be taken. This poster looks to a trial and error (decision and error) social engineering as a replacement methodology for the basing of decisions on facts.

The Importance of capelin (*Mallotus villosus*) in the Northwest Atlantic

GK. Davoren, P. Penton, C. May, B. Reinfort, N. Record, B. deYoung, C. Burke, W.A. Montevecchi, D. Andrews, A. Buren, M. Koen-Alonso, J.T. Anderson, C. Rose-Taylor, T. Bell, and S. Garthe

The Northwest Atlantic has undergone extensive ecosystem shifts involving oceanographic change and over-fishing. Capelin (*Mallotus villosus*) is the focal forage fish species, preying on invertebrates and in turn being preyed on by most large predators, including cod, seals, whales and birds. Recently, the biology and behaviour of capelin has changed dramatically but the basis of these changes is not well understood. Through a collaborative, multi-disciplinary initiative among university, government and commercial fishers, we investigate the bio-physical mechanisms underlying these changes. Our mesoscale study area encompasses the Funk Island Seabird Ecological Reserve, owing to its globally significant populations of marine fish, birds and mammals. Combining a remotely operated vehicle, sediment grab, and acoustic seabed mapping systems resulted in the identified eleven off-beach (demersal) spawning sites of capelin. Sites were associated with 4 acoustic seabed classes, primarily small gravel (0.5-4.0 mm), and found in bathymetric depressions where temperatures were > 2°C. Determination of the spatial extent of demersal spawning is underway. Comparisons of beach and demersal spawning sites revealed that demersal spawning is a viable reproductive strategy, contrary to previous research. Quantification of the relative contribution of larvae to recruitment from each strategy is underway. Integrating vessel-based and fixed hydroacoustic systems with biological sampling equipment suggested that the diel vertical migratory patterns of capelin is food-driven. Larger capelin (> 120 mm) migrated with larger, longer-distance (0-300 m) migrators (amphipods, euphausiids), whereas smaller capelin migrated with smaller, shorter-distance (0-100 m) migrators (copepods). These patterns impact the diurnal feeding patterns of top predators. Finally, combining vessel-based (trawl) and colony-based (seabird diet) samples of capelin with modeling techniques revealed that seabird diets are sensitive indicators of large capelin density. Models assessing the consequences of density shifts for top predators are under construction. The inclusion of this new information will be important for future stock assessments.

Rocky intertidal community structure across gradients of elevation, wave exposure, and ice scour in northern Nova Scotia

Christine Heaven, Lindsay Eckersley, Ricardo Scrosati

We provide the first comprehensive account of community diversity for intertidal rocky habitats on the west (Gulf of St. Lawrence) and east (Atlantic) coasts of northern Nova Scotia. In the summer of 2005, we identified 38 seaweed species and 29 macroinvertebrate species. Patterns in species abundance and community diversity were determined for the full gradients of intertidal elevation, wave exposure, and ice scour observed on these shores. In general, diversity is lower on the Gulf of St. Lawrence coast than on the Atlantic coast and in habitats where environmental stress is higher. Our study has generated detailed baseline information that could be used in studies of environmental impact assessment for these shores in the future. Our study also constitutes the starting point for experimental studies testing models of community organization and population traits across environmental stress gradients. This next research phase has been initiated in the summer of 2006. Research topics include the effects of dominant seaweeds and grazer invertebrates on community diversity and the variability in invertebrate recruitment rates and population structure across environmental stress gradients. The long-term goals of StFX's Marine Ecology Laboratory are to develop the ecological theory on the organization of populations and communities from marine rocky shores.

Seabird numbers and prey consumption in the North Atlantic

Robert T. Barrett, Gilles Chapdelaine, Tycho Anker-Nilssen, Anders Mosbech, William A. Montevecchi, Jim Reid and Richard R. Veit

We compared seasonal composition, abundance and biomass of seabirds between the northeast (ICES) and northwest (NAFO) Atlantic fisheries regions to identify differences in community assemblages and prey consumption. The abundance of birds was higher in the northwest Atlantic, but biomass was greater in the

northeast. This disparity resulted from enormous numbers of little auks Alle alle breeding in West Greenland and of Leach's storm-petrels *Oceanodroma leucorhoa* breeding in Newfoundland, plus large numbers of non-breeding shearwaters Puffinus spp. entering southern NAFO areas in summer. The northeast Atlantic communities were dominated numerically by northern fulmars *Fulmarus glacialis* and large auks *Uria* spp. and the Atlantic puffin *Fratercula arctica*. Seabirds occupying the North Atlantic consume approximately 11 x 106 t of food annually. Overall consumption rates peak during summer as a result of increased breeding activity and seasonal movements of birds into the North Atlantic. Due to the higher biomass of birds in the northeast, consumption (mainly by piscivores) in ICES areas was approximately 20% higher than in NAFO areas where planktivores dominate. NAFO areas had, however, a much higher consumption rate per unit area than ICES areas. Comparative studies such as these could prove highly informative in assessing large predator responses to fisheries influences and ocean-scale climate change.

Thursday, 14 September

Session 2. Dynamics of NW Atlantic Ecosystems

Comparisons of the Georges Bank Ecological Network: EMAX in Historical Context

Jason Link, William Overholtz, Jay O'Reilly, Jack Green, David Dow, Debra Palka, Chris Legault, Joseph Vitaliano, Vincent Guida, Michael Fogarty, & Jon Brodziak

The Energy Modeling and Analysis eXercise (EMAX) has developed a network analysis model of the entire food web of the northeast US continental shelf. The model includes 34 network "nodes" or biomass state variables across a broad range of trophic levels. The present emphasis has been on the role of small pelagics in the ecosystem. Simpler energy budgets have been constructed for Georges Bank under different ecosystem conditions (Clarke 1946, Cohen *et al*. 1982). Accounting for previous choices in number and type of nodes, we compare and contrast the major energy flows on Georges Bank and how they have changed at distinct points over the past six decades. We also explore how the assumptions and philosophies underlying the construction of energy budgets have affected model results. Despite massive changes to both the ecosystem and our understanding of how it functions, many of the fundamental features of the Georges Bank ecological network have remained remarkably consistent.

Recent changes in the effect of predators on stock size and recruitment of Northern shrimp (Pandalus borealis) in West Greenland waters

Kai Wieland, Marie Storr-Paulsen and Kaj Sünksen

Close linkages between stock sizes of Northern shrimp and cod have been documented for the Northeast Atlantic. Likewise, it has frequently been reported also for the Northwest Atlantic that cod can consume a substantial proportion of northern shrimp stock biomasses. Hence, annual estimates of predation mortality caused by cod or a proxy for this variable have been incorporated in the assessment of several stocks of Northern shrimp in the North Atlantic.

The cod stocks in the Newfoundland and Labrador area as well as at West Greenland collapsed in the beginning of the 1990s and stock sizes of Northern shrimp have increased considerably in the past years, but recent studies conclude that in both areas "bottom up" mechanisms in the ecosystem rather than a release from predation pressure by cod might have been responsible for this.

Comparison of indices of stock size for Northern shrimp and cod at West Greenland do not indicate significant correlations with reasonable time lags applied to account for a possible response of Northern shrimp biomass to changes in cod stock size. Furthermore, stock-recruitment models with environmental variables incorporated suggested that Greenland halibut and not cod biomass explains a significant part of the variability in the recruitment of northern shrimp. However, in both cases changes in the spatial distribution, which have been remarkably for all of the three species in the most recent years, were not considered here.

The present study provides the results of an analysis of the interaction between northern shrimp and its main predators cod and Greenland halibut in West Greenland waters, which explicitly accounts for differences in the spatial distribution of these species. An index of collocation derived from geostatistical characteristics such as the centre of gravity and the inertia measuring spatial dispersion is presented and included in the comparison of the time series of stock size for the three species as well as in the stock-recruitment analysis for Northern shrimp.

Long-term trends in Greenland groundfish assemblages : Interplay of climate, ocean productivity and fisheries

Heino O. Fock

Analysing German goundfish survey data from 1981 to 2005 by means of PCA, four main trend components are identified accounting for 60 % of assemblage variance. The leading principal component (PCA1) accounts for 23 % of total variance and is positively correlated to redfish > 17 cm (*Sebastes mentella* and *S. marinus*). PCA2 accounts for 17 % of total variance and is correlated to juvenile redfish. PCA3 and PCA4 account for 12 % and 8 % of total variance, respectively. American plaice and Atlantic wolffish are attributed to PCA3. Atlantic cod is equally assigned to both PCA3 and PCA4. PCA1 and PCA4 are significantly correlated with air temperature records from Nuuk ($p<0.01$), a long-term Greenland climate proxy. PCA2 is correlated ($p<0.05$) with the ocean phytoplankton colour index from the CPR series for East Greenland (CPR area B 7). Taking respective data from the West Greenland cod fisheries as the major fisheries impact until its depression in 1992, PCA3 negatively correlates with cod VPA fishing mortality as well as calculated total fishing effort derived from reported coastal landings and coastal survey CPUEs and reported commercial CPUEs from 1981-82. For the Greenland coastal zone, shrimp fisheries increased in the 1990's, so that fishing effort calculations based on cod catches cannot be extended further.

It is discussed, that the four main principal components merely not only represent species components, but also major impact factors. By this, climate (PCA1&4), ocean productivity (PCA2) and fisheries (PCA3) are the main structuring forces in the Greenland groundfish assemblage, with about 31 % of total variability assigned to climate. With respect to Atlantic cod, fisheries by means of PCA3 and climate by means of PCA4 are equally important to elucidate long-term dynamics.

The Effects of Fishing Exclusion on the Groundfish Community in the Western Gulf of Maine

K. Blinkoff, L. Kaufman, R. Brown, J. Link

Marine protected areas (MPAs) provide an opportunity to study the effects of fishing on local fish populations. Examination of a dataset collected one year after the establishment of the Western Gulf of Maine Closed Area, a de facto MPA, revealed few detectable differences in biodiversity, abundance, biomass, or size distribution of groundfish species inside versus immediately outside the closed area. Two species that exhibited significant differences in density inside versus outside the closed area were spiny dogfish, which were more abundant outside, and Atlantic wolffish, a relatively stationary species which was more abundant inside the closure. A greater number of significant differences were detected between the shallow zone and deep zone stations in our data, emphasizing the relative importance of habitat in comparison to inside versus outside location. The otherwise lack of detectable differences could either be due to a lack of response to the fishery exclusion, or inability of our sampling design to detect major differences. Mobility of groundfish, displacement of fishing effort, and lack of recovery time are suggested as reasons for a lack of differences. However, low sample size and high variance suggests that low power may limit conclusions drawn from a lack of significant differences. This comparison and comparisons like it will help to assess the long term efficacy of closed areas and the fishing history of the Gulf of Maine region.

Changes in the fish community of the Newfoundland Shelf (NAFO Divisions 2J3KLNO) in the period 1981-2005: Signals and trends from the Canadian multi-species bottom trawl survey

Mariano Koen-Alonso, Fran Mowbray and George Lilly

The Newfoundland marine ecosystem underwent dramatic changes in the last 30 years. During this period, Fisheries and Oceans Canada carried out bottom-trawl surveys mainly intended for stock-assessment of commercial species. These surveys have been used for several studies of the changes in this fish community. This paper adds to them in two ways: a) it expands the time window to include recent years, and b) instead of focusing on some core species, it considers the whole fish assemblage as seen by the survey gear. The analysis was geographically split into Newfoundland Shelf (Div 2J3K) and Grand Bank (Div. 3LNO). We calculated biomass and abundance indices, biomass/abundance ratios (BA-ratios), diversity, and Abundance-Biomass Comparison plots (ABC plots). The results indicated that the collapse of the main commercial stocks was accompanied, and sometimes preceded, by collapses in non-commercial species, most noticeably large demersals. Many collapses were also characterized by reductions in BA ratios. Since then, no major recovery has been observed, but the fish community is still undergoing changes. Some small demersals and Arctic cod, which increased when the major stocks were collapsing, are now declining. As "ecosystem indicators" no single survey index performed well in isolation; only if examined together they may provide useful flags for changes in community structure. Spatially aggregated diversity indices were poor indicators, but summary statistics from ABC-plots showed potential for tracking changes in community structure. In any case, stand-alone indicators without knowledge of the processes behind them only provide a rudimentary basis for management advice. Understanding these processes must become a priority if we want to seriously move towards ecosystem-based fishery management.

Marine Sponge Bycatch in the Northwest Atlantic

Susanna Fuller and Ransom Myers

Following the collapse of the groundfish fishery in the Northwest Atlantic in the early 1990's, many vessels moved into deeper water and targeted new species. This move into areas that previously had not experience heavy fishing pressure resulted in increased bycatch of non-commercial species. Since the advent of the fisheries observer program in 1977, primarily on foreign vessels and then extended to domestic vessels, sporadic records of sponge catch have been made. Catches up to 8000kg per tow have been recorded in Davis Strait area, while catches of 1000kg-5000kg are recorded from the Labrador Shelf and Emerald Basin on the Scotian Shelf. Similar catches have been recorded in research trawl surveys both on the Scotian Shelf, the Grand Banks and the Labrador Shelf.

A marked increase in sponge catch per tow was occurred immediately following the 1991 groundfish moratorium. The increase in sponge catch is attributed to the fact that vessels immediately moved to deeper waters (from 600m to over 1200m) to fish for new species. The greatest bycatch occurs in the Greenland halibut fishery in depths between 800 and 1200m in the Davis Strait. A second hotspot of sponge abundance occurs on the Scotian Shelf, with catches up to 5000 meters at depths of 180-220m. This population is a monospecific patch of the glass sponge, Vazella pourtalesi. Despite the lack of systematic collection of non-commercial bycatch, important biogeographical patterns can be determined from the data that is available. The trend towards fishing deeper and resultant increase in sponge bycatch, indicates a clear pattern of removal of structural species that take decades to centuries to form large scale patches.

Mini-Session on Capelin

Results from a combined survey for capelin, polar cod, krill, marine mammals and birds off West Greenland

B. Bergstrøm, H. Vilhjalmarsson, K. Wieland, S. Jonsson, M. Simon, M.P. Heide-Jørgensen and J. Nyeland

This paper describes the large scale distribution of capelin, polar cod, krill related to hydrography and combined with synoptic data on mammals and seabirds over the West Greenland plateau from 73°N to about

60° N -including some fjords, in September/October 2006. This study represents a first attempt to apply an "ecosystem approach" to pelagic survey work in Greenland waters.

The results are based on acoustic (38 Khz and 120 KHz) data, CTD data, pelagic trawl-"groundtruthing", and sampling with a bongo net. Data were collected during E/W transects spaced at about 22 nautical miles between a distance of approximately 3 nautical miles from the coast and the 400 m isobath. Along transects two separate teams of observers identified and counted marine mammals and sea birds.

Preliminary results indicate that "East Greenland Current" water was present throughout the entire survey area to 73°N, while the influence of the warm "Atlantic water" began to decline around 67-68°N. A very strong thermo cline (3-4°C) still persisted in the northern half of the study area, while it was much less pronounced and even absent in places in the southern part of the investigated area.

Generally polar cod (*Boreogadus saida*) and amphipods (*Themisto* sp.) where found in the northernmost part of the survey area (73-70° N).

Capelin (*Mallotus villosus*) was virtually absent on the banks but present in fjords and near shore areas (between 70-60° N). The capelin biomass in these fjords and near shore areas was estimated to be between 170-200 thousand tonnes. A preliminary analysis of size distributions in the obtained samples indicates that most of the oldest and largest fish (next year's spawning component) as well as the 0-group were missing in the survey area during the investigated period. Capelin observed in the fjords and near shore areas was 1 and 2 years old.

Krill (mostly *Meganyctiphanes norvegica*) were found in scattered aggregations between 69° and 62° N with a slightly increased prevalence between 63° and 62° N.

Juvenile cod (*Gadus morhua*) (0-group), occasionally mixed with 0-group redfish (Sebastes sp.), occurred in fairly high densities between the Narsalik and Nanortalik banks (61°-60°N).

One hundred and ninety-five sightings were made of 577 individual marine mammals during 222 hours on-effort observations. Thirteen species of cetaceans were sighted in all. The largest diversity of cetaceans was however observed in the Denmark Strait and off East Greenland (11 of the 13 cetacean species) during transit to the main survey area off West Greenland. Generally fin whale sightings were aggregated in the offshore areas, with the core areas being between Disko Bay and Sisimiut, west of Kap Farvel and off King Frederik VI's coast up to Ammassalik. Minke whales were observed in the same areas as the fin whales. No cetaceans were observed north of Disko Bay. Humpback whales were observed both off and in-shore and the only species observed inside fjords, usually close to the mouth of the fjord

A total of 34 bird species were recorded of which 27 were observed within a 300 m. transect band during about four hundred ten-minute systematic count periods (67 hours). The most common and numerous species recorded was Fulmar (n>2578 in the 300 m. transect band) followed by Kittiwakes (n=2132), Little Auks (n=1675) and Brünnich's Guillemots (n=347). Fulmars were seen near the ship almost all the time during the cruise and occurred at times in such large numbers around the ship that systematic counts of this species was impossible, due to the risk of double counting.

Nature's experiments on capelin introduction on the Flemish Cap – what are the reasons of failure?

V.A.Borovkov, A.L.Karsakov, and N.G.Ushakov

The Flemish Cap Bank is located outside the normal capelin range but with strong cooling of adjacent waters the short-term occurrences of adult capelin in this area were recorded in early 1970s and early 1990s. In those periods, the reproduction of capelin did not occur though available data on spawning conditions including water temperature and salinity, spawning depth and ground type do not exclude this opportunity. Mass irrevocable carrying out of juvenile capelin outside the bank in the period of the first wintering seems to be the most probable reason of reproduction absence on the Flemish Cap that was caused by seasonal weakening of the Taylor column circulation.

Friday, 15 September

Capelin (Mallotus villosus) spawning biology on the Northeast coast of Newfoundland: a comparison between two reproductive tactics

Paulette Penton and Gail Davoren

Capelin (*Mallotus villosus*), the key forage fish in the Northwest Atlantic, typically spawn on beaches in Newfoundland with the exception of one documented off-beach (demersal) spawning ground located 300 km from shore. Capelin biology and behaviour, however, changed in the 1990s, which coincided with the discovery of eleven demersal spawning sites at varying depths (18 - 33 m) and varying distances from shore (2.5 – 17.7 km) on the exposed Northeast coast of Newfoundland. To date, there has been no documentation of demersal spawning as a successful reproductive mode in coastal Newfoundland. We simultaneously investigated beach and demersal spawning sites (2004-2005) to compare the environmental features of these spawning sites (i.e. temperature, substrate type) and their influence on the timing and intensity of spawning, as well as the developmental and survival rates of eggs. In both years, spawning events at demersal sites were later and more protracted than at beach sites and egg densities were higher at demersal sites than at the beach. Developmental rates were slower at demersal sites due to lower temperatures (1.5-16.2°C) relative to the beach (4.0-20.2°C). Egg mortality was consistently higher at the beach (4 - 90 %) relative to demersal sites (0 - 18 %), possibly owing to the higher daily fluctuations in temperature at beach sites relative to demersal sites. Results indicate that demersal spawning is a viable alternative reproductive strategy on the exposed Northeast coast of Newfoundland.

Specialist (common murre Uria aalge) and generalist (Atlantic puffin Fratercula arctica) avian predators and forage fish availability

Chantelle M. Burke, William A. Montevecchi, J.T. Anderson, and M. Koen-Alonso

We compared the parental food deliveries of two closely related pursuit-diving alcids with forage fish availability at Funk Island in the northwest Atlantic during 2004 and 2005. To meet increased energy demands and cope with the restrictions of central place foraging, parental seabirds are likely efficient and often selective predators during chick-rearing. Murres that are more than twice the mass of puffins (1 kg vs 400 g) and deliver a single prey to their chicks can search deeper and farther and tend to be more selective predators. In contrast, puffins often carry multiple fish to their chicks are often less selective taking fish that require less energy to find and capture. An integrated colony and vessel-based approach was used to assess prey preferences through a direct comparison of the species and sizes of forage fish in parental prey loads with those available in the foraging environment. Diets were assessed from parental prey deliveries and forage fish availability was estimated from a mid-water trawl within avian foraging ranges. Murres in the Northwest Atlantic are capelin specialists and exhibited a strong preference for large (> 140 mm) female capelin during both years despite a significant decrease in abundance in 2005. Parental puffins showed a preference for post-metamorphic sandlance available in high densities near the colony in 2004 but switched to female capelin in 2005 when sandlance were unavailable. Inter-specific differences in the composition of prey loads relative to the availability of capelin and sandlance suggest that puffins respond more readily to shifts in forage fish availability than murres that forage selectively.

Modeling the link between prey availability and diet: Common murre (*Uria aalge*) and capelin (*Mallotus villosus*) interaction during the breeding season around Funk Island

Alejandro D. Buren, Mariano Koen-Alonso, William A. Montevecchi, John T. Anderson, Brad deYoung, and Gail K. Davoren

The underlying relationship between predators' diet and prey availability is an important aspect of ecosystem functioning. However, concurrent field evaluations of these two variables are scarce. This paper tackles this issue using common murres at Funk Island as study case. We gathered synoptic data on diet (prey deliveries to chicks) and prey availability around the colony during the reproductive season. Diet composition was characterized using percentage by number and its confidence limits were obtained by bootstrap. Common

murres are capelin specialists. They mostly feed on capelin larger than 100mm ("suitable capelin"), but other species are occasionally recorded in the diet. Therefore, we defined three prey categories: small suitable capelin (100-140mm), large suitable capelin (>140mm), and "others" (species other than capelin). Prey availability was estimated from a mesoscale survey using a pelagic trawl (IYGPT). Two approaches were implemented to model the relationship between diet and prey availability. The first one was a standard statistical method, a multicategory logit model. The second approach had ecological roots. It estimated the probability of consuming different prey categories from a generalized form of the multispecies Holling functional response. Both models described well the observed diets, but the ecological model had a better fit. Overall, our results indicate that, although clearly non-linear, there is a detectable relationship between capelin availability and common murre's diet. One intriguing observation is that in years when abundance of suitable capelin was high, the proportions of large and small capelin consumed did not differ significantly. However, in those years when suitable capelin abundance was low, there was a significant difference in the proportions of large and small capelin in the diet.

Session 3. Comparison of ecosystems, and social and economic consequences of changes in the NW Atlantic Ecosystems

Invited Paper: Comparative Analysis of Continental Shelf Ecosystems in the Northwest Atlantic

Nancy Shackell on behalf of Ken Frank

This talk will summarize recently completed and on-going research on the inter-comparison of the eastern and western Scotian Shelf ecosystems.

The eastern Scotian Shelf experienced a collapse of the groundfish community and a complete restructuring of the food web while the western Scotian Shelf (WSS) did not, despite similar historical levels of commercial fishery exploitation. The differences are explained on the basis of the strength of top-down (consumer drive) versus bottom-up (nutrient flux) control mechanisms. The conclusions from this cross system analysis require further testing and the intent is to expand the geographic scope of the analysis through efforts coordinated by DFO's Fisheries Oceanography Committee.

Fishing in the NAFO Regulatory Area: Integrated Modeling of Resources, Social Impacts and Fleet Viability

Dan Lane

The paper reports on the results of an integrated spreadsheet model that describes the biological, social, and economic attributes of the international groundfish fishery off the Nose and Tail of the Grand Banks in NAFO Divisions 3LNO. The historical involvement of the fisheries is traced from 1972 to the present and the harvesting and processing operations from six key groundfish stocks are examined. The model explores the impacts of the fishery system on: (1) the status of the groundfish stock populations, (2) the economics of the international commercial fishery, especially as experienced by Canada, Spain and Portgual, and (3) the social status of Canadian coastal communities. The paper traces the historical development of the Canadian and NAFO commercial groundfish fisheries, the impact on the status of the fish stocks, and the key historical involvement of the European Union fishing fleets from Spain and Portugal. Groundfish catches in the Grand Banks NAFO Regulatory Area (NRA) are used to estimate the annual integrated economic performance of the Canadian, and EU fishing fleets. Social impacts of the fisheries on the labour opportunities in domestic Canadian communities are also presented. The integrated spreadsheet model is useful for exploring the impacts on stocks, fisheries, and communities under alternative input assumptions, e.g., on costs and fish prices, and the impacts due to regulatory policies over the historical period and projections into the future. The results enable users to understand the underlying historical behaviour that can be assumed to validate the empirical impacts observed on Northwest Atlantic groundfish stocks, economic viability from fishing, and domestic Canadian coastal communities social stability.

Needs of changes on the Grand Bancs Fisheries Organisation, a drastic change of life for Western Maritime Europe and Eastern Canada

Henri Motte & Rosa Garcia-Orellan

Europe's need of fish as a staple foodstuff has been enormous since the fifteenth century when it led captains to launch far-flung fishing operations a long way away from of their home countries. We do not know, with any accuracy, why and when the distant fishery trade began. But the reading of papal bulls, treaties and other written records show that this activity was already well under way as from 1480 onwards.

This kind of fishing was run on very traditional lines until the beginning of the XXth century when it underwent a major change with the advent of mechanically powered units (steam or internal combustion engines). The change became comprehensive with the further advent of a sea-borne freezing capability in 1954.

The USA also began at the time to worry about the management and conservation of the deep sea resources off its Atlantic shore line.

A conference held in Washington (D.C.) in 1949 led to the setting up of the International Commission for the Northwest Atlantic Fisheries (ICNAF). It was for many years the leading organisation in charge of the management of fisheries. The new aproach brought about by the new Law of the Sea prompted a change in the terms of reference of ICNAF, which became the Northwest Atlantic Fisheries Organisation (NAFO) in 1978. But the major weakness in the system lies in the Policing of the Sea and this dates back to as early as 1490.

New Factory Freezing Trawlers (F.F.T.) sailing the oceans set a new dynamic trend. They are no longer supplying mainly their own country with their catch. Instead they cater for the demands of the international market wherever they are in the world and where the yield is best for the relevant fish product.

Today NAFO must enforce all kinds of rules relating to the sustaiened management of ressources. The long term survival of fisheries can only be achived if the member states of NAFO reach an early consensus on rules (governance) and if they enforce them.

If the governance seems to be the resolution to all problems today, governance is certainly not the easy solution in the fishery crisis we face today. In fact, the big problem is difficult our impossible to regulate the fishery situation by the only decisions of the shoreline countries or by the international organisms. The fishery problem must be approached by a total restructuring of this industry which would go from the fishing organization itself up to the seafood products market.

Methods for Standardizing, Validating and Enriching Taxonomic Metadata

Robert M. Branton, Daniel Ricard, Lenore Bajona , Lou Van Guelpen

Metadata give information about data to enable a data analyst or end-user to understand them. Biological data include the name(s) of the organism(s) in question either in the body of database, in its title, or in its descriptive text. In each case the name comprises taxonomic metadata. Simply providing the common name(s) for species, particularly when data are to be combined with those from other sources, is impractical, thus unacceptable. A data provider generally starts by determining the scientific name and authority for the organisms at hand. A scientific name must be the version currently accepted by taxonomic specialists and must be spelled correctly. This can be a difficult task, especially when a database contains hundreds of names. In this paper we show how taxonomists at the Atlantic Reference Centre (ARC) of the Huntsman Marine Science Centre in St. Andrews, New Brunswick and scientific data managers at the Bedford Institute of Ocean Oceanography (BIO) in Dartmouth, Nova Scotia treat organism names in biological databases for global internet access via portals such as the Ocean Biogeographic Information System (OBIS). We particularly describe the ARC Museum of Canadian Atlantic biota and its accessibility through the OBIS portal, the North Atlantic Registerof Marine Species (NARMS), and the Canadian component of the North American Integrated Taxonomic Information System (ITIS). Finally we give a detailed description of the data rescue software being

developed at BIO, which uses ITIS to facilitate the use of currently accepted scientific names, authorities and taxonomic hierarchies for lists of scientific names representative of those in typical scientific databases.