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Environmental and Ecosystem Histories in the Northwest Atlantic – What Influences Living Marine Resources?

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Journal of Northwest Atlantic Fishery Science

Scientific publications by ICNAF and NAFO have been in existence since ICNAF began in 1949 with the ICNAF Special Publication series dealing with Proceedings of scientific symposia. The *ICNAF Research Bulletin* was started in 1964 to provide a means of publishing results of scientific research relevant to ICNAF. The ICNAF Research Bulletin was terminated in September 1979 after the issue of Number 14. The first volume of the *NAFO Journal of Northwest Atlantic Fishery Science* was published in December 1980, after NAFO came into force replacing ICNAF in 1979.

The Northwest Atlantic fisheries have a rich history, and a great deal of research has been sponsored and encouraged by NAFO and its predecessor ICNAF. NAFO has been a leader in international organizations in the application of science to fishery management and in the regulation of fisheries. In accordance with its mandate to disseminate information on fisheries research to the scientific community, the Scientific Council of NAFO publishes the *Journal of Northwest Atlantic Fishery Science*, which contains peer-reviewed primary papers, and NAFO Scientific Council Studies, which contains unrefereed papers of topical interest and importance to the Scientific Council. Lists of these and other NAFO publications are given on the back of this issue.

Editorial Policy

The Journal provides an international forum for the primary publication of original research papers, with emphasis on environmental, biological, economic and social science aspects of fisheries and their interactions with marine habitats and ecosystems. While the Journal is intended to be regional in scope, papers of general applicability, and methodological and review papers, irrespective of region, are considered. Space is available for notes and letters to the editor to facilitate scientific discussion of published papers. Both practical and theoretical papers are eligible. All papers are peer-reviewed to determine their suitability for primary publication. Associate Editors arrange for the peer-reviews and ensure that the papers accepted for publication meet the high standards required for the Journal. Manuscripts approved for publication are accepted with the understanding that they are not copyrighted, published or submitted elsewhere except in abstract form. There are no page charges.

Editorial Board

Foreword

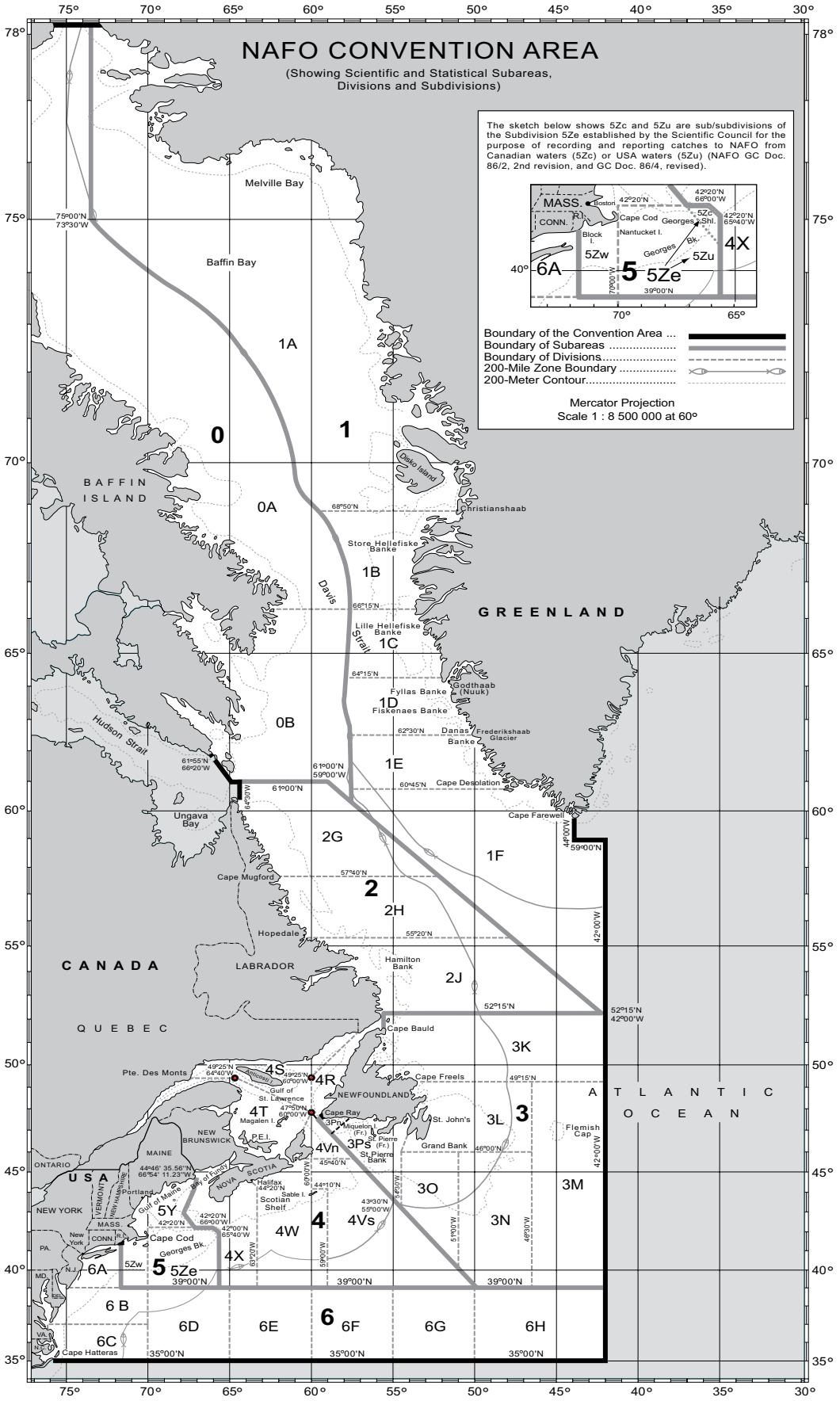
The Scientific Council of NAFO publishes the *Journal of Northwest Atlantic Fishery Science*, which contains peer-reviewed primary papers on original research. In 2005, Scientific Council took steps necessary to modernize the journal's publication medium and introduced a more appropriate copyright notice. Articles are now published electronically and all are freely available at http://journal.nafo.int. The bound print volumes are treated as a compilation of the web-based articles. Additionally, the journal supports the use of the digital object identifiers (doi) for electronic media and encourages others to support the doi initiative.

This volume presents selected papers from the symposium on "*Environmental and Ecosystem Histories in the Northwest Atlantic – What Influences Living Marine Resources?*" held in Dartmouth, Nova Scotia, Canada, during 13–15 September 2006. Many of the presentations focused on the Grand Banks, Flemish Cap and Georges Bank, with discussions providing the broad-based comparative context by examining recent events in both a wider geographical framework and in a historical context. There was a general sentiment that ecosystems are highly complex and can turn over quickly and apparently unpredictably, from one state to another. The participants generally came from four schools dealing with the physical aspects, single-species fisheries assessment, ecosystem considerations and interactions, and the social science and economics fields. At the single species level, for example, there is a common belief that for most fisheries it is possible to manage the system to obtain the desired outcome – the more you catch the lower the stock and *vice versa*. The social scientists may explain why this is difficult to accomplish in real life, but it is generally felt that, to a large extent, we can (or could) control the abundance of a particular target species. This was not considered to be the case with respect to ecosystems that can react in apparently unpredictable ways. Here it was believed that climate considerations play an important role, and that quite large regime shifts may be waiting to happen given a slight nudge in one direction or another.

The complexity increases when we consider Ecosystem Approaches and Ecosystem Based Fisheries Management. Protecting the ecosystem, for example, from damaging operations or pollution, can be considered and even achieved, but managing and manipulating ecosystems is much more of a challenge.

March 2008

Anthony Thompson
General Editor,
Journal of Northwest Atlantic Fishery Science


NAFO CONVENTION AREA
(Showing Scientific and Statistical Subareas, Divisions and Subdivisions)
The sketch below shows 5Zc and 5Zu are sub/subdivisions of the Subdivision 5Ze established by the Scientific Council for the purpose of recording and reporting catches to NAFO from Canadian waters (5Zc) or USA waters (5Zu) (NAFO GC Doc. 86/2, 2nd revision, and GC Doc. 86/4, revised).
Boundary of the Convention Area ...
Boundary of Subareas .....
Boundary of Divisions.....
200-Mile Zone Boundary .....
200-Meter Contour.....
Mercator Projection
Scale 1 : 8 500 000 at 60°
Melville Bay
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Davis Strait
Hudson Strait
Ungava Bay
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Fiskenaes Banke
Danas Banke
Frederikshaab Glacier
Godthaab (Nuuk)
Christianshaab
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Cape Farewell
Cape Mugford
Hopedale
CANADA
LABRADOR
QUEBEC
Hamilton Bank
Cape Bauld
Pte. Des Monts
Gulf of St. Lawrence
NEWFOUNDLAND
Cape Freels
Cape Ray
St. John's
Grand Bank
Flemish Cap
ATLANTIC OCEAN
NEW BRUNSWICK
P.E.I.
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ONTARIO
USA
NOVA SCOTIA
Halifax
Sable I.
Scotian Shelf
Portland
NEW YORK
VERMONT
NEW HAMPSHIRE
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Contents

Report of the Symposium

Environmental and Ecosystem Histories in the Northwest Atlantic – What Influences Living Marine Resources?

The Symposium 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: Bill 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 62 people from 9 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 Fishery Science* (scheduled print date December 2007).

Session 1: Climatic, Physical and Biological Factors Affecting NW Atlantic Ecosystems (Session Chair: M. 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 bycatch 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 were noted. However, this cod/shrimp switch did not appear to occur in the more southern areas. Other discussion focused on ecosystem dynamics, primarily on George's Bank, and how they may have changed over time.

Mini-Session on Capelin (Chair: H. 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 shelf 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 iden-

tification on capelin spawning sites, 2) Comparison between two reproductive strategies, 3) Seabirds as sensitive indicators of large capelin density, and 4) A model assessing the consequences of density shifts for top predators.

In the general discussion the role of capelin in the Northwest Atlantic ecosystem was addressed. This included the role of 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: J. 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 (Phytoplankton, Zooplankton, 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 (Ecosystem Approach to Fisheries), 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*.).

Final Discussion and Wrap-up

To focus the discussion at the end of the Symposium, the convenors prepared the following map, which roughly outlines some areas to be considered as different ecosystems. The boundaries are not meant to be exact, and some discussion focused on differences within and between adjacent areas. Table 1 was meant to capture some of the key ecosystem properties and dynamics, and was filled in using the knowledge of Symposium participants. Where there was no expertise available at the symposium, or there was known to be no information on a particular topic, the cell was filled with a question mark. Completing the table challenged the Symposium participants to compare the different regions, and allowed the similarities and differences in the "ecosystems" to be seen at a glance (Fig. 1).

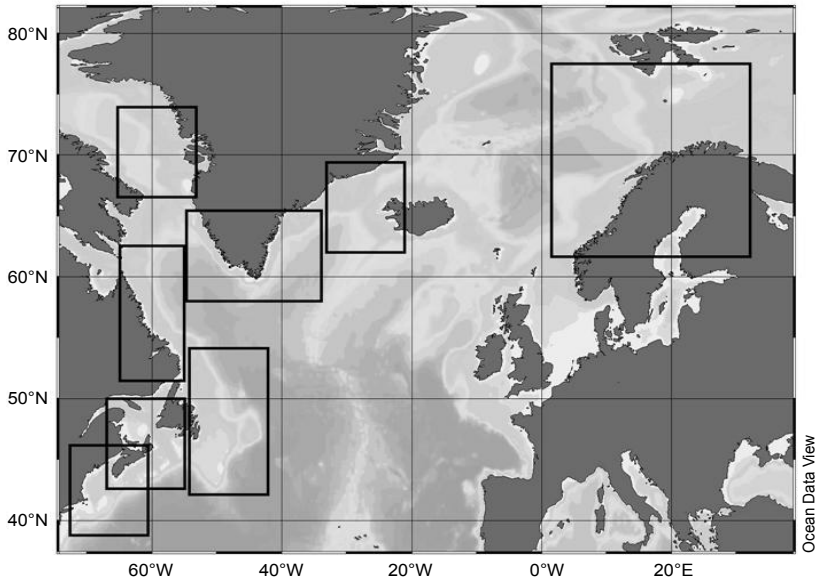

Fig. 1. Location of regions referred to in Table 1.

TABLE 1. Dynamic history and simple description of changes in major features of the NW Atlantic ecosystems. Table shows current trend (1995–2005) and what is known about present state of anomaly. Key: + is increasing; - is decreasing; 0 is stable; ? is unavailable, unknown or no data; N/A is not applicable.

	Barents Sea	E Greenland-W Iceland	S Greenland	W Greenland	Labrador	Grand Banks-Flemish Cap[1]	Scotian Shelf (GSL Later)[2]	Gulf of Maine-Georges Bank[2]
Meterology & Climate	+	+	+	+	+	+	+	+
Ice Cover	0	-	-	-	-	-	N/A	N/A
Water Masses (T & S)	+	+	+	+	+	+	?/+	0/+
Phytoplankton	?	0/?	0/?	0/?	?/+	?/+	?/+	0
Zoooplankton	?	0	0	0	?	?	?	+
Other Benthos	?	?	?	?	?	?	?	0
Commercial Benthos	?	-	?	?	+/?	?	+	+
Shrimp	?	0	-	+	+	+	+	0
Demersal Fish	?	-	-	-	-	-	-	-
Pelagic Fish	?	?	?	?	?	?/-	+	+
Seals	?	++	+	+	+	++	+	0
Birds	?	?	?	?	?	0	0	?
Total Landings	?	0	0	+	0	-	-	-
Total Value of Landings	?	?	0	0	?	-	+	+
Yes (Y) or No (N)								
Capelin		Y	Y	Y	Y	Y	N	N
Cod-Shrimp switch		Y	Y	Y	Y	Y	Y & N	N
Major Fishery targets		Shrimp, Gr Halibut, Pelagics (HMS)	Shrimp, Seals, Gr Halibut, Pelagics (HMS)	Shrimp, Seals, Gr Halibut, Pelagics (HMS)	Shrimp, Seals, Gr Halibut, Redfish, Snow Crab	Shrimp, Seals, Gr Halibut, Redfish, YT, Skates, Snow Crab, Capelin, Lobster	Snow Crab, Shrimp, Lobster, Haddock, Cod, Scallops, Small Pelagics	Scallops, Lobster, Flatfishes, Goosefish, Squids
Degree of influence on phytoplankton by physical oceanography	Y	Y	Y	Y	Y, ++	Y, moderate	Y	Mild
Scale of longer time series- comparison with historical time series (have we seen it before):		Y	Y	Y	N	Y	Y	Y

[1] Could be split north and south.
[2] Could be split east and west.

Following the discussion, the convenors thanked the participants and presenters for their contributions, and the NAFO Secretariat for their usual excellent support before and during the Symposium. The convenors also extended thanks to the NAFO Secretariat for hosting a reception during the poster display, which was very well received. The Vice-Chair of Scientific Council then extended his thanks, and officially closed the Session.

SYMPOSIUM SCHEDULE

Environmental and Ecosystem Histories in the Northwest Atlantic – What Influences Living Marine Resources?
13–15 September 2006
Holiday Inn Harbourview (Alderney Room)

Wednesday, 13 September 2006

0845–0915	Registration
0915–0930	Introduction (Scientific Council Chair, Convenors)
	Session 1. Climatic, Physical and Biological Factors Affecting NW Atlantic Ecosystems
0930–1000	PERRIE, W. J. JIANG, Z. LONG, Y. YAO, W. ZHANG, and B. TOULANY. Climate change impacts on NW Atlantic storm, wind and wave estimates.
1000–1030	COLBOURNE, E. B., H. LOENG, K. F. DRINKWATER, and V. OZHIGIN. Ocean climate variability - comparisons of the Northwest Atlantic to the Barents and Nordic Seas.
1030–1100	**Break**
1100–1130	PERSHING, A. Remote forcing of marine ecosystem dynamics in the Gulf of Maine.
1130–1200	SIGAEV, I. K. Interannual variations of hydrological fronts in Northwest Atlantic and tendencies in the year-class abundance of some commercial stocks.
1200–1230	STEIN, M. 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.
1230–1330	**Lunch**
1330–1400	HARRISON, W. G. Phytoplankton growth and regulation in the Labrador Sea – light and nutrient limitation.
1400–1430	LI, W. K. W. Multiyear change in the phytoplankton community of the Northwest Atlantic continental shelf and the Labrador Sea.
1430–1500	HEAD, E. J. H. Variations in over wintering depth distributions of *Calanus finmarchicus* in the slope waters of the NW Atlantic continental shelf and the Labrador Sea.
1500–1530	**Break**
1530–1600	FUENTES-YACO, C., P. KOELLER, K. WIELAND, U. SKULADOTTIR, M. ASCHAN, T. PLATT, and S. SATHYENDRANATH. Influence of the spring phytoplankton bloom on the life history and population dynamics of shrimp (*Pandalus borealis*) in the North Atlantic.
1600–1630	NEUHEIMER, A. B., and C. T. TAGGART. Growth in fishes – a near-universal metric.
1630–1715	**Session Discussion**
1715–1745	**Poster presentations**
	WWF-CANADA. Toward ecosystem-based fisheries management in the NAFO Regulatory Area.
	CORKETT, C. J. Why an ecosystem approach is the wrong paradigm for the next stage of fisheries management.

DAVOREN, G. K., 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 importance of capelin (*Mallotus villosus*) in the Northwest Atlantic.

HEAVEN, C., L. ECKERSLEY, and R. SCROSATI. Rocky intertidal community structure across gradients of elevation, wave exposure, and ice scour in northern Nova Scotia.

BARRETT, R. T., G. CHAPDELAINE, T. ANKER-NILSSEN, A. MOSBECH, W. A. MONTEVECCHI, J. REID, and R. R. VEIT. Seabird numbers and prey consumption in the North Atlantic.

1800 **Reception/Poster Display**

Thursday, 14 September 2006

Session 2. Dynamics of NW Atlantic Ecosystems

0900-0930 LINK, J., W. OVERHOLTZ, J. O'REILLY, J. GREEN, D. DOW, D. PALKA, C. LEGAULT, J. VITALIANO, V. GUIDA, M. FOGARTY, and J. BRODZIAK. Comparisons of the Georges Bank Ecological Network: EMAX in historical context.

0930-1000 WIELAND, K., M. STORR-PAULSEN, and K. SÜNKSEN. Recent changes in the effect of predators on stock size and recruitment of Northern shrimp (*Pandalus borealis*) in West Greenland waters.

1000-1030 FOCK, H. O. Long-term trends in Greenland groundfish assemblages: Interplay of climate, ocean productivity and fisheries.

1030-1100 **Break**

1100-1130 BLINKOFF, K., L. KAUFMAN, R. BROWN, and J. LINK. The effects of fishing exclusion on the groundfish community in the Western Gulf of Maine.

1130-1200 KOEN-ALONSO, M., F. MOWBRAY, and G. LILLY. 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.

1200-1230 FULLER, S., and R. MYERS. Marine sponge bycatch in the Northwest Atlantic.

1230-1330 **Lunch**

1330-1400 **Session Discussion**

1400-1430 BERGSTRØM, B., H. VILHJALMARSSON, K. WIELAND, S. JONSSON, M. SIMON, M. P. HEIDE-JØRGENSEN, and J. NYELAND. Results from a combined survey for capelin, polar cod, krill, marine mammals and birds off West Greenland.

1430-1500 BOROVKOV, V. A., A. L. KARSAKOV, and N. G. USHAKOV. Nature's experiments on capelin introduction on Flemish Cap – what are the reasons of failure?

Friday, 15 September 2006

0900-0930 ROSE-TAYLOR, C., J. T. ANDERSON, and T. BELL. Characterization and acoustic classification of demersal capelin spawning habitats in coastal northeast Newfoundland.

0930-1000 PENTON, P., and G. DAVOREN. Capelin (*Mallotus villosus*) spawning biology on the Northeast coast of Newfoundland: a comparison between two reproductive tactics.

1000-1030 BURKE, C. M., W. A. MONTEVECCHI, J. T. ANDERSON, and M. KOEN-ALONSO. Specialist (common murre *Uria aalge*) and generalist (Atlantic puffin *Fratercula arctica*) avian predators and forage fish availability.

1030-1100 **Break**

1100-1130 BUREN, A. D. M. KOEN-ALONSO, W. A. MONTEVECCHI, J. T. ANDERSON, B. DEYOUNG, and G. K. DAVOREN. Modeling the link between prey availability and diet: common murre (*Uria aalge*) and capelin (*Mallotus villosus*) interaction during the breeding season around Funk Island.

1130-1200 **Session Discussion**

1200-1300 **Lunch**

Session 3. Comparison of Ecosystems, and Social and Economic Consequences of Changes in the NW Atlantic Ecosystems

1300-1330 SHACKELL, N. (on behalf of K. Frank - Invited Paper). Comparative analysis of continental shelf ecosystems in the Northwest Atlantic.

1330-1400 LANE, D. Fishing in the NAFO Regulatory Area: integrated modeling of resources, social impacts and fleet. Viability

1400-1430 MOTTE H., and R. GARCIA-ORELLAN. Needs of changes on the Grand Banks Fisheries Organization, a drastic change of life for Western Maritime Europe and Eastern Canada.

1430-1500 **Break**

1500-1530 BRANTON, R. M., D. RICARD, L. BAJONA, and L. VAN GUELPEN. Methods for standardizing, validating and enriching taxonomic metadata.

1530-1600 **Session Discussion**

1600-1630 **Overall Discussion/Close**

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