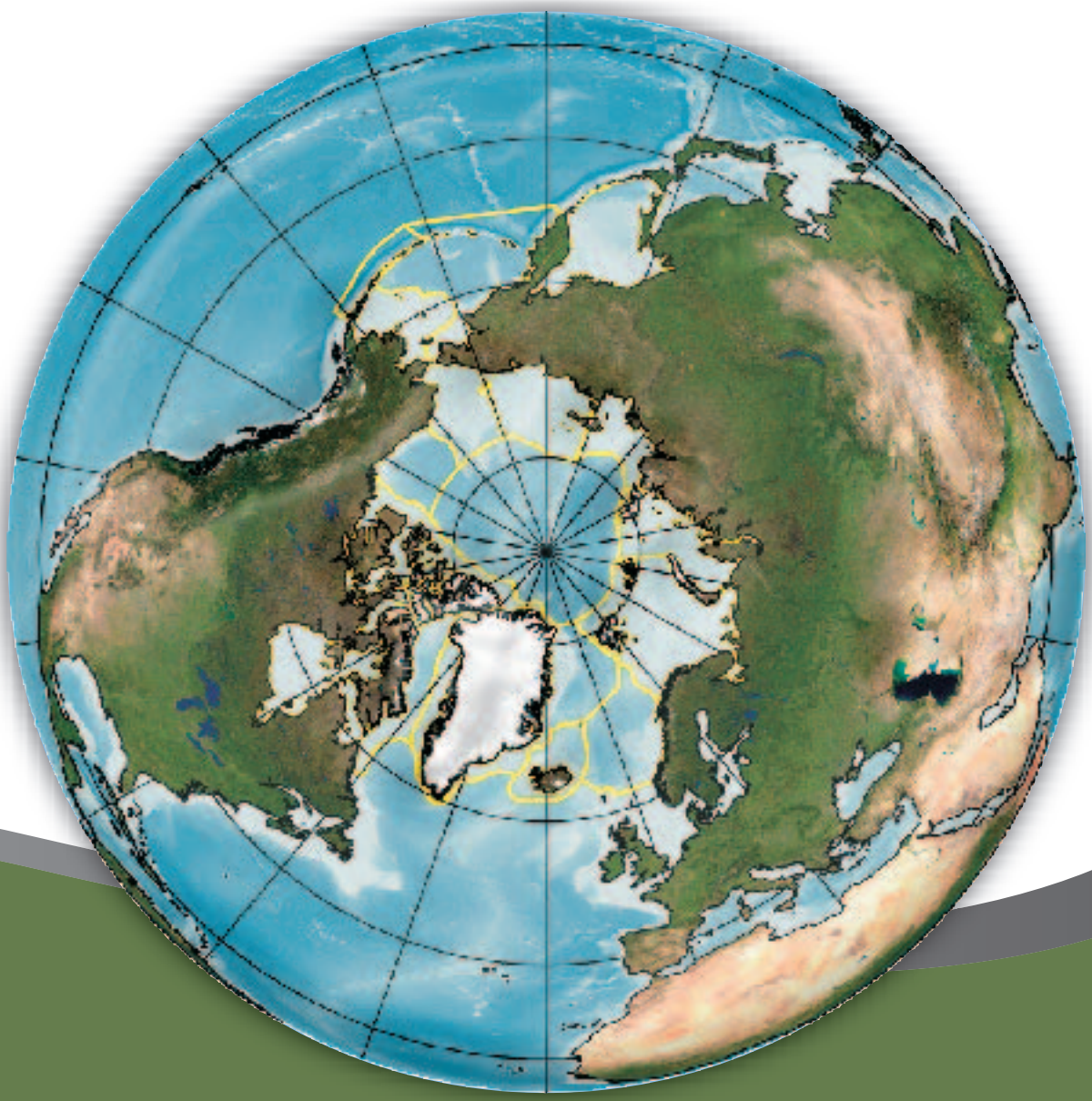


PAME Progress Report on the Ecosystem Approach to Arctic Marine Assessment and Management 2006-2008

PAME
Protection of the Arctic Marine Environment

ARCTIC COUNCIL



PAME Progress Report on the Ecosystem Approach to Arctic Marine Assessment and Management

2006-2008

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I. Terms of Reference

This progress report is based on the work assigned to the PAME Working Group in close coordination with other Arctic Council working groups and related projects in an effort to promote the implementation and compliance of applicable international instruments and governmental commitments through increased coordination and collaboration and trends towards integrated approaches such as ecosystem approaches in addressing the challenges of coastal and marine environment. An integrated ecosystem approach to management requires that development activities be coordinated in a way that minimizes their impact on the environment and integrates thinking across environmental, socio-economic, political and sectoral realms.

In 2002, the Arctic Council agreed "to develop a strategic plan for the protection of the Arctic marine environment under the leadership of PAME". This plan, the Arctic Marine Strategic Plan (AMSP) was adopted by Arctic Council Ministers in 2004 and refers to following commitments towards ecosystem approach:

- *Identify the large marine ecosystems of the Arctic based on the best available ecological information (AMSP Strategic Action 7.4.1)*
- *Identify elements that can serve as key environmental and socio-economic indicators of the state of Arctic marine ecosystems and thus guide effective decision-making (AMSP Strategic Action 7.4.2)*
- *Promote pilot projects that demonstrate the application of an ecosystem approach to management (AMSP Strategic Action 7.4.3)*

PAME developed a working map of 17 Arctic Large Marine Ecosystems as adopted by Ministers in 2006 and established an LME Experts Group in 2007.

*The Arctic Council **endorsed** the working map of the 17 Arctic LMEs, and **requested** PAME to advance the work on the suites of indicators of the changing state of Arctic LMEs and **encouraged** PAME, in close collaboration with AMAP and CAFF, to develop the LME approach for pilot assessment and management projects for the Arctic.*

This work supports the World Summit on Sustainable Development which called for the application of the ecosystem approach by 2010.

II. Background

The Large Marine Ecosystem (LME) approach methodology is one of the approaches applied within the framework of an integrated ecosystem-based management with the key features including a consideration of multiple scales, a long-term perspective, the recognition that humans are an integral part of ecosystems, an adaptive management perspective, and a concern for sustaining production and consumption potential for goods and services.

The LME approach is applied within geographical management areas which are based on distinctive ecosystems rather then political boundaries. LMEs are relatively large regions of ocean space based on four ecological criteria: (1) bathymetry, (2) hydrography, and (3) productivity, and (4) trophic relationships.

A five-module indicator approach to the assessment and management of LMEs consists of 3 science-based indicators focused on: (1) productivity, (2) fish and fisheries, marine birds and marine mammals (3) pollution and ecosystem health. The other two are (4) socio-economic conditions, and (5) governance.

The Arctic Large Marine Ecosystems (LMEs) are diverse and dynamic systems under stress from global warming and the melting of sea ice. Marine species are few but are present in

high numbers. Unprecedented minima of sea ice area have occurred in the Arctic Ocean in 2003-2006. In the Arctic, "the average extent of sea-ice cover in the summer has declined by 15-20% over the past 30 years. This decline is expected to accelerate, with the near total loss of sea ice in the summer projected for late this century" (Arctic Climate Impact Assessment (ACIA), 2004). Advances in the melting of Arctic ice have implications for zooplankton, fisheries, fish stocks, marine mammals, and marine birds, which appear to be shifting northward. They also impact socioeconomic conditions for Arctic people that include indigenous communities, traditionally dependent on the use of natural resources to hunt and fish. New activities are linked to non-renewable resources such as offshore oil, carried out under severe climatic conditions. The unique ecological conditions and unique coastal communities of the Arctic region make it vital to plan for both traditional and new resource activities to be carried out in a sustainable manner. For information on LMEs and the 5-module LME approach refer to the PAME webpage www.pame.is

III. PAME Work Plan 2006-2008 on the Integrated Ecosystem-based Management Approach

The United States represented by NOAA and the Large Marine Ecosystem (LME) Program has led this work on behalf of PAME. The PAME Work Plan 2006-2008 outlines the following tasks as a continuation of previous work and as a contribution to the implementation efforts of the AMSP:

1. Initiate by correspondance a review of the suites of indicators for assessing and monitoring the changing states of the LMEs of the Arctic based on productivity, fish and fisheries, pollution and ecosystem health, socioeconomics, and governance.
2. As a follow on to the presentation on Arctic LMEs, made during the Feb 2006 meeting of the American Association for the Advancment of Science, encourage the preparation for peer review and publication of a volume on the changing conditions of LMEs of the Arctic for publication in the Elsevier Science LME series.
3. Organize a session on Arctic LMEs for the Second Global Conference on LMEs to be held in Qingdao, China, Sep 11-13, 2007.
4. Develop the LME approach for pilot assessment and management projects for the Arctic, for example in the West Bering Sea and the Beaufort Sea.

The first three tasks have been accomplished and the fourth task is considered "work in progress", in collaboration with other Arctic Council working groups and projects including the Arctic Monitoring and Assessment Working Group (AMAP), the Conservation of Arctic Flora and Fauna (CAFF) Working Group, the Sustainable Development Working Group (SDWG), the Arctic Climate Impact Assessment (ACIA) and the Arctic Marine Shipping Assessment (AMSA).

The Best Practices in Ecosystem-Based Ocean Management in the Arctic (BePOMAr) project is a joint PAME/SDWG effort led by Norway. The objective of the BePOMAr project is to present the practices of Arctic countries in the application of an ecosystem-based approach to ocean management. With this country by country review, lessons can be learned from practices that have proved most successful and most useful in moving toward the protection and sustainable use of Arctic environments. Important components of this document are the description of governance mechanisms, institutions for ecosystem-based management, legislation, policy tools and transboundary agreements relevant to the management of Arctic marine ecosystems that both complement and provide inputs into the ongoing work of PAME on integrated ecosystem-based management approaches in the Arctic.

IV. LME Group of Experts

In 2007 PAME moved from defining ecosystems to evaluating ecosystem change and developing a methodology that would include socioeconomic considerations and stakeholder participation. Consequently the PAME LME Expert Group was formed and asked to contribute its expertise and products to other relevant Arctic Council projects such as the Arctic Marine Shipping Assessment (AMSA).

> *Establish a PAME Experts Group to consider information requirements including suites of indicators of the changing states of Arctic LMEs as measured against baselines of the five-module indicator approach (productivity/climate; fish and fisheries/marine birds and mammals; pollution and ecosystem health; socioeconomics and governance) to guide effective decision making [refer AMSP Strategic Action 7.4.2]. The Expert Group shall work in close cooperation with other experts associated with the activities of AMAP, CAFF and SDWG.*

The PAME LME Experts Group has representatives from 8 participating countries: Canada, Denmark (including Greenland), Finland, Iceland, Norway, Russian Federation, Sweden, and the United States. In e-mail exchanges between key experts from each of the Arctic Council countries, the US provided each member with background information on the Large Marine Ecosystem approach to marine resource assessment and management and a copy of a proceedings paper presented at the 26-28 September 2006 Bergen Conference on implementing the ecosystem approach to fisheries. The experts were asked to consider suites of indicators of changing states of Arctic LMEs, as measured against baselines of (i) productivity/climate, (ii) fish and fisheries/marine birds and mammals, (iii) pollution and ecosystem health, (iv)socioeconomics, and (v) governance.

The LME Group of Experts met for the first time in Montreal 13-14 May 2008, following a series of e-mail correspondences as mentioned above. Participants included representatives of the US and Canada, the Baltic Sea LME Director and LME Expert Group member from Sweden, and representatives from SDWG, CAFF and AMSA. The principal topics of the meeting were as follows:

- the LME indicator approach to marine resource assessment and management with specific application to the Arctic Region;
- collaboration with other Arctic Council Working Groups; and
- status of the Arctic LME pilot projects.

Contingent on approval by PAME, each country involved in the candidate pilot LME projects will be expected to initiate discussions and workshops to move ahead with these pilots. The United States and Canada, and the United States and Russia, have already initiated discussions with support from the UNDP-GEF funding process. In the two pilot projects, a transboundary diagnostic analysis will identify the main issues and joint priorities of the participating countries.

The Chair of the Circumpolar Biodiversity Monitoring Program (CBMP), a cornerstone program for the Arctic Council's Conservation of Arctic Flora and Fauna (CAFF), made a presentation in support of the Arctic Biodiversity Assessment. The representative of the Sustainable Development Working Group showed the relevance to the LME perspective of its sources of socio-economic information and data, including ArcticStat, which compiles statistics from all circumpolar countries, and the Survey of Living Conditions in the Arctic (SLICA). The AMSA final report will include a study of the Beaufort Sea and other areas of heavy traffic in the Arctic region. The Expert Group will continue to improve collaboration with the Circumpolar Biodiversity Monitoring Program (CBMP) team in Norway. It will maintain liaison with the Arctic Marine Shipping Assessment (AMSA) and with the

Sustainable Development Working Group (SDWG), which provides an excellent source of socioeconomic information and data. The US representative announced that an LME report with UNEP will describe changing ecological conditions in the world's 64 large marine ecosystems based on the 5-module methodology. The report includes the Arctic LMEs and summary chapters on the global condition of marine productivity, marine fisheries, nutrient over-enrichment, and accelerated LME warming. The report has been published and is available on the LME portal site.

The LME Experts Group will continue to maintain liaison with other experts associated with the activities of other Arctic Council Working Groups including AMAP, CAFF and SDWG.

(A) 5-module assessments

A key factor in reaching a determination on the status of ecosystem condition is the quantitative output from 5 modules of spatial and temporal indicators of ecosystem productivity; fish and fisheries; pollution and ecosystem health; socioeconomics; and governance. Finer scale measurements are contingent on more localized issues such as hotspots of persistent organic pollutants or persistent toxic substances. The Global Environment Facility (GEF) since 1995 has been partnering with national and international agencies to assist developing coastal countries in meeting ecosystem-related targets. The geographic extent of the LME, its coastal zone and contributing basins constitute the place-based area for assisting countries to focus on ecosystem-based strategies to recover depleted fisheries, reduce coastal pollution, and restore damaged habitats. The LME approach and 5-module methodology highlights linkages among root causes of degradation and is a useful strategy for integrating needed changes in sectoral economic activities. The International Waters (IW) focal area of the GEF Strategic Operational Guidance for the period 2007-2010 is focused around 3 themes: fish and fisheries and LMEs; nutrient over-enrichment and LMEs; and freshwater in relation to drainage basins. The 4th theme is pertinent to the Arctic and addresses ice melt and its effect on Arctic LMEs. The Russian Federation as a GEF-recipient country is eligible for funding to support an ecosystem-based project. For a summary of information on all five modules that was sent to the members of the Group of Experts refer to the PAME webpage www.pame.is

(B) Indicators

The Expert Group discussed the usefulness of focusing on these indicators at the macro-level and highlighted the importance of cross-cutting issues such as climate change and biodiversity. Climate change considerations are included in the three science-driven modules of (i) productivity/environment; (ii) fish and fisheries, marine mammals and marine birds; and (iii) pollution and ecosystem health.

Pollution is a module of major concern in the Arctic Ocean in terms of both land-based (sewage and river inputs) and ocean activities (oil and gas exploitation, shipping). Some of the pollution is global because of the long range transport of persistent organic pollutants and heavy metal contaminants via atmospheric and oceanic pathways. Not all cumulative impacts due to particle deposition, polluted sediments and bioaccumulation in the marine food web are reported or even fully known at the ecosystem scale. The Group emphasized the importance of discussions on crosscutting issues with the other Arctic Council working groups, particularly AMAP, CAFF, SDWG and EPPR. An assessment of the Arctic marine environment can be provided by the Arctic GOOS (Global Ocean Observing System), which is under development as an important tool for assessments of marine resources and marine transportation. GOOS can provide an important component on climate variability and forcing, and meteorological and ocean forecasting for shipping and other maritime operations.

The Group began discussions on LME boundary delineations in the Arctic. LME delineation is based on the 4 ecological criteria of bathymetry, hydrography, productivity and trophic linkages.

The Group benefited from LME experiences where the indicator approach has been most useful, as in the Benguela Current and Guinea Current LME Projects, and other start-up operations being conducted by Norway: one in the Barents Sea in cooperation with the Russian Federation, the other in the Norwegian Sea. In effect the Group already has considerable experience and expertise, including the activities underway in the Baltic Sea LME project that apply to all 5 modules. From the Group's experience to date, there are 2 classes of indicators:

(i) Indicators that are broad-scale and responsive to generic sources of stress, as identified by Jackson and 18 other authors in *Science* 293, 27 July 2001. The article, "Historical overfishing and the recent collapse of coastal ecosystems" is based on an exhaustive review of over 100 years of pertinent scientific literature. The authors highlight 5 principal causes of LME degradation: fishing, pollution, habitat destruction, introductions of non-indigenous species, and climate change, for this generic approach. The application of the 5 LME modules provides the framework for the appropriate spatial and temporal measurements and assessments of changing ecosystem condition on the broad scale.

(ii) Indicators at the smaller scale within the LMEs. Specific indicators address high priority stressors in specific LMEs. For example in the Baltic Sea LME, special emphasis is placed on the effects of dioxins on fish resources as a significant pollution and ecosystem health issue for mitigation.

The two levels provide an important crosswalk between basic and applied science that is linked directly to socioeconomic and governance actions within the described framework of the Large Marine Ecosystem. In practice, (i) productivity, (ii) fish fisheries, mammals and birds, and (iii) pollution and ecosystem health have been identified as transboundary issues encompassing overfishing, habitat degradation, coastal pollution, nutrient over-enrichment, biodiversity loss and climate change as principal problems leading to the loss of socioeconomic benefits to civil society bordering the LME. In recognition of the transboundary nature of environmental degradation and resource unsustainability, the LME approach has been successful in providing a modular framework for 110 countries to work cooperatively with 5 UN agencies and $1.8 billion in financial support. Improving conditions and moving toward the sustainable use of resources are based on monitoring key indicators under the 5 modules of the LME approach (LME website at www.lme.noaa.gov/Portal/).

Monitoring and assessment of persistent organic pollutants and persistent toxic substances would be a high priority for the Arctic LMEs with relation to sub-lethal toxic effects on humans, marine mammals and marine birds, whereas the reduction of ice cover and mass would be addressed principally in relation to large ecosystem-wide effects. Within the context of this 2-level indicator strategy, the Group sought to reach consensus on large-scale generic measurements across all Arctic LMEs, and to provide a common baseline and specific indicators of LME condition at the smaller scale. Where there are AMAP assessments pertinent to pollution and ecosystem health, they will be included in the more broadly based integrated ecosystem assessments.

(C) Pilot Projects

Assessment and management projects based on the 5-module LME strategy are being developed for the West Bering Sea (US/Russia) and Beaufort Sea (Canada/US) Large Marine Ecosystems. LME indicators will be tested and evaluated in these pilot projects which will serve as prototypes of the 5-modular LME approach for all 17 Arctic LMEs under consideration for assessment and management activities in the Arctic Council and PAME work plan. Special attention is to be paid to projections of ice reduction as it affects shipping and food chain dynamics in Arctic LMEs.

V. The LME delineation process in the Arctic Region

The 2005 PAME Meeting preceding the 7th LME Consultative Committee Meeting convened by the Intergovernmental Oceanographic Commission (IOC) of UNESCO in Paris and the National Oceanic and Atmospheric Administration (NOAA) discussed Arctic issues and the usefulness of focusing on these indicators at the macro-level, and highlighted the importance of cross-cutting issues such as climate change and biodiversity.

At the same time discussions began on LME boundary delineations in the Arctic. LME delineation is based on the 4 ecological criteria of bathymetry, hydrography, productivity and trophic linkages. It was agreed to review the 15 already designated Arctic LMEs, and to compile more information on boundary features for future adjustments recommended by Norway in relation to the AMAP Oil and Gas Assessment Areas, and by Canada.

The aim was to identify optimal units for supporting ecosystem-based management objectives. Two new LMEs were designated, and existing LME boundaries were modified, based on the four LME ecological criteria and on the pertinent peer-reviewed published literature. The process was undertaken through email exchanges among representatives from countries of the Arctic region. In 2006 the countries had reviewed and accepted a working map of 17 Arctic LMEs (see **Figure 1**) that would be used to guide the PAME work plan. Based on discussions that took place with representatives from the Russian Federation, Canada and Norway, the following LMEs were modified:

- the Norwegian Shelf (LME #21), in light of the recently published monograph on "The Norwegian Sea Ecosystem" (Skjoldal 2004), extending the boundary beyond the immediate shelf area to include the Norwegian Sea, based on a unique geography, currents and water masses; and

- the Beaufort Sea (LME #55), shared by the U.S. and Canada and based on deliberations between the two countries.

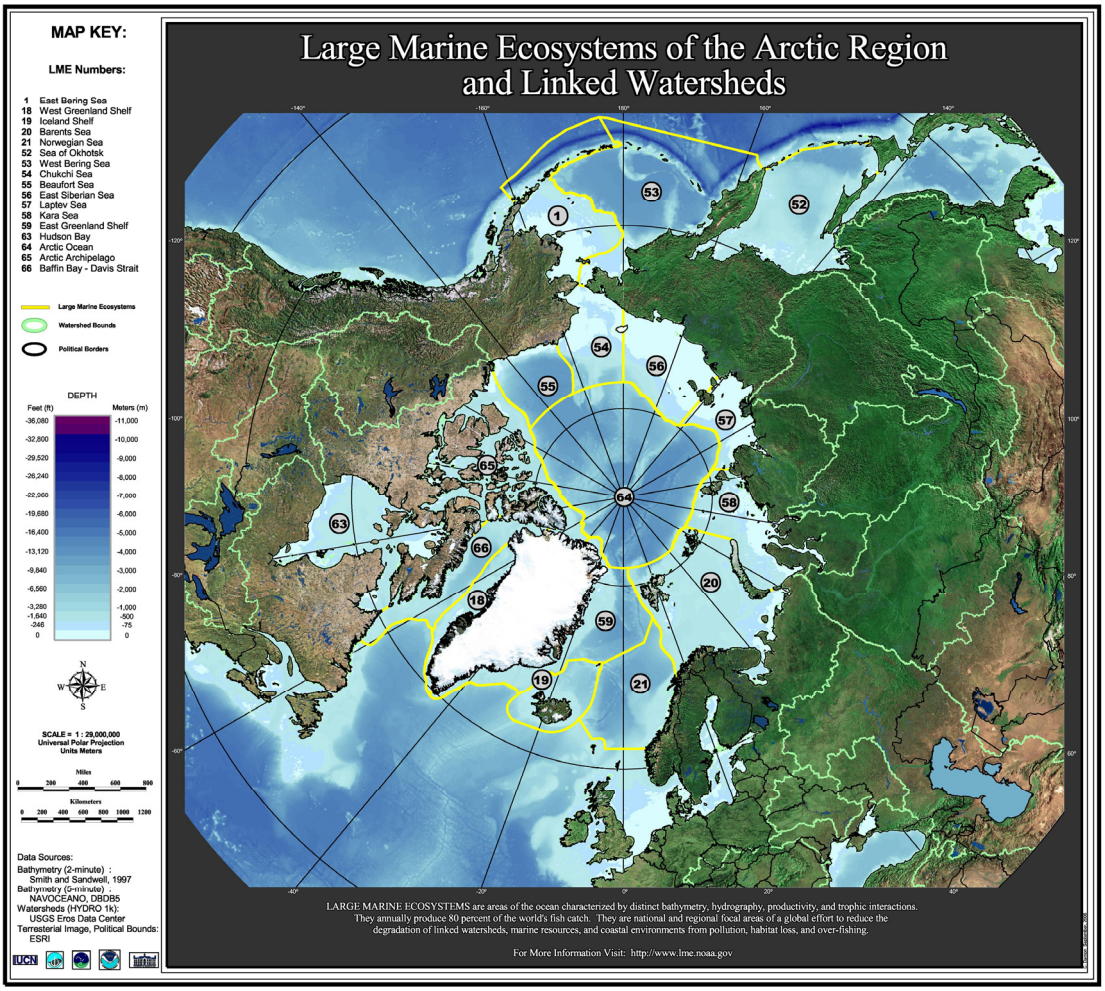


Figure 1 - Map of the 17 LMEs of the Arctic

Two new LMEs were put forward: the Baffin Bay/Davis Strait and the Arctic Archipelago LMEs. For the Baffin Bay/Davis Strait LME, the boundary line was the outcome of deliberations with Canada. The proposed delineations, based on geological, physical, oceanographic and biological properties of the ocean areas, came from ocean experts including from Canada. A map created by the GIS department of the University of Rhode Island incorporated the boundary changes (**Figure 2**). The University has also produced a global map showing the boundaries of the original 64 LMEs (**Figure 3**). The numbering of the Arctic LMEs corresponds to this global map.

The working map of 17 Arctic Large Marine Ecosystems was finalized after significant scientific review of the ecological boundaries. The map was accepted by PAME and is available on the PAME website at: http://www.pame.is. An Arctic volume, edited by Kenneth Sherman and Hein Rune Skjoldal, is being prepared in collaboration with the Institute of Marine Science in Bergen, Norway, and is based in part on the presentations given at the annual meeting of the American Association for the Advancement of Science (AAAS) in St. Louis in 2006. The focus of the presentations was the magnitude, extent and consequences of ice reduction on Arctic LMEs

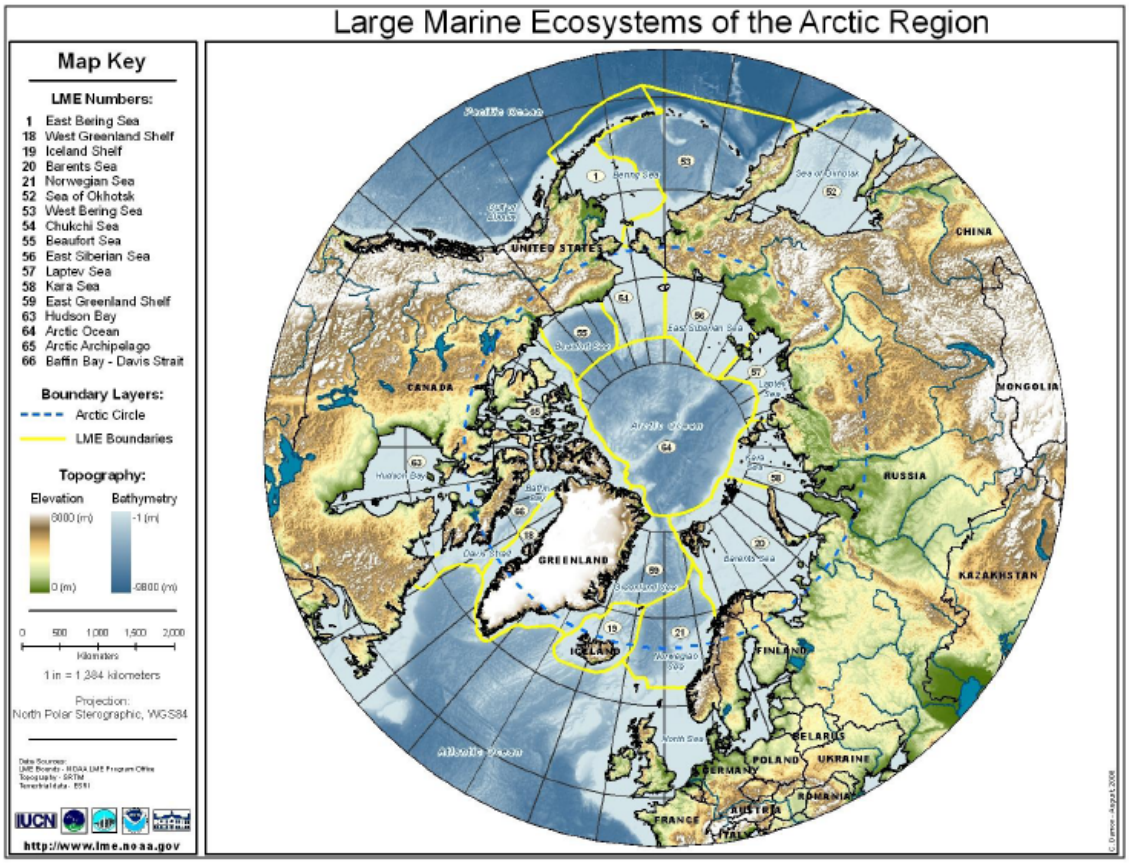
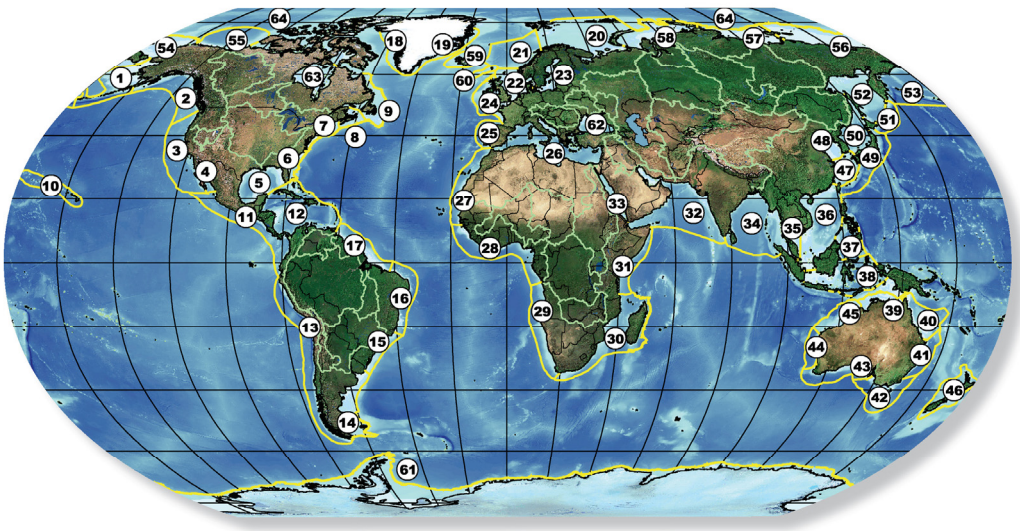


Figure 2 - Map and names of the 17 LMEs of the Arctic

Large Marine Ecosystems of the World and Linked Watersheds



1 East Bering Sea
2 Gulf of Alaska
3 California Current
4 Gulf of California
5 Gulf of Mexico
6 Southeast U.S. Continental Shelf
7 Northeast U.S. Continental Shelf
8 Scotian Shelf
9 Newfoundland-Labrador Shelf
10 Insular Pacific-Hawaiian
11 Pacific Central-American Coastal
12 Caribbean Sea
13 Humboldt Current
14 Patagonian Shelf
15 South Brazil Shelf
16 East Brazil Shelf
17 North Brazil Shelf
18 West Greenland Shelf
19 East Greenland Shelf
20 Barents Sea
21 Norwegian Shelf
22 North Sea
23 Baltic Sea
24 Celtic-Biscay Shelf
25 Iberian Coastal
26 Mediterranean Sea
27 Canary Current
28 Guinea Current
29 Benguela Current
30 Agulhas Current
31 Somali Coastal Current
32 Arabian Sea
33 Red Sea
34 Bay of Bengal
35 Gulf of Thailand
36 South China Sea
37 Sulu-Celebes Sea
38 Indonesian Sea
39 North Australian Shelf
40 Northeast Australian Shelf-Great Barrier Reef
41 East-Central Australian Shelf
42 Southeast Australian Shelf
43 Southwest Australian Shelf
44 West-Central Australian Shelf
45 Northwest Australian Shelf
46 New Zealand Shelf
47 East China Sea
48 Yellow Sea
49 Kuroshio Current
50 Sea of Japan
51 Oyashio Current
52 Okhotsk Sea
53 West Bering Sea
54 Chukchi Sea
55 Beaufort Sea
56 East Siberian Sea
57 Laptev Sea
58 Kara Sea
59 Iceland Shelf
60 Faroe Plateau
61 Antarctic
62 Black Sea
63 Hudson Bay
64 Arctic Ocean

Figure 3 - Map of the 64 Large Marine Ecosystems of the world and their linked watersheds (Sherman et al. 2004)

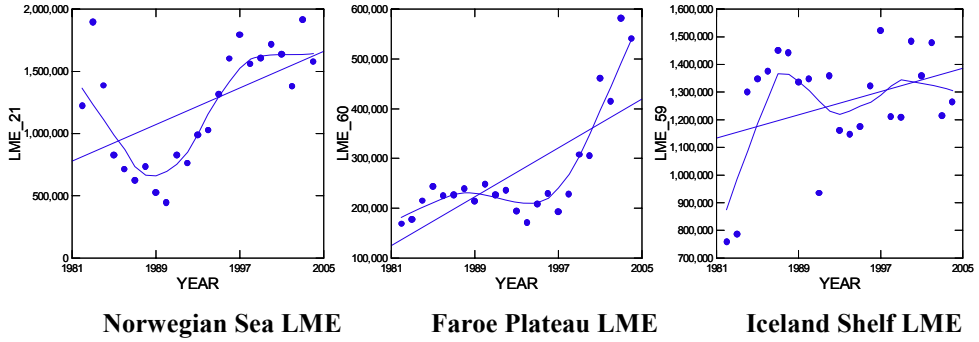
VI. The Results of a Study of Sea Surface Temperatures (SSTs) for the Arctic LMEs

A study undertaken by Dr. Igor Belkin and Dr. Kenneth Sherman found that Sea Surface Temperatures in 61 of the 64 LMEs were in a warming trend over the past 50 years (2008 UNEP LME Report, at: www.lme.noaa.gov/Portal/). In the past 25 years, in situ observations showed that SSTs have accelerated the warming trend in 1985-2006 at a level that is 2 to 4 times greater than previously reported in a global analysis by the IPCC. This finding is important to the assessment of the 17 Arctic LMEs. Issues to be examined are the effects from global warming of strengthening thermoclines on the exchange of nutrients between surface and bottom waters, and bottom up annual productivity cycles affecting Arctic food webs including fish, marine mammals and marine birds. The time series information on SST, chlorophyll, and primary productivity will be made available to the Arctic Council, specialists and working groups through the LME Narragansett Laboratory portal.

Comparative fisheries biomass yields in fast warming Arctic LMEs

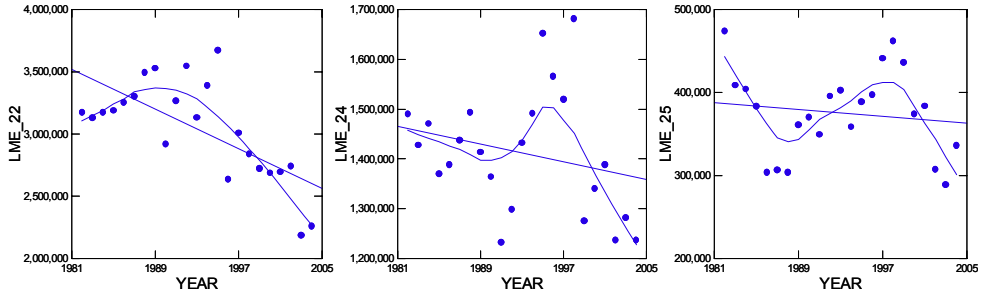
In the Norwegian Sea, Faroe Plateau, and Iceland Shelf LMEs, the fisheries biomass yields are increasing. These three LMEs (**Figure 4**) accounted for 3.4 million tons, or 5% of the world mean annual fisheries biomass catch (2000-2004). This cluster of LMEs was influenced by bottom up forcing of increasing zooplankton abundance and warming hydrographic conditions in the northern areas of the North Atlantic, where stocks of herring, blue whiting and capelin are benefiting from an expanding prey field of zooplankton supporting growth and recruitment of these three species.

(A)



Norwegian Sea LME **Faroe Plateau LME** **Iceland Shelf LME**

(B)



North Sea LME **Celtic Biscay LME** **Iberian Coastal LME**

Figure 4 - Comparative Mean Annual Fisheries Biomass Yields (in metric tons) in Fast Warming Clusters of (A) European Northern; and (B) Southern LMEs, 1961 to 2004.

The warming trend in the Norwegian Sea driving the increase in biomass of herring, capelin and blue whiting yields has been reported by Skjoldal and Saetre (2004). On the Faroe Plateau LME, Gaard et al (2002) indicated that the increasing shelf production of plankton is linked to the increased production of fish and fisheries in the ecosystem. Astthorsson and Viljalmsson (2002) have shown that variations of zooplankton in Icelandic waters are greatly influenced by large scale climatic factors and that warm Atlantic water inflows favor zooplankton that supports larger populations of capelin that serve as important prey for cod. The productivity and fisheries of all three LMEs are benefiting from the increasing strength of the sub-Polar gyre bringing warmed waters to the LMEs of the region generally in the northern northeast Atlantic, and contributing to decreasing production and fisheries yields in the relatively warmer southern waters of the northeast Atlantic (Richardson and Schoeman 2004). In southern Europe three LMEs in fast warming clusters, the North Sea, Celtic Biscay, and Iberian Coastal, are experiencing declines in biomass trends.

The PAME LME Group of Experts will continue to review and evaluate the scientific evidence supporting the designation of the proposed two new LMEs. Given the present accelerated warming conditions of the Arctic LMEs, the Group of Experts will make a special effort to maintain cognizance of the effects of climate warming on the productivity, fish and fisheries/marine mammals and birds, and pollution and ecosystem health of Arctic LMEs, and implications of these changes on the socioeconomic and governance condition of the Arctic LMEs.

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