Final Report

Inventory of Research and Monitoring for Fish Stocks in the Central Arctic Ocean

Third Meeting of Scientific Experts on Fish Stocks in the Central Arctic Ocean
Montlake Laboratory
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Preface

The scope of the inventory has been narrowed during the post meeting editorial and information gathering process. Although some of the individual responses to the inventory questionnaire distributed after the meeting, were excellent and thorough, it soon became apparent that organizing and distributing the information was a data management project unto itself. In receiving and cataloging the responses it also became apparent that with the exception of web sites aggregating metadata and data, that the information in the other categories could be gleaned from the bibliographic information already in hand, when combined with references and web sites submitted in response to the questionnaire. The bibliographies provide the gateways to types of Arctic information products, the people who make these products and the institutions, nations and international organizations that support the people and make the products possible.

Those who submitted responses to the questionnaire will find that every effort has been made to incorporate the information in the IARM Appendices and elsewhere in the reports of the meeting. A lesson learned is that the volume of Arctic information is large and rapidly growing, albeit not in a manner that necessarily produce direct information on Arctic fish stocks.

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Summary

The Inventory of Arctic Research, IARM, is a work in progress, as indeed was the case with all such past efforts. Observations and information products are accumulating at a pace that gives any static inventory a limited shelf life. The possibility is growing that future IARMs could be produced and updated in a manner that would at once guarantee that each is both complete and timely. As nations and institutions increasingly promote international cooperation and collaboration by exposing metadata and data on the internet, the automation of production of future IARMs moves closer to reality (Appendix A). Full or partial automation could sharply lower the number of hours of labor required for production, and decrease the likelihood of omission thereby making it possible to produce a high quality IARM more frequently, and eventually to produce the IARM virtually on demand.

Shelf life notwithstanding, the present IARM is a powerful heuristic tool for scientists, students and policy makers concerned with the Arctic. It has been specifically crafted to include information on fish populations, making it particularly useful to those concerned with Arctic fisheries matters in the context of the ecosystem approach to management. The present IARM is an authoritative collection of descriptions and graphical presentations on the national programs of research and monitoring of Canada, China, Japan, the Kingdom of Denmark, the Kingdom of Norway, the Republic of Korea, the Russian Federation, and the United States of America (Appendix B). In addition IARM provides a convenient means to quickly review a large number of contemporary and cutting edge national and international web sites that aggregate metadata, observations (data) and information products such as climatologies and visualizations (Appendix C). A number of bibliographies (Appendix C) provide gateways to Arctic information products, the people who make these products and the institutions and nations that support the people and products. For example the main meeting bibliography contains 81 references for *Boregadus* and 11 references to *Arctogadus*.

It must be said that the pace of accumulation of physical and lower trophic level biological information is and has been much faster than that of the fish information, which is spotty to non-existent in much of the central Arctic Ocean, although often abundant in adjacent waters. The large volume of physical and non-fish biological data somewhat obscures this major information gap in the Arctic. As noted below and elsewhere in the reports of this meeting, the meagre amount of information available on fish populations needs to be addressed through a systematic pan-Arctic program of research and monitoring containing sampling methods appropriate to fish.

Conclusions

With regard to observations (data), model data and information products (information) relevant to fish stocks in the central Arctic Ocean (Artic);

1. The information and data available from Arctic research and monitoring are highly variable in geographic distribution and temporal density.
2. Geographic variation in information is pronounced, being generally more available from areas without permanent ice.
3. Areas with commercial fisheries adjacent to or nearby the Arctic tend to have more biological information than others.
4. Physical disciplines (ocean and atmosphere) have more information than biological, economic and human dimensions.
5. Physical information on the (atmosphere and) surface is much more dense than in subsurface.
6. There are many sources of Arctic information.
7. Sources of information have not been systematically identified; there is no identifiable starting point for locating Arctic information.
8. The volume of Arctic information is now very large and growing rapidly, nonetheless the growth is not necessarily organized or directed toward types of information most suitable to understanding management of fish stocks in the central Arctic Ocean and relevant adjacent areas.

Introduction

Terms of Reference

The five Arctic Ocean Coastal States (Canada, the Kingdom of Denmark, the Kingdom of Norway, the Russian Federation, and the United States of America), the A5, have identified a need for further scientific research and monitoring on the state and nature of living marine resources and associated ecosystems, as well as an increased understanding of the impact of climate change on Arctic ecosystems in general and fish stocks in particular. To satisfy this need the terms of reference for the Third Meeting of Scientific Experts on Fisheries of the Central Arctic Ocean (3rd Arctic Fisheries Meeting) call for an inventory of Arctic research and monitoring to serve the purposes of providing for information gap analysis, and for understanding the status of relevant Arctic research and monitoring activities. To quote the terms of reference,

> *1. Continuing the review of current programs for research and monitoring environmental parameters and patterns of fish distribution and abundance;* ***establishing an inventory of research and monitoring programs*** *and preparing a report on the status of and gaps in knowledge on the distribution and abundance of fish in the central Arctic Ocean. Such an inventory should include programs occurring in immediately adjacent shelf areas (i.e., within EEZs), which are linked and have relevance to the central Arctic Ocean (high seas).*

Purpose

The inventory of Arctic research and monitoring, IARM, serves the Arctic coastal states, A5, and other interested parties as a means to identify sources of information relevant to ecosystem based fishery management, EBFM, of fish stocks in the central Arctic ocean. Identification of sources of information is fundamental to understanding the current status of relevant research and monitoring activities, as well as to understand what further research needs to be conducted, and what aspects of the Arctic biology and environment need to be monitored in order to advise EBFM in the Arctic. Given the large number of public and private institutions located in a wide variety of nations that are now actively gathering physical and biological information in the Arctic, and in view of the accelerating pace of information gathering, the IARM needs to be developed as one part of a larger effort to foster international coordination and collaboration on data discovery and management. A single "snapshot" in time is useful for short term planning purposes, but for long term planning of cooperation in scientific research and monitoring of fish stocks in the Arctic, the IARM needs to be constantly updated with emerging information, as part of an ongoing international process for coordinating Arctic data discovery and management (Appendix A). The IARM is a first step in the process of identifying, defining, and implementing a data discovery and management process that serves the needs of EBFM in the Arctic.

Geographic Scope and Definition

For the purposes of the Joint Program of Research and Scientific Monitoring, JPPRSM, ecosystems of interest are defined to be the large marine ecosystems, LME, as adopted by the Arctic Council in Kiruna (2013). (see Large Marine Ecosystems of the Arctic). According to the ToR, the primary focus of the IARM is the portion of the Arctic that includes the central Arctic Ocean outside the EEZs and adjacent areas to the extent biological and physical processes link them to the central Arctic. For the purposes of defining scientific processes the areas are represented by the Central Arctic LME and relevant portions of adjacent LMEs (map). The use of the LME definition provides a physically and biologically coherent definition of the scale and location of the ecosystems of interest.

Guiding Principles

Both the geographic scope and the types of biological and physical attributes that are the subject of IARM are defined by the principles and practice of ecosystem based fishery management (EBFM) and ecosystem based management (EA). Ecosystem based management practices are supported by integrated ecosystem assessment (IEA), which are integrative with respect to physical and biological attributes of the large marine ecosystem, and which are also integrative with respect to the human communities, laws, stock assessments, and regulatory approaches of fishery management. The IARM process makes possible integrating disciplinary subject matter and aggregation of subject matter over spatial scales appropriate to the Large Marine Ecosystem.

> *The IARM is to be conducted on the scale of large marine ecosystems, organizing data discovery and management that permit integration of a suite of physical and biological observations and modeled data (species, temperature, salinity, …) over LMEs for the ultimate purpose of applying the information to the ecosystem based management of fisheries.*

The IARM provides the data discovery and management process necessary to support describing the adequacy of information for managing sustainable fisheries under the ecosystem approach EA. In order to be able to provide for the management of central Arctic Ocean fish stocks, it is necessary to discover and manage information relevant to the position of fishes and shellfish in the trophic structures of large marine ecosystems, as well as the information defining the physical linkages of the central Arctic Ocean with the shelf areas and with Arctic gateways, such as the Bering and Fram Straits.

The development of the IARM is guided by the principles of international coordination and cooperation within the spirit of the work plan now being implemented by the Arctic Data Committee, ADC, of the International Artic Science Committee, IASC (including Sustained Arctic Observing Network, SAON). (Appendix A). It is essential for the parties concerned to develop the means of fostering international coordination and cooperation in the matter of Arctic data.

Overview of Break Out Session Outcomes

Discussions regarding what mechanisms and or structures would allow for an ongoing and timely inventory of Arctic research and monitoring provided eight conclusions (presented in the front of this document) regarding the inventory of Arctic research and monitoring. Discussions concluded that the format of the inventory would depend on the needs of the users, and therefore the processes of data and metadata discovery and of producing each inventory would need to be flexible and relatively inexpensive. An initial requirement for assembling any inventory is a ready (searchable) connection to metadata. Looking below the level of metadata, it was recognized that access to the actual data would proceed according to limits established by states, institutions, and other applicable conventions, and therefore should not be expected to be uniform. Resolving governance issues of the means and process for gathering, organizing and disseminating metadata and data is essential to progress. The advice based on experience from ocean observing systems in the United States is to establish a sustainable governance of a “close-to-source” (distributed) means of access to searchable metadata and data (see Appendix A). Note that governance of data management addresses “data rescue” in cases where national or institutional conservation mechanisms have been lost.

In addition a large body of information was contributed by the participants and correspondents. A discussion paper circulated in advance of the meeting and a presentation to the meeting addressed how the inventory of Arctic research and monitoring might be conducted on a regular basis with a minimum of human intervention (Appendix A). National representatives provided National Summaries and Reports on Arctic Research and Monitoring (Appendix B). The meeting participants and correspondents identified a large body of published literature and other written work, as well as establishing lists of key information resources, including notable references by Large Marine Ecosystem, national websites for metadata and data discovery, Arctic research institutes by nation, and other significant information resources (Appendix C).

The Appendices contain the bulk of the information content of the inventory. The appendices are hyperlinked to web locations so that they may be accessed by users of the inventory without having to reproduce them here, as the total number of pages of information is formidable.

Appendices

Appendix A: Arctic Data Management Solutions

Appendix A.1 Mapping the Arctic Ocean Fisheries Data Ecosystem: using network science and linked data to enhance data access.

Appendix A.2. Presentation on Data Ecosystem

Appendix B. National Summaries and Review Reports on Arctic Research and Monitoring

Appendix B.1. Canada

B.1.a. Canada: Inventory Report of Arctic Research & Monitoring Activities

B.1.b. Canada Presentation

Appendix B.2. China

B.2.a. China Summary Report

B.2.b. China Presentation

Appendix B.3 Greenland (Kingdom of Denmark)

B.3.a. Greenland Summary Report

B.3.b. Greenland Presentation

Appendix B.4. Iceland

B.4.a. Iceland Summary Report

B.4.b. Iceland Presentation

Appendix B.5. Japan

B.5.a. Japan Summary Report

B.5.b. Japan Presentation

Appendix B.6. Korea

B.6.a. Korea Summary Report

B.6.b. Korea Presentation

Continued next page

Appendix B.7. Norway

B.7.a. Norway: Inventory Report of Arctic Research and Monitoring Including Cooperation with Russia

B.7.b. Norway Presentation

Appendix B.8. Russia

B.8.a. Russia Summary Report

B.8.b. Russia Presentation

Appendix B.9. United States

Appendix B.9.a. USA: Inventory Report of Arctic Research and Monitoring

Appendix B.9.b. USA Presentation

Appendix B.9.c. A Framework for coordinated marine ecosystem research in the U.S. Chukchi and Beaufort Seas.

Appendix C. Bibliographies and Other Information Resources

Appendix C.1. Bibliography 3rd Meeting Scientific Experts Fish Stocks Arctic Ocean Apr 14, 2015

Appendix C.2. Contributed Bibliography Arctic Fish Stocks

Appendix C.3. United States' Bibliographies of Fisheries Related Arctic Research and Monitoring Contributed by NOAA Fisheries and the Bureau of Ocean Energy Management, BOEM, Alaska

Appendix C.4. Contributed Web Sites Arctic Fish Stocks

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Appendix D. Contact Information for Break Out Group Attendees and Correspondents

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