PAME

Third Ecosystem Approach to Management Workshop Report

Reykjavik, Iceland
June 10 – 11, 2013

PAME
Protection of the Arctic Marine Environment

ARCTIC COUNCIL

Third Ecosystem Approach to Management Workshop Report

Reykjavik, Iceland
June 10 – 11, 2013

Table of Contents

Vision: An exploration of the needs for data and data management at the regional scale of LMEs and for reporting at the Pan-Arctic scale. Most of the data we have at either scale are generated by existing management for some management purpose. The workshop will develop a general overview or "road-map" of the current status of the various data aspects across these two main scales (or three, recognizing also the national scale/level as a part of the LME scale in many cases, e.g. Beaufort and Barents).

Introduction

This is the third workshop organized by the Ecosystem Approach Expert Group (EAEG). The first was held in Tromsø in January 2011 and focused on the issue of boundaries of the identified Large Marine Ecosystems (LMEs) of the Arctic as a step in their revision. The second workshop was held in Stockholm in March 2012 where the topics addressed were the issues of scale and the central role of Integrated Assessment (IA; or Integrated Ecosystem Assessment, IEA) for the Ecosystem Approach to Management (EA).

The Arctic Council adopted the principle of EA as part of the Arctic Marine Strategic Plan in 2004, as the best approach to managing the Arctic marine environment to advance sustainable Arctic marine resource use and conserve Arctic marine biodiversity and ecosystem functions. One of the strategic actions was to identify the large marine ecosystems of the Arctic based on the best available ecological information. This was done by work under PAME led by the USA, and a working map of 17 Arctic LMEs was adopted by the Arctic Council in 2006.

PAME established in 2007 an expert group on the EA (the EAEG). This was broadened in 2011 to become a PAME-led expert group with participation also of other Arctic Council working groups (AMAP, CAFF and SDWG). Items on the work plan for the EAEG (as part of the PAME biannual work plans) have included revision of the Arctic LME map (which was completed in May 2013; PAME 2013), production of an EA concept paper, Integrated Assessment, and ecological objectives. The present workshop was arranged as part of the work plan for the EAEG.

The 3rd EA workshop was prepared by a small planning group with representatives of the two lead countries Norway (Hein Rune Skjoldal, IMR) and the USA (Phil Mundy, NOAA), Canada (Martine Giangioppi, DFO), AMAP (Jon Fuglestad) and CAFF (Kári Lárusson). The program was organized with the following four sessions:

Session 1 provided background and presented the scope for the workshop.

Session 2 included case study reports from three of the Arctic LMEs: Barents Sea, Northern Bering-Chukchi, and Beaufort Sea LMEs.

Session 3 included presentations by AMAP and CAFF on their work related to assessments and by James Stotts from ICC Alaska as one of the Permanent Participants on the use of Traditional Ecological Knowledge (TEK).

Session 4 comprised a general discussion and conclusions from the workshop.

There were discussions as part of sessions 2 and 3. We have recorded the discussion in session 2 separately. The discussion in Session 3 continued into the general discussion and has been recorded as part of the discussion in Session 4.

The workshop agenda is included as Annex II. The workshop was attended by 29 participants from 8 countries. The list of participants is given as Annex III. An additional presentation on a new method to monitor dissolved organic matter, oil spills and algal pigments by underwater spectrofluorometry was added to the program, and a summary of the presentation is included as Annex IV.

Session 1 – Overview of ecosystem approach and data needed for integrated assessment

Hein Rune Skjoldal, IMR, Norway

The Ecosystem Approach to management and the role of Integrated Assessment

The ***Ecosystem Approach to Management*** (EA or EAM) is an integrated and holistic approach to management of human activities. The EA represents a shift in emphasis towards the well-being of the natural ecosystem and maintenance of its integrity. It relies on the recognition that ecosystems are functional units where species are connected in predator-prey relationships as part of food-webs, and where the species depend on habitats that are defined by hydrography, bathymetry, topography, and the productivity of their fellow species. In short EA is integrated management of human activities aimed at maintaining the state of the ecosystem in good condition. This is in line with a formal definition of EA that has been used in European policy contexts (by OSPAR, HELCOM and the EU) and recently (May 2013) also adopted for use in the Arctic Council after one slight amendment, the addition of 'scientific and traditional knowledge':

'The comprehensive integrated management of human activities based on the best available scientific knowledge about the ecosystem and its dynamics, in order to identify and take action on influences which are critical to the health of marine ecosystems, thereby achieving sustainable use of ecosystem goods and services and maintenance of ecosystem integrity.'

The focus on the state and status of ecosystems guiding management decisions has two sides to it. One is that we need to define and characterize what we mean with good environmental or ecosystem status. How do we determine with operational objectives what is the desired state of the ecosystem where sustainable use and maintenance of ecosystem integrity are achieved? The other side is that we need to assess the state and status of the ecosystem. We know well from historical and empirical evidence that the state is not stable and static but rather dynamic and ever changing. So a main challenge facing us, as scientists and managers, is to detect these changes and determine what are causing them. How much is due to natural variability (driven by climate variability and interactions in the ecosystem) and how much is due to effects of human activities such as fishing or pollution? This is not a simple question to answer, and the main tool we use to address it is what we call ***Integrated Assessment*** (IA; or Integrated Ecosystem Assessment, IEA).

A schematic diagram illustrating a framework for the EA to management is shown in Figure 1 below.

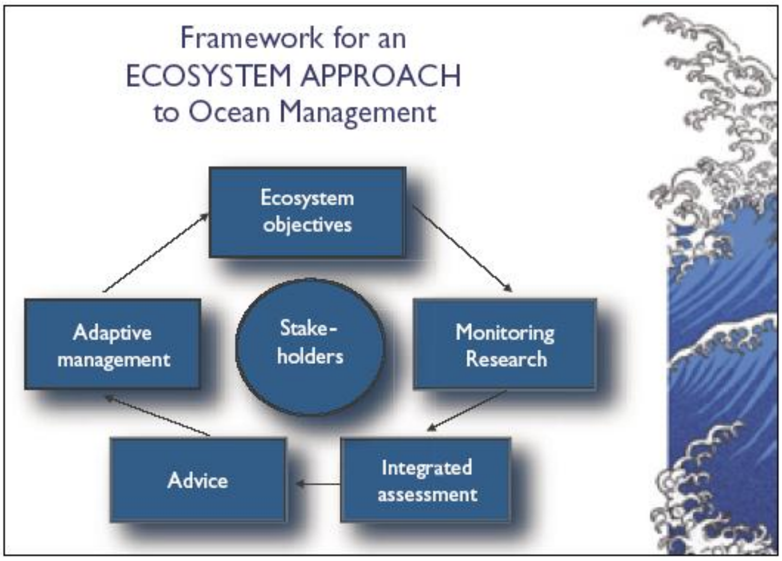

Figure 1: A framework for the EA to management, illustrating a management cycle with 5 main components, one of them being Integrated Assessment (IA). IA builds on updated information from monitoring and new data and insight from research and it provides in turn the basis for advice to an adaptive management system on issues related to status and impacts on the ecosystem.

This particular framework is from the Bergen Declaration from the Fifth North Sea Conference in Bergen in 2002 (Anon. 2002, Skjoldal and Misund 2008). There are other similar frameworks and they commonly share the same main features.

Based on a review of the development of concepts and elements, a system with 6 elements was suggested as the main components of the EA framework in the EA concept paper:

- Identify the ecosystem
- Describe the ecosystem
- Set ecological objectives
- Assess the ecosystem
- Value the ecosystem
- Manage human activities

Three of the elements are the same as in the Bergen framework in Fig. 1 (objectives, assessment, and management actions). The three new elements emphasize the need to geographically define the ecosystem (LME, as we now have done for the Arctic), describe the ecosystem (to remind us and force us to be occupied with the functional aspects and integrity of the ecosystem), and valuing ecosystem goods and services (an important aspect of 'greening the economy'). The two elements from the Bergen framework which are not included here are monitoring and scientific advice, which are taken implicitly to be required for IA and for management decisions on the basis of IA.

IA was characterized in the EA concept paper as follows: *"An integrated assessment is an assessment of the status and trends in all relevant ecosystem components and thereby of the overall state of the ecosystem as such. It includes assessments of the impacts by various human activities such as fishing, pollution, coastal development, etc., as well as the overall or* *cumulative impacts by those activities. Integrated assessments include also socioeconomic factors and conditions, e.g. as driving forces for use and impacts, and as consequences back on society from altered provision of ecosystem goods and services."*

Integrated assessments may be carried out in a modular fashion with detailed accounts as separate thematic assessments of ocean climate conditions, plankton production, fish stocks impacted by fisheries, habitat conditions, pollution effects, conservation status of birds and mammals, and others. Assessment of climate conditions (including variability and trends) and biological impacts of climate may help in distinguishing between natural variability and impacts from single sectors or factors such as fishing or pollution. Finally it also allows the overall situation including cumulative impacts to be addressed and assessed.

A conclusion arising from the 2nd EA workshop in Stockholm last year and agreed by PAME at the spring meeting (PAME I-2012) was that

"the LME should be pursued as the appropriate and primary unit for applying the ecosystem approach to management of the marine environment recognizing that it accommodates management at other spatial scales."

It follows that the LME is also the appropriate scale for conducting IA given that this is a central component of the EA. Trophic interactions in food webs (e.g. predator-prey relationships) and relationships between habitats and species (e.g. spring migration of bowhead and beluga whales through lead systems, breeding colonies of seabirds, etc.) are best dealt with at this scale. This includes a range of smaller scale features and issues within an LME, where IA allows one to address in a systematic manner what all these features mean for the overall well-being or status of the larger ecosystem, the LME. The LMEs are not in isolation but have open boundaries with fluxes of water, plankton and contaminants, and migrations of birds and mammals across them. These larger scale interactions are important characteristics of each of the LMEs. Climate variability and change and long-range persistent pollutants are two important factors that must be evaluated at the larger scale (e.g. pan-Arctic) but where the direct and indirect effects (e.g. through food web interactions or habitat alterations) take place within the regional ecosystems. Climate change and pollution can be seen as large-scale drivers of change or pressures for biological and ecological changes within LMEs and are important aspects to be addressed in IAs at the scale of LMEs.

Arctic Council is not a management organization, and since EA is an approach to management with IA as a core element, much of the work on implementing EA and in carrying out IA at the scale of LMEs is likely to be done by Arctic states outside the sphere of the Arctic Council. However, EA and IA are relevant frameworks and activities also for the Arctic Council, for at least three reasons. The first is the methodology aspect. Progress should be reported and experiences shared on how Arctic states are pursuing EA and IA, and there may be a future need of a common approach (e.g. guidelines) to how to do an IA. A second reason is the fact that the Arctic LMEs do not sit in isolation but have open boundaries to neighbor LMEs. The boundary conditions and the fluxes across them are important characteristics of each LME, while they also represent interactions among adjacent LMEs that may span the areas of jurisdiction of two or more Arctic states. A third good reason is the opportunity for aggregated reporting on the state of the Arctic environment based on the more detailed assessments (IA) carried out in the various Arctic LMEs as part of the implementation of the EA by Arctic states.

Overview of Arctic Data Sources, Management and Large Scale Integration: LME and Pan-Arctic

Phillip R. Mundy, Auke Bay Laboratories, Juneau, Alaska, USA

The Arctic Council has adopted the ecosystem approach to management, EA, as one approach to protect arctic marine environments during development. The geographic boundaries of arctic ecosystems have been defined as a collection of Large Marine Ecosystems, LME's, as accepted by the Council (Kiruna 2013) as a starting point for implementing EA. Fundamental to its implementation is the determination of the status of each LME. The Arctic States do not have a single approach to assessing the status of ecosystems on the scale of the LME. The IA cannot be completed without data and information on the people and their activities, climate, oceanography and biota of the LME. For example the IA process in the US (refer to the Northern Bering Chukchi Seas presentation below) establishes a societal context of objectives. The objectives are bounded by policies and laws that are reflections of the ecological, social and cultural context for the LME. The scientific, social, cultural and economic data resources are applied by managers to satisfy the objectives.

Among the purposes of the workshop is to understand the extent of the data resources available to support status determination. At this workshop we addressed only physical and biological portion of the scientific data resources necessary to enable conduct of IA (or IEA) in the LME's of the Arctic. To foster this understanding the following questions now before the workshop are to be answered, "Where are the data?, "Who can help us get them?", "Can the data sets be pooled or combined for analysis?", "Are nations cooperating in data acquisition so that data sets can be pooled or combined?", and "Do we have common language for sharing data sets?"

Following are formal statements of these questions:

1. What are the most relevant data sets (databases)?
2. What are the relevant data management systems?
3. To what extent are the relevant datasets (databases) compatible (interoperable)?
4. Do transboundary LME's have methods to reconcile differences in sampling of living marine resources?
5. Are current protocols adequate to enable international data sharing?

In order to answer the questions it is necessary to categorize the data resources by type of information, physical, microbiota and macrobiota, which correspond to the data used in atmospheric and physical oceanographic sciences, biological oceanography, and the disciplines and institutions concerned with birds, fish, shellfish and mammals. It is also important to note that the sources of data are predominantly national or regional governments, universities, NGO's and Arctic communities and a large body of proprietary information held by private enterprise. It is noted that data produced and used in fields such as economics, anthropology, and benthic ecology that are also required for an IEA may not fit readily into these broad, abstract categories, which are nonetheless useful for the purposes of this discussion.

For the purposes of fostering discussion an initial set of answers to the questions was provided based on the information presented (see Annex I).

<u>Conclusions:</u>

The federal and regional governments ultimately control most of the data not held by industries, and governments also determine all aspects of its availability, comparability and communicability

From the initial answers (Annex I) three key points emerged.

First there are fundamental differences among the basic scientific data types (physical, microbiological, macrobiological) with respect to the temporal and spatial resolution over which data are available to support integrated syntheses intended to determine status and trends at the LME and sub-LME scales. Since the beginning of satellite coverage in the early 1970's the spatial and temporal densities of physical data to support pan-arctic syntheses have been growing rapidly. Biological data (microbiological, macrobiological) are in general less spatially and temporally dense, being more likely to be adequate to support sub-LME scale status and trend determinations, and less likely to be adequate to support such determinations on the LME and pan-Arctic scales.

Second, the basic scientific data and information necessary to implement EA in the Arctic on the LME scale are most likely to be available across all major categories of information (physical, microbiota and macrobiota) in those LME's where commercial fisheries exist (e.g. Barents, East Bering) and/or where other types of major project development occurs, e.g. oil and gas development, and mining exploration. Where international cooperation in fishery management exists in LME's that straddle an international boundary, such as in the Barents Sea, LME-scale information is available. In cases where international agreements do not exist or commercial fisheries have not occurred, non-physical information is likely to be regional scale at best.

Third, ease of data access controls costs. It is important for policy makers to understand that the cost of pan-arctic and LME scale studies is inversely proportional to the ease of data access. When pan-arctic studies such as the report, Snow Water, Ice and Permafrost in the Arctic (SWIPA, Arctic Monitoring and Assessment Programme) could be enabled by ready access to data collected by common (or reconciled) sampling methods that move readily among different data management systems, the costs would be minimized. Lack of access, incompatible sampling methods, and lack of data-sharing protocols all increase costs. So the state of the Arctic data bases will determine how quickly pan-arctic and LME studies may be accomplished, and it will constrain the number and scope of studies that can fit within operating budgets. The federal, regional governments ultimately control most of the data not held by industries, and governments also determine all aspects of availability, comparability and communicability.

Session 2 - LME Case studies: Geographic paradigms in ecosystem-level data acquisition, integration and dissemination for conducting assessments and advancing EA

<u>The Barents Sea LME</u>

Monitoring of the Barents Sea ecosystem through Joint Norwegian-Russian surveys

Elena Eriksen, Institute of Marine Research, Norway

The monitoring of the Barents Sea ecosystem is a joint effort between Norway and Russia, and collaboration between the two countries has been developed since 1954. Traditional marine monitoring programs have generally focused on individual elements of the ecosystem, while in recent years the monitoring programs have changed focus to study the whole marine ecosystem by measuring all components of the ecosystem simultaneously. Therefore, since 2003 the Institute of Marine Research in Norway (IMR) and the Polar Research Institute of Marine Fisheries and Oceanography in Russia (PINRO) have started with ecosystem surveys in the Barents Sea (BESS). Data collected during BESS are fundamental for single stock fisheries assessments (e.g. capelin, shrimp), for supporting single stock fisheries assessments (cod, haddock and other demersal fishes), in providing long time series of 0-group fish and hydrographical conditions, and for monitoring interactions by trophic studies of pelagic (capelin and polar cod) and demersal (cod) fish.

Monitoring of a huge and complex range of environmental and biological processes is difficult and requires modern research vessels, equipment and facilities. IMR is now developing a new data-infrastructure: old databases are replaced by a new family of databases administered by Norwegian Marine Data Centre (NMD) at IMR. Although the data are split on several databases, for instance one for fisheries acoustic data, one for biological data, another for physical oceanographic data and yet another for chemical data, they are linked through a common reference database and all data can be seen through a common user interface.

Comprehensive spatial coverage and adequate resolution enable capturing of large scale changes in spatial distribution due to climate variation and other factors. Important factors that have influenced the survey program are optimal seasonal timing for covering maximum distribution of key components, occurrence of both immigrating and local species, and period of least ice coverage. The results/output covers important assessment tasks and several ecosystem components and processes, including for instance single-species stock assessments, and process understanding (stomach sampling). The multidisciplinary focus of the survey increases the scientific knowledge about the ecosystem as a whole, and the competence scope of those involved both among the scientists and users of the information such as managers. There is a high level of dissemination of results in the form of reports, stock assessments, management plans, and scientific publications. Results are also widely used in internal and external research projects.

More information about BESS is available on:

http://www.imr.no/tokt/okosystemtokt_i_barentshavet/survey_report/nb-no

Data collection and reporting in relation to assessment and management

Dmitry Prozorkevich, Polar Research Institute of Marine Fisheries and Oceanography (PINRO), Murmansk, Russia

In the presentation it was shown how the Barents Sea Ecosystem Survey (BESS) data are currently used for fish and invertebrate stock size assessments. A list of ICES working groups who use this data was presented. The presentation then went on to describe how data from the BESS is currently used in various themes related to fisheries in the Barents Sea. A list of organizations and other users who use BESS data was also presented. More information about BESS results can be found on the IMR web site at:
http://www.imr.no/tokt/okosystemtokt_i_barentshavet/nb-no

Northern Bering Chukchi Seas LME

Case study of data resources to support integrated ecosystem assessment

Phillip R. Mundy, Auke Bay Laboratories, Juneau, Alaska, USA with Dennis Thurston, Bureau of Ocean Energy Management, Anchorage, Alaska, USA

Fundamental to the implementation of the ecosystem approach to management (EA) is the determination of the status of each LME through a cyclical process known as Integrated Ecosystem Assessment, IEA (after Levin et al. 2009)[1]. The information requirements for IEA span a large variety of social, policy, economic, biological and other scientific information, however this talk takes a narrow approach by assuming there is a basic subset of basic scientific without which the IEA process cannot be completed. The limiting subset of information is basically the same as that used for definition of the LME; hydrography, bathymetry, productivity and trophic structure on the scale of the LME. Arctic LME's have varying levels of information on these four types of information.

The Northern Bering Chukchi Seas LME, NBC LME, has a wealth of information on all four information types, however long time series (> 40 years) are limited to physical data and a few biological time series. International data sets, collected for a common purpose with similar methods, are limited. Both the US and Russia share the LME, however this presentation focuses on the US region, except for two international surveys (BASIS, RUSALCA) and an emerging international survey, the Distributed Biological Observatory, DBO. Note that the boundaries of the NBC LME encompass most of the Pacific-Arctic CBMP Arctic Marine Area, and the East Siberia Sea LME encompasses the balance of the Arctic-Pacific AMA. This presentation will highlight only new developments in data acquisition for the NBC LME.

Where is the data and what are the most relevant data management systems? Original data sources are distributed across a number of federal agencies and the many research projects funded by these agencies at universities, non-governmental organizations and other federal and state agencies. Fortunately, there is a single source for much of the data, the Alaska Ocean Observing System, AOOS, which provides both original observations and model data for the US region of the LME, and data for the Russian region of the Chukchi Sea gathered by RUSALCA. The arctic data portal of AOOS has been developed in response to two circumstances in the United States; increased oil and gas exploration and development and the implementation of the first U.S Arctic Fishery Management Plan. An additional impetus was provided by the intense physical and biological data production of the Bering Sea Integrated Ecosystem Research Program. The AOOS graphic interface provides geospatially organized data filtered by sensor, institution, and transect. Mouse over access is provided to metadata and some data.

On the US side, the Bering Alaska Salmon International Survey (BASIS) has been expanded during 2012 to 2013 to conduct fisheries and oceanographic research surveys in the northeastern Bering Sea and Chukchi Sea in cooperation with other institutions.

On the international level the Distributed Biological Observatory, DBO, is an effort involving six nations in developing a series of biological (benthic and pelagic) and physical sampling

[1] Levin, P. S., Fogarty, M. J., Murawski, S. A., and Fluharty, D. 2009. Integrated ecosystem as-sessments: developing the scientific basis for ecosystem-based management of the ocean. Public Library of Science (PLOS) Biology 7(1): e1000014 (0023–0028).

from five areas along a locus that runs from the northern Bering through the Chukchi, and which includes Russian waters in the southern three stations. In 2010 and 2011 sampling efforts included four of the six nations, and 2012 results are forthcoming. The BASIS program started as a trilateral (Russia, Japan, US) fisheries oceanography survey of the Bering Sea, and it has persisted and expanded northward into the Chukchi Sea to 71N as a unilateral U.S. project. The Russian-American Long-term Census of the Arctic (RUSALCA) is a scientific sampling program that studied the biological, geological, chemical and physical oceanography in the Bering and Chukchi Seas in 2000, 2004, 2005, 2007, 2009, and 2010. The many independent sources of information on the US region of the NBC LME, and the RUSALCA studies are available at www.aoos.org.

Conclusion: Despite the wealth of the three data types in the Northern Bering Sea area, the limiting subset of basic information necessary to the IEA does not appear to be available on the scale of the LME due to the limited history of international monitoring projects in the Chukchi Sea. Fostering US Russian cooperation in monitoring of the NBC LME should be a top priority activity that precedes the IEA process.

Beaufort Sea LME

Examining the potential for US/Canada Integrated Ecosystem Assessment in the Beaufort Sea: A consideration of methods, data, and data management

Presenters:

Martine Giangioppi, Department of Fisheries and Oceans, Canada

Phil Mundy, NOAA Fisheries, US

Molly McCammon, Alaska Ocean Observing System, US

This topic addressed the availability of ecosystem-level data in the Beaufort Sea Large Marine Ecosystem - which crosses the US/Canada boundary – within the context of a potential collaborative Integrated Ecosystem Assessment (IEA) of the Beaufort Sea. Obtaining, integrating and disseminating ecosystem data is essential in order to conduct such an assessment and ensure that the results are available on data portals and in information products that can be used to inform various decision-making processes within each of the two countries. Presenters described the types of ecosystem data, spanning multiple years, which have been acquired and analyzed in the past in the Beaufort Sea. In order to be most useful for a collaborative US/Canada IEA, the data must be collected using common sampling protocols and standards in a manner that ensures the data are interoperable (or can be made so) and available through spatially explicit products and integrated data portals.

The Government of Canada, through the *Oceans Act* (1997), is committed to the integrated management of human activities in or affecting Canada's marine ecosystems. Integrated ocean management (IOM) is implemented through an ecosystem approach—or Ecosystem-based Management (EBM). The Beaufort Sea Large Ocean Management Area (LOMA) is one of the 5 priority areas identified for IOM. The IOM process in the Beaufort Sea, initiated in 2006 by the Department of Fisheries and Oceans and involving more than 53 organizations, is currently moving from planning to implementation.

Executive and legislative mandates in the US Beaufort support the concept of an international collaboration by requiring the geographically comprehensive management approach known as the ecosystem approach to management (EAM), ecosystem based management (EBM) or ecosystem approach (EA). EA occurs within the framework of the integrated ecosystem assessment (IEA). The concept of the IEA framework now under development within NOAA embodies four decades of legislation designed to protect and promote sustainable uses of natural resources. Under the principles of EA, the US Arctic Fishery Management Plan (FMP) now in place for the Chukchi and Beaufort Seas closes the area within the US Exclusive Economic Zone (and not including state of Alaska waters) to all commercial fishing pending information on the environment necessary to guide sustainable use. An international IEA would satisfy the objectives of the FMP, in addition to informing other objectives in other areas of development, such as oil and gas and shipping. Further scoping of US and Canadian objectives would be necessary in the design of the international IEA.

Two of the goals of the Alaska Ocean Observing System (AOOS) are particularly relevant for development of an international IEA: to provide easy access to scientific information about Alaska's oceans and coasts and to generate tools for informed decision-making. AOOS has developed an Arctic Ocean Data Portal with an initial focus on the northern Bering and Chukchi Seas, with plans to expand to the Beaufort Sea. The portal allows for integration of real-time sensor data, satellite imagery and model forecasts and spatially explicit project data. New products including an electronic sea ice atlas and downscaled climate model projections will be available in fall 2013.

The Beaufort Sea, due to data collection, analysis and dissemination efforts currently underway by the Canadian Department of Fisheries and Oceans, the US-based Alaska Ocean Observing System, NOAA and other agencies of the US government offers one of the most likely opportunities for a collaborative international Integrated Ecosystem Assessment in the near future.

Summary of discussion

Objectives:

It was pointed out that monitoring and assessment need to be seen in relation to the specific objectives set for management of an ecosystem. We are in the situation where general objectives and commitments exist but where the specific ecological (quality) objectives still are in need of development. Summarizing information on existing ecological objectives in current management systems and review of methodology for setting such objectives are on the work program for the EA EG.

Ecosystem Approach (EA) implementation and role of Integrated Assessment (IA)

The issue of mandate for integrated assessment (IA) was raised. In response it was noted that the mandate is in the general commitment of using the EA to management and the recognition that IA is a core element of the EA. Work on IA is accordingly a main issue and part of the 2013-2015 Work Plan of PAME.

We are in the development and implementation phase of the EA to management and this has proceeded to varying degree in different parts of the Arctic. For the Barents Sea LME for instance, there is a formal Management Plan for the Norwegian sector and there are plans in Russia to develop one for their sector. The situation is similar in the Beaufort LME; the Canadian part of the Beaufort Sea has a formal integrated management plan which is currently being implemented, whereas the United States does not yet have a comprehensive management plan. For the N Bering-Chukchi LME there is not yet formal and practical adoption of the EA to management in the form of overall management plans. In neither case is there a plan or a clear expectation for how the IAs will be used in the practical integrated management systems. We are therefore operating in the mode of developing something which is considered a necessary step, but we are necessarily doing so in the absence of feedback from management systems which have specific plans to incorporate it as a basis for management decisions.

Methodology for IA

The methodology for IA is under development. It was noted that ICES is having WGs for IA for various regions or LMEs, including a new group established this year for the Norwegian Sea LME. We can expect that useful experiences and guidance will come out from the work in the ICES groups. At present we know in broad terms what an IA is in terms of contents and aims. However, there are many possible ways to perform an IA including through the use of models and indicators. The focus needs obviously to be on key species and habitats and on the main human activities and pressures in any given marine ecosystem. Ideally, one should have a good basic knowledge and information on all the main features and properties of specific LMEs, in order to allow assessments which distinguish the impacts (or potential impacts) of human activities from the natural variability of the system.

Session 3 - Arctic Council Working Groups

AMAP Assessments and 'Adaptation Actions for a Changing Arctic' (AACA) project

Jon Fuglestad, AMAP Secretariat

AMAP has a mandate to monitor and assess the Arctic region with respect to climate and pollution. AMAP has developed a monitoring programme but do not perform monitoring ourselves. The Arctic Council member countries have made national implementation plans of the monitoring programme. Matrices mostly monitored are air, water, snow, fish, marine mammals, birds, plankton and humans.

AMAP uses the results from national environmental monitoring and research projects to do high quality assessment products. These products can be science reports, layman`s reports, fact sheets, summary for policy makers and videos. The assessments are performed by AMAP Expert groups and a number of international experts, e.g. there were ca. 60 scientists involved in the latest Arctic Ocean Acidification assessment.

For the different data sets AMAP has thematic data centers, and some data are also stored nationally.

The AACA project is divided into three different parts. AACA-A is a compilation of assessments by Arctic Council working groups the last ten years. AACA-B is an overview of existing adaptations to a changing Arctic. Most of these adaptations are local or regional adaptations. Part A and B were reported to the 2013 Arctic Council Ministerial Meeting.

AMAP is responsible for AACA part C. There are three pilot areas; Bering/Chukchi/Beaufort Sea, Davis Strait and Barents Sea. All three regions include the marine areas and adjacent coastal and terrestrial areas. The detailed extent of the three pilot areas has not yet been decided. AACA-C is divided into three phases. Phase 1 is climate projections on a short and long term and was finalized in May 2013. Phase 2 started in mid-May 2013 and the regional reports should be finalized in autumn 2015. Phase 3 is the integrated report for all three pilot areas and will be reported to the 2017 Ministerial Meeting. The next step is the Barents regional workshop planned in November and the workshop will recommend e.g. which sectors to be included in this region and the prioritization of sectors.

The Circumpolar Biodiversity Monitoring Program (CBMP-CAFF marine plan)

Lis Lindal Jørgensen (IMR, Norway) on behalf of the CBMP-marine secretary

The Circumpolar Biodiversity Monitoring Program (CBMP) is an international network of scientists, governments, indigenous organizations and conservation groups working to harmonize and integrate efforts to monitor the Arctic's living resources.

The goal is to facilitate more rapid detection, communication, and response to the significant biodiversity-related trends and pressures affecting the circumpolar world.

CBMP are developing four (Marine, Freshwater, Terrestrial and Coastal) coordinated and integrated Arctic Monitoring Plans to help guide circumpolar monitoring efforts. The results will be channeled into effective conservation, mitigation and adaptation policies supporting the Arctic.

The CBMP-marine is working with experts across the Arctic to harmonize and enhance long-term marine monitoring efforts. These efforts are led by a Marine Steering Group representing the Pan-Arctic countries, PAME, AMAP and Permanent Participant (Traditional knowledge). There are six Marine Expert Networks (Benthos, Fish, Marine mammals, Cbird (seabirds), Sea-ice biota, Plankton) represented by members from all the countries and groups.

The CBMP-marine will monitor and evaluate possible causes of changes in the biodiversity of Arctic seas. CBMP will also report to the Convention on Biological Diversity (CBD) on the “Aiche-biodiversity targets", meaning that our data, parameters and indicators will give necessary and important input to evaluate the achievement of the targets.

Eight Arctic Marine Areas (AMAs) has been defined on bases of: data availability, species hotspots, gateways importing/exporting species, blocking domains affecting migration of fauna. Except for the Beaufort Sea and the southernmost border in the Davis Strait-Baffin Bay, the AMA outer boundaries are very similar to the LME boundaries defined by PAME. For each of these areas, CBMP-marine will develop Long-Term Data (LTD) on the six defined Ecosystem Components.

So the main goal of CBMP-marine is to develop a rapid net-based system for detection, communication, and response with respect to significant biodiversity-related trends and pressures affecting the Pan-Arctic. This is to be posted on http://caff.is/monitoring.

It would be preferable to have Long-Term Monitoring (LTM) of benthos in all the AMAs/LMEs so that benthic information from the Pan-Arctic countries could be added annually into the same Pan-Arctic map. As the AMAs and LMEs are large and each are covering different depths and temperature regimes, a Benthic Pan-Arctic map will need to be divided into operative subareas giving possible signals of changes in the benthos. The benthic group of CBMP-marine has approached this goal by trying to identifying LTM series on benthos. Part of the conclusion shows that, in the Atlantic Gateway, only the Barents Sea has an ongoing LTM program.

Changes in benthos might be related to other changes in other components of the ecosystem. Benthos might also be used to answer specific scientific questions such as on Trawling Impact or Climate Change, or Pollution content.

Session 4 - General discussion and conclusions

IA methodology

It was proposed that we should aim to produce a set of guidelines for how to do an IA. This will be followed-up by the EA expert group where IA is a central issue on the 2013-2015 work program. In the short term we plan to collect and share information on whether IA is performed or planned for the various Arctic LMEs and what approach and methodologies are followed. For this work it will be beneficial to collaborate with ICES which now has a WG on IA for one of the Arctic LMEs (the Norwegian Sea; there is a proposal to establish a new for the Barents Sea LME next year).

The issue of guidelines should be revisited over the next few years. One possible option could be to look to ICES for general guidance or guidelines for IA. There is a balance to be struck in how detailed any guidelines should be. On the one hand we should recognize the need for and encourage development of approaches and methods tailored to the specific conditions (ecological, social, and other) in different LMEs. On the other hand it would be desirable to have a simple set of guidelines that defined the minimum requirement for an IA.

Overview and access to data

There is a need for continued work to provide a better overview of data sets collected (regularly or ad hoc) in the Arctic area. This should build on existing work and overviews provided by AMAP, CAFF and SAON. Emphasis should be on identifying compatible and interoperable data sets. For pan-Arctic scale data, SAON would probably by the most appropriate vehicle for this work, with contributions from AMAP and CAFF.

Presentations in the LME case session demonstrated the large amount of data collected (e.g. in the joint Norwegian-Russian ecosystem surveys in the Barents Sea) and ways in which they were made available (e.g. the Alaska Ocean Observing System - AOOS) for specific LMEs. This illustrates the extensive data collection and use by present day management, industry, academia and others, for purposes that lie largely outside the sphere of the Arctic Council. There is a general need to improve access to data, to facilitate its use both outside and inside the Arctic Council family.

Geography and scales

The point was made that we should have a common geography within the Arctic Council in the way we divide the Arctic area into regions or ecosystems, and that the LMEs were the obvious choice for this purpose. The LMEs are intended to be geographical units used for implementing the EA, have been identified based on ecological criteria, and now have been revised in a lengthy and thorough process. An effort should be made to reconcile any remaining boundary issues between the LMEs and the AMAs (Arctic Marine Areas) used by CAFF in the CBMP. While it may not be necessary for these boundaries to be identical, the reasons for choosing different boundaries should be clearly explained. It is also important that the LME boundaries be used for work in AMAP where relevant, such as to define the pilot areas for the planned AACA. Use of a common set of boundaries will facilitate exchange and use of information between the various groups and activities under the Arctic Council (e.g. boundary fluxes of water, plankton, and contaminants, ecosystem budgets, etc.).

The Arctic area for work of the Arctic Council spans a wide range of conditions from boreal to High Arctic environments (from about 52^{o}N to the North Pole). The southern part of the Arctic area in the largely open water environments includes areas for some of the major fisheries in the world (Bering, Iceland, Norwegian and Barents Seas). Extensive data collection takes place in these areas as part of the fisheries management systems. In the northern part in the largely ice-covered waters, the data collection is generally less extensive and more ad hoc in relation to industrial development projects (EIAs and the like) and to provide a basis for evaluating the sustainability of subsistence harvesting.

Institutional aspects

One of the outcomes of the 2nd EA workshop (Stockholm, March 2012) and agreed by PAME at the I-2012 meeting was that: *the LME should be pursued as the appropriate and primary* *unit for applying the ecosystem approach to management of the marine environment recognizing that it accommodates management at other spatial scales.*

The Arctic Council is not a management organization and the work by Arctic states to implement the EA for their marine waters (cooperating with neighbor states for transboundary LMEs) will fully or largely be done outside the Arctic Council. Nevertheless, there are some good reasons for cooperation within the Arctic Council. One is the exchange of experiences in implementing the EA and developing and using IA as a tool. A second reason is the fact that adjacent LMEs are not independent but have open boundaries and interactions such as fluxes of water and contaminants and migrations of animals across the boundaries. A third reason is the opportunity to use information collected and used as part of the EA of each LME as a contribution to pan-Arctic scale reporting on the Arctic environment (e.g. to the UN led Regular Process).

While much of the data available and used for management purposes of LMEs are collected outside the Arctic Council programs, the information is relevant and should be made available to work within the Arctic Council such as the CBMP and AACA projects. It is important that there is strong and effective cooperation between the working groups in connection to data and data management in order to achieve a better integration of assessments of climate and pollution effects (by AMAP) on the Arctic biodiversity (species and habitats; monitored by CAFF through the CBMP). The primary scale for such integration is the LMEs as reflected in the subdivision into AMAs in CBMP and pilot areas in AACA (assuming that these areas are equivalent to and corresponds to one or more LMEs). There is therefore a clear need for AMAP and CAFF to work with the management systems that implement and operate EA and associated IA in each of the LMEs where relevant.

Some aspects of integration also take place at larger scale such as the pan-Arctic. This is the case for climate variability and change as drivers for ecosystem change, transport routes and fates of contaminants, and migration patterns of long-range migrating animals such as many birds and marine mammals.

We know from practical experience that access to data can be difficult to achieve. Some of the reasons are related to the ownership aspects of data and the resources available to manage them in an effective manner that facilitates exchange by the institutions that generate them. This can be an obstacle but may also be regarded as an opportunity. The data can generally be made available through the scientists that have the primary responsibility for their collection and use. By including these scientists into teams responsible for carrying out IAs, not only the data but also expertise around the use and interpretations of them in the context of the ecosystem are brought into the play. The links between experts and data is particularly valuable in the context of EA and IA, where interpretations of what the data tells us about what is going on in the ecosystem is of primary importance.

Annex I – Initial Answers to Workshop Questions

The information below was developed by Phil Mundy to provide workshop participants with an initial set of answers to the questions around which the workshop was organized.

1. ***What are the most relevant data sets (databases)?***

From the working definition of a "data set" as both original observations and derivative products such as models, available in time series of varying lengths, we see that the most relevant data sets available on pan-arctic and LME scales are physical observations, such as temperature, for the atmosphere and surface of the oceans collected by satellite, and increasingly, model data sets that integrate multiple sources of satellite and surface observations to provide gridded estimates of atmospheric and surface ocean conditions. When atmospheric observations are coupled with oceanographic observations and ocean circulation models, model estimates of subsurface ocean conditions may also be available.

For microbiota and macrobiota pan-Arctic data sets are available for only a small number of species, however LME scale microbiota data sets exist for some LME's, for example the Barents Sea, the East Bering Sea, Aleutian Islands and the Northern Bering-Chukchi Seas, although the length of the time series and spatial densities of sampling differ among these LME's. In addition regional scale microbiota data sets are available for most LME's. Relevant data sets on macrobiota on a pan-Arctic scale are available for species of special concern such as walrus and polar bear. In those LME's where commercial fisheries occur, such as the Barents Sea, Norwegian Sea, and East Bering Sea, LME scale data sets of varying length of time series and spatial density are available for prominent species of fish, crustaceans, mammals and birds. Relevant pan-arctic scientific data sets suitable for LME-scale IEA have been identified in Arctic Council products such as the Arctic Climate Impact Assessment (ACIA), the report on Snow, Water, Ice and Permafrost in the Arctic (SWIPA), the Arctic Biodiversity Assessment, ABA (ABA http://www.arcticbiodiversity.is/index.php), and in the many records in the published literature on the Barents Sea, the Norwegian Sea, East Bering Sea, Northern Bering-Chukchi Seas and others.

2. ***What are the relevant data management systems?***

The relevant data management systems are primarily operated by national and regional governments and organizations funded by government, such as universities and NGO's, where a data management system is defined as a means of delivering original observations to end users. Pan-arctic data management systems are available for physical observations from ocean surface and atmosphere, and for model data, where pan-arctic data are served by a variety of national governments and their agents. Rapid user friendly access to model data for the East Bering Sea and Aleutian Islands LME's and to the US regions of the Northern Bering-Chukchi Seas and Beaufort Sea LME's is provided by the Virtual Sensor software. Virtual Sensor provides a map-based graphical user interface that allows users to find and download data by dragging a virtual sensor icon to a location on a map, dropping it to receive a visualization of the time series, and providing the opportunity to download the data by clicking on a link. The Virtual Sensor avoids the need for the user to learn the arcane file structure conventions of physical data management systems in order to download data, and so it increases the number of data management systems relevant to non-physically trained practitioners. The delivery of the National Centers for Environmental Prediction (NCEP) reanalysis model by NOAA is an example of a pan-Arctic, LME scale physical data management system, among many possible.

Data management systems for microfauna are predominantly regional, although there are a number of LME-scale data sets. The published and unpublished scientific literature appears to be the primary data management system for Arctic areas. An example of an online regional zooplankton data management system is provided by the University of Svalbard, NORKLIMA http://www.forskningsradet.no/en/Newsarticle/Zooplankton_the_most_important_animal_in_the_Arctic/1253966446654. Data management systems for macrofauna are available for LME and regional scales depending on the species. An example of an LME scale data management system for macrobiota is walrus http://alaska.usgs.gov/science/biology/walrus/pwid/manual/ The Pacific Walrus International Database (PWID).

The International Council for Exploration of the Sea (ICES) has extensive data management systems and databases for date sets from ICES area in the North Atlantic, including hydrography, nutrients, chlorophyll, contaminants, zooplankton, benthos and fish. ICES serve as data center for contaminants and other data for the OSPAR Commission and the Arctic Monitoring and Assessment Program (AMAP). In addition to fish stock assessments, ICES produces various assessment reports, including an annual Ocean Climate Status Report for the North Atlantic (insert web address) and a bi-annual Report on Status and Trends in Zooplankton in the North Atlantic (insert web address).

3. ***To what extent are the relevant data sets (databases) compatible (interoperable)?***

In terms of data compatibility by geographic areas the pattern seen for data management systems continues, with pan-arctic arrangements available for meteorological and oceanographic data (World Meteorological Organization, WMO and Intergovernmental Oceanographic Commission, IOC), competing international standards for microbiota (zooplankton) identification (Sir Alister Hardy Foundation for Ocean Sciences, SAHFOS and Polish Sorting Center, others), and some pan-arctic and LME scale cooperation on certain species of macrobiota (i.e. walrus, Northern Bering-Chukchi Seas, polar bear, pan-arctic). A promising development in developing pan-arctic compatibility in micro and macrobiota is the Circumpolar Biodiversity Monitoring Program marine expert networks (http://www.caff.is/marine/marine-expert-networks and steering group (http://www.caff.is/marine/marine-steering-group), as these groups have addressed a number of similar questions. See especially the CBMP Marine Plan (http://www.caff.is/marine/marine-monitoring-plan) and the Arctic Biodiversity Data Service (http://www.abds.is/).

4. ***Do transboundary LME's have methods to reconcile differences in sampling of living marine resources?***

In the majority of macrobiota species there is no pan-arctic scale effort to coordinate and reconcile sampling methods, although the efforts of CAFF mentioned above should be noted. In the case of threatened macrobiota, e.g., polar bear, the IUCN has developed http://pbsg.npolar.no/en/status/ a pan-arctic database. Both microbiota and macrobiota have LME and regional scale efforts to coordinate and reconcile differences in sampling methods (e.g. Barents Sea Russian-Norwegian Surveys) and Northern Bering-Chukchi Seas (RUSALCA and BASIS). As noted above the efforts of the CBMP in developing a marine monitoring plan and expert network may contribute to developing pan-arctic sampling reconciliation methods.

5. ***Are current protocols adequate to enable international data sharing?***

While similar to 4th question on interoperability of methods it is noted that "interoperable" does not necessarily imply the capability of data sharing is enabled. For example the international organizations involved with standardizing meteorological and oceanographic observations have also enabled common pan-arctic data sharing protocols. In the case of microfauna data sharing protocols are regional, as multiple standards apply. In macrofauna, international fishery management in the Barents Sea has encouraged the development of common data sharing protocols. Optimistically the development of CBMP's Marine Monitoring Plan will incorporate data sharing protocols.

Annex II - EA Workshop Agenda

Monday 10 June

0900-1030 Session 1 - Background and Introduction

Welcome, practical information (Norway, USA, PAME)

Background and Objectives for the Workshop

Hein Rune Skjoldal (Norway) – Overview of ecosystem approach and data needed for integrated assessment

Phil Mundy (USA) – Overview of data sources, management and integration

Discussion

1030-1100 Coffee

1100-1230 Session 2 – LME Case studies: Geographic paradigms in ecosystem-level data acquisition, integration and dissemination for conducting assessments and advancing EA

The Barents Sea LME

Norway: Elena Eriksen (IMR, Norway) - Monitoring of the Barents Sea ecosystem through Joint Norwegian-Russian surveys

Russia: Dmitry Prozorkevich (PINRO, Russia) - Data collection and reporting in relation to assessment and management

1230-1330 Lunch

1330-1500

Session 2 continued: LME case studies: Geographic paradigms in ecosystem-level data acquisition, integration and dissemination for conducting assessments and advancing EA

Northern Bering-Chukchi LME

USA: Dennis Thurston, BOEM (presenting; co-author Phil Mundy)

Beaufort Sea LME

Canada: Martine Giangioppi (DFO)

USA: Molly McCammon, AOOS

1500-1530 Coffee

1530-1730

General discussion - Lessons from LME case studies; data needed for integrated assessments and ecosystem status reports at the scale of LMEs

Tuesday 11 June

0900-1030 Session 3 - Arctic Council WGs

AMAP

Jon Fuglestad (AMAP Secretariat)

- Various data aspects (collection, availability, QA, management) and experiences gained from comprehensive assessments of Arctic pollution and climate change;
- Plans for '*Adaptation Actions for a Changing Arctic' (AACA)*

CAFF

Kári Lárusson (CAFF Secretariat, Iceland)

- Arctic Biodiversity Assessment (ABA)

Kári Lárusson and Lis Lindahl Jørgensen (IMR, Norway)

- Circumpolar Biodiversity Monitoring Program (CBMP)

1030-1100 Coffee

1100-1230

Permanent Participants - Presentation on indigenous peoples perspectives and use of traditional knowledge (TBC)

Discussion

1230-1330 Lunch

1330-1500 Session 4 - Conclusions

General discussion

1500-1530 Coffee

1530-1700 Conclusions and recommendations

Annex III – List of Participants

Last name	First name	Country	Organization	Email
Baldursson	***Trausti***	Iceland	CAFF	trausti@ni.is
Bjarnadottir	***Sesselja***	Iceland	Ministry for the Environment and Natural Resources	Sesselja.Bjarnadottir@umh.stjr.is
Elisenberg	***Anja***	Norway	Ministry of Environment	anja.elisenberg@md.dep.no
Eriksen	***Elena***	Norway		
Fiorani	***Luca***	Italy	Italian National Agency for New Techn, Energy and Sustainab Economic Developm	luca.fiorani@enea.it
Fuglestad	***Jon L***	Norway	AMAP	jon.fuglestad@amap.no
Gamble	***James***	USA	Aleut International Association (AIA)	aia@alaska.net
Giangioppi	***Martine***	Canada	Department of Fisheries and Oceans	Martine.Giangioppi@dfo-mpo.gc.ca
Gudmundsdottir	***Soffia***	Iceland	PAME International Secretariat (PAME)	soffia@pame.is
Jensson	***Helgi***	Iceland	Environment of Iceland / AMAP	helgij@Umhverfisstofnun.is
Jørgensen	***Lis Lindal***	Norway	Institute of Marine Research	lis.lindal.joergensen@imr.no
Kroglund	***Marianne***	Norway	Climate and Pollution Agency	Marianne.Kroglund@klif.no
Larusson	***Kari***	Iceland	CAFF/Circumpolar Biodiversity Monitoring Program	kari@caff.is
Laughlin	***Tom***	USA	Expert	tomlaughlin3@verizon.net
McCammon	***Molly***	USA	Alaska Ocean Observing System	mccammon@aoos.org
McConnell	***Martha***		IUCN	martha.mcconnell@iucn.org
McLanahan	***Elizabeth***	USA	NOAA Office of International Affiars	elizabeth.McLanahan@noaa.gov
Mortimer	***Diana***	UK	UK's Joint Nature Conservation Committee	Diana.Mortimer@jncc.gov.u
Mundy	***Phil***	USA	NOAA Auke Bay Laboratories	phil.mundy@noaa.gov
Olafsson	***Hugi***	Iceland	Ministry for the Environment and Natural Resources	hugi.olafsson@umh.stjr.is
Palsdottir	***Olga***	Iceland	PAME International Secretariat (PAME)	olga@caff.is
Prozorkevich	***Dmitry***	Russia	PINRO	
Skjoldal	***Hein Rune***	Norway	Norwegian Maritime Institute	hein.rune.skjoldal@imr.no
Sommerkorn	***Martin***	Norway	WWF	msommerkorn@wwf.no
Sorensen	***Jan***	Faroe Islands	Faroeese Natural Museum/Circumpolar Biodiversity Monitoring Program	jans@savn.fo
Speer	***Lisa***	USA	Circumpolar Conservation Union - CCU	lspeer@nrdc.org
Stotts	***James***	USA	ICC Alaska	jimmy@iccalaska.org
Quillfeldt	***Cecilie***	Norway	Norwegian Polar Institute	quillfeldt@npolar.no
Valtyrsson	***Hreidar***	Iceland	University of the Arctic	hreidar@unak.is

Annex IV - Presentation on light induced fluorescence, a powerful tool for marine ecosystem monitoring

Luca Fiorani, Researcher at ENEA and Professor at "Tor Vergata" and "Lumsa" Universities of Rome

The Diagnostic and Metrology Laboratory (UTARPRAD-DIM) of the National Agency for New Technologies, Energy and Sustainable Economic Development (ENEA) has recently developed SOMBRERO, an underwater spectrofluorometer, building on its experience on CASPER, a patented instrument for the bio-optical characterization of natural waters by laser-induced fluorescence (LIF). The breakthrough of SOMBRERO is the use of new technologies, as ultraviolet and blue LEDs, to reduce size, weight and cost.

SOMBRERO can monitor dissolved organic matter, oil spills and algal pigments.

The innovative technology of SOMBRERO could pave the way to the development of a constellation of underwater sensors, revolutionizing our way to monitor salty sea and ocean environment, as well as lakes and ponds of fresh water.

SOMBRERO data can be used to validate present satellite images and to develop new regional algorithms.