EAF-Nansen Programme expert workshop on ecosystem characterization

Rome, Italy
21–23 August 2018
The EAF-Nansen Programme “Supporting the Application of the Ecosystem Approach to Fisheries Management considering Climate and Pollution Impacts” supports partner countries and regional organizations in Africa and the Bay of Bengal improving their capacity for the sustainable management of their fisheries and other uses of marine and coastal resources through the implementation of the ecosystem approach to fisheries (EAF), taking into consideration the impacts of the climate and pollution.

The EAF-Nansen Programme is executed by the Food and Agriculture Organization of the United Nations (FAO) in close collaboration with the Institute of Marine Research (IMR) of Bergen, Norway, and funded by the Norwegian Agency for Development Cooperation (Norad). This Programme, which started in 2017, represents the current phase of the Nansen Programme which started in 1975.

The aim of the Programme is that sustainable fisheries improve food and nutrition security for people in partner countries. It builds on three pillars, Science, Fisheries Management, and Capacity Development, and supports partner countries to produce relevant and timely evidence-based advice for fisheries management, according to the EAF principles and to further develop their human and organizational capacity to manage fisheries sustainably. In line with the EAF principles, the Programme adopts a broad scope, taking into consideration a wide range of impacts of human activities and natural processes on marine resources and ecosystems including fisheries, pollution, climate variability and change.

A new state of the art research vessel, the Dr Fridtjof Nansen, is an integral part of the Programme. A comprehensive science plan, covering a broad selection of research areas, and directed at producing knowledge for informing policy and management decisions, guides the Programme's scientific work.

The Programme works in partnership with countries, regional organizations, other UN agencies as well as other partner projects and institutions.
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Programme report
Preparation of this document

This is a report of an expert workshop organised under the EAF-Nansen Programme “Supporting the application of the Ecosystem Approach to Fisheries management considering climate and pollution impacts”. The workshop took place at the premises of the Food and Agriculture Organization of the United Nations (FAO) headquarters in Rome, Italy from 21 to 23 August 2018. The expected outputs of the workshop were a report describing best methods/approaches for ecosystem characterization in data-limited regions and an action plan for future case studies in two regions. This report has been prepared using workshop presentations, deliberations, and recommendations from experts at the workshop. A draft report was shared with workshop participants for their inputs, and all revisions have been considered in the final report.
Abstract

Under the EAF-Nansen Programme (Supporting the application of the Ecosystem Approach to Fisheries management considering climate and pollution impacts), an expert workshop on ecosystem characterization was convened on the premises of the FAO headquarters in Rome, Italy from 21 to 23 August 2018. The overarching objective of the workshop was to identify best practices for ecosystem characterization in data-limited areas, how they can be used and what they should not be used for. 19 experts drawn from fisheries and marine research institutes in eight countries, and from FAO attended the workshop. The three-day workshop included presentations and discussions on identifying relevant ecosystem characterization approaches for data-limited areas, defining best practice methods for ecosystem characterization in data-limited regions and their application, and how to feed scientific knowledge into decision-making at different levels. Presentations also dealt with how uncertainty in the methods can be taken into account and communicated, and to understand existing challenges and ongoing efforts in targeted regions that may be of relevance to ecosystem characterization.

The next steps included the development of a scientific paper “Six steps towards ecosystem characterization” and an ecosystem characterization guideline to guide approaches on how to perform ecosystem characterization based on different degrees of data limitation. Additionally, a full reference list of all relevant papers on the subject, categorized into existing validated theories will be prepared and shared among the group. Finally, the proposed areas to pilot this activity were agreed to be the Canary Current Large Marine Ecosystem (CCLME) area, the Benguela Current Convention (BCC) region and Mozambique.
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<tr>
<td>BCC</td>
<td>Benguela Current Convention</td>
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<td>BCLME</td>
<td>Benguela Current Large Marine Ecosystem</td>
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<td>BoBLME</td>
<td>Bay of Bengal Large Marine Ecosystem</td>
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<td>CBD</td>
<td>Convention on Biological Diversity</td>
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<td>CCLME</td>
<td>Canary Current Large Marine Ecosystem</td>
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<tr>
<td>CEFAS</td>
<td>Centre for Environment, Fisheries and Aquaculture Science (United Kingdom of Great Britain and Northern Ireland)</td>
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<td>CEPA</td>
<td>Conservation and Environment Protection Authority</td>
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<td>CSIRO</td>
<td>Commonwealth Scientific and Industrial Research Organisation (Australia)</td>
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<td>EAF</td>
<td>Ecosystem approach to fisheries</td>
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<td>EBSA</td>
<td>Ecologically or biologically significant marine areas</td>
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<td>EBM</td>
<td>Ecosystem-based management</td>
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<td>EIA</td>
<td>Environmental impact assessment</td>
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<td>ELVIS</td>
<td>Ecosystem and Livelihoods Values Interrogation System</td>
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<td>EMU</td>
<td>Ecological marine unit</td>
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<td>FAO</td>
<td>Food and Agriculture Organization of the United Nations</td>
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<td>FPI</td>
<td>Fishery performance indicator</td>
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<td>GDP</td>
<td>Gross domestic product</td>
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<td>GEBCO</td>
<td>General Bathymetric Chart of the Oceans</td>
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<td>GFW</td>
<td>Global Fishing Watch</td>
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<tr>
<td>GIS</td>
<td>Geographic Information System</td>
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<td>GOBI</td>
<td>Global Ocean Biodiversity Initiative</td>
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<td>GSV</td>
<td>Global shoreline vector</td>
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<td>ICES</td>
<td>International Council for the Exploration of the Sea</td>
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<td>IEA</td>
<td>Integrated ecosystem assessment</td>
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<td>IEO</td>
<td>Institute of Oceanography (Spain)</td>
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<td>IIP</td>
<td>Institute of Fisheries Research (Mozambique)</td>
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<tr>
<td>IMR</td>
<td>Institute of Marine Research (Norway)</td>
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<tr>
<td>IMROP</td>
<td>Mauritanian Institute of Oceanographic and Fisheries Research</td>
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<tr>
<td>INRH</td>
<td>National Institute of Fisheries Research (Morocco)</td>
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<tr>
<td>IOC</td>
<td>Intergovernmental Oceanographic Commission</td>
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<td>IUCN</td>
<td>International Union for Conservation of Nature</td>
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<tr>
<td>LCCS</td>
<td>Land Cover Classification System</td>
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<td>LME</td>
<td>Large marine ecosystem</td>
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<td>MPA</td>
<td>Marine protected area</td>
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<td>NAFO</td>
<td>Northwest Atlantic Fisheries Organization</td>
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<td>MODIS</td>
<td>Moderate resolution imaging spectroradiometer</td>
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<td>MSP</td>
<td>Marine spatial planning</td>
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<tr>
<td>NOAA</td>
<td>National Oceanic and Atmospheric Administration (United States of America)</td>
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<tr>
<td>R/V</td>
<td>Fishery research vessel</td>
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<td>SES</td>
<td>Social-ecological system (framework)</td>
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<td>SIEAA</td>
<td>System of Environmental-Economic Accounting</td>
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<td>SIA</td>
<td>Strategic impact assessment</td>
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<tr>
<td>Acronym</td>
<td>Full Form</td>
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<tr>
<td>SMEA</td>
<td>School of Marine and Environmental Affairs</td>
</tr>
<tr>
<td>TBL</td>
<td>triple bottom line</td>
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<tr>
<td>UN</td>
<td>United Nations</td>
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<tr>
<td>UNEP</td>
<td>United Nations Environment Programme</td>
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<tr>
<td>UNESCO</td>
<td>United Nations Educational, Scientific and Cultural Organization</td>
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<tr>
<td>USGS</td>
<td>United States Geological Survey</td>
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<tr>
<td>VME</td>
<td>vulnerable marine ecosystem</td>
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<tr>
<td>WGEAWESS</td>
<td>Working Group on Ecosystem Assessment of Western European Shelf Seas</td>
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<tr>
<td>WGIAB</td>
<td>Working Group on Integrated Assessments of the Baltic Sea</td>
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1. Introduction

1.1 Workshop background, scope and expected output

The long-term objective of the EAF-Nansen Programme is that “sustainable fisheries improve food and nutrition security for people in partner countries”. This is to be achieved through the implementation of the ecosystem approach to fisheries (EAF).

The EAF framework was adopted by the international community as an appropriate approach to ensure sustainability of fisheries in an ecosystem context, and formally adopted by FAO’s Committee on Fisheries in 2005. The EAF is a holistic approach to manage fisheries across the ecological, social and economic dimensions of sustainability. It is widely recognized, however, that fishery resources are impacted by stressors outside the control of the fisheries sector, and a growing challenge in the context of ocean sustainability lies in managing interactions between multiple ocean uses. At the same time, climate variability and change also contribute to increasing uncertainty on the future outlook of how resources and ecosystems will respond to the multiple drivers that are affecting them. Understanding overall marine ecosystem properties and how these can be affected by multiple drivers of change, both anthropogenic and natural, is key for their sustainable use.

In this context, and as part of the Science Plan developed within the framework of the EAF-Nansen Programme, a specific theme is dedicated to “ecosystem characterization”, recognized as a crucial step for ecosystem assessments and monitoring. From the renewable resources perspective, information on main ecological characteristics, identification of bioregions and zones of particularly sensitive or ecologically important areas is key to the process of coordinating the planning and development not only of fisheries but more broadly of any activities at sea. In addition to providing a description of main and spatially-defined ecosystem features as a fundamental piece of information to enable coastal countries to plan activities at sea minimizing negative impacts on productivity, biodiversity and overall resilience of the system, ecosystem characterization provides the basis for ecosystem monitoring, including to detect possible climate related impacts.

These ecosystem characterizations will include past, present and likely future states of the ecosystems, taking possible development of pressures into account, with methodologies that will also include those for data-poor situations.

It should be noted that some work relevant to ecosystem characterization has already been done in regions covered by the programme, such as the work under the large marine ecosystem (LME) projects, and the activities that will be carried out in selected regions will take these previous efforts into account.

Numerous approaches for ecosystem characterization exist, also applied within the integrated ecosystem assessment (IEA) frameworks within the International Council for the Exploration of the Seas (ICES) and the National Oceanic and Atmospheric Administration (NOAA). However, the methods are typically developed and applied in data rich regions. Through this expert workshop, FAO aims to identify best practices for ecosystem characterization in data-limited areas, how they can be used and what they should not be used for.
The uncertainty that arises from data limitation should be discussed and taken into consideration when deciding upon which methods are applicable.

As part of the EAF-Nansen Programme activities, a workshop was organized on ecosystem characterization at FAO headquarters in Rome, Italy from 21 to 23 August 2018. The workshop had the following objectives:

- identify relevant ecosystem characterization approaches for data limited areas;
- define best practice methods for ecosystem characterization in data limited regions and how these should be applied;
- suggest how this knowledge can feed into decision-making at tactical and strategic levels;
- define how uncertainty in the methods can be taken into account and communicated; and
- understand existing challenges and ongoing efforts in targeted regions that may be of relevance to ecosystem characterization.

The expected outputs of the workshop were a report describing best methods/approaches for ecosystem characterizations in data-limited regions and an action plan for future case studies in two regions. The agenda for the workshop is shown in Annex I and the list of participants in Annex II.

1.2 Workshop opening

The workshop participants were welcomed by Ms Merete Tandstad, the EAF-Nansen Programme Coordinator. Ms Vera Agostini, Deputy Director of the FAO Fisheries Division, who opened the workshop, highlighted the importance of the EAF for the fisheries and for the work of the Fisheries Division of FAO.

Ms Cecilie Hansen of the Institute of Marine Research (IMR), Norway, went through the background, scope, and expected outputs of the workshop. She said that the main work to be carried out is to agree on methods to be applied, and to test these in agreed pilot areas. Additional work would entail the preparation of a short guidance paper. She also informed participants about examples of work conducted related to ecosystem characterization in other areas such as the Annual Barents Sea ecosystem survey undertaken by IMR in cooperation with the Russian Federation since 2004 and the methodology that is used.

Ms Tandstad made an introductory presentation on the EAF-Nansen Programme explaining its objectives, expected outcomes and outputs, with specific focus on how the different areas of the work of the programme can contribute and feed into the work on ecosystem characterization and the importance of having a clear methodology for the work to proceed.

Several suggestions were made by participants on the way forward for the workshop including the need to set up clear and simple sets of indicators that will work for data- and capacity-poor environments as well as a ranking of methods to be tested.
2. Overview of possible methods to use in data-limited systems

2.1 Thoughts from the South African perspective including ecological risk assessments and how these are (not well) received in South Africa

Ms Lynne Shannon, senior researcher at the Marine Research Institute (MA-RE) of the University of Cape Town, South Africa, delivered a presentation on IndiSEAS which is a scientific program endorsed by the Intergovernmental Oceanographic Commission (IOC)/United Nations Educational, Scientific and Cultural Organization (UNESCO) and aimed to evaluate the effects of fishing on the health status of marine ecosystems, using a suite of biodiversity, environmental and human dimension indicators.

She explained the practical steps that lead the evaluation group to the definition of the ecosystem status, including scoring procedures and descriptors, providing trends, visual representation of results and types of indicators.

She also presented the paper “EAF implementation in Southern Africa: Lessons learnt” by Barbara Paterson and Samantha Petersen. The paper proposes a generic framework for reviewing ecological risk assessment through stakeholder workshops.

2.2 From ecosystem characterization to bioregionalisation and back again

Mr Piers Dunstan, Commonwealth Scientific and Industrial Research Organisation (CSIRO) of Australia, made a presentation on the activities of CSIRO concerning bioregionalisation and on the marine and coastal values framework. He informed that the CSIRO has been working to develop sub-regional bioregionalisations for the Southwest Pacific Ocean and the Indian Ocean. This will combine approaches developed by CSIRO in Australia and used in the Bay of Bengal (in collaboration with the Bay of Bengal Large Marine Ecosystem (BOBLME) project) with similar approaches that have been used throughout the Indian Ocean to derive a single combined bioregionalisation. The project will develop an expert derived bioregionalisation in the Indian and Pacific Oceans through expert workshops and novel statistical analysis of physical and biological data. The data collected in the bioregional analysis is compatible with ecosystem characterizations and the boundaries identify broad ecoregions that may form a basis for characterization.

New bioregionalisations for the western-south Pacific and Indian oceans will incorporate understanding of shallow, deep and pelagic species, ecosystems, physical environments and their likely boundaries based on current information. The expert-based bioregionalisations will be supported by development of statistical analysis of datasets of selected species groups to identify bioregions specific for each taxon, with data from the ecologically or biologically significant marine areas (EBSA) process and additional regional biogeographies based on new invertebrate and fish collections from CSIRO, University of Tasmania, Victoria Museum and regional partners. Further, the bioregionalisations will be strengthened through the inclusion of local and traditional knowledge.
The project will draw on experience in CSIRO, partners of the Global Ocean Biodiversity Initiative (GOBI) and other collaborators, using approaches currently being trialed in Australia and around the Antarctic margins. It will also collaborate with regional and national stakeholders to ensure a consistent approach. The final outputs will combine expert and statistical regions with qualitative models of ecosystem function.

The livelihoods and wellbeing of the people of New Britain are linked inexorably with the health of their land and seascapes, which support their incomes, their culture and their food security. Efforts to support this, such as integrated ocean governance, sustainable development, natural resource management, climate change adaptation, disaster and incident response, require access to spatial information on a full range of values associated with ecosystems, representing stakeholders at all scales from national to local.

CSIRO has developed a marine and coastal values framework that can be applied to natural resource, ecological and socio-cultural data to comprehensively value ecosystem features and cultural assets. These assets can be mapped across land and seascapes to produce a comprehensive understanding of who values what and where. This information can then be used in land and sea development and planning activities. This framework includes four value categories and 19 value types. The value categories and metrics are based on best practice approaches for environmental valuation and are capable of integrating a broad range of environmental, socio-cultural and resource-use data.

CSIRO has also developed a linked database–geographic information system (GIS) application Ecosystem and Livelihoods Values Interrogation System (ELVIS), suitable for selected area queries that provide a summary of the importance of natural resources, regulatory values, sociocultural sites and areas important for ecosystem structure and processes. It is also suitable for deeper data interrogation and the production of electronic and hardcopy maps.

CSIRO has used the values framework to build a comprehensive marine and coastal values database for the Bismarck Sea “Seascape” in Papua New Guinea, using information collected in East and West New Britain Provinces. The information came from existing sources and new data collected during the participatory workshops.

The values data are represented in ELVIS spatially by linking to mapped ecosystem (and also some human built) features. This provides the basis for determining the interaction of values with pressures and potential impacts and for spatial planning. The spatial values data can be utilized by stakeholders using GIS, centralized spatial data inventories or hardcopy maps. To date the database contains over 8 000 values records of natural resource, ecosystem structure and processes, ecosystem regulation and socio-cultural values attached to features from high mountain forests to deep offshore waters.

The ELVIS has been delivered to Papua New Guinea stakeholders as a standalone GIS package and through spatial layers suitable for uploading to existing centralized spatial data infrastructure in Papua New Gunea ministries, primarily the Conservation and Environment Protection Authority (CEPA), and provincial governments. This application and database will give Papua New Guinea national and provincial governments significantly improved capability to make decisions that benefit the people for the long term.
2.3 Characterizing the human part of the fishery ecosystem

Mr Edward H. Allison of the School of Marine and Environmental Affairs (SMEA) at the University of Washington, made a presentation on “Characterizing the human part of the fishery ecosystem”. In his presentation, he highlighted that in most models, humans are positioned as external forces of destruction to the ecosystems. Other way of thinking is that humans are part of the ecosystems.

Mr Allison noted that the EAF is a systems framework including the social, cultural, economic and institutional dimensions of fisheries and that fishery performance indicators (FPIs) constitute a practical, low-cost method to include human dimensions in EAF. He recalled the Ostrom’s social-ecological system (SES) framework (resource units, resource system, governance, system, and users) elaborates a series of indicators for these systems. He underscored the challenge of integrating “human dimensions” into EAF in data-poor context and noted that these kinds of models can be parameterized and used at different spatial scales. Therefore, certain aspects of these systems and approaches which will work in these data-poor situations are being considered.

Mr Allison also recalled that FPIs can be used as a framework for human dimensions of EAF in data-poor situations. FPIs are a rapid performance assessment to measure the generation of benefits from fishery resources. The aim is to assemble a large set of case studies to identify “what works”. One of the potential applications is to track triple bottom line (TBL) outcomes and how to assess human dimensions in EAF. FPIs can also be used to understand what kind of policy or capacity development interventions could be used for certain outcomes. FPI rapid assessment outputs are broken down into three categories: ecology, economics and community. The ecological outputs of the existing datasets can be done in a period of weeks. Some patterns emerge in ecological similarities, as well as social and economic outcomes.

2.4 Application of the EAF in the CCLME. Improving knowledge and capacities for scientific knowledge in the CCLME Region. Reality or a scientific fantasy?

Ms Ana Ramos Martos of the Spanish Institute of Oceanography (IEO) made a presentation on the application of the EAF in the CCLME region. The CCLME region hosts one of the four main upwelling systems of the world, constituting an important fishing area for demersal and pelagic species. Nevertheless, the application of this new approach to fisheries management in the CCLME is yet to be widely adopted, despite the support that has been provided to support countries in its implementation, including through FAO. From a scientific perspective, assessment of fish stocks in the framework of FAO Working Groups continues to be performed applying the traditional methodology. The study of commercial species, mainly fishes, still remain basically the main research objective of local institutes, and despite some institutes, like the Mauritanian Institute of Oceanographic and Fisheries Research (IMROP) and the National Institute of Fisheries Research (INRH, Morocco), maintaining long time series of research surveys, the surveys are focused on the assessment of commercial species.

However, although it may seem contradictory, marine biodiversity and ecosystems of the CCLME are currently the best known of Africa at regional level. The basis of this knowledge
has been obtained thanks to the 11 bottom-trawl surveys carried out in the region on-board Spanish and Norwegian research vessels (R/V) Vizconde Eza and Dr Fridtjof Nansen respectively between 2004 and 2012, the latter operated in the context of the FAO executed EAF-Nansen project and through a collaboration with the CCLME project. Demersal surveys provide a huge amount of data and faunistic material, representing an extraordinary opportunity and an excellent platform to obtain biodiversity data and environmental information on bathymetry, geomorphology, sediments and water masses characteristics.

The sampling programme for benthic research developed in the framework of the Spanish EcoAfrik project (a collaborative programme launched in 2008 by the IEO and the University of Vigo) in the demersal surveys carried out in the CCLME, most intensive in Morocco, Guinea--Bissau and specifically in Mauritania, accomplished 1 350 commercial bottom trawl hauls, 25 beam-trawl hauls and 28 dredge tows over hard-bottoms. In addition, 1 269 CTD profiles and other oceanographic recordings were obtained.

The application of the EAF requires managing wide information, not only on commercial species, but also on habitats and ecosystems. The main problem to apply this approach in developing countries is the lack of knowledge to characterize biodiversity, communities and habitats. A key question is also how to approach and fund the extremely time-consuming post-survey study of these data and samples in the African research institutes, which lack basic scientific capacity and skills to develop research on biodiversity and ecosystems that allow a real contribution of broader knowledge in support of the application of the EAF.

It is very difficult to organize oceanographic surveys specifically focused on biodiversity or taxonomy studies in these countries. Nevertheless, research surveys for the assessment of demersal resources are periodically carried out by both local institutes and international programmes. The commercial otter trawls employed as sampling gears in fisheries evaluation collect a large amount of benthic megafauna as by-catch, providing a very important source of samples and data for the study of biodiversity and habitats, but the benthic fauna is usually discarded and this valuable biological information is lost. However, the development of an adequate on-board methodology, together with the subsequent land-based research, allow to capitalize the demersal surveys, with a minimum effort and cost.

The application of this methodology during the R/V Vizconde de Eza and R/V Dr Fridtjof Nansen surveys in the CCLME region, has significantly improved the knowledge on marine ecosystems in this data-poor region.

Subsequent research has been developed in the framework of the EcoAfrik Project. The main results obtained during the period include a monograph on deep-sea ecosystems off Mauritania (Ramos et al., 2017) with 17 chapters devoted to the study of geomorphology, oceanography, biodiversity, assemblages, vulnerable marine ecosystems (VMEs) and zoological collections. The last chapter provides a general overview on the deep-sea ecosystems and the identification of several EBSAs along the Mauritanian continental slope, based on criteria established by the Convention on Biological Diversity (CBD, 2009). In addition, four PhD dissertations dealing with decapods (de Matos-Pita, 2015), echinoderms (Calero, 2017), mollusks (Castillo, 2017) and hydroids (Gil, 2017), were presented at the University of Vigo.
At present, the main effort in the EcoAfrik Project is focused on transferring the acquired knowledge and experience in research and management of biodiversity and habitats to CCLME countries. To achieve this goal, the project team has submitted a long-term capacity development project to the Abidjan Convention (UNEP) focused on “Building capacities for research, conservation and management of marine biodiversity and habitats in Northwest Africa (CCLME Region)”. The proposal envisages the participation of 15 young African scientists. The project includes the following items:

- two months training course at the University of Vigo for young African scientists;
- provision of equipment to local laboratories in the seven partner countries for biodiversity research;
- support and scientific guidance during the project;
- working groups in African countries; and
- scientific production and outreach.

Development of capacity in Northwest African countries in biodiversity and habitats research will be a basic and essential tool for implementing the EAF in the CCLME region and will contribute to the planned work on ecosystem characterization under the EAF-Nansen Programme.
3. Relevant ecosystem characterization approaches

3.1 Review of integrated ecosystem assessments of North Atlantic ecosystems

Mr Marcos Llope of IEO reviewed how the IEA of North Atlantic ecosystems is organized and coordinated within ICES. In particular, he reviewed the techniques that have been used in the ICES Working Groups on Integrated Assessments of the Baltic Sea (WGIAB) and on Ecosystem Assessment of Western European Shelf Seas (WGEAWESS) as well as the terms of reference they have pursued over the years. Mr Llope also showed work that is being developed in the Gulf of Cadiz, one of WGEAWESS ecosystems, both in terms of IEA and how this relates to the anchovy fishery. The latter relies, to a great extent, on the Guadalquivir estuary for recruitment and there are a number of sectoral activities, whose trade-offs would need to be considered in order to implement an ecosystem based style of management in the area.

3.2 Relevant ecosystem characterization approaches—Benguela ecosystem context

A presentation on relevant ecosystem characterization approaches with specific focus on the Benguela ecosystem context, was made by Mr Stephen Kirkman of the Department of Environmental Affairs, Ocean and Coast of South Africa.

Classification and mapping of the ecosystem and its components is essential to ecosystem characterization. Some obvious principles that emerge from a brief review of global biogeographic-type classification schemes show that the schemes that are hierarchical/nested in nature facilitate multi-scale considerations; those that are informed by multiple taxa and/or drivers are more likely to capture robust and recurring patterns than those that are not, and systematic approaches are more rigorous and replicable than those that are merely expert derived. Two approaches to ecosystem characterization that have been followed in the Benguela ecosystem were described.

Mr Kirkman noted that LMEs such as the Benguela Current Large Marine Ecosystem (BCLME) are an example of a classification that are neither hierarchical nor systematic, although information on multiple ecological criteria were considered in their delineation. Each LME is large, on average about 200,000 km$^2$ and as such they are mostly applicable to very general management approaches including with regard to transboundary issues. LMEs generally represent regions with common oceanography and productivity, but in the BCLME, it has been documented that there are different subsystems, each functioning more or less as a separate entity. Confirming the boundaries and developing a common understanding of the spatial and some temporal characteristics of the subsystems in terms of their main drivers, features, resources and ecosystem changes, was considered to be in the interests of ecosystem-based management (EBM) and also for marine spatial planning (MSP) which is emerging in the region. This was done through a workshop, the report of which was developed into a publication (Kirkman et al. 2016). The workshop and write up were informed by scientific knowledge and a vast body of scientific literature, much of which had previously been synthesized in the final analysis of the Nansen Climate Change (NansClim) project (Jarre et al. 2015). The subsystem boundaries and
classification were the basis for proposed lines (in addition to several existing lines) for monitoring of physical and biological variables, with the aims of i) characterizing the BCLME variability, ii) verifying boundaries of the subsystems and fluxes across the boundaries, and iii) monitoring environmental changes.

Mr Kirkman also described the ecosystem mapping and characterization that have been used for biodiversity assessment and planning in South Africa since 2004, and more recently extended to Namibia and Angola. The assessments are conducted at a scale that allows for spatially explicit management advice, with a resolution of 5’ x 5’ grid cells (a compromise between the finer resolution data for coastal areas and the cruder data that are often available for offshore areas). The process requires classification and mapping of habitat types, which is conducted using a hierarchical approach. At the broadest level, ecoregions are distinguished based on large scale biological variability and biogeography, plus large scale habitat differences related to different current systems with different temperatures and productivity. Nested within Ecoregions are ecozones, but biological information is considered to be not comprehensive enough to classify areas at this level. Thus, in the case of the benthic ecosystem component (the sea-bottom deeper than 30 m), depth, slope and general topography were used to classify offshore benthic biozones and nested within these, ecosystem types, because they are considered to provide easily measurable, well established surrogates of biodiversity patterns in offshore environments.

For the coastal environment (between 30 m depth and 500 m distance inland) the influences of geology, grain size and wave exposure were also taken into account in the classification of coastal ecozones and ecotypes. The coastal classification was assisted with the use of Google Earth imagery. Thus, the classification of ecosystems for both the benthic and coastal components was largely heuristic in nature, making use of features (e.g. bathylines, topography) to demarcate boundaries where possible. For the pelagic component (between the surface and the sea-bottom deeper than 30 m), classification was based on remotely-sensed layers as surrogate variables for mapping regional biodiversity patterns and processes. These layers included sea surface temperature, net primary productivity, chlorophyll-a, depth, turbidity, frequency of eddies, and the distribution of temperature and chlorophyll fronts. A cluster analysis was performed on these data to classify the pelagic ecosystem types and delineate boundaries. From the above, an integrated ecosystem map of all the main ecosystem components was developed.

Mr Kirkman continued that pressures on the ecosystem for which spatial data could be obtained were mapped, to overlay the grid configuration of the study domain. Pressures included the efforts of different commercial fisheries sectors, artisanal (Angola) and subsistence fishers, coastal development, mining, the oil and gas industry, waste water outflows, and several others that could be mapped. As was the case with biological data, there was a decline in the availability of spatial pressure data from south to north in the region (South Africa to Angola), such that some pressures could not be mapped for Namibia and Angola, or pressures had to be inferred from global databases (Angola commercial fisheries). Comparison of these pressure maps allowed for the cumulative impact of all pressures (taking into account the severity of their impacts and their recovery times, which were estimated in an expert workshop) to be estimated. From this, the condition of each ecosystem type could be adjudged as good, fair or poor, based on the proportion that was impacted and the severity. This allowed for estimation of threat status of each ecosystem types as per International Union for Conservation of Nature (IUCN) categories. These, and other
information such as protection levels (the proportion of each ecosystem type already under protection), information on ecosystem processes and features including habitat that were at insufficient resolution to be included in the ecosystem maps, as well as distribution of species, communities or area of importance for life history stages, were all taken into account, together with costs that would be incurred by sectors or industries if areas were placed under protection, in order to prioritize areas for protection, or more particularly, where some form of place-based management should be considered to maximize conservation gains and reduce potential future loss of biodiversity. The prioritization was conducted using the decision support software Marxan.

The ecosystem characterizations provided by the project, including the maps of ecosystem types, processes, features, species distributions, pressures, ecosystem condition, threat status, existing protected areas and priority areas for conservation, have formed the basis for the process of identifying potential EBSAs in the region, or revising existing EBSAs. Areas identified as potential EBSAs were then further characterized in terms of the seven EBSA criteria. As part of a current project in the region, the identification of pressures and assessment of the threat status of each EBSA shall provide the basis for management options for MSP in the region. It is recognized that robust characterizations of the EBSAs are required if necessary spatial management measures are to be secured through MSP or other processes.

After the presentation, it was highlighted that static mapping used for fisheries management do not fully represent the temporal movements of single species. It was suggested then to include a descriptor that takes into account the dynamic nature of the ecosystems.
4. Best practice methods and application of ecosystem characterization in data-limited regions

4.1 Delineating distinct abiotic environments in the ocean and coastal zone in support of global marine ecosystem characterization

Mr Roger Sayre of the United States Geological Survey (USGS) made a presentation on high resolution, standardized global marine data that can be used to support marine ecosystem characterization. The global ecological marine units (EMUs) were presented as 37 physically and chemically distinct volumetric regions of the ocean based on differences in temperature, salinity, dissolved oxygen, nitrate, silicate and phosphate. The EMUs were objectively derived from statistical clustering of long term average data from NOAA’s World Ocean Atlas resource. A new, standardized, 30 m global shoreline vector (GSV) was also described as potentially useful for coastal marine ecosystem characterization. The presentation concluded with the following recommendations:

- Ecosystem characterization should include geospatial delineation and attribution of ecologically meaningful areas within the region of interest.
- Delineation of these areas should be hierarchical.
- Ecosystem mapping should be exhaustive, conceptually and geographically, and mutually exclusive (non-overlapping) in 2D expressions.
- Coupling of biological assemblage distributions with environmental variation is encouraged in ecosystem characterization.
- Identified ecosystems should aggregate up into broad, domain relevant, high level categories such as those being used for United Nations System of Environmental -Economic Accounting (UN SEEA), IUCN Red List, FAO Land Cover Classification System (LCCS), etc.

4.2 Learning from data rich case studies: applying knowledge from data-rich to data-limited situations

Mr Andrew Kenny of the Centre for Environment, Fisheries and Aquaculture Science (CEFAS), Lowestoft, the United Kingdom of Great Britain and Northern Ireland, delivered a presentation on learning from data rich case studies: applying knowledge from data rich to data limited situations. Two case study areas were presented, i) habitat modelling of vulnerable marine ecosystems and impact assessments of bottom fishing activities in the Northwest Atlantic Fisheries Organisation Regulatory Area (NAFO), and ii) biophysical characterization of the North Sea as part of the ICES integrated ecosystem assessment process.

From both studies some general observations were made that provide context for any planned ecosystem characterization programme, namely that it is important:
• to establish an appropriate spatial scale for both assessment and management needs: essentially this recognizes the fundamental importance of EAF management being place based;

• to understand and identify from the outset the policy and management objectives: these will invariably determine what attributes of the ecosystem are particularly important for monitoring and assessment purposes, and finally

• to agree the assessment methods with stakeholders so they fully understand the management advice and the necessary trade-off decision making processes.

Furthermore, it was highlighted that the cost and scope of characterization should be assessed against the ‘value’ of the ecosystem goods and services provided, e.g. it would potentially be costly if the ‘value’ of the ecosystem was assessed to be low, but the scope and cost of characterization was determined to be relatively high.

The NAFO case-study provided an example of how a quantitative assessment of bottom fishing impacts on sponge VME could be applied to other (data limited areas) where predictions of comparable VME habitat may be found. In this case, a defined limit of fishing effort (hours trawled per km² per year) was established above which the likelihood of observing sponge VME in predicted VME sponge grounds would be very low. Such analysis can help define habitats at greatest potential risk of fishing impacts in data limited situations and therefore help to define the limits of closed areas to fishing activity, whilst not prejudicing access to existing important fishing grounds.

With respect to the North Sea case study, long-time series of biophysical data spatially representative of the entire North Sea, have been analyzed which revealed significant biophysical spatial gradients in the North remain remarkable stable over time. This is not the same as saying the status of the North Sea remains constant over time, the status has and does change! However, the significant boundaries separating one substrate type or water-body type from another, do remain spatially constant over relatively long periods of time, e.g. 30 years or more, and this is important to recognize from a spatial management and ecosystem assessment perspective. The underpinning ecosystem biophysical characteristics, at least in the context of the North Sea, and mostly likely elsewhere, are:

• bathymetry (geomorphology)
• seabed substrate/sediment/habitat type
• ocean and tidal currents/fronts
• stratification (vertical mixing)
• primary and secondary production
• water quality (nutrients, pH, salinity, contaminants)
In summary, the two case studies concluded the following steps as particularly important in developing programmes for ecosystem characterization in data limited situations:

1. Data limited situations favour risk based methods.
2. Start with broadscale (low resolution), freely available data/information, e.g. General Bathymetric Chart of the Oceans (GEBCO), Moderate Resolution Imaging Spectroradiometer (MODIS), Global Fishing Watch (GFW).
3. Define/map potential spatial management units, using GIS and statistical techniques such as k-means clustering.
4. Utilize habitat/species models to predict potential sensitive habitat and species distributions.
5. Utilize existing knowledge of specific habitat and species ecology to establish potential marine protected areas (MPAs) and spatial management measures.
6. Establish targeted (area specific) monitoring and assessment programmes.
5. How can ecosystem characterization feed into decision-making?

5.1 Challenges/ongoing efforts in targeted regions

Mr Bernardino Malauene from the National Institute of Fisheries Research (IIP) in Mozambique gave a presentation on the draft concept note for the Northern Mozambique ecosystem characterization project linked to the EAF-Nansen Programme. He showed that apart from the Nansen Programme and the IIP’s historical data, there are a number of local public and private institutions that may have data to contribute to the project. It is also important to check reports of environmental impact assessments (EIAs) and strategic impact assessment (SIA), both of which are publicly available. There are also the corresponding EIA process (raw) data. Some of the EIA data, however, are not publicly available and special request and authorization may be needed to obtain such data. Invitation letters including a short overview of the objectives and methodology of the ecosystem characterization will be sent to the different institutions to participate in the project. GIS and map overlays approach is proposed to put together data and knowledge from local community and experts’ opinions on the Northern Mozambique ecosystem characterization.

Ms Souad Kifani of INRH, Morocco, gave a presentation on existing challenges and ongoing efforts in the CCLME region. She explained that the CCLME is a LME with a mosaic of subsystems with different regime of productivity and socio-ecological roles ensuring one of the most important fisheries productions among the large marine ecosystems of Africa (~ 3 million tons). Shared small pelagic stocks constitute by far the largest stocks and fisheries (more than 80 percent of the catches) while contribution of fisheries to the gross domestic product (GDP) is between 2 percent and 4 percent for countries such as Senegal, the Gambia and Cabo Verde. Fisheries in the CCLME support an estimated one million jobs and at least 150 000 artisanal fishers migrate widely, fishing and trading across national borders. She noted that the major issues of concern in the area are declining water quality, habitat degradation and declining marine resources. The vision of the objectives of the strategic action programme for the CCLME were shown and discussed. The three themes of the project (living marine resources, habitats and water quality) were presented and discussed.

In her presentation, Ms Kifani highlighted that despite limited capacity in the region on the ability to carry out ecosystem surveys, other opportunities in the region could be capitalized on and that it is important not only to focus on the use of the R/V Dr Fridtjof Nansen, but also on the possibility for other studies using existing data and information.
6. Uncertainty

6.1 Three uncertainties for ecosystem-based management: life-history, spatial heterogeneity, and forecast skill

In this presentation, Mr. James Turner Thorson of NOAA summarized three categories of uncertainty that are worth considering when developing approaches for integrated ecosystem assessment: i) life-history parameters for data-poor stocks, ii) spatial heterogeneity in ecosystem processes, and iii) forecast skill for ecosystem models. First, he summarized recent research developing Bayesian priors for adult life-history (maturity, mortality, growth) and stock-recruit parameters for all described fishes. These priors estimate parameters based on taxonomic similarity and globally available data, and characterize uncertainty in a statistically robust manner. Priors could be used to parameterize a life-cycle (e.g. stock assessment) model for all fishes in any region.

Next, Thorson discussed ongoing efforts to estimate spatial heterogeneity in population abundance and resulting species interactions using models that scale continuously from data-rich to data-poor regions. This example illustrates the potential to fit spatial models of intermediate complexity to the same data that are commonly used for static species distribution models. Finally, he highly recommended the need to compare model performance using forecast skill as a “common currency” among different model types. He used data for 20 species in the Eastern Bering Sea to show that widely used “thermal envelop” models have poor predictive skill for short term forecasts of distribution shift. In each case, he expressed the hope to encourage ecosystem modelers to conduct integrated ecosystem assessment in data-poor regions using the same tools that are used for stock, ecosystem, climate, and habitat assessments in data-rich regions.
7. Summary, conclusions and next steps

At the end of the meeting, the following recommendations were agreed:

- A scientific paper to guide approaches on how to perform ecosystem characterization based on different degrees of data limitation will be produced. The agreed title is “A hitchhikers guide to an ecosystem characterization” and the coordinator for this activity is Ms Cecile Hansen of IMR, Norway.

- A shared workspace will be set up to facilitate sharing of information.

- A reference list, including all relevant papers on the subject, will be provided by Mr James Turner Thorson. He will also categorize them into existing validated theories.

- The proposed areas to pilot this activity are CCLME, BCC and Mozambique.
8. References


**CBD.** 2009. Azores scientific criteria and guidance for identifying ecologically or biologically significant marine areas and designing representative networks of marine protected areas in open ocean waters and deep-sea habitats. CBD, Montreal


## Annex I. Agenda

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<td><strong>Tuesday, 21 August 2018</strong></td>
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<td><strong>Agenda item 1.</strong> Opening of the workshop</td>
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<td><strong>Agenda item 2.</strong> Workshop background, scope and expected output</td>
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<td><strong>Agenda item 3.</strong> Food for thought – overview of possible methods for use in data-limited systems</td>
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<td><strong>Wednesday, 22 August 2018</strong></td>
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<td><strong>Agenda item 5.</strong> Best practice methods and application of ecosystem characterization in data-limited regions</td>
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<td><strong>Agenda item 6.</strong> How can this feed into decision-making?</td>
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<td><strong>Agenda item 8.</strong> Challenges/ongoing efforts in targeted regions</td>
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<tr>
<td>15.30–16.30</td>
<td>Summary, conclusions and ‘to-do’</td>
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Annex II. List of participants

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As part of the EAF-Nansen Programme activities, a workshop was organized on ecosystem characterization at the FAO Headquarters in Rome from 21 to 23 August 2018. The workshop aimed at identifying relevant ecosystem characterization approaches for data limited areas, defining best-practice methods for ecosystem characterization in data limited regions and how these should be applied, suggesting how this knowledge can feed into decision-making at tactical and strategic levels, defining how uncertainty in the methods can be taken into account and communicated, and understanding existing challenges and ongoing efforts in targeted regions that may be of relevance to ecosystem characterization.

The expected outputs of the workshop were a report describing best methods/approaches for ecosystem characterizations in data-limited regions and an action plan for future case studies in two regions.

For more information:

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