Chapter 9

# The Nansen Programme in the Western Indian Ocean – a synthesis of results

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"The enduring success of the Nansen Programme has been ascribed to its ability to identify emerging needs within a changing political landscape, and to evolve accordingly."

## Abstract

The Nansen Programme has been active for more than four decades, making it the longest-lasting fisheries development initiative in Norwegian history. Over this period, it has identified with "fish" as a key source of food, livelihoods and economic growth in developing countries. The programme undertakes surveys of fish resources and ecosystems, facilitates capacity development through training, and supports fisheries management and policy implementation. Key events that influenced its scope and priorities in the Western Indian Ocean were: limited knowledge of fish resources, combined with a post-colonial need for fisheries development in newly independent states (1960s and 1970s); the UNCLOS resolution to adopt a 200 nautical mile exclusive economic zone (early 1980s); emerging resolutions for responsible fisheries (early 1990s); and the introduction of ecosystems considerations into fisheries management (Reykjavik Declaration, 2001). The RV *Dr Fridtjof Nansen* played a key role in the activities of the Nansen Programme, both as a research platform for collecting data at sea, and as an icon of marine research. *Nansen* data have contributed to the identification of eddies in the Gulf of Aden and Mozambique Channel, described the flow structure of the Southeast Madagascar Current, and observed upwelling events in several locations. Consolidated information from *Nansen* surveys and other research programmes have shown that the main mechanisms that control fish biomass, abundance and distribution in the Western Indian Ocean are upwelling, mesoscale eddy circulation, frontal systems, riverine outflow, and monsoon winds. Productivity in surface waters was generally low, with a chlorophyll maximum at around 100 m depth. Coastal embayments and productive continental shelves, such as Delagoa Bight and Sofala Bank were exceptions. During the monsoon-driven upwelling, zooplankton biomass along the Somali Coast reached about double the highest value found elsewhere in the region. Pelagic fish surveys by the *Nansen*, done 25 years apart in southern Madagascar, found comparable fish distribution and abundance patterns. Conversely, surveys in Mozambique found markedly lower clupeid biomass in 2007–2014 than prior to 1990. Bottom trawls reflected a high diversity of demersal fauna, but apart from prawns and deep-water crustaceans, surveys showed only limited fisheries potential. Demersal fish densities were higher along the Somali Coast than further to the south, on the shelf than on the slope, and near river outflows. After 2007, the Nansen Programme extended its activities from a national to a regional Western Indian Ocean level, to support the Nairobi Convention and Southwest Indian Ocean Fisheries Commission mandates. We show how the Nansen Programme has evolved to retain its relevance, and synthesize findings into a "big picture", by linking ocean processes, productivity and resources at a Western Indian Ocean regional level. The drivers of success, remaining challenges and unresolved issues are explained.

**Previous page:** The three *Dr Fridtjof Nansen research vessels* (1975–2017). Artist: Yves Berube. Photo: Magne Olsen, IMR. © IMR.

## 9.1 Fish and fisheries – the golden thread and more

At the beginning of this book, the word "fish" was defined as the metaphoric golden thread that would run through all the chapters, linking them together. "Fish" has been seen throughout the Nansen Programme as a key source of food and livelihoods, especially in developing nations. From this perspective, the initial *Nansen* surveys sought to identify new fish stocks for the development of commercial fisheries. Trawl nets and acoustic equipment were used primarily to sample and estimate fish biomass, and to determine the species composition of fish schools. Later, sampling was expanded to include oceanographic processes, and the productivity, structure and functioning of marine ecosystems. Ocean processes, such as current direction and strength, eddies, gyres and upwelling cells (Chapter 4) bring nutrients into upper ocean layers, giving rise to phytoplankton blooms when sunlight is captured by chlorophyll (Chapter 5). These blooms form the base of the food chains that sustain fish; dense fish schools are found where productivity is high, and fewer fish where it is low (Chapters 6 and 7). The potential of fish resources to support fisheries therefore depends on the productivity of marine ecosystems, which are complex, and not always well understood.

Apart from the fish resources and natural systems that sustain them, the "fish" metaphor also encompasses the human impacts on them, such as exploitation through fisheries, and the environmental change brought about by anthropogenic activities. Over time, the interactions between the natural and human systems have attracted more attention in the Nansen Programme, leading to a broader ecosystems approach, and a greater investment in scientific capacity development, policy formulation and support for the implementation of ecosystems approaches to fisheries (Figure 9.1). This progression was clearly demonstrated by the third phase of the Nansen Programme (Monitoring, management and capacity development; 1990–2006) and by its fourth phase (Strengthening the knowledge base for and implementing an ecosystem approach to marine fisheries in developing countries; 2006–2016) (see Chapter 2).

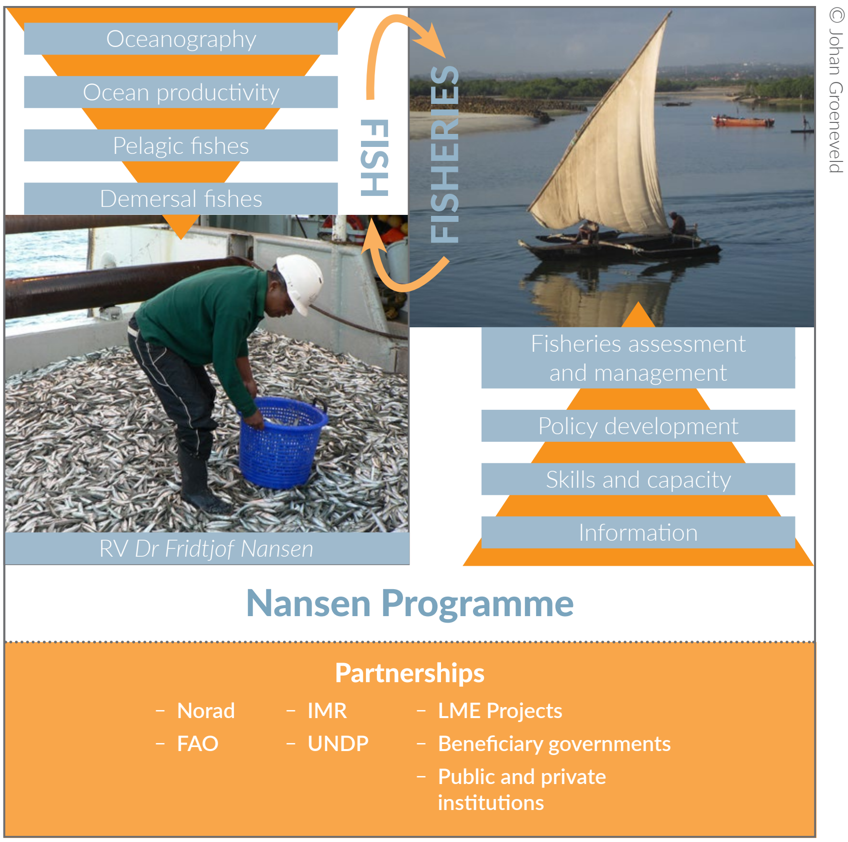


**Figure 9.1** Fish and fisheries of the Western Indian Ocean, and the role of the Nansen Programme in understanding the interactions between components. The RV *Dr Fridtjof Nansen* was the main tool for acquiring data at sea to describe oceanographic processes, productivity and the potential of fish resources. Partnerships played a crucial role in the success of the Nansen Programme.

Chapter 9 synthesizes the activities and achievements of the Nansen Programme in the Western Indian Ocean focussing on:

- the evolution of the programme, relative to the proclamation of international resolutions for responsible fisheries, and emerging issues such as the effects of climate change;
- the linkages between oceanographic processes, ocean productivity and fisheries resources at a broad regional level in the Western Indian Ocean; and
- the drivers of success, remaining challenges and unresolved issues of the programme.

## 9.2 Evolution of the Nansen Programme in the Western Indian Ocean

Development agencies usually expect tangible results within short periods of time, and infrequently commit to funding projects for longer than five years. The Nansen Programme, however, has been active for more than four decades, making it the longest lasting development initiative in Norwegian history. The longevity of the programme is ascribed to an ability to identify emerging needs, and to evolve accordingly. The

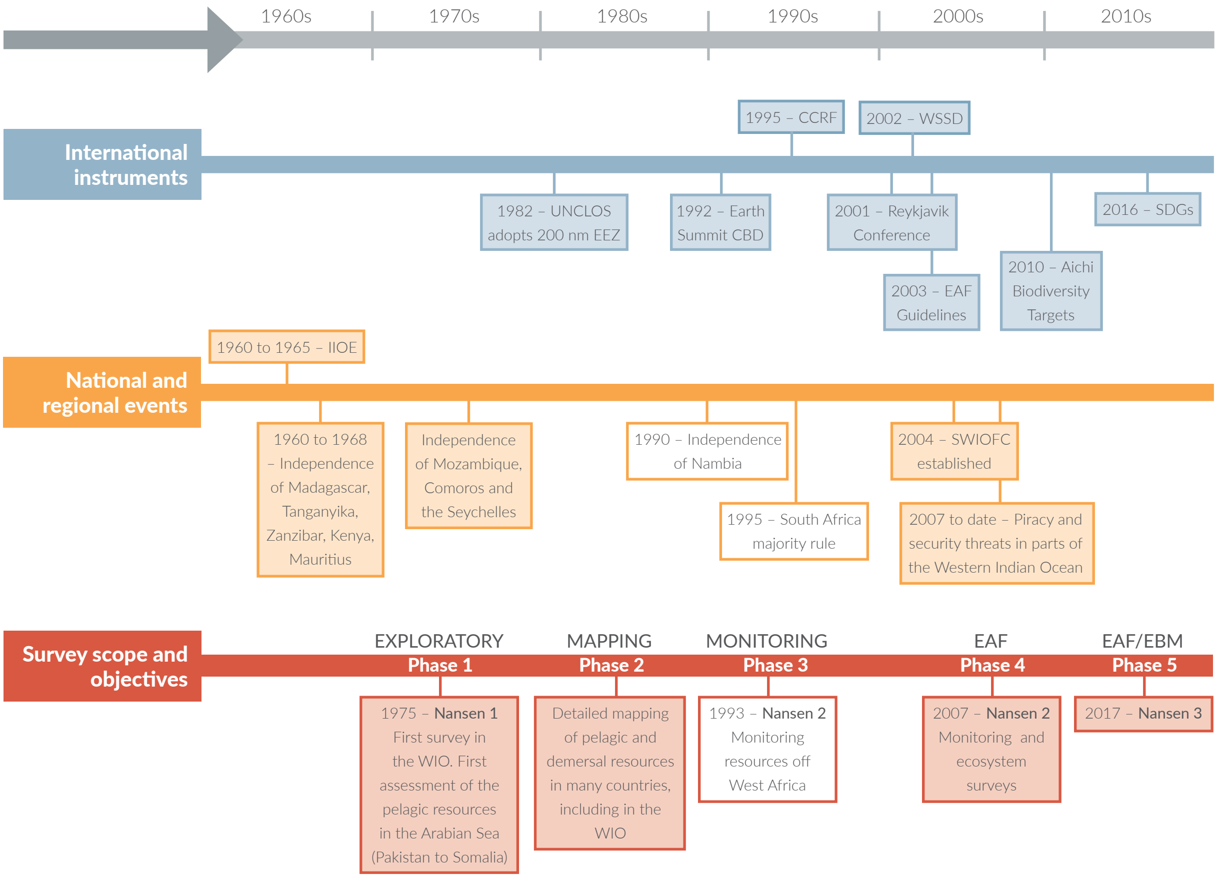


**Figure 9.2** A timeline of events affecting the growth of the Nansen Programme in the Western Indian Ocean (1960–2017). Un-shadowed events are those outside the region, but still influential in the programme development. Abbreviations are as follows: CCRF = Code of Conduct for Sustainable Fisheries; WSSD = World Summit on Sustainable Development; UNCLOS = United Nations Convention on the Law of the Sea; EEZ = Exclusive Economic Zone; CBD = Convention on Biological Diversity; EAF = Ecosystems Approaches to Fisheries; SDG = Sustainable Development Goals; IIOE = International Indian Ocean Expedition; SWIOFC = Southwest Indian Ocean Fisheries Commission.

RV *Dr Fridtjof Nansen* has been available to the programme throughout all its phases, but the vessel was absent from the Western Indian Ocean between 1990 and 2007, when it was deployed in the Atlantic. The objectives, scope and priorities of the Nansen Programme have changed over time (see Chapter 2) – to adapt to changing political landscapes, and in response to emerging international agreements and instruments for the sustainable use of the oceans and marine resources (Figure 9.2).

Several Western Indian Ocean countries became independent during the 1960s and 1970s, and the new administrations prioritized economic development. At the time, a lack of knowledge of fish resources and biomass hindered fisheries development in the region, thus providing a rationale – to provide information on fish resources – for building the first RV *Dr Fridtjof Nansen*. Within a few years of operation, information collected during *Nansen* surveys showed that prior expectations of high fish biomass in the Western Indian Ocean would not be met, and advised that economic investment in the fishing industry should be moderate. This advice, to avoid overinvestment in fishing fleets relative to the available resources, contributed to a new approach, where resource surveys were seen as crucial input to making development and investment decisions.

Having accomplished this initial mission, a new focus for the Nansen Programme was provided by the nascent United Nation Convention on the Law of the Sea (UNCLOS, also described as "Constitution for the oceans") with an agreement reached in December 1982, in which the international community established rights and responsibilities of coastal states (Box 9.1). Developing countries, and especially newly independent states such as Mozambique, Tanzania, Kenya, Madagascar, and Seychelles, were not then in a position to fulfil the responsibilities required in terms of the Law of the Sea Convention (such as setting sustainable quotas for fishery resources), because of a lack of information, infrastructure and scientific expertise. Article 202 of UNCLOS encourages scientific assistance to developing countries, in relation to the marine environment. Within this context, the Nansen Programme assisted the then newly-independent administrations in the Western Indian Ocean with detailed mapping of marine resources, and estimates of fish abundance, from which maximum sustainable yields (MSY) could be established.

A first evaluation of the Nansen Programme in 1982 pointed out that more had to be done to enable partner countries to make good use of the knowledge generated through surveys (Hallenstvedt *et al*., 1983). It was recognized that a lack of knowledge on resources and ecosystems was not the only limitation for sustainable resource use, but that support to fisheries administrations and capacity development were equally important. Another assessment in 1989 (CIC-Marine, 1989) recommended that the ageing first RV *Dr Fridtjof Nansen* be replaced by a new research vessel.

The final decision to build a second RV *Dr Fridtjof Nansen* in 1991 (the vessel was commissioned in 1993) was motivated mainly by political developments in southern Africa. Norway had been supporting the liberation movements in Namibia and South Africa. Following on Namibian independence in 1990, and given the highly productive (but potentially over-exploited) fish resources along its coastline, the Nansen Programme entered a new phase to strengthen resource monitoring and capacity development in fishery research and management in Namibia. The vessel was also used to monitor the resources in Angola, as a platform for collaborative research between Angola, Namibia and South Africa, through the BENEFIT programme. Unique time series data were recorded, and at the same time the capacity to monitor their own resources was established in Namibia – a task done locally for both pelagic and demersal resources since 2000. That phase of the Nansen Programme kept the vessel away from the Indian Ocean for more than a decade, resulting in a 17-year gap in the time series information collected by the *Nansen* in the Western Indian Ocean.

For some years after 2000, the Nansen Programme's rationale became more diffuse. Norad

BOX 9.1

## Two key articles of the United Nations Convention on the Law of the Sea

Two key articles of the United Nations Convention on the Law of the Sea (UNCLOS) are relevant to the scope of Chapter 9 – Article 56 and Article 61.

**Article 56: Rights, jurisdiction and duties of the coastal State in the exclusive economic zone**

1. In the exclusive economic zone, the coastal State has:
   (a) sovereign rights for the purpose of exploring and exploiting, conserving and managing the natural resources, whether living or non-living, of the waters superjacent to the seabed and of the seabed and its subsoil, and with regard to other activities for the economic exploitation and exploration of the zone, such as the production of energy from the water, currents and winds;

   (b) jurisdiction as provided for in the relevant provisions of this Convention with regard to:
   (i) the establishment and use of artificial islands, installations and structures;
   (ii) marine scientific research;
   (iii) the protection and preservation of the marine environment;

   (c) other rights and duties provided for in this Convention.

**Article 61: Conservation of the living resources**

1. The coastal State shall determine the allowable catch of the living resources in its exclusive economic zone.

2. The coastal State, taking into account the best scientific evidence available to it, shall ensure through proper conservation and management measures that the maintenance of the living resources in the exclusive economic zone is not endangered by over-exploitation. As appropriate, the coastal State and competent international organizations, whether subregional, regional or global, shall cooperate to this end.

3. Such measures shall also be designed to maintain or restore populations of harvested species at levels which can produce the maximum sustainable yield, as qualified by relevant environmental and economic factors, including the economic needs of coastal fishing communities and the special requirements of developing States, and taking into account fishing patterns, the interdependence of stocks and any generally recommended international minimum standards, whether subregional, regional or global.

4. In taking such measures the coastal State shall take into consideration the effects on species associated with or dependent upon harvested species with a view to maintaining or restoring populations of such associated or dependent species above levels at which their reproduction may become seriously threatened.

5. Available scientific information, catch and fishing effort statistics, and other data relevant to the conservation of fish stocks shall be contributed and exchanged on a regular basis through competent international organizations, whether subregional, regional or global, where appropriate and with participation by all States concerned, including States whose nationals are allowed to fish in the exclusive economic zone.

prioritized development support to benefit main cooperating partner countries, most of which were not fishing nations (Hersoug *et al*., 2004). Ending the Nansen Programme was considered, and the vessel and minimum funding were offered to FAO. At the same time, profound changes were taking place in the international arena, on the requirements for sustainability of fisheries.

In 2001, FAO organised a conference on "Sustainable fisheries in the marine ecosystem", which resulted in a declaration to manage fisheries in a way that would avoid or reduce impacts on marine ecosystems to sustainable levels. More specifically, the Reykjavik Declaration (2001) requested that FAO prepares "...guidelines for best practices with regard to introducing ecosystem considerations into fisheries management".

A year later, the World Summit on Sustainable Development (WSSD, Johannesburg, South Africa, 2002) led to a plan of action, in which targets were set for the adoption and use of an Ecosystem Approach to Fisheries (EAF) management.

Guidelines for an EAF were published in 2003, and adopted shortly thereafter by the FAO Committee on Fisheries. The publication of these guidelines, combined with a need to train EAF implementors in developing countries, gave rise to a new phase of the Nansen Programme, designed to facilitate EAF implementation. The RV *Dr Fridtjof Nansen* would be used to study ecosystem features that may be impacted by fishing, such as vulnerable habitats, biodiversity or other factors important for resource productivity. The return of the *Nansen* to the Indian Ocean, in 2007, after a 17-year absence, was expedited by collaboration with the Southwest Indian Ocean Fisheries Project (SWIOFP) and the Agulhas and Somali Currents Large Marine Ecosystem Project (ASCLME), which also co-funded the vessel operation costs.

Collaboration with LME programmes was a natural development, given the converging objectives of these programmes (Bianchi *et al*., 2016a). Also, the implementation of an EAF (which concerns mainly fisheries management) complements EBM (Ecosystem Based Management), which entails multi-sectoral management (Bianchi *et al*., 2016b). Importantly, EBM is the conceptual framework adopted by the LME programme.

The replacement of the second *Nansen* with a new one coincided with a period when ocean issues were again receiving attention in the international discourse, and with the formulation of a dedicated sustainable development goal on the oceans (SDG 14) in 2016. The "blue economy" concept, combining aspects of growth and conservation, was also relevant. In March 2017, the Norwegian government announced an ocean strategy, to support development cooperation which emphasizes growth and sustainability aspects. In this strategy, the Nansen Programme forms the primary instrument for cooperation on ocean issues with developing world partners. In its new form, the programme will assess the status of biological resources, ecosystems, and how they are affected by climate change, pollution, and oil and gas activities. The new RV *Dr Fridtjof Nansen* and the next phase of the Nansen Programme have, therefore, once more been realigned to address emerging issues in the international arena. As such, its return to the Western Indian Ocean is imminent.

## 9.3 Regional synthesis of survey results

Throughout the preceding chapters, *Nansen* surveys and scientific results have been shown from a subregional perspective, based on six subregions (Somali Coast, East Africa Coastal Current [EACC], Mozambique, Madagascar and Comoros, Mascarene, and Seamounts). These subdivisions were based on a combination of marine ecoregions described by Spalding *et al*. (2007), political boundaries between countries, and the spatial coverage by past *Nansen* surveys (see Chapter 3). The subregional approach was necessitated by an unbalanced survey coverage across the Western Indian Ocean, and over time. As such, some subregions, such as Mozambique, were sampled regularly, whereas others, such as the Somali Coast and EACC, were sampled only during the 1970s and 1980s. Mauritius and Comoros were only sampled recently, after 2007.

Apart from flexibility to cope with unbalanced coverage, a subregional approach allowed for a better description of features unique to individual areas, and formed a framework for comparisons between them. The regional synthesis provided here attempts to combine the findings into a "big picture", by linking ocean processes, productivity and resources at a Western Indian Ocean regional level. This approach is in line with the move towards EAF described above. Importantly, the synthesis below is not based on *Nansen* data alone, but includes information from many other surveys and studies – each contributing to the body of knowledge on the Western Indian Ocean.
Physical properties (water temperature, salinity and oxygen profiles, fluorescence, etc.) and ocean processes (ocean circulation, heat transfer, upwelling, riverine input) influence ocean productivity on spatial and temporal scales, and thus determine the distribution and abundance of fisheries resources. Early *Nansen* surveys between 1975 and 1993 focussed on fisheries exploration and

resource mapping, and used the Nansen reversing bottle to sample temperature, salinity and oxygen in the water column (see Chapter 4 and Appendix 4.1). The Nansen bottle was replaced by a CTD with Niskin bottles in 1994, when the first RV *Dr Fridtjof Nansen* was replaced with a more modern second vessel. Surveys conducted in the Western Indian Ocean during the EAF-Nansen phase after 2007 used technologically much more advanced sensory techniques – such as satellite technology and high resolution underway sensors to measure sea surface temperature, chlorophyll concentrations and water current velocities. As part of broader ecosystems surveys, the collection and analysis of oceanographic information received far more attention than previously.

Chapter 4 reviewed the contributions of the *Nansen* to oceanographic findings with a focus on the Somali Coast and EACC subregions (surveys in 1975–1984), Mozambique and Madagascar (1977–2014), and the Mascarene subregion (1978–2010). The *Nansen* surveys followed on several oceanographic surveys done during the first International Indian Ocean Expedition (IIOE, 1959–1965), which provided baseline information. Together with surveys of contemporary research vessels, such as the RV *Meteor* (Germany) and the RV *Marion Dufresne* (France) the *Nansen* has provided much of the information, have provided the information that underlies the present understanding of Western Indian Ocean features, and its dynamics.

Whereas many of the early observations on the *Nansen* were inconclusive at the time, more recent studies, by other vessels and during the "satellite era" (after 2001, when the Global Ocean Ecosystem Dynamics or GLOBEC programme was launched) have corroborated earlier findings. For instance, *Nansen* data contributed to the first identification of eddies in the Gulf of Aden, and the Mozambique Channel eddies. *Nansen* data from a 2008 survey described the flow structure of the Southeast Madagascar Current. Upwelling events were observed near Angoche in Mozambique and off southeast Madagascar. Surveys on the Mascarene Plateau in 2008 and 2010 suggested sub-surface maximum phytoplankton densities at around 100 m depth, a major factor in explaining the functioning of local marine ecosystems. With hindsight, the *Nansen* played an important role in describing the physical oceanographic processes of the Western Indian Ocean – often from a perspective of how they would affect productivity, fish distribution and abundance patterns.

As primary production is mainly influenced by sunlight and nutrient availability (see Chapter 5), water movements that bring nutrients to the upper ocean layers which are adequately illuminated stimulate photosynthesis, and hence primary production. In the Western Indian Ocean, the main mechanisms that control biomass, abundance and distribution are upwelling, mesoscale eddy circulation, frontal systems, riverine outflow, and monsoon winds. Seasonal monsoon winds either cause turbulence (strong SW monsoon winds that mix layers) or result in stratified water layers under calm conditions (weak NE monsoon winds, with associated consequences such as blooms of *Trichodesmium* that fix nitrogen). In the Somali Coast subregion, monsoon-related upwelling is the most important driver of productivity. Further to the south, in the Mozambique and EACC subregions, riverine outflow, particularly during rainy seasons, enriches shelf waters near river outlets (for example the Zambezi, Rufiji, Tana and Sabaki rivers), giving rise to localized higher productivity (Munga *et al*., 2013).

In general, high chlorophyll *a* concentrations, the result of photosynthesis, were also associated with high zooplankton biomass, although this was not always the case. Organisms at higher trophic levels were also found to follow this trend, for example the relatively more abundant prawn and fish resources off Mozambique. The Western Indian Ocean is relatively impoverished, in terms of productivity, especially in surface waters. Chlorophyll concentrations and fluorescence were always lower than in the sub-surface layers, with the deep chlorophyll maximum usually located at around 100 m depth. Exceptions were coastal embayments (such as around Madagascar) and productive continental shelves, such as Delagoa

Bight. Nutrients were also observed to be relatively low in surface concentrations, but increased with depth. This was mostly true for nitrate, nitrite, ammonia and phosphate, while silicate was not limiting in surface waters.

The highest zooplankton biomass in the Western Indian Ocean was measured along the Somali Coast during the monsoon-driven upwelling, reaching approximately double the highest biomass found elsewhere in the region (see Chapter 5). The second highest biomass was recorded over the Sofala Bank during the rainy season, followed by the Seychelles Bank, but these were all for relatively shallow depths (40–50 m) over large shelf areas. The correlation between phyto- and zooplankton can be extended to higher trophic levels, especially fish. Simply stated, phytoplankton are consumed by zooplankton (also known as secondary producers), and these are then consumed by fish larvae and forage fishes and so the chain goes on to the top predators. Because phytoplankton are at the base of the food webs, any impact on them is transmitted to higher trophic levels – either directly or indirectly. Thus, understanding the dynamics of the primary and secondary producers will lead to a better understanding of ecosystem functioning.

The *Nansen* used a combination of acoustic methods (echo-integration) and trawl sampling to quantify "small pelagic fish" resources in the Western Indian Ocean (see Chapter 6). The initial *Nansen* surveys in the Somali Coast and EACC subregions in 1975 provided the first estimates of pelagic fish biomass and distribution in the region, and these early estimates remain the only reference points in some areas. Sardines (clupeids), anchovies (engraulids), jacks and scads (carangids), mackerels (scombrids), barracudas (sphyraenids) and hairtails (trichiurids) are common pelagic families in the Western Indian Ocean.  Carangids and clupeids were common in shallow shelf areas, from the Horn of Africa, along the coast to the Mozambique Channel, and around Madagascar and the smaller islands. Engraulids were more abundant in the southern part of the EACC subregion, the Mozambique Channel, and around Madagascar. Mesopelagic fishes (mainly lanternfish belonging to the Myctophidae, and occurring in the 200–1 000 m depth range) were widely distributed throughout the Western Indian Ocean, but they were far more abundant than any other fish group in the northwest (Horn of Africa, Arabian Sea, Gulf of Oman; Nellen, 1973; Sætersdal *et al*., 1999).

Surveys done 25 years apart found relatively unchanged abundance, distribution patterns and species composition of fish populations along the southeast Madagascar coast. In Mozambique, however, clupeid biomass was markedly lower in surveys done in 2007 and 2014, than in pre-1990 surveys. This finding was supported by declining catches made by the artisanal fishery off Mozambique. Pelagic fish migrate widely, and many of the stocks can be better considered as regional, rather than belonging to a specific country. Information from acoustic surveys over large geographical areas is therefore required to determine seasonal migrations, and to develop regional fisheries management approaches.

Demersal species (fish and crustaceans) live and feed on the seafloor, which usually consists of mud, sand, gravel or rocks (see Chapter 7). The *Nansen* has accumulated large amounts of valuable information on seafloor topography and fish communities, based mainly on bottom trawling and acoustic recordings. Over 1 500 trawls have been completed, mostly (68 percent) on the shelf (less than 200 m depth). Rocky or steep areas that cannot be trawled have, in some cases, been sampled with baited traps and hook-and-line methods. Despite the unbalanced distribution of surveys over time and space, broad patterns in fish distribution and densities across the Western Indian Ocean were apparent. Pelagic taxa such as scads (Carangidae) and sardinella (Clupeidae) were often also abundant in demersal trawls.

In general, demersal fish diversity was high in near-bottom habitats, with an average of around 21 taxa caught per trawl. A total of more than 300 families have been recorded, more than 80 percent of which were fishes from around 1 660 genera. There was considerable variability in abundance between surveys, subregions and depth strata. From a commercial marketing perspective, the traditionally valuable demersal fish families from shelf waters (Haemulidae, Lethrinidae, Lutjanidae Serranidae and Sparidae) were generally found in low densities. No traditionally valuable fishes were found in commercially viable quantities on the continental slopes. Invertebrate resources were chiefly represented by crustaceans, which were found mainly on the shelf and slope on both sides of the Mozambique Channel, along the central coast of Mozambique (Sofala Bank) and off western Madagascar.

Demersal fish densities were relatively higher in the Somali Coast subregion than elsewhere, and also higher on the shelf than on the slope. Densities of snappers (Lutjanidae) were consistent across shelf subregions, particularly after 2007, whereas seabreams (Sparidae) exhibited a subequatorial distribution, occurring in Somalia and in the southern parts of Mozambique and Madagascar, but not in equatorial waters in-between. Crustaceans predominated on the Mozambique shelf, consistent with the information from prawn trawl fisheries. Estimates produced from *Nansen* surveys are similar to those produced by other surveys in the Western Indian Ocean (Gulland, 1978; Birkett, 1979; Tarbit, 1980; Mahrika *et al*., 2008).

Overall, *Nansen* surveys reflect a high diversity of demersal fauna, but apart from prawns and deep-water crustaceans, the surveys show only limited fisheries potential on the generally narrow shelf and upper continental slope. Apart from the Somali Coast subregion, where upwelling dominated, the main Western Indian Ocean demersal fisheries are located near river mouths, suggesting that nutrients from terrestrial sources are of major importance to demersal fish communities and abundance.

## 9.4 The Nansen Programme – drivers of success, remaining challenges and unresolved issues

***Drivers of success***

In 2011, the EAF-Nansen Project was selected as an FAO Success Story – an acknowledgement of its performance against multiple development aid criteria. But what made the programme successful? Undoubtedly, the approach used – to assist with collecting offshore fisheries data (using mainly the RV *Dr Fridtjof Nansen*), with capacity development to support science, policy and fisheries management, and with implementation support – was a major factor (Figure 9.3). This approach evolved over time, and is now well-established in the Western Indian Ocean, showing clear and enduring gains. A long-term commitment by Norway, in terms of providing the vessel, expertise and funding was also an important success factor, as opposed to other shorter programmes, in which gains have often been transient, or unsustainable. The strategic partnership with FAO, as the management arm of the Nansen Programme, sets it apart from its contemporaries, because its objectives are thus aligned with the UN development aid mandates. Within this context, the ability of the Nansen Programme to adapt, and to service emerging needs brought by changes in international legislation or UN resolutions, ensured its continued relevance in fisheries development.

Partnerships with regional fisheries management organizations (such as the Southwest Indian Ocean Fisheries Commission, or SWIOFC), regional research projects (such as the SWIOFP and ASCLME projects), and bilateral agreements with individual governments, were central drivers of success. Also important were the hands-on on-board and on-land capacity development activities, through sponsoring developing scientists at multiple levels, such as participation in *Nansen* surveys, training courses and workshops, as well as support for formal post-graduate studies.

To achieve success, many challenges integral to the developing world, or to the Western Indian Ocean had to be overcome, and in some cases, remain




**Figure 9.3** The Nansen Programme contributes to scientific support, mainly through the information collected by the RV *Dr Fridtjof Nansen* at sea, capacity development for research and management, and support for fisheries management and policy implementation.

to be resolved. We outline these challenges in the remainder of Chapter 9, at both strategic (programmatic) and operational (technical) levels.

## Challenges at strategic level

### *Governance model*

A key and overarching challenge is the underlying governance model indirectly adopted in the implementation of the Nansen Programme in most of its phases. This entails promotion of "hard science", within a top-down management approach, as the fundamental tenet for sustainability. This model, developed in western societies, has been challenged not only in the context of development cooperation, but also more generally, recognizing that environmental management may require a more "adaptive" model using "soft knowledge" (such as empirical indicators or even traditional knowledge) (Hersoug *et al*., 2004). "Hard science" also bears issues of legitimacy vis-à-vis fishing communities and weak management institutions, because it is not easily translatable into a language that can be understood by non-experts. While the introduction of the EAF-approach, which entails development of management systems that are suitable to a given context and with full participation of stakeholders, addresses these aspects, the vessel component, which has remained a key feature of the Nansen Programme, is still anchored in the "hard science" framework. It may also be argued that the vessel produces the most relevant results in high productivity regions characterised by large stocks, such as in the upwelling regions off West Africa. The usefulness of the data collected by the vessel and the resulting knowledge in the Western Indian Ocean, a region of high diversity but low productivity, is recognised, but more as a "global public good" than as a key element for improved fisheries management at community/fisheries level.

Other issues that remain unresolved are related to the weaknesses of governance systems and related institutions in developing countries. In addition to capacity issues, overall poor transparency and overall democratic processes may undermine efforts to improve the performance of an individual sector, such as fisheries. The implications thereof, relative to achieving the objectives of the Nansen Programme, need to be assessed to a greater extent than in the past.

***Broad-based approach***

The broad approach used by the Nansen Programme in the Western Indian Ocean (see Figure 9.3) evolved over time, and is geared towards both short- and long term outcomes. Over the short term, while local infrastructure and the capacity to collect and interpret information are lacking, assistance is provided with all the steps required to implement sustainable fishing practices. At the same time, and with a view towards longer term self-reliance, local scientific capacity and infrastructure are gradually strengthened, through support for research institutes and training of promising fisheries scientists. All three of the key steps in the broad approach (expanding the knowledge base; capacity development; and support for policy and management plans) have some limitations, and may not be entirely efficient, in design or in the way it has been implemented.

Through surveys, the RV *Dr Fridtjof Nansen* has provided new data on marine resources and ecosystems, spanning from 1975 to 1990 and 2007 to 2015 (expanding the knowledge base). These data would otherwise not have been available to science, nor for the management of the use of those resources. The *Nansen* can, however, not be everywhere at the same time, and therefore the spatio-temporal coverage of data collected by the vessel is severely limited. Further, the *Nansen* is not suitable for regular collections of site-specific time-series data, even though such data are important for assessing changes in the physical environment, ecosystem functioning, or the status of fisheries resources. Relying on the *Nansen*, as the primary tool for data gathering, therefore imposes some severe limitations on the Nansen Programme, particularly in the Western Indian Ocean, where most fisheries are near the coast, in shallow waters. An important question to ask then, is how such a limitation can be overcome. A change in focus, from using only the *Nansen*, to also using other methods for data collection, better suited to the Western Indian Ocean environment, might hold promise.

Capacity development in the Nansen Programme focussed on strengthening of both human resources and institutional capacity. Human resources development has included a range of initiatives, such as ship-based training and short-term courses in data management (including with Nansis), taxonomy and fish species identification, trawling and acoustic surveys, fish stock assessment and EAF principles. It has also facilitated studies towards masters and doctoral degrees, where students from coastal states have used data collected by the *Nansen* for their theses. Capacity development efforts have targeted both scientific and management levels, and have often been carried out in partnership with other regional projects, such as SWIOFP and ASCLME.

Nevertheless, whether the capacity development efforts have achieved the desired outcomes, remains unclear. The numbers of trainees have been impressive, but where have they gone? Capacity development has not been based on specific assessments, but rather on priorities set on the basis of what the Nansen Programme could offer. In many cases, interactions between a particular trainee and the Nansen Programme occurred once only, or over a short-term (for example, a few days on the vessel during a survey), without a longer term plan. The student retention rate has therefore been low, and the present capacity development programme appears to be inefficient, at least in terms of markedly increasing the numbers of active fisheries researchers and managers in the region. Tuning capacity development efforts to specific needs, identified through a more formal process (for example, capacity assessments), might assist in increasing the numbers of skilled scientists, as well as extending the Nansen Programme's working relationships with selected alumni.

In terms of support for policy implementation and fisheries management plans, the Nansen Programme has piloted the use of key EAF principles in the preparation of fishery management plans (FAO, 2013). The implementation of these management plans has started in Comoros, Madagascar, Mauritius, Mozambique, Kenya and Tanzania. At regional level, the joint Strategic Action Plan of the ASCLME and SWIOFP projects, developed in collaboration with the Nansen Programme, was approved by governments. The programme has also contributed to the EAF Toolbox (FAO, 2012), which guides users through the EAF planning steps. With the support of the FAO Legal Office a "How-to Guide on Legislating for EAF" has been developed (FAO, 2017), in response to a need identified by legislators and fisheries managers. The guide shows how to draft national legislation that incorporates EAF-relevant components, and strengthens the legal framework for fisheries management in FAO member countries.

Fisheries management plans for the industrial shrimp- and line fisheries in Mozambique, the demersal fishery in Madagascar and Comoros, the Saya de Malha and Nazareth Banks fisheries in Mauritius, and the small and medium pelagic fisheries in Tanzania, among others, have been based on *Nansen* data as a key input. Data from earlier *Nansen* surveys in Kenya were used for a co-management plan for Malindi – Ungwana Bay (GOK, 2016). Whereas the process of developing the management plans has been positively received, they have often not been fully implemented. A lack of political will to implement management plans, which by definition will restrict fishing, is perhaps not surprising, because for many coastal fishing communities, there are few other livelihood alternatives. It appears that there are more fundamental issues that will have to be resolved among fishing communities along the Western Indian Ocean coastline, before fisheries management initiatives will be accepted. Among these are the role of traditional fishing rights and practices, human population growth and dependence on fish for food security along the coast, and developing alternative livelihood strategies at least as attractive as fishing.

***Partnerships***

The *Nansen* is owned by Norad, operated by the IMR, and managed by FAO. This partnership binds the vessel to the FAO fisheries development agenda, but also facilitates its access to the waters of many FAO member countries. Apart from sailing under a UN flag, which allows the vessel to move more freely across maritime boundaries, the negotiating power of the FAO with governments far exceeds that of unaligned development programmes. Thus, the tripartite relationship between the vessel owner (Norad), operations and scientific expertise (IMR) and management (FAO) has been crucial to the success of the Nansen Programme. Partnerships with other regional projects in the Western Indian Ocean (such as SWIOFP and ASCLME) are also important, but have been more ephemeral. The potential for conflicting interests, when engaging with multiple partners within a limited survey period, should not be ignored.

***Use of the Nansen data***

Data and information gathered by the Nansen Programme have been used for policy documents, development of management strategies, scientific papers, field guides and as basic data for further research (Chapter 8). *Nansen* data have also been used for educational purposes, such as in training courses, theses, and exhibitions to make people aware of the marine environment. But to what extent has the *Nansen* data been used by individual scientists from the Western Indian Ocean region?

Information technology (IT), including data storage, accessibility and processing have undergone major developments over the past decade or two. Large databases can now be shared over the internet, and specialist software has revolutionized data exploration and analysis. The data processing systems used by the Nansen Programme have kept pace with technological advances. The Nansis database and software are good examples of the technology developed by the Nansen Programme – it is now widely available to scientists and technicians worldwide, and can be used to store and manage data from different types of surveys.

There is concern that the uptake, or use of *Nansen* data, by scientists in the Western Indian Ocean have been below expectations. It is not yet clear what the reasons may be, although it is probably a combination of various factors, such as: a lack of scientific support at local level; a small number of users in the region (for example few oceanographers, marine ecologists and fisheries researchers); a lack of access to data stored on Nansis, either because of IT shortcomings, or lack of data processing skills; too few local supervisors for post-graduate students; or the limited relevance of *Nansen* data to nearshore fisheries, or to local issues of concern.

An investigation of why the uptake of *Nansen* data is suboptimal would be worthwhile, and may also shed light on the type of data that would be most useful to researchers confronted with local issues in the Western Indian Ocean region.

## Challenges at operational (technical) level

Practical issues at the level of individual surveys, and the quality of the data that can be made available, are explained below. Some of these are long-standing issues, related to the limitations brought by using the *Nansen* as the primary tool for data collection, or as a result of political instability in parts of the Western Indian Ocean region, or to skills and infrastructure shortages. Potential solutions are held over to Chapter 10, where they are discussed within the context of the future of the Nansen Programme in the Western Indian Ocean.

### *Spatio-temporal distribution of surveys*

The spatio-temporal coverage of *Nansen* surveys across the Western Indian Ocean was uneven, resulting in many data gaps. Drawbacks of the "gappy" data are that time series information to assess long-term trends are not available, that recent data are only available for some subregions, and that seasonality cannot easily be taken into account in analyses.

### *Gaps in geographical coverage*

Although surveys were conducted in the Somali Coast and EACC subregions before 1984, no nutrient, phytoplankton or zooplankton data were collected. The two subregions were not surveyed after 2007, because of security concerns. Therefore, contemporary data from these two subregions are sparse.

### *Deep and shallow areas under-sampled*

Sampling of deep-water demersal resources and habitats on the continental slopes and on seamounts has been less intensive than on shallower shelf areas, with only 30 percent of demersal trawls undertaken at depths beyond 200 m. To an extent, this reflects the initial purpose of *Nansen* surveys – to provide information on potential fisheries, expected to be more prevalent on productive shelf areas. Shallow water less than 20 m deep has also been excluded from surveys, owing to vessel safety concerns. Consequently, fish resources that inhabit shallow areas, either permanently or seasonally, would have remained under-sampled. For example, the survey along the west coast of Madagascar in 2009 found exceptionally low acoustic abundances of small pelagic fishes. The question then arises whether small pelagic fishes may simply have been in shallower waters, closer to the coast, at that time of the year. It is important to note that all research vessels of the size of the *Nansen* would have similar limitations in shallow areas.

### *Sampling rocky and other untrawlable substrates*

Seafloor topography made bottom trawling very difficult in the Mascarene subregion, and reef-like structures also prevented trawling on large parts of the Madagascar shelf and slope, and in northern Mozambique. The dynamic multidisciplinary sampling strategy used by the *Nansen* largely precludes static sampling methods, such as trapping and hook-and-line methods, and hence these rocky substrates remain under-sampled, compared to trawlable areas. The lack of samples from different habitats perhaps accounts for the limited efforts in reviewing the demersal fish biodiversity of the region since the early work by Bianchi (1992). A preliminary review was undertaken by Fennessy and Everett (2011), but a more detailed analysis is overdue.

***Record-keeping of samples***

An important concern has been the sometimes inadequate record-keeping of samples, as well as oversight of their off-loading after surveys, including who the responsible agent(s) would be for sample curation and analysis. Linked to this is the issue of archiving and access – it is often a difficult task to establish exactly which samples and data have been analysed for some surveys. Survey reports have been of varying quality and content, proving invaluable in some cases, and frustratingly thin in others, thus emphasizing the need to tabulate survey data, showing its quality and availability to researchers.

***Post-survey analysis of samples***

While analysis of physical data from CTD casts, for example, is a relatively rapid process, analysis of biological samples such as phytoplankton and zooplankton (particularly for taxonomic identification) can be time-consuming and requires scarce taxonomic skills. In many cases the post-survey analysis was not followed up, with an end result of far fewer outputs than would be expected, as well as a much longer time to eventual publication. Substantial volumes of underway recordings of bathymetry and data for modelling the nature of the substrate have been collected since 1994, but have not been analysed.

***Verification of species names***

The identification of species in the database requires attention with respect to verification of names assigned during the surveys. There has been very limited collection of voucher specimens to assist with this, and local fish experts did not always participate in surveys, which may have compromised this aspect of data collection.

***Utilization of biological data***

The biological data of crustaceans and fish collected by the *Nansen* are extensive. However, their use have been limited and the rationale and related sampling strategy have not always been clear. Demersal species such as groupers and snappers are considered to be commercially important and therefore their length frequencies have been measured. Prawns are particularly important in Mozambique, where they are measured. Small pelagic fishes are often measured. In most cases, however, the data are stored and not used to their full potential. A rationale for the collection of specific biological data should be clearly stated – and where possible, linked to collaborative projects which will use the data.

## 9.5 Conclusion

Three key aspects of the Nansen Programme in the Western Indian Ocean were assessed: a) its evolution over the past four decades; b) its role in understanding the linkages between oceanographic processes, productivity and fisheries resources; and c) the factors contributing to its success, the challenges that remain and the unresolved issues. The synthesis provided here prepares the way for Chapter 10, on the future of the Nansen Programme in the Western Indian Ocean. ■

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