A Decade of Namibian Fisheries and Biodiversity Management

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Summary

This overview gives a description of the major living resources of the Namibian part of the Benguela Current, and of the attempts that have been made, particularly in recent years, to manage them rationally and sustainable. The distribution and habitats of the most important harvested species are briefly described and discussed. Changes in the abundance and distribution of the commercially important species, as determined by acoustic and trawl surveys and catch-based analytical methods are presented. The importance of biodiversity in terms of management is discussed.

The historic background and other factors influencing the evolution of the Namibian fisheries-management approach are highlighted and reasons why the management system developed the way it did is described. The level of success of the system in attaining the national goals set for development of the industry in the first few years after independence and the response of fish stocks to management measures are presented.

Introduction

The Namibian coast is approximately 1500km long and is hyper-arid desert along its entire length (Figure 1). The majority of the shore consists of sandy beaches with occasional rocky outcrops, which are exposed, to heavy wave action. The continental shelf off Namibia is generally narrow and is one of the deepest in the world, with an average shelf edge depth of 350 m (Shannon 1985). The marine environment of Namibia falls within the Benguela system and, although the system is continuous, there is an unusually intense cell of upwelling off Lüderitz, which effectively divides it into two parts. The southern Benguela system thus extends as far northwards as Lüderitz, while the rest of the Namibian coast as far as the Kunene River mouth falls within the northern Benguela system.

The driving physical process in the Benguela system is coastal, wind-induced upwelling. Prevailing south to southwesterly winds, which occur all year round off Namibia, tend to move nearshore surface water northwards and offshore, while cool, central water from a depth of about 300m wells up to take its place (Shannon 1989). The deeper water is rich in dissolved nutrients which, when present in the photic zone, facilitate rapid growth of phytoplankton (Chapman and Shannon 1985). The high productivity of these microscopic plants supports abundant marine life. The most intense upwelling regions off Namibia are found where the continental shelf is narrowest and the wind strongest, e.g. off Cape Frio, Palgrave Point and Lüderitz (Figure. 1). The most extensive and intense center of upwelling in the entire Benguela system is near Lüderitz (Shannon 1989).

Associated with high productivity in the Namibian surface waters are the death, sinking and decay of large numbers of microscopic organisms. Shelf sediments off the Namibian coast comprise extensive areas of diatomaceous mud's which support little or no marine life, but which have high concentrations of organic matter and sulphur (Rodgers and Bremner 1991). Decaying organic matter also consumes oxygen, so that bottom waters over much of the Namibian continental shelf, extending out to a depth of 100 to 150m or more, have low oxygen concentrations (Chapman and Shannon 1985). Water low in oxygen (as low as 0.25ml/ ¯1) is common off central Namibia, where it may extend as much as 90 km offshore.

Upwelling in the Benguela system is potentially of great significance for the biological diversity of Namibia's marine environment. Continuous physical, chemical and biological changes give rise to a three-dimensional mosaic of environmental conditions, which varies continuously in time and space.

The Benguela Current is one of the world's major eastern boundary current systems and is rich in pelagic and demersal fish populations, supported by plankton production driven by intense coastal upwelling (Shannon and Pillar 1986). In comparison to the other eastern boundary upwelling systems, the Benguela is probably the second most productive, in terms of fish, behind the Humboldt. The Humboldt has provided annual yields of up to 15 million tons of anchovy *Engraulis ringens* and 6 million tons of sardine *Sardinops sagax* (although not in the same year) compared to a combined yield of 0.6 and 1.5 million tons of the equivalent congeners in the northern and southern Benguela system respectively. For more information on the dynamics of the Benguela system the reader is referred to Payne *et al*. (1992) and in particular Hutchings (1992), Mann (1992) and Wade (1992).

Fishing is the third-largest sector of the Namibian economy, behind agriculture and mining. This sector has generated more than 10% of the GDP since 1998, up from 5% in 1991, and the projected export value for 2000 is N$ 2 900 million (N$ 1 = ZAR 1 ≈ US$ 0.13), which will make the fishing sector the second-largest export earner behind mining. It is the second fastest growing industry in the Namibian economy (behind tourism) with the value of exports now being approximately six times greater than at Independence.

Not surprisingly, the fisheries sector is extremely important in the economy of Namibia, particularly in Walvis Bay, which is the major fishing port and is where most of the processing plants are situated. Local employment in the sector grew rapidly after Independence, and an estimated additional 6 000 jobs were created between 1991 and 1994. The integration of Walvis Bay into Namibia in 1994, and the removal of the uncertainty regarding the port's future, stimulated an influx of investment in the fishing industry and subsidiary service industries with a further growth in employment. The number of people directly employed in the fisheries sector in 1998 was about 15 000, of which some 7 500 were fishers. Of these, 34% were foreigners, mainly in the horse mackerel and tuna fisheries, a proportion that has decreased from around 66% in 1993.

The demersal fishery is the most valuable fishery in Namibia (Figure 2). In 1996 the catch had a landed value of N$ 593 million, and a final value after product enhancement of N$ 718 million. About 90% of the catch is either sea-frozen or wetfish hake, and currently 58% is processed on shore compared to just 6% in 1992. Monkfish make up most of the remainder of the demersal catch with the average landed value of the catch in recent years amounting to over N$ 100 million per year. Almost the entire demersal catch is exported.

The pelagic fishery is second in importance, with canned sardine the most valuable product. In recent years the total export earnings from the pelagic fishery were around N$ 400 million per annum, except in 1996 when no fish were canned, causing export value of this fishery to fall to N$ 91 million. In most years, canned fish make up more than 90% of the export earnings of the fishery, with almost all of it exported to South Africa, and fishmeal contributes most of the remainder.

The midwater trawl fishery for horse mackerel has contributed some N$ 250 million per year in exports in recent years, mostly in the form of relatively low-value frozen fish, with minor contributions from fishmeal (around 10%) and dried fish (approx. 3 % in 1996). There is little product enhancement, and export value of the catch is typically only about 10% above the landed value. Horse mackerel is one of the few marine species consumed in any quantity by Namibians with about 3 % of the production consumed domestically.

The Fishery Resource an its Exploitation

In the past three decades there has been a marked change in fishing worldwide as the realization has grown that fisheries resources are not unlimited. In addition, commercially exploited fish stocks previously capable of sustaining major fisheries collapsed. This change in perception revolutionized fishing culture and led to the widespread introduction of exclusive fishing privileges for fishers of coastal states in the mid-1970s, which culminated in the introduction of Exclusive Economic Zones (EEZS) on the adoption in 1982 of the United Nations Convention on the Law of the Sea (UNCLOS).

In terms of international law, the adoption of UNCLOS was indeed a major achievement. Anyone experienced in negotiating at international level on text acceptable to a broad spectrum of nations has to agree that acceptance of the text was in itself a great achievement. In practice, it paved the way for coastal states to have the exclusive right to manage their own fishing resources.

The distant water fishing nations

According to WWF (1998) a large number of Distant Water Fishing Nations (DWFNs) used to fish off Namibia when this country was under South African rule and the 200-mile EEZ had not been declared. The most important DWFNs operating in Namibian waters since in the early 1960s were: the former USSR and Spain (since 1964); Japan, Bulgaria and Israel (since 1965); Belgium and Germany (since 1966); France (since 1967); Cuba (since 1969); Romania and Portugal (since 1970); Poland (since 1972); Italy (since 1974); Iraq (since 1979); Taiwan (since 1981); and the Republic of Korea (since 1982). Reportedly, in the years prior to Independence, more than 300 mid-water and bottom trawl vessels were operating off the Namibian coast (Beaudry *et al.* 1993).

According to one report (AED 1993), the former USSR had a 32 per cent market share in the country’s fish, followed by Spain with 26 per cent, and South Africa with 7 per cent. Hake stocks declined by more than half, whilst the pilchard stock fell to only 2 per cent of its previous level between 1976 and 1986. As soon as the independent government announced the EEZ regime in 1990, there was a drop of more than 90 per cent in the number of unlicensed foreign vessels fishing in the area. According to Beaudry *et al.* (1993) just prior to the independence of Namibia, the USSR and Portugal caught about 88 per cent of the hake off Namibia, and the USSR, Romania, Bulgaria, Cuba, Spain, and Poland caught 78 per cent of the horse mackerel. According to Goffinet (1992) the USSR fished so hard off Namibia that it caused the collapse of the hake stocks in the late 1970s. Horse mackerel catches peaked at 570,000 t in 1982, hake catches peaked at 570,00 t in 1982, hake catches peaked at 800,000 t in 1972, and the pilchard catch is estimated to have reached 1,5 million t in 1968 (WWF 1998).

With a few notable exceptions, "abuse" rather than management is unfortunately what happened. The abuse continued with fish stocks heavily overfished inside EEZ's and with even less control and restraint elsewhere. Namibia is painfully reminded of this every time the International Commission for the South-East Atlantic Fisheries (ICSEAF) is mentioned, an organization in which a total of 17 nations from all over the world participated. In Namibia, it is generally perceived that ICSEAF was misused by many member states to legitimize the plundering of fish stocks in the South-east Atlantic. Once the gains from fishing Namibian waters stopped, member nations lost all interest in ICSEAF to the extent that nobody even bothered to disband it formally when Namibia declined the invitation to become a member after its independence (Oelofsen 1999).

The ICSEAF experience also produced a positive effect in that the Namibian public and politicians became so aware of the negative effects of overfishing that tremendous national support for measures to rebuild the stocks after independence made it easy for politicians to implement drastic conservation measures. In the creation of perceptions, however, this also had a down side. The problems with vessels refusing to leave the Namibian EEZ after independence caused Namibians to view the fisheries world solely from the perspective of a developing coastal state. This is reflected in the way its Fisheries Act (Act 29 of 1992) was drafted. Keeping in mind also that the concepts developed in the United Nations Agreement on Straddling Fish Stocks and Highly Migratory Fish Stocks were not formulated at that time, it is understandable that issues such as port state control and control over Namibian vessels fishing outside the Namibian EEZ do not feature in the 1992 Act. This, among other considerations, has recently prompted the Ministry to decide to rewrite the Act in its entirety. The draft bill has already been discussed extensively with industry and has been approved for further processing by the Namibian Cabinet Committee on Legislation.

At independence, when the Namibian EEZ was declared, the country gained jurisdiction over all its fish stocks. The acute need to rebuild many of them was put into practice by introducing total allowable catches (TAC'S) for all major species (the only exception being monkfish, *Lophius* spp., which for the time being is still effort-controlled).

The 1992 Act was written in such a manner that resource rent could be extracted from those granted access by charging levies based on the quotas allocated. In the process, Namibia endeavoured to adapt the modern trend in fisheries management to its own needs and to develop a system based on the allocation of rights, quotas on most species and vessel licences. All of these are linked in the management system, as will be explained below. The system takes into account collective international wisdom on fisheries management, but it steers clear of blindly following other models. It has become clear to fisheries managers in Namibia that there is no universal recipe for good fisheries management.

Any fishing country needs to assess its own circumstances, its fish stock profile, its socioeconomic priorities and the importance it would attach to each of the parameters that feed into the equation on how and at what level its resources should be harvested. In short, do politicians have the political will to take decisions in the interest of long-term gain and sustainability of resources and not give in to the pressures that may demand short-term gain for socioeconomic reasons and political popularity. Since independence, Namibian politicians have clearly demonstrated their will to do the former.

Fisheries-management systems, therefore, although required to be based on the principles spelled out in the FAO Code of Conduct for Responsible Fisheries, need to be developed by countries individually and, in many cases, within that country, differentiating between species to cater for the individual particularities of resources. This philosophy clearly steered and is still steering the continuous evolution of the Namibian fisheries-management system.

The Namibian fisheries-management system

The way fisheries management works is currently pre- scribed by the Fisheries Act (Act 29 of 1992). The Act spells out a clear and transparent process through which, whenever opportunities to catch fish commercially become available, the Minister responsible for fisheries has to invite the public, through a notice in the country's Government Gazette, to apply for the right to fish. The applications are then processed, and the Act spells out what the Minister may have regard for when allocating rights. These criteria are:

- whether or not the applicant is a Namibian citizen;
- where the application is a company, the extent to which controlling interest of the company is vested in Namibian citizens;
- the beneficial ownership of any vessel that will be used by the applicant;
- the ability of the applicant to exercise the right in a satisfactory manner; and
- the advancement of persons who have been socially, economically, or educationally disadvantaged by discriminatory laws or practices that were enacted or practiced before the independence of Namibia.

From the above the aims of these criteria are clear; they ensure that Namibians get a fair chance to enter the industry and to facilitate the empowerment of previously disadvantaged groups.

This in turn should also make it clear why the individual transferability of quotas as practised in New Zealand and elsewhere is not regarded as the ideal system to be implemented in Namibia (Morgan 1997). The notion of fixed rights in perpetuity is equally unsuitable for the Namibian situation because, in a system where shares rather than companies and/or assets change ownership, it can easily happen that a company holding a right may, in time, change in such a way that the original profile that earned it a right no longer exists. Expiry of rights gives the government a chance to reconsider and re-evaluate the situation. Companies that do not change are certain of having their rights extended. The term of a right can be 4, 7, or I 0 years for a Namibian-owned company without investments (so-called newcomers), a foreign-owned company with investments, and a Namibian-owned company with investments, respectively. Namibian ownership is defined as 90% of the shares being held by Namibian citizens.

The criteria determining the allocation of rights at independence operated in a void in two of the three most important fisheries, hake (*Merluccius* spp.) and horse mackerel (*Trachurus* spp.) as no Namibian right holders existed before independence. In the case of sardine (*Sardinops sagax*) (also called pilchard), the existing rights-holders under the previous government were retained and the quotas allocated generally on the same basis as prior to independence, despite the fact that a few new rights-holders were also allowed into the fishery. The dilemma of deciding on the initial basis for allocating quotas to rights-holders, as discussed for example by Morgan (1997), was therefore not a major consideration. Monkfish, which was previously mainly landed as a by-catch species to the hake fishery, is the only resource still managed by effort control - the number of vessels, vessel size, and horsepower of each fishing vessel all being limited.

All vessels participating in any fishery are licenced and a vessel licence can only be obtained where a right as well as a quota have been granted for a specific year.

Resource rent

By and large, the Namibian fishing industry operates without subsidies, with the exception of some rebates granted on fuel purchases. Moreover, the industry pays the Ministry a resource rent or "quota levy" in advance and upon acceptance by the rights-holder of the quota it is allocated for a specific fishing year.

Over and above the quota levy, industry is required to pay a small levy per tonne of fish landed to support research on the stocks. This money is deposited in a separate account, referred to as the Sea Fisheries Fund, and its budget is approved by the Minister responsible for fisheries and the Minister of Finance. Research costs of the Directorate of Resource Management (for research on marine resources) are defrayed from the fund. Salary and other personnel costs are budgeted for from the central revenue budget.

A third contribution is made by industry towards the payment of the salaries of fisheries observers, which will be referred to later.

Incentives for Namibianization

Apart from the criteria which the Minister may have regard for, as explained above, a further incentive system is in place when the granting of rights is being decided, i.e., quota levies differentiate between different categories of rights-holders. Hake quota levies, for example, differ as follows:

- N$880* per metric ton of hake allocated to foreign vessels (only wetfish vessels are allowed into the fishery in this category).

- N$660 per metric ton allocated to foreign registered vessels based in Namibia.
- N$440 per metric ton allocated to Namibian vessels.

On these levies, a rebate of N$220 per metric ton of wetfish is granted if the fish is landed in Namibia, irrespective of the category of vessel by means of which the hake was caught.

It is clear from the above that the aim of these measures is to provide an incentive towards integrating vessels fully into the Namibian fleet and for crews to be Namibian. To be eligible for a rebate within such a system, it is implicit that the vessel crew is 80% Namibian. Linked with this, training facilities for Namibian seamen have been established. Although initiated by the Ministry, these schools (now one institution) in Lüderitz and Walvis Bay are operated as a trust, funding coming from school fees and the Sea Fisheries Fund, of which 20% by law is earmarked for training and development.

A further aim is clearly to entice companies to process on land for job creation and to encourage the development of value-added fish products in Namibia. In the case of horse mackerel, because of the marginal economical profitability of the species, the quota levy for fish landed in Namibia has been abolished altogether to encourage companies to land and market horse mackerel in Namibia and southern Africa. This is seen as a contribution to a campaign to encourage Namibians to eat more fish, to allow affordable marine fish to compete with freshwater fish to assist in conservation, and to enhance food security in the region.

Setting of TACs

The Minister sets TAC levels responsible for fisheries on advice given by way of the following process. The Directorate of Resource Management is tasked with carrying out research on the various resources and to produce advice on the state of the environment and of the various commercially exploited species. The results are compiled into reports tabled for discussion by the Sea Fisheries Advisory Council. The manner in which the Council members are appointed, the criteria for appointment, and the way the Council functions is prescribed in the Act. The Council deliberates on the advice tabled and, taking socioeconomic factors into consideration, makes its recommendation to the Minister. The motivated recommendations of the Council and the scientific recommendations are scrutinized by a committee of the Ministry. This committee, the Fisheries Management Committee, then puts its recommendations to the Minister, who normally consults senior management and the Deputy Minister before making a decision. The decision of the Minister is finally communicated to Cabinet for collective endorsement.

This process, once research results are available, may seem very bureaucratic and drawn-out, but the exercise from the time the Advisory Council meets to the announcement of quotas is usually completed within a period of less than one month.

Other mechanisms of resource management

Various area restrictions are in effect to restrict fishing effort. Trawling is not allowed at depths shallower than 200 m to protect juvenile hake and horse mackerel that normally occur in relatively shallow water. In the case of horse mackerel, this restriction is also linked to a ban on all mid-water trawling south of 23'S. Such restrictions effectively also safeguard sardine from being landed accidentally by mid-water trawlers targeting horse mackerel.

A vessel observation system is being implemented so that there is even better control over the area restrictions and more flexibility when the boundaries of the restricted fishing areas are being drawn. The restrictions are stipulated as conditions of being granted a licence, making it possible to discriminate between purse-seiners, bottom trawlers, and mid-water trawlers in their implementation.

Short-lived species, e.g. anchovy (*Engraulis capensis*), that nowadays only occur sporadically in Namibian waters, are managed not on a TAC system but by means of an open-ended "olympic" system. The limiting factor in this case is the amount of sardine by-catch allowed. The by-catch is normally limited to a maximum of 5% of the total bag. Whenever this limit is approached globally by operators, industry, through one of its own committees, can close an area to further operation. The committee recommends such a step to the Permanent Secretary of the Ministry, who then routinely endorses the closure for a period.

Where two industries fish the same species (e.g. juvenile horse mackerel by purse-seiners and adult horse mackerel by mid-water trawlers), efforts are made to estimate the most beneficial way to direct the efforts of the two industries in getting the most out of the resource in terms of direct income, job creation, benefits to Namibians, and so on.

Apart from depth restrictions and cod-end mesh-size limitations in, for example, hake and monkfish fisheries, experiments with bar-sorter grids are being carried out to establish whether better selection cannot be achieved with alternative gear. Should sorter grids prove to be as effective as the initial experimental results suggest, it may even be feasible to consider reducing cod-end mesh sizes. At present, an estimated 500 t or more Cape hake is lost annually through the meshes when the cod-end breaks the surface. If these fish could be landed without damage, they might sustain a small company and a number of people could be employed without increasing the fishing mortality. However, any decision on this would call for a clear understanding of the auxiliary role the cod-end meshes may still play in size selection once sorter grids are employed.

Whenever an application is received for experimental exploitation of a new resource, or for using new gear types in an existing fishery, the application is considered by the Fisheries Management Committee and an experimental right granted (or not) on the advice of that committee by the Permanent Secretary of the Ministry. Strict conditions are prescribed and such rights are granted for a limited period only. The operation is monitored closely and is reconsidered after the experimental period has lapsed. Should the new resource prove to be viable, applications for rights are called for. The orange roughy (*Hoplostethus atlanticus*) fishery is an example of an experiment that has now developed into a fishery, although still experimental in nature, for which rights were allocated.

By-catch species are levied to a level where it is only marginally profitable to land them in order to discourage targeting of such species, but not to a level that would encourage dumping.

Control and surveillance

After having experienced problems with foreign vessels fishing illegally immediately after independence, Namibia solved the problem by arresting some of them. Although blatant illegal fishing in controlled EEZ areas is frowned upon by the international community, recent plundering of the Patagonian toothfish (*Dissostichus eleginoides*) resource in the Southern Ocean shows that, if the reward is considered worth the risk, vessels will still venture into EEZ's to fish illegally. Namibia therefore remains vigilant in order to discourage a possible return to illegal fishing. At present, however, the surveillance task of the two patrol vessels and an aircraft is very much a matter of controlling licenced vessels and seeing that regulations and licence conditions are being adhered to.

In terms of control at sea, the task of the patrol craft is augmented by the presence of fisheries observers on board all vessels that have vacant berths. Their task is twofold. First, they observe whether or not the vessel is keeping to the rules (a report is submitted on return to port) and, second, they gather biological data on the catches. The data collected by the observers are of immense value to the scientists in the research environment, in providing biological parameters such as fish length, otoliths (for age reading), stage of sexual maturity, and stomach contents. The extent and quality of data collected are primarily dependent on the level of training of an individual observer. Placing well-trained observers on fishing vessels targeting species for which key data need to be collected is obviously a priority. Observers are paid by the owner of the vessel on which they serve, but they are placed on board by the Ministry to ensure a healthy rotation of personnel between vessels. On the larger vessels, 100% observer coverage is obtained.

In port, fisheries control officers (inspectors) check all offloaded fish by counting and registering boxes or recording scale readings of fish offloaded in bulk. In this way, and by use of conversion factors, the filling of quotas is monitored and excesses prevented. The same information serves as the basis for payment of Sea Fisheries Fund levies.

Measuring the success of Namibian fisheries management

In measuring success, two main parameters need to be considered, the level of success in managing the living resources and the levels achieved in realizing goals set to steer the development of the industry itself.

Of the three main resources - hake, sardine, and horse mackerel (Figure. 3) - only sardine has not performed well since Independence. Some of the smaller, longer-lived resources, e.g. rock lobster (*Jasus laiandii*), red crab (*Chaceon maritae*), and Cape fur seals (*Arctocephalus pusillus pusillus*), show either a steady recovery or stabilization. In the case of rock lobster, a further recovery of fishable biomass is expected, as an exceptionally strong cohort from 1993 is currently recruiting into the fishable biomass.

For most resources, the effect of a major environmental aberration experienced in the northern Benguela in 1994/1995 is evident in the way the biomass estimates decreased during these years. A return to normal environmental conditions has underpinned the recoveries during 1997/1998. On the basis of these trends it is evident that, despite the adverse conditions of 1994/1995, the well-disciplined and conservative, precautionary approach to setting TACs, allied to ensuring that landings do not exceed the set limits, is being rewarded by a recovery of stocks. Note that the 1995 discrepancy in sardine landings exceeding the TAC is because of landings made by the Namibian fleet, under licence, fishing in Angolan waters.

During 1994, a first National Development Plan (Anon 1995) was compiled for Namibia with projected targets over the 5-year period 1995/1996 to 1999/2000. Various targets were set for fisheries, the more important indicators of which are considered below.

Contribution of the fishing sector to the national economy

The results show that the projected and actual growth rates correspond broadly. The adverse environmental conditions of 1994/1995 show up in these figures, but the contribution of the fisheries sector to the GDP increased from 7.8% in 1997 to 10.1% in 1998, up from a mere 4% at Independence. The projected NDP I value for the year 2000 of 11% contribution to the GDP is therefore well within reach. Of particular interest is the fact that the fisheries contribution is made up of 4.2% from fishing and 5.9% from fish processing. These figures clearly illustrate not only growth in the industry but in particular the success of the incentives in the form of rebates on levies devised to entice companies to process on land.

Employment in the fishing sector

Two targets were set in terms of employment for the fisheries sector: (1) Increased employment in the sector from 12 000 in 1994 to 21 000 by the year 2000. The decreased landings in the labour intensive sardine canning industry negatively impacted this target. During 1998, employment was estimated at about 15 000, and the prospect of reaching the target of 21 000 by the year 2000 seems unlikely unless the sardine stock undergoes a major recovery; (2) achieve 80% Namibianization of crew on fishing vessels by the year 2000 (excluding midwater trawlers). Progress towards this goal has been better than expected and 78% was already reached by 1997.

Processing of fish ashore

A target was set of 50% hake to be processed ashore by the year 2000. This target has already been met, because the wetfish (processed ashore) share grew from zero in 1991 to 52% in 1997; this is expected to reach 60% in 1999. In the process, the aim of creating extra jobs was met in that more than 4000 were created in hake-processing factories alone.

Curbing fishing by non-licenced vessels

The target was to eliminate illegal fishing by the year 2000, and this has effectively been achieved.

Conclusions

The success of the Namibian fisheries-management system can be gauged from the recovery of resources, the fact that landings have been kept at or below their TAC, and the meeting of development and other targets set for the industry.

Managing Namibian fish resources has required managers to deal with uncertainties brought about by the highly variable Benguela ecosystem. The only way that risk levels in managing resources can be reduced is to be conservative in harvesting. This may not be the optimal way of utilizing the resources, but unless a better understanding of the fluctuations in the system is achieved and some reliable medium-term predictive capability is developed by which to forecast good and bad years, this will remain the only way of ensuring that the resources are not put at risk.

Summary of Status and Trends of Target Species

Hake

Distribution

The two species of hake occur on the shelf and upper slope in the Namibian waters. *M.* capensis occur at depths from about 100 m to about 350 m and overlaps with the shallow and of the distribution range of *M.* paradoxus which occur at depths of 300 m up to 500 m and even beyond 500 m, having been found at depths exceeding 900 m. A depth-related size distribution, with the smaller fish of both species occurring shallower than the larger fish as been recorded. Cape hake spawning takes place after a lapse in the main upwelling and usually occurs between 20º and 27º S. Larvae are commonly found between 18º and 24º S.

Biomass

The total biomasses of both Cape hake and deep-water hake are higher by 14% and 22% respectively than during the same period in 1999 (Figure 3). The increase in the total biomasses (about 16%) are mainly due to the increases in the non-fishable parts of the stocks.

The fishable biomass of Cape hake has decreased by 21%. This is mainly due to the decline in the number of fish within the length classes of 35-40 cm. The non-fishable component of the biomass (<36-cm) for Cape hake has increased by approximately 29% since the 1999 survey. This increase is due to the very strong 1998 year-class observed during this year's survey. The size structure of the fishable part of both Cape hake and deep-water hake still remains more balanced in comparison to the early 1990's, a sign that the fishing pressure is not responsible for the decline in fishable biomass.

The fishable biomass of the deep-water hake stock, on the other hand, has increased by 8%. The non-fishable part of the biomass of deep-water hake increased by approximately 36%. This good recruitment may be a result of inflow from a healthy deep-water hake stock in South Africa.

Fishery

Three types of vessels (freezers, wet fish and long-liners) are currently operating in the hake fishery. Fillets are produced on factory ships (skin off and skin on) and in processing facilities in Walvis Bay and Lüderitz. Work has been done on improving value-added products currently being produced in processing facilities in Walvis Bay, in order to promote local hake marketing.

A general linear modeling (GLM) procedure was used to analyse the commercial daily catch-log data from 1991 to 1999 in order to recalculate the CPUE, compensating for factors not related to stock size, such as different boats, area of fishing, month of the year and different years. Data from the whole fleet, including wet boats and freezer boats, were used in this analysis. The mean annual CPUE from GLM shows that the CPUE in 1999 decreased with 14.6% compared to 1998.

Research

Swept-area surveys are conducted annually to obtain an index of abundance and to collect biological information. During the 2000 swept-area survey (14 January to 24 February), the commercial vessel, F/V "Frans Aupa Indongo", conducted the whole survey from the Orange to the Kunene River.

An Interim Management Procedure (IMP) is used to assess the hake resource. In this procedure, the trends in survey biomass and commercial CPUE are used in the calculation of the TAC recommendation.

An ageing project was started in 1999 and this data (catch-at-age) can be used in applying age-structured models in the future.

Trained observers are collecting biological and length frequency data on a daily basis. This information will in the future be used in age based analysis as an alternative assessment method.

Pilchard

Distribution

The southern border of the Namibian pilchard distribution is described as being formed by the cold up-welling region centred around Lüderitz, and the northern border by the Angolan warm water front in southern Angola.

Pilchard usually occur in shallow waters close to the coast, out to a depth of 100 m. From June 1998 to November 1999, however, a large part of the stock was found further offshore to depths of up to 300 m. This change in distribution coincided with a period of colder than average sea surface temperatures in the inshore area. Since March 2000 most pilchard was again found close inshore, less than 40 m bottom depth, with only a small part of the population in deeper waters (between 100 m and 200 m bottom depth).

Sexual maturation occurs during the second year of life and the majority of individuals will spawn the following spawning season (September to April) at approximately two years of age. Pilchard are batch-spawners capable of releasing several batches of eggs per month. Peaks in spawning activity are reported to occur during September/October and February/March, although some spawning may occur throughout the year. According to historical studies the main spawning areas are in the vicinity of Walvis Bay (23°00' S) and around the upwelling cell of Palgrave Point (20°30' S).

Fishery

Currently the pelagic fishing fleet consists of 13 purse seiners. This number is much reduced from the more than 40 vessels, which fished for pilchard earlier in the decade, and represents a large reduction from over 30 vessels fishing last year.

Virtually all pilchard are canned for human consumption, with lesser amounts being processed for pet food or frozen as bait. 5-10% of the canned pilchard is sold on the local market, while the rest is exported, mainly to South Africa.

Biomass

The early 1990s saw a slight increase when catches exceeded 100 000 tons for several years, but this was followed by the lowest catch since commercial fishing on this species began; a little over 2 000 tons in 1996 (Figure 3). It is most likely that these collapses were largely due to overfishing, especially in the late 1960s when in addition to the Walvis Bay fleet, there were two factory vessels operating outside territorial waters. A number of years of poor recruitment as a result of adverse environmental conditions exacerbated the decline.

After the disastrous 1996 season, catches improved in 1997 and 1998 as the total allowable catch (TAC) was increased following several years of good recruitment (Boyer 2001 (a)). However, this respite for the pelagic industry proved temporary and by 2000 the catch was a mere 25 000 tons.

A number of Namibian vessels have fished under licence in southern Angola since 1994, and in 1995, 47 000 tons of sardine were caught by these vessels.

Research

Since 1990 hydro-acoustic surveys have been used to estimate the biomass of pilchard in Namibian waters. Twenty-eight surveys have been conducted to date of which eleven included southern Angola. During 1999 two surveys of the pilchard stock were completed, one in April and one in November. The first survey in 2000 was conducted in March and a second survey was called for in June.

Trained observers are collecting biological and length frequency data on a daily basis. This information will in the future be used in age based analysis as an alternative assessment method.

Horse Mackerel

Distribution

Although the Namibian horse mackerel is mostly confined to the cold waters of the Benguela system, its geographical range of distribution extends to the warmer waters on the East Coast of South Africa. However, it is believed that geographical and environmental barriers, such as the Lüderitz upwelling cell, create obstacles and that the genetic flow between the horse mackerel in the Northern and Southern Benguela is minimal. The separation thus prevents mixing between the fish in the two systems and for management purposes they are regarded as separate stocks.

Horse mackerel in the Benguela system reproduce throughout the year with a peak in spawning activity occurring in the austral summer months. The eggs and Juvenile (<15 cm) fish occupy shallower waters (from (~20 – 100 m), but as they grow older they migrate into deeper waters up to the shelf edge at a bathymetry of about 500 m.

Biomass

Field surveys (acoustic) are conducted annually to determine the size of the population. In addition data collected from the industry such as the catch and length are used in statistical models to complement results from surveys.

The horse mackerel population has experienced both growth and decline in the past ten years (Figure 3). A significant drop in the stock occurred from 1992 to 1997. However, from the most recent surveys it appears that the stock is in a recovering phase. Biomass estimates in the past two years estimated the stock to be about two million tonnes. During this period the catches remained below the stock size and the TAC was in most instances landed.

Fishery

Juvenile fish are exploited by the pelagic industry using purse seiners, while the Mid-water trawler fleet, which employs a 60 mm mid-water net, targets larger fish. Since the inception of the fishery in 1961, the species on average sustained landings in the order of 300 000t. Currently the two fisheries combined yield the highest bulk of catches with an export value of approximately 500 million Namibia dollars. Despite the anthropogenic mortality on the species, its abundance has remained stable.

Research

Annual horse mackerel acoustic surveys are conducted for biomass determination and to collect biological information.

Trained observers are collecting biological and length frequency data on a daily basis. This information will in the future be used in age based analysis as an alternative assessment method.

A Horse Mackerel Working group has been established recently.

Management History, Successes and Failures

Catches for most species were monitored through ICSEAF (International Commission for the South East Atlantic Fisheries) in the 1970s and 1980s. The figures available should be treated with caution as it is alleged that many countries either over or under-reported their catch according to various political and/or management considerations, while the catches of other countries were simply inaccurately recorded. Additionally, catches were recorded in arbitrary five degree bands of latitude (viz. 15°-20°, 20°-25° and 25°-30°) conforming to neither national nor environmental boundaries.

Landings prior to 1970 were frequently unrecorded, but as the south-east Atlantic only became the focus of international fishing fleets in the late 1960s, they are not likely to be substantial. In contrast, the catches of the 1990s were closely monitored by fisheries control officers and are believed to be accurate.

The area to which this Agreement shall apply shall be waters of the Convention Area lying between 17°17' S latitude and 28°38' S latitude, and between 10°00' E longitude and 20°00' E longitude, excluding waters falling in a closed area established by the Commission (Table 1) (Hbk 1984a,b).

ICEAF consists of 17 member countries namely (date of deposit of instruments of ratification, acceptance, approval, or adherence):

- Japan (22nd June 1970)
- South Africa (2nd October 1970)
- Portugal (22nd January 1971)
- Union of Soviet Socialist Republics (24th September 1971)
- Spain (6th December 1971)
- Bulgaria (24th April 1972)
- Poland (2nd March 1972)
- France (4th October 1972)
- German Democratic Republic (19th June 1974)

- Cuba (15th January 1975)
- Italy (22nd December 1975)
- Israel (5th January 1976)
- Angola (4th October 1976)
- Federal Republic of Germany (17th November 1976)
- Romania (18th August 1977)
- Republic of Korea (19th January 1981)
- Republic of Iraq (4th June 1981)

Pursuant to Article XVIII, the Convention entered into force on 24th October 1971.

Article VI

1) In order to achieve the objectives set out in this Convention, the Commission shall be responsible for the study of all fish and other living resources in the Convention Area. Such study shall include research on the abundance, life history, biometry, and ecology of these resources, and the study of their environment. In undertaking the study of these matters the Commission shall collect, analyse, publish, and disseminate, by all appropriate means, statistical, biological, and other scientific information on the said resources.

2) The Commission, in carrying out its responsibilities, shall, insofar as feasible, utilize the technical and scientific services of, and information from, official agencies of the Contracting Parties. The Commission may, when necessary, utilize other services and information, and may, also undertake, within the limits of its supplementary budget, independent research to supplement the research being done b governments, national institutions, or their international organizations.

3) The Contracting Parties shall furnish, on the request of the Commission, any available statistical and other data and information the Commission may need for the purposes of the Convention.

Article VII

1) The Commission may establish a Regional Committee for each of the regions into which Convention Area my be divided on an ecological basis, and a Stock Committee with respect to any stock to be found in the Convention Area. The Commission may also establish a Scientific Advisory Council, hereinafter referred to as "the Council". The Commission may establish such other subsidiary bodies as are necessary for the

performance of its functions, determining their composition and terms of reference in each case.

2) Regional Committees shall have the functions specified in this Article, except with respect to any stock for which a Stock Committee is competent.

3) A Regional or Stock Committee may initiate, on the basis of the results of scientific investigations, proposals regarding measures that are applicable to the region or stock for which it has been established and shall consider any proposal that may be referred to it by the Commission.

4) A Regional or Stock Committee may prepare draft recommendations for consideration by the Commission. The Commission may adopt such draft recommendations, with any amendments it may consider desirable, in accordance with Article VIII of this Convention.

5) The Commission shall designate the Contracting Parties that may be represented on a Regional or Stock Committee. However, when a Regional or Stock Committee is established a Contracting Party shall automatically have the right to be represented thereon if it fishes in the region; or if it exploits the stock concerned; or if it has a coastline adjacent to the region concerned or the area where the stock is to be found. If a Contracting Party exploits a stock outside the region covered by a Regional or Stock Committee, it may be eligible to be represented thereon if the Commission so decides.

6) The functions of the Council shall be to advise and assist the Commission and its Regional and Stock Committees with respect to the scientific aspects of their responsibilities.

7) Each Contracting Party may seen a delegation of scientists to the Council composed of as many experts as it wishes. The Council may establish subsidiary bodies and determine their composition.

8) The Council may, with the concurrence of the Commission, invite other scientist or experts to participate in its deliberations in an advisory capacity.

9) The Council shall hold regular sessions whose timing shall be determined by the Commission by the Commission in relation to its regular sessions. The Council may hold special sessions subject to the approval of the Commission.

Article VII

1) The Commission may make, on its own initiative or on the proposal of a Regional or Stock Committee and on the basis of the results of scientific investigations, recommendations relating to the objectives of this Convention. These recommendations shall become binding on the Contracting Parties under the conditions laid down in Article IX.

2) The matters with respect to which the Commission may make recommendations shall be:

a) the regulation of the sizes of mesh of fishing nets:

b) the regulation of the size limits of fish that may be retained on board any fishing craft or landed, or exposed or offered for sale;

c) the establishment of open and closed seasons;

d) the establishment of open and closed areas;

e) the regulation of fishing gear and appliances, other than regulation of the size of mesh of fishing nets;

f) the improvement and the increase of living resources, which may include artificial propagation, the transplantation and acclimatization of organisms, the transplantation of young, and predator control;

g) the regulation of the total catch by species, group of species, or, if appropriate, by regions; and

h) any other type of measure directly related to the conservation of all fish and other living resources in the Convention Area.

Importance of Biodiversity in the Fishery

Overview of Namibian marine biodiversity

Sakko (1998) mentioned that biodiversity in the Namibian marine environment shows several pertinent trends. In most habitats there are no endemic species. A few species are endemic to the Benguela system, of which Namibian waters form a part. Species richness in most habitats is considered to be relatively low. This is evident amongst sandy shore, rocky shore and marine benthic invertebrate communities, littoral algae, phytoplankton, fish of the littoral and pelagic habitats, as well as demersal fish in the shelf and slope habitats. In all these cases diversity is lower than in comparable habitats in the southern Benguela system off the west coast of South Africa. In most cases the low diversity is accompanied by high biomass in those species that are represented.

There is some evidence in support of a latitudinal gradient in patterns of global species richness with highest diversity recorded in equatorial regions and lowest diversity towards the poles. Namibian marine diversity provides an anomaly in this gradient since, in general, species richness is substantially lower than in the more southerly marine habitats off South Africa. In addition, there is a clear trend of decreasing species richness from the south to the north of the marine system off Namibia.

Upwelling systems in general are extreme cases of unstable environments, where continuous variation prevents the fine-tuning of genotypes to local conditions. Food availability is variable and generalist feeders are favoured (Brown 1984). Such systems predictably support a low diversity of species, while at the same time being among the most productive habitats in the world (Barnes and Hughes 1988). Significantly, the Namibian marine environment (and particularly the northern Benguela system) supports low numbers of species even in comparison to other upwelling systems, such as the southern Benguela system and the West African upwelling system. This is possibly partly due to the intense and perennial upwelling off this coast, and to the irregular anomalies in temperature, salinity and oxygen concentration, which lead to extreme instability and unpredictability of environmental factors.

Potential threats to Namibian marine biodiversity

Natural threats

The functioning of the Benguela system typically is based on continuous environmental changes, on time scales from hours to decades. Fluctuations are thus a feature of the Benguela system. However, exceptional conditions, such as those recorded during Benguela-Nino and during the upwelling of anoxic water from the deep ocean floor onto the continental shelf, can cause substantial mortality of marine organisms. During a Benguela-Nino event a deep layer of warm, saline water of equatorial and Angolan origin intrudes into northern Benguela waters and occupies approximately the upper 100m of the water column (Boyd and Thomas 1984; Shannon 1989; O'Toole and Bartholomae 1995). Considerable impact on the marine biota has been recorded (Stander and de Decker 1969; Boyd et al. 1985), and includes decreases in plankton abundance, fish mortalities and movements, and poor spawning and recruitment in commercially exploited fish species.

Similarly, anomalous environmental conditions associated with the presence of low- oxygen water have been reported in the past. Documented effects of such conditions on marine biota include mortalities of fish and seals, and movements of fish to less-affected areas. Following the 1994 intrusion of anoxic water onto the shelf off northern and central Namibia, biomass of commercially exploited pelagic species such as pilchard, anchovy and horse mackerel was markedly reduced in inshore waters (O'Toole and Bartholomae 1995).

Natural fluctuations in environmental conditions in the Benguela system could thus be seen as a potential threat to marine species off Namibia. However, these fluctuations are inherent in the functioning of the system, a system which has been in existence (certainly off northern Namibia) for more than two million years (Shannon 1985). Clearly, species that persist have evolved mechanisms for coping with the inherent variability. Mortalities in response to environmental fluctuations should therefore be seen as significant only on a local scale.

Anthropogenic threats

Pollution of ship and shore origin. Namibia's coastal zone is sparsely populated and the inland desert is not suitable for agricultural development. The marine environment is thus free from the level of pollution commonly associated with large urban communities, and is considered 'relatively pristine' (Moldan 1989). In addition, most vessels using shipping lanes along the southwestern African coast remain outside Namibian waters. There are harbour facilities and fish-processing factories at Lüderitz and Walvis Bay. However, monitoring of water quality in Walvis Bay has, to date, not indicated pollution levels, which have anything more than a local impact.

Diamond mining. Extensive areas of the marine environment in southern Namibia are currently set aside for diamond mining activities (approximately 300 km between 28'S and 26'S). Public access to these areas is restricted and mining activities are conducted in all the marine habitats from coastal land to deep sea (about 120m deep). All operations involve the removal of sediment in search of diamonds, and the re-deposition of this sediment, mostly in a suspended form in the water column. On a local level these activities are highly destructive to biodiversity since substratum morphology is altered and entire communities may be disturbed or totally eradicated. In addition, the effects of numerous small mining concerns along the coast may be cumulative in terms of decreasing the supply of eggs and larvae, which are essential for the recovery of, disturbed areas. Strict control and monitoring of mining activities is necessary to prevent large-scale loss of biodiversity due to this activity.

Introduced exotic species. The invasive alien Mediterranean mussel *Mytilus galloprovincialis*, which was introduced to South Africa in the late 1970s (Hockey and Van Erkom Schurink 1992), has become well-established on southern Namibian rocky shores where it has displaced the indigenous intertidal mussels *Aulacomya ater* and *Choromytilus meridionalis*. Thus far the presence of *M. galloprovincialis* does not appear to have had any ecosystem effects. The intertidal distributions of indigenous species have, however, altered on a local level.

Fishing. The high productivity of the waters off Namibia supports large stocks of commercially valuable species. Three main resource groups have formed 90% of the total catches since the major fisheries commenced in the mid 1900s. These are the pelagic species (pilchard, anchovy and juvenile horse mackerel) which are caught by purse seine, the adult horse mackerel which is caught with mid- water trawls, and the demersal species (two hake species, kingklip, Cape monk *Lophius vomerinus*, and west coast sole *Austroglossus microlepis*) which are caught with bottom trawls. In addition, there are experimental fisheries on orange roughy and alfonsino, both fish of the shelf slope and Deep Ocean. Important fisheries also exist on the deep-sea crab and the Cape rock lobster *Jasus lalandii*.

Most commercially exploited species are currently nowhere near as abundant as they have been in the past, and there are few of these species that have not, at some time, experienced population crashes (Crawford et al. 1987). Unfavourable environmental conditions have usually accompanied these reductions in numbers, and there is evidence of cyclical booms and crashes in pilchard and anchovy populations, which predate the commencement of commercial fisheries in the area. However, injudicious exploitation of already declining populations has doubtless exacerbated the situation. Such crashes can result in a reduction in the genetic diversity (heterozygosity) of the remaining populations, and a consequent potential decrease in the ability of populations to adapt to changing environmental conditions. The crashes of Namibian pilchard stocks several times in the past three decades have no doubt lead to reduced heterozygosity. In addition, records of increased growth rates and reduced age at maturity in pilchard are available (Boyer et al. 1997).

Conclusions

The Namibian marine environment is remarkable in several ways. It is part of one of four major upwelling systems in the world and is exceptionally productive, supporting abundant marine life. However, the flora and fauna are characterised by low species richness and paucity of endemics in all the major marine habitats, a situation, which reflects the position of Namibia's marine waters within the Benguela upwelling system. The marine habitats are relatively pristine, and the Namib Desert, lying just inland of the coast, makes increased urban and agricultural pressures unlikely in the future. And lastly, the fact that many organisms in the Namibian marine environment are adapted to survival in the inherently variable and unpredictable Benguela system perhaps makes Namibia's biological diversity somewhat resilient to the vicissitudes of human activities.

Non-Target Biodiversity Concerns (eg. Impacts on Other species)

Draft Strategic Plan for Coastal and Marine Biodiversity has been drafted and submitted to the Ministry of Environment and Tourism (Table 2).

How Biodiversity has been Incorporated in Fisheries Management (National, Regional, or Individual Project Level)

Benguela Environmental Fisheries Interaction & Training (BENEFIT)

BENEFIT is a regional marine science and training programme involving three member states of the Southern African Development Community (SADC): Angola, Namibia and South Africa.

It’s overall goal it to promote optimal and sustainable utilisation of the Benguela ecosystem’s living resources by:

- Increasing knowledge of fluctuations in important fish resources of the Benguela Current, and improving understanding of the way in which environmental factors influence these fluctuations.

- Developing human capacity and infrastructure for marine science and technology in the countries bordering the Benguela ecosystem, particularly in Angola and Namibia.

Through these activities, BENEFIT will provide more effective management of the Benguela’s living marine resources, promote job creation and contribute towards food security for the region.

BENEFIT is a 10-year programme, with the first (four-year) phase scheduled to start in 1997. It will be funded from a variety of local, regional and international research and development sources.

Stakeholders in the Programme include the governments of Angola, Namibia and South Africa, the fishing communities and peoples of the region, higher education authorities, scientists, conservation bodies, coastal developers and funding agencies.

The Benguela Current Large Marine Ecosystem Project (BCLME)

The Benguela Current Large Marine Ecosystem Project, which is a regional initiative between Angola, Namibia and South Africa, is aimed at sustainable integrated management of the Benguela Current ecosystem. The project is in a developmental phase and one of the key activities identified in the proposed work plan has been the synthesis and assessment of existing information on the BCLME. The five key areas that have been identified for review are the following:

- fisheries,
- oceanography and environmental variability,
- diamond mining,
- offshore oil and gas, and
- coastal zone development.

South East Atlantic Fisheries Organisation (SEAFO)

In 1997, following an initiative by coastal States of the South East Atlantic region, meetings of coastal States and other interested parties were convened in order to consider the text of a convention to create a regional fisheries management organisation for the South East Atlantic Ocean. The coastal States were Namibia, the Republic of South Africa, Angola and the United Kingdom of Great Britain and Northern Ireland in respect of its overseas territory of St Helena and its dependencies Tristan da Cunha and Ascension Island. The coastal States held four preliminary meetings during the course of 1997 in which they prepared an initial draft text of a convention on the conservation and management of the fishery resources of the South East Atlantic Ocean.

The coastal States endeavoured to design a convention which would implement the highest international standards related to responsible fisheries management, in particular those reflected in the United Nations Convention on the Law of the Sea of 10 December 1982, the Agreement for the Implementation of the Provisions of the United Nations Convention on the Law of the Sea of 10 December 1982 relating to the Conservation and Management of the Straddling Fish Stocks and Highly Migratory Fish Stocks, 1995, the FAO Agreement to Promote Compliance with International Conservation and Management Measures by Fishing Vessels on the High Seas, 1993, and the FAO Code of Conduct for Responsible Fisheries,

1995. The draft convention was also designed to take particular account of the specific regional context and situation of the coastal States, which include developing States.

"Strengthening Fisheries & Biodiversity Management in ACP Countries" (Project PN.7.ACP.RPR.545)

Namibia, together with approximately 50 other ACP (Africa, Caribbean and Pacific) countries is presently part of an international project financed under the European Development Fund, through the Lomé Convention. It is the first and leading event in the ACP/European Union (EU) joint "Fisheries Research Initiative". The project started in 1997 and will end in June 2001, and is being executed by the International Center For Living Aquatic Resources Management (ICLARM) --- the World Fish Center, a member of the Consultative Group on International Agricultural. It has set up five regional project nodes (three in Africa) and provided rigorous, formal training to 114 researchers and fishery managers in ACP countries in regional training courses.

This project has three Objectives:

1) To build up the aquatic resource management and scientific capacity of ACP institutions by providing managers, researchers, teachers and students in ACP countries with reliable and easy to use key information and with state-of-the art management tools and by training them in the use of these tools.

2) To promote an enabling environment for research which is relevant and critical to sustainable aquatic resource management in ACP countries, by promoting co-operation between researchers and managers in individual ACP countries, scientists and their institutions in ACP and EU member states, and by actively fostering intra-regional co-operation. Given the global nature of the resource and these information systems, to encourage also wider participation.

3) To further improve the quality, completeness and usefulness of **FishBase**, the national Biodiversity databases, and the other management tools.

The project has an international Steering Committee that advises the European Commission on project implementation, and Namibia is represented on this through the Ministry of Fisheries and Marine Resources. Additionally, the project is operated through a series of five regional nodes worldwide in Africa, the Caribbean and the Pacific. Within Africa, Namibia has been selected as the project node for southern Africa (hosted at the Ministry of Fisheries and Marine Resources, in Swakopmund) servicing eight (8) countries: Angola, Botswana, Malawi, Mozambique, Namibia, Swaziland, Zambia, and Zimbabwe including the SADC Fisheries Units. The project node in Swakopmund has been operational since 1998.

FishBase

The FishBase project started in September 1990 with the goal to improve fisheries and biodiversity management in developing countries by making key information and easy-to-use tools available to managers. FishBase is the world's most comprehensive electronic encyclopaedia on finfish. Information on fish biology is structured in more than 1 000 database fields grouped into 60 major and 70 minor tables. This software tool contains biological information, including growth and mortality parameters of fish, to facilitate management-oriented research on major commercial species. FishBase contains more than 22 500 species of the existing 25 000 Pisces. Information range from taxonomy, physiology, morphology, and ecotoxicology, population dynamics, reproduction, aquaculture and numerous more.

FishBase is also available on the Internet at www.fishbase.org. FishBase has grown enormously since it was originally designed. The site offers a feature to engage in immediate search or retrieval of specific records by entering either the species or genus name.

Examples of Best Practices

The major species caught by trawl off Namibia are Cape hake and deep-water hake, which are caught in bottom trawls. A third species of hake, *M. polli*, occurs in Angola, but is rarely caught in Namibian waters. Species caught as by-catch in the hake fishery in Namibia are monkfish *Lophius* spp, kingklip *Genypterus capensis*, snoek *Thyrsites atun* and the West Coast sole *Austroglossus microlepis*. In recent years, a monk-directed fishery has developed, with hake as the most important by-catch (Maartens 1999). On the outer Namibian shelf there is also a valuable deep-water trawl fishery directed at orange roughy *Hoplostethus atlanticus* and, to a lesser extent, alfonsino *Beryx splendens*. Between the late 1970s and mid 1980s large by-catches of chub mackerel *midwater trawlers took Scomber japonicus and snoek.*

Cape hake and deep-water hake are found throughout Namibian and South African waters, although deep-water hake is primarily restricted to the south (Burmeister *et al.* 2001). Deep-water hake occurs in deeper water than Cape hake, although the two species co-occur at intermediate depths (Burmeister 2000). Typically the former is found in water 150 – 800 m deep, mostly at temperatures between 4 and 8^{o}C, whereas the latter occurs from the coast to a water depth of about 380 m, in temperatures between 4 and 12^{o}C. Larger individuals of both species are found at greater depths than smaller fish, and there is little overlap in the distribution of mature fish. *M. capensis* is the more common species off Namibia, especially in the central region, although *M. paradoxus* has become increasingly abundant and more widely distributed in recent years (Burmeister 2000).

Hake spawn in the midwater throughout the year, with a peak in early summer for both M. capensis and M. paradoxus.

Hake feed both close to the bottom and in midwater. They tend to be off the bottom at night, although this is variable (Iilende et al. 2001). This results in aperiodic, asynchronous vertical movements of individuals, depending on food availability and recent feeding activity. Huse et al. (1998) and Iilende et al. (2001) have recently reported this lack of a distinct diel feeding rhythm. Hake are opportunistic feeders, resulting in considerable seasonal and spatial variability in their diet (Traut 1996). M. paradoxus becomes increasingly cannibalistic on young M. paradoxus with age. Because of their catholic feeding habits and abundance, hake are extremely important predators in the Benguela.

The Namibian fishery started in the late 1950s. In the early 1960s, with the arrival of foreign trawling fleets, there was an explosive increase in effort and hence landings throughout the Benguela and by 1972 the annual hake catch in the southeast Atlantic exceeded 1.1 million tons (van der Westhuizen 2001). Subsequently, catch rates and landings of hake declined sharply. Off Namibia, hake catches from 1973 to Independence in 1990 averaged 500 000 – 600 000 tons annually, and were mainly taken by foreign fleets. At Independence, strict conservation measures were introduced, including the exclusion of foreign vessels. The hake catch is now taken exclusively by Namibian-registered vessels and it rose from 55 000 tons per annum at Independence to almost 200 000 tons by 1999-2000 making this the most valuable fishery in Namibia. Around 80% of the catch is exported to Spain, although this has declined during the latter part of the decade as exports to other EU countries, USA and Australia have increased.

Stock assessment on hake stocks was carried out under the auspices of ICSEAF. Various surplus production models based on catch and effort data from the Soviet and Spanish fleets were used. The fishery was managed by mesh regulations and limits on the TAC, which was apportioned between nations according to their historic interest and performance in the fishery.

Since Namibia's declaration of an EEZ in 1990, and the subsequent withdrawal of foreign fleets, the hake TAC has been based on biomass estimates obtained from bottom trawl surveys by the *Dr Fridtjof Nansen* and more recently, commercial trawlers, with a correction made according to acoustic estimates of hake off the bottom (Iilende *et al.* 2001; van der Westhuizen 2001).

The marine fishery of Namibia is in a transitional stage. Following years of overexploitation of many of the resources by foreign fleets, management of these resources was taken over by the Namibian government in early 1990. Faced with the monumental task of rebuilding the stocks, and hence the fishery, strict controls were enforced, both in the number of vessels licenced to fish, and the total allowable catches. Furthermore, the hake fishery is regulated through mesh size (110mm cod end) and area restrictions (not allowed to trawl shallower than 200m). In parallel, an extensive research programme was instituted to monitor and assess the state of the various stocks. This programme was initially supported by foreign donors (notably Norway), but in more recent times has been increasingly conducted by Namibians.

The surveys produce estimates of the fishable (> 36 cm) and non-fishable (<36 cm) components of the population for both *M. capensis* and *M. paradoxus*. From Independence until 1998, the recommendation was set at 20% of the estimated fishable stock. In 1998 a working group comprising of members of the hake industry and Ministry scientists implemented an interim management procedure (IMP) with the intention of replacing this with a full operational management procedure by 2002. The IMP was based on a simple formulation, in which the TAC was adjusted up or down according to trends in CPUE and survey estimates of the fishable stock (Butterworth and Geromont 1997).

It is notable that there has been a marked increase in the abundance of deep-water hake off Namibia since 1992, which is confirmed by a marked increase in the proportion of deep-water hake in the Namibian hake catches in recent years (van der Westhuizen 2001). This increase may indicate northward displacement or expansion of the stock from South Africa (Burmeister 2000), or alternatively, a shoreward displacement in response to changes in the oxygen content of bottom waters (Hamukuaya *et al.* 1998). In Namibia, the Cape hake stock grew between Independence in 1990 and 1992, but thereafter declined for the next four years. The most recent survey results indicate good recruitment in 1997, with a modest increase in the fishable biomass since then (van der Westhuizen 2001).

Results and Lessons Learned

After several decades of over-exploitation, several of Namibia's marine resources are showing signs of a recovery. The monk catches have increased since Independence and this fishery is now an important component of the trawl industry. Similarly the hake fishery has grown since Independence, although catches are still considerably below those of earlier years.

If the recoveries are to be sustained, and the factors preventing the remaining stocks from increasing are to be understood, further developments in the research and management techniques will be needed. Transboundary effects and indeed environmental teleconnections around the globe are being increasingly recognised as having a major effect on national fisheries. Increased international scientific co-operation will be needed to investigate and understand these issues and to incorporate them into the management process.

Management procedures themselves also need to be developed. At present, harvesting levels are set to enable stocks to return to levels that will provide maximum sustainable yields, without any clear idea of what such levels may be, or even if they are attainable. While adherence to constant proportion harvesting rates has worked well for several stocks during the past decade, more sophisticated procedures will be needed in the future. The formal incorporation of such concepts as reference points (either biological or economic) and the precautionary approach needs to be considered and long-term management strategies adopted.

At Independence few Namibians had any experience or training in marine fisheries research. Through assistance from the donor countries and exposure to the international research community Namibia has, a decade later, a core group of fisheries scientists able to conduct monitoring and assessment work at a level comparable to that found in many countries with a much longer history of fisheries research. The Namibian research programme is now central to international programmes, such as the BENEFIT Programme, and is likely to be of major importance in the Benguela Current Large Marine Ecosystem (BCLME) Programme.

Guidelines, Policies or Legislation that have Resulted from this Experience

Stock assessment

Over the past three years, scientific recommendations for the hake resource have been based on a formula called the "Interim Management procedure" (IMP). This adjusted the recommended TAC up or down depending on trends in the research survey and the commercial CPUE data. This formula was introduced at a time where there was great uncertainty about the status of the hake resource. Amongst other things the formula needed to be able to reduce TAC's rapidly if abundance trends continued to decline, indicating that resource status was poor. Equally, catches could be safely increased if the reverse was observed.

The process of developing and testing a new formula to replace the IMP is currently underway, but not as yet complete. Hopefully by 2002 a set of options for formulae with the associated pros and cons will be put to the SFAC for consideration. For the current transitional period, scientific advice on the appropriate TAC is based on the conventional fisheries approval of assessing the resource and using the results to project resource status forward for a set of alternative series of future annual TAC's.

Fisheries working groups

It is acknowledged that any success in fisheries management could not have realised without the participation of the industry. Working groups have been established between the Ministry of Fisheries and Marine Resources and the associations of the various commercially important species. The objectives of the fisheries working groups are:

1) Develop an appropriate management strategy for the optimal and sustainable utilisation of the Namibian Resource based on the results of biological, stock assessment and socio-economic research.

2) Deliberate on the stock biomass in order to assist MFMR researchers in making recommendations on annual TAC's (Total Allowable Catches) based on outputs from the approved operational procedures when applicable.

3) Facilitate the collection of biological data.

4) Review scientific research already undertaken, identify possible improvements and recommend priorities for further research.

5) Analyse the socio-economic status of the relevant fishery to facilitate a better understanding of management options.

6) Ensure that the required expertise and resources are available to conduct the above work, both through training of local staff and where necessary, through recruiting consultants on short-term contracts.

7) Develop a Code of Conduct for the fishery and promote adherence to all permit conditions and Fisheries Regulations in general.

Linkages

The importance of the environment as driving factor of the eco-system and the processes behind it are realized and hence the emphasis on research focussing on regarding linkages between the environment and fish stocks. The research thrust is to improve our predictability and to come up with an index of environmental parameters that could be used in operational management procedure (OMP) of long lived species.

Eco-system modeling

Currently single species assessment is used to assess the commercial species except for Hake. The main objective of this project over two years was to construct an improved, updated and dynamic ecosystem model of the trophic flows through the Northern Benguela to facilitate the development and evaluation of multi-species management techniques for the marine resources of Namibia and possible for the entire Benquela region.

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- Boyer, D.C. and I. Hampton. 2001. An overview of the living marine resources of Namibia. S. Afr. J. mar. Sci. 23 (in press).
- Oelofsen, B. W. 1999. Fisheries Management: the Namibian approach. ICES Journal of Marine Science 56:999-1004.
- Sakko, A. L. 1998. The influence of the Benguela upwelling system on Namibia's marine biodiveristy. Biodiversity and Conservation7:419-433.

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Figures and Tables

Figure 1. Map of Namibia depicting the upwelling zones along the coast.

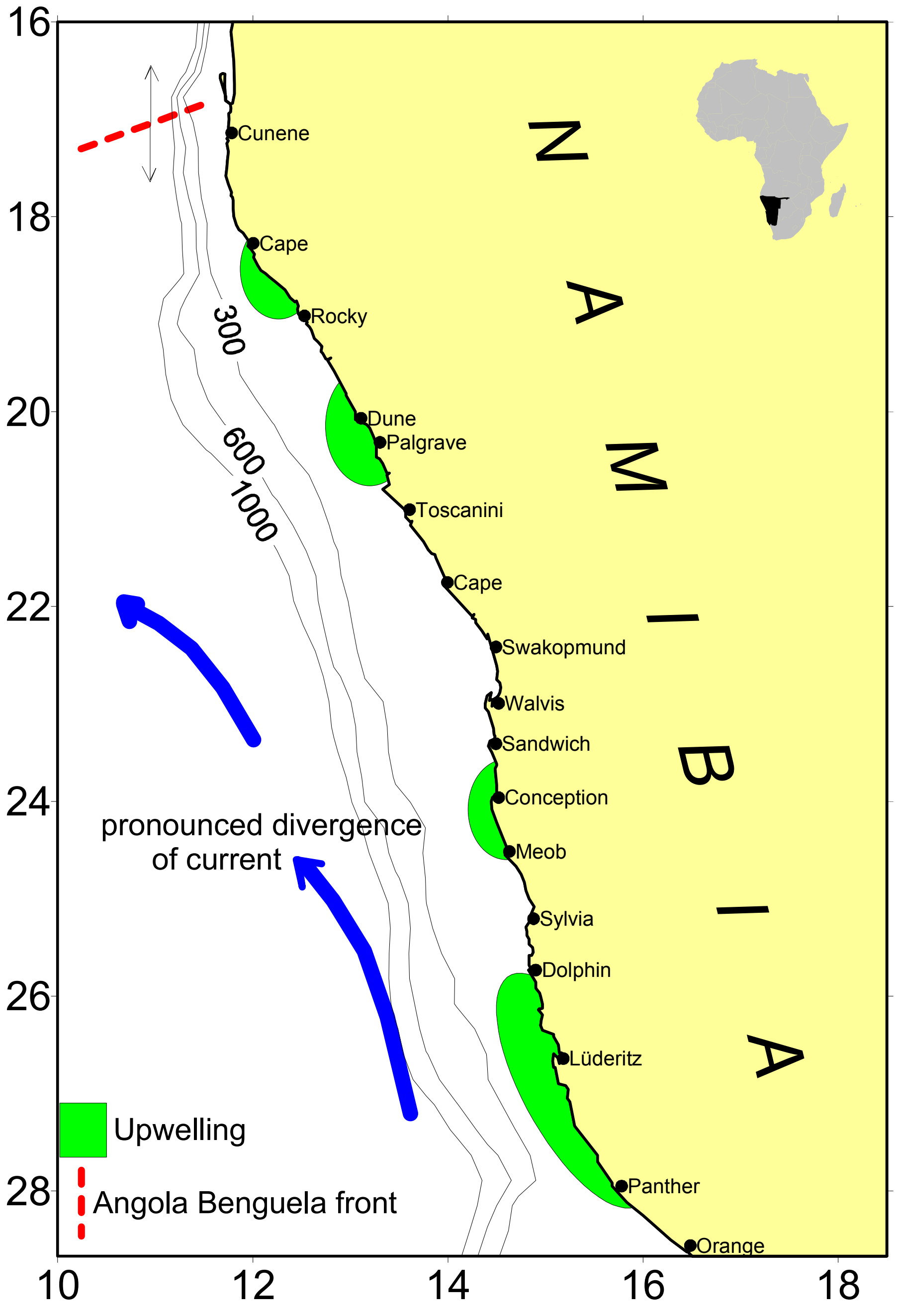


Figure 2. Monetary value of the different Namibian fisheries.

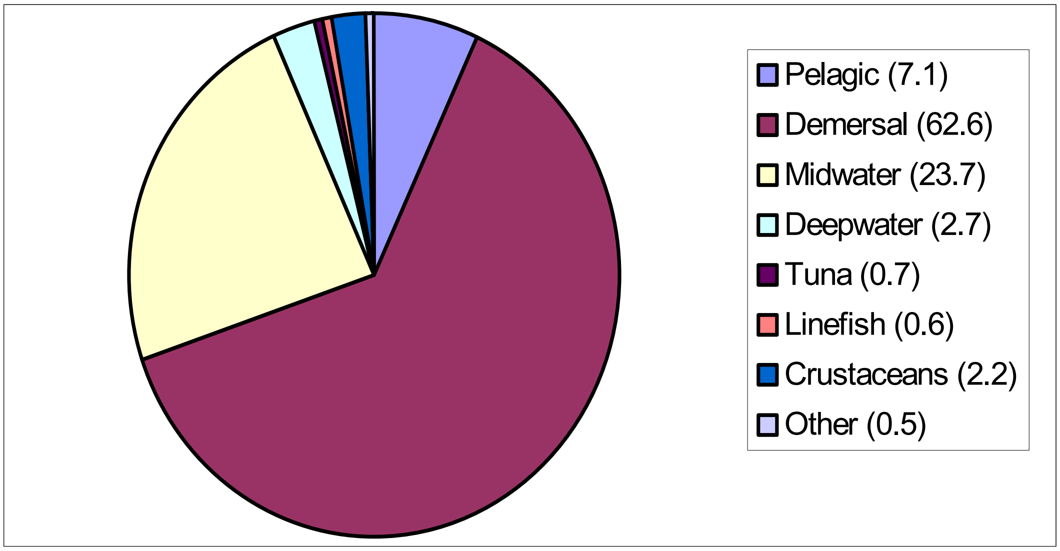
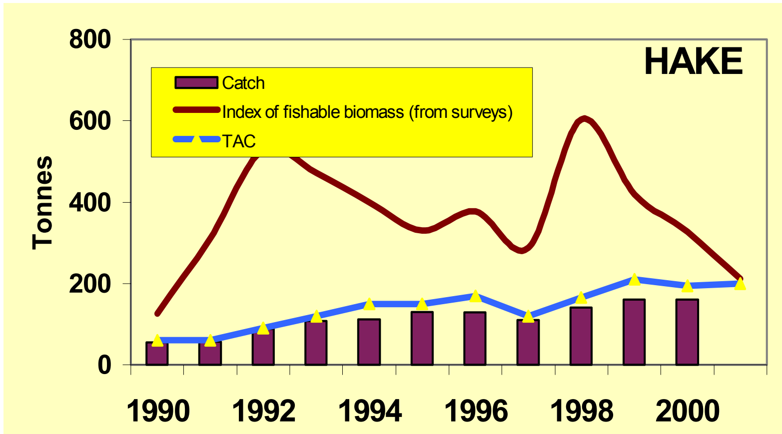
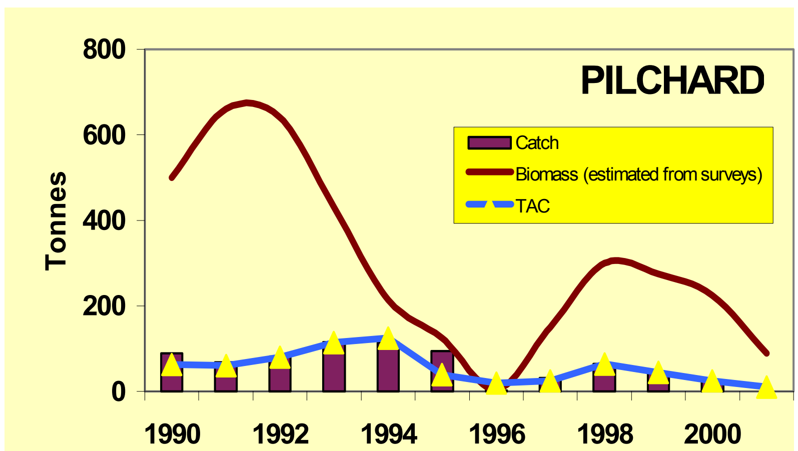


Figure 3. Total allowable Catch (TAC), catch and stock size of Hake, Pilchard and Horse Mackerel.





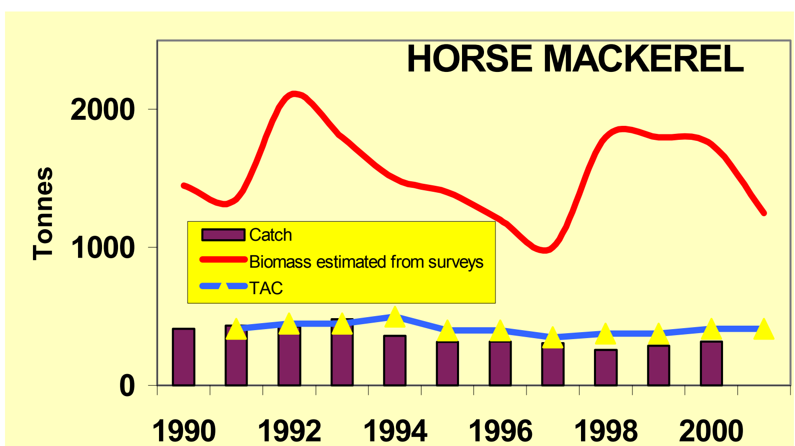


Table 1. Breakdown of the ICSEAF Convention Area (the Southeast Atlantic and Southwestern Indian Oceans).

Areas	Sub-areas and Division	ICSEAF Code #	FAO world-wide code #
Southeast Atlantic			47.0.0
	Western Coastal Subarea	1.0	47.10
	Cape Palmeirinhas Division	1.1	47.1.1
	Cape Salinas Division	1.2	47.1.2
	Cunene Division	1.3	47.1.3
	Cape Cross Division	1.4	47.1.4
	Orange River Division	1.5	47.1.5
	Cape of Good Hope Division	1.6	47.1.6
	Agulhas Coastal Subarea	2.0	47.2.0
	Middle Agulhas Division	2.1	47.2.1
	Eastern Agulhas Division	2.2	47.2.2
	Southern Oceanic Subarea	3.0	47.3.0
	Tristian da Cunha Subarea	4.0	47.4.0
	St. Helena and Ascension Subarea	5.0	47.5.0
Western Indian Ocean			51.0.0
	Marion-Edward Subarea	7.0	51.7.0
	Mozambique Subarea	8.0	51.8.0

Table 2. Draft strategic plan for coastal and marine biodiversity.

Objective	Activity	Lead agency (& collaborators)	Timeframe	Priority
Commercial fishing: continue efforts to minimise impacts on non-targeted species	Consistent enforcement of legislation, penalties and sanctions regarding by-catch regulations (SFAct)	Ministry of Fisheries and Marine Resources (MFMR) Management, Inspectorate	ongoing	1
	Continue and expand experimental fishing research (net-types, escape grids, fish behaviour etc)	MFMR Resource Management, fishing companies	ongoing	1
	Investigate the impact of longlining (in Namibian waters) on albatrosses	MFMR with Ministry of Environment and Tourism (MET)	2001	?
Aquaculture: establish effective legislation: Aquaculture Act	Maintain control through enforcement of procedures proposed in the Aquaculture Policy	MFMR	2001, ongoing	1
	Legislation: promote steps: Aquaculture Policy to Aquaculture Act	MFMR, finally to Min. Justice	2001	1
	Follow recommendations from aquaculture planning documents, to establish aquaculture zones	MFMR with MET, through Aquaculture Act		1
	Co-ordinate and approve zonal EIA's for aquaculture	MFMR with consultants		
Marine Mining: continue investigations of impacts on the marine environment and promote co-management of marine resources	Continued assessment of the impact of mining on benthic fauna	Mining companies with MFMR	ongoing	1
	Continued assessment of water quality changes associated with mining	Mining companies with MFMR	ongoing	1
	Control of effluent into the sea	Mining companies	ongoing	1
	Continue efforts towards harmonious co-management (Lüderitz Forum, symposia etc)	MFMR, Ministry of Mines and Energy (MME), fishing and mining companies	ongoing	1
	*Monitor shoreline habitat modification	MFMR with MET		
Marine protected areas: maintain protection of selected areas & proclaim the islands	Maintain the present regulations for protection of certain areas	MFMR	ongoing	1
	Assess marine areas for protection as Marine Reserves: declare and proclaim the islands. This will require: Inventories, management plans and legal procedure	MFMR, MME, BCLME, MET, Ministry of Justice (legal drafting)	?	?
	Establish unexploited sanctuary areas as scientific baseline sites	MFMR		1
	Maintain enforcement of control measures	MFMR (+ others?)		
	*Ensure appropriate protection of Ramsar sites	MFMR with MET		

Table 2. Cont'd

Objective	Activity	Lead agency (& collaborators)	Timeframe	Priority
Pollution: reduce pollution of coastal waters	Comply with Marpol standards; Namibia become a signatory	Ministry of Works Transport and Communication (MWTC)	a.s.a.p.	2
	Functional OSCP ready	MWTC and assisting line Ministries	Ongoing with continual updating	
	Regulate and monitor effluent discharges from land into the sea: formulate and enforce regulations	Dept. Water Affairs, Namport, industries, municipalities, appropriate jurisdiction		
Taxonomy: enlarge and update marine collection and database species	Strengthen central collection	National Museum with MFMR, BCLME		2
	Incorporate species database within present MFMR and/or National Museum databases	National Museum with consultant, BCLME		2
	Extend investigations on species distribution e.g.benthic species > 30m depth; include meio- and micro-fauna	MFMR through BCLME, mining companies	Already started on small scale, ongoing	3
Integrated Coastal Zone Management ICZM: Ensure that CZ development is in line with marine biodiversity issues	CZM initiatives comply with jurisdiction on the marine environment (Sea Fisheries Act, aquaculture, protected areas etc.)	MFMR, BCLME, industry involved in marine exploitation, MET, and all other stakeholders	ongoing	1
	Provide information to stakeholders on marine environment	MFMR with consultants	ongoing	3