3 BIODIVERSITY OF THE NAMIBIAN EXCLUSIVE ECONOMIC ZONE: A BRIEF REVIEW WITH EMPHASIS ON ONLINE DATABASES

*Maria Lourdes D. Palomares and Daniel Pauly**

Abstract

A summary of available information on Namibian marine biodiversity is presented including the species' scientific and common names in English and Afrikaans, when available. This also includes a listing, when reported, of preferred habitat, status, national and international protective measures by species as well as biological information specific to Namibian locales. This review is based on data currently available from various sources through the Internet, i.e. searchable databases such as FishBase, a global database on fishes of the world, which was updated to include recently published information, including that presented in other chapters of this volume. An updated version of this national database will be maintained and kept available online (at *www.seaaroundus.org*) illustrating the type of 'minimum databases' that we believe maritime countries should create and maintain.

INTRODUCTION

The living marine resources of Namibia are relatively well-known, having been listed and commented upon in the field guide published by Bianchi *et al.* (1999), who relied on an extensive literature. The productivity of these resources, however, is due to their being imbedded in a faunistically or floristically much richer ecosystem. In this contribution, therefore, we briefly review the status of that biodiversity in terms of functional groups, i.e. groups of species with similar functions within the ecosystem (Figure 1). This contribution can thus be seen as an ecosystemic extension of the guide

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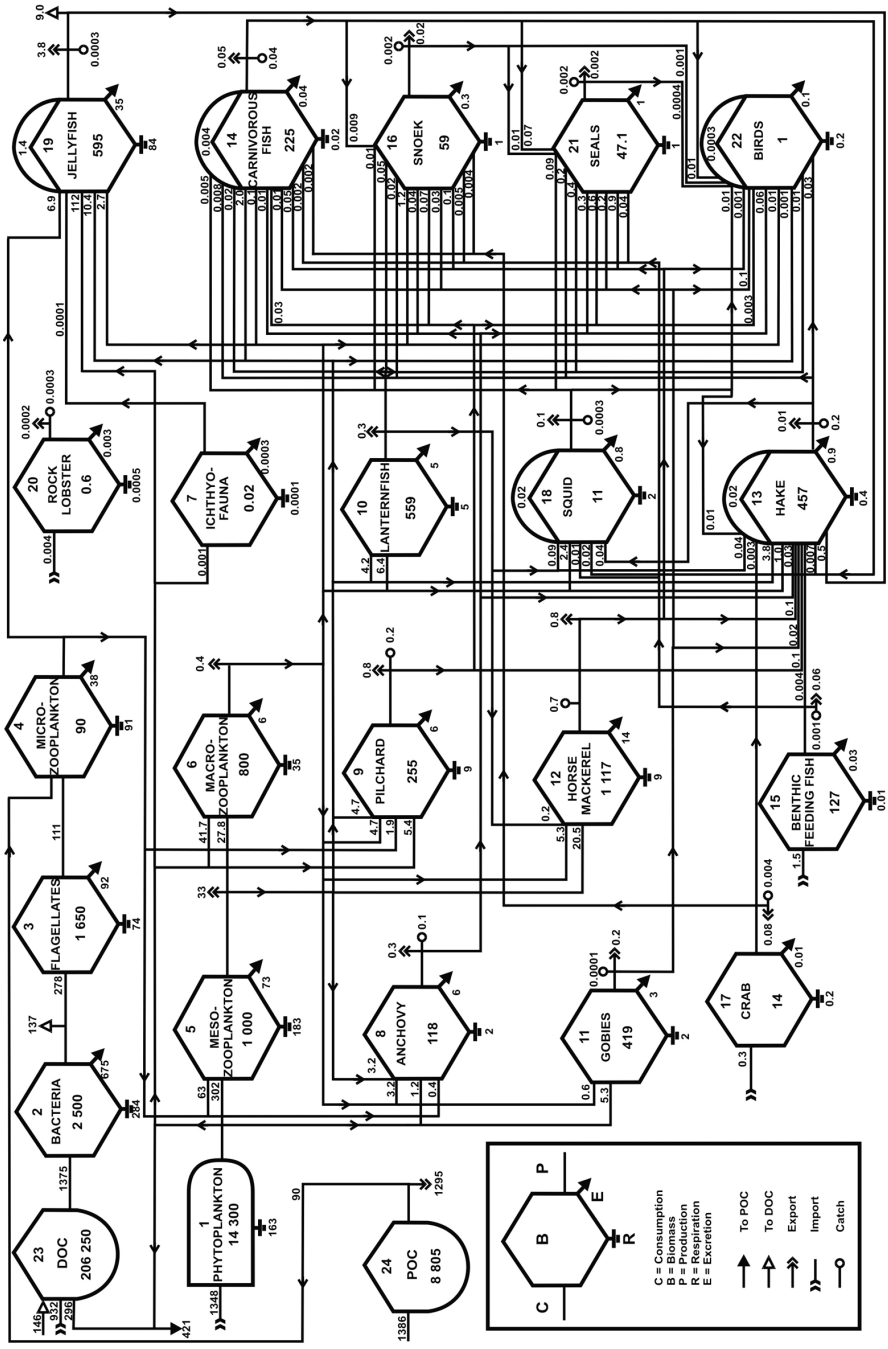

Figure 1. Flow diagram of the northern Benguela upwelling ecosystem adapted from Figure 2 of Heymans and Baird (2000). The species groups identified in this ecosystem model were used to structure the description of the biodiversity of the Namibian Exclusive Economic Zone.

to commercially important marine organisms of Bianchi *et al*. (1999) and an update of the same, as we will comment on the change of status of some of the marine resource species covered by these authors a decade ago.

The ecosystem structure we used follows roughly that of a food web model constructed and documented by Heymans and Baird (2000) and consisting of 24 functional groups (Figure 1). For each of the functional groups, we present the following:

- number of species;
- habitat requirements and other key biological information;
- IUCN status of component species, when available;
- treaties and/or protection measures relevant to these species;
- available sources of additional information on these species, with emphasis on online databases.

Our list is tentative, incomplete, and most likely biased towards fish and crustaceans, which are commercially important and thus better studied (Table 1). However, this list may serve as an example of what we believe is the minimum database each country should create and maintain to document its marine biodiversity.

BRIEF BACKGROUND OF THE NAMIBIAN MARINE ECOSYSTEM

The Namibian continental shelf is narrow, being at its widest off the mouth of Orange River and Walvis Bay, and extends to 90 km offshore between Cape Cross and Conception Bay, with a shelf area of about 110,000 km^2 (Sakko, 1998). The Namibian oceanic zone includes the SE Atlantic abyssal plains, i.e. the Angola and Cape basins, separated by the Walvis Ridge off northern Namibia. Sakko (1998) identifies four major oceanic regions: the epipelagic zone (0-200 m); the mesopelagic (200-1000 m); the bathypelagic (1000-4000 m); and the zone from 4000 m to the sea floor or the abyssopelagic which is generally poorly known; and two major shore habitats: the sandy littoral and the rocky intertidal habitats.

The Namibian EEZ is part of the Benguela system, the eastern boundary current characterized by the equatorward drift in the southeast Atlantic Ocean (Shannon and Pillar, 1986). This large marine ecosystem is divided into two highly productive sub-ecosystems, the northern and southern Benguela systems, separated by a permanent upwelling centre near Lüderitz at 27°S (Heymans and Baird, 2000). The oceanography of the northern limit of the Benguela, off Moçamedes, is similar to the equivalent systems in the South Pacific (the Peru or Humboldt current), characteristically with cool

Table 1. Number of species by habitat and by functional group assembled mainly from data in Sakko (1998) and supplemented with data from Bianchi *et al.* (1999) and other published sources.

Habitat	Functional group	Number of species	Endemics	Remarks	Reference
Sandy littoral	Macrofaunal invertebrates	<30	None	33.3% r/Restricted to Benguela system.	Fig. 3.3 in Sakko (1998)
Rocky intertidal	Benthic invertebrates	<200	1 Endemic to Namibia (*Discinisca tenuis*)	40% Gastropods and prosobranchs; 11.5% bivalves; 5% crustaceans; 4% polyplacophorans; 0.5% cephalopods; 15% restricted to Benguela system.	Bustamante *et al.* (1993); Fig. 3.4 and Table 3.1 in Sakko (1998);
0-200 m	Seaweeds	205			Lawson *et al.* (1990)
0-200 m	Bony fishes	410		Representing 13 orders of which 14.6% belong to Perciformes; 22.2% found at <30 m; 14.3% demersals.	Sakko (1998)
0-200 m	Cartilaginous fishes	83		Representing 10 orders; 36.1% found at <30 m; 21.7% sharks; 14.5% skates and rays.	Sakko (1998)
0-200 m	Zooplankton	>267		91% Copepods, 3.75% chaetognaths, 5.25% planktonic crustaceans.	Carola (1994)
0-200 m	Cephalopods	6		Data from R/V *Dr. Fridtjof Nansen*.	Sakko (1998)
0-200 m	Ichthyoplankton	>100		Eggs and larvae of commercially exploited fish species, e.g. *Austroglossus microlepis*, *Engraulis capensis*, *Hygophum macrochir*, *Lampanyctodes hectoris, Maurolicus muelleri*, *Merluccius* spp., *Parablennius pilicornis*, *Sardinops ocellatus*, *Scomberesox saurus scombroides*, *Sufflogobius*	Karaseva and Shiganov (1993); Olivar and Barange (1989); Sakko (1998)

				bibarbatus, *Symbolophorus* sp., *Trachurus capensis*.	
0-200 m	Phytoplankton	340	None	52.9% Diatoms, 47.1% dinoflagellates; 1.2% restricted to Benguela system.	Sakko (1998)
200-1000 m	Bony fishes	500		Mostly demersal species.	Sakko (1998)
1000-4000 m	Bony fishes	57	1 Endemic to Namibia (*Dicrolene pallidus*)	12.3% Exclusively bathypelagic.	Bianchi *et al.* (1999); Nielsen (1990); Sakko (1998)
1000-4000 m	Cartilaginous fishes	21			Sakko (1998)
0-4000 m	Nekton			10 Species of bony fishes pelagic in shelf waters, 14 species pelagic in shallow coastal waters, 13 species pelagic in habitats ranging from neritic to oceanic, 21 species occur in water column above sea bed in shallow coastal waters, 16 benthopelagic in shallow to deep ocean, no cartilaginous fish specifically neritic, 12 in pelagic as well as deep ocean.	Bianchi *et al.* (1999)
0-4000 m	Sea turtles	5			Bianchi *et al.* (1999)
	Seabirds	62		32.2% Rare or occasional visitors; 19.4% breed in Namibian waters.	Bianchi *et al.* (1999)
	Mammals	31	1 Endemic to Benguela system (*Cephalorhynchus heavisidii*)	74.2% Dolphins and toothed whales; 25.8% baleen whales.	Jefferson *et al.* (1993)

surface waters, while the southern limit of the Benguela, off Cape Town, is characterized by the warm waters of the Agulhas retroflection zone (Shannon, 1989). The fundamental differences in the two parts of the system make the often assumed occurrence of species in the north based on their occurrence in the south a risky proposition.

Table 1 presents a summary of the number of species so far listed occurring in these environments from the various reviews and reports consulted and reflecting the low species endemicity reported by Sakko (1998) of this marine system as a whole. Note that some of the references used here (and also in the online database available at *www.seaaroundus.org*) include species occurring slightly to the south and occasionally to the north of the Namibian border. In such cases, it is assumed that the species also occur within Namibia.

Kruger (1980) observed that the phytoplankton composition of Namibian waters is similar to that of the Mediterranean Sea (73% of Namibian species are also found in Mediterranean waters) and the Southwest Indian Ocean (72% overlap). Shannon and Pillar (1986) noted that the maximum zooplankton abundance lies in a belt parallel to the Namibian coastline but further offshore than the belt of maximum phytoplankton abundance. The high planktonic abundance, notably in the Benguela upwelling system, does not, however, reflect a high level of species diversity.

Macpherson and Gordoa (1996) reported that the benthic (100-800 m) fish assemblages off the coast of Namibia were located in areas covering both the active upwelling centres on the shelf and zones of lower productivity on the lower slope. This study also reports a high abundance of small individuals with low community diversity in the main upwelling centre, predominated by bony fishes and mid trophic level predators (on krill and pelagic crustaceans). Low productivity zones, on the other hand, tend to be dominated by cartilaginous fishes.

PROTECTION OF MARINE BIODIVERSITY IN NAMIBIA

The country has signed and ratified several international treaties and conventions, aimed at or indirectly related to the conservation of marine and coastal resources, *viz*.:

- the Vienna Convention for the Protection of the Ozone Layer;
- the Ramsar Convention on Wetlands;
- the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal;
- the United Nations Framework Convention on Climate Change;

- the Convention on Biological Diversity;
- the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES);
- the Migratory Bird Treaty;
- the International Whaling Commission;
- the UN Convention on the Law of the Sea;
- the Subcommittee of Forestry, Fisheries and Wildlife of the South African Development Community;
- the Lomé Convention; and
- the South East Atlantic Fisheries Organization (SEAFO).
- Namibia signed as well several trade agreements impacting on the sustainability of exploited resources within the region, viz.:
- the World Trade Organization;
- the South African Development Community (SADC);
- the Southern Africa Customs Union (SACU);
- the Common Market for Eastern and Southern Africa (COMESA); and
- the Generalized System of Preferences (GSP).

Namibia protects all seabirds occurring in its waters (Bianchi *et al.,* 1999) and the relevant legislation is being updated, along with legislation protecting other groups (McGann *et al.,* 2002). Regular coastal bird surveys along Sandwich Harbour, Walvis Bay and Lüderitz Bay are being conducted as part of a 25-year study by the Directorate of Environmental Affairs, Ministry of Environment and Tourism, Namibian National Biodiversity Programme (see *www.dea.gov.na/programmes/biodiversity/birds.htm*).

Monitoring surveys have been conducted since the 1960s for plankton, fish (sardines, horse mackerels, hakes, orange roughy, etc.), seals and other important groups. An example is the Namibian lobster research programme launched in the 1960s, which incorporates regular environmental and lobster surveys on the main fishing grounds for *Jasus lalandii* stocks (Grobler and Noli-Peard, 1997). Results obtained by this research programme indicate a recent improvement in the recruitment and abundance of this stock.

Since Independence in March 1990, the Namibian government has been incorporating a number of provisions into its legislation concerning, among others, ownership of marine resources, fisheries in the Exclusive Economic Zone, forfeiture of vessels used in committing fishery offences and international cooperation in enforcing fishery laws (Devine, 1993). Also, the Namibian government exercised its authority to control the access to marine resources by its domestic fishers (FAO, 2000).

The legislation protecting wildlife and natural resources cited by Sakko (1998; see also *http://www.mfmr.gov.na/policy/policies.htm*) include:

- the Parks and Wildlife Act;
- the Environmental Management Act;
- the Conservation of Biotic Diversity and Habitat Protection Policy;
- the Marine Traffic Act;
- the Merchant Shipping Act;
- the Prevention of Pollution of the Sea by Oil Act;
- the Territorial Sea and Exclusive Economic Zone Act;
- the Sea Fisheries Act of 1992; and
- the New Marine Resources Act of 2000.

MATERIALS AND METHODS

We describe in the following, the data sources we tapped and the method we used to assemble the biodiversity lists presented further below.

The list of commercial marine resources of Namibia by Bianchi *et al.* (1999) was used as a starting point. Branch *et al.* (1994) and Sakko (1998) supplied a considerable part of the marine invertebrate list. Note that Bianchi *et al.* (1999) supplied not only information on the commercial importance of some species, but also on whether some species are potentially important or likely to be affected by commercial fishing (see online database at *www.seaaroundus.org* for more details). The list of marine mammals was improved with additional information from Jefferson *et al.* (1993). Birdlife International (2001; see *www.birdlife.net*) supplied almost all information on seabirds. Information on fish groups was obtained from FishBase (Internet version April 2003; see *www.fishbase.org*). CephBase (*www.cephabase.org*) was used to supplement Bianchi *et al.* (1999), notably on common names, feeding and predator information for cephalopods (noted only for localities near or in Namibian waters). AlgaeBase (see *www.algaebase.org*) was used to supplement the list provided by Bianchi *et al.* (1999) of important algae present or potential use in Namibian marine waters.

The taxonomic list was expanded to include, when applicable, the names of the Order, Suborder, Infraorder, Super Family and Family to which the species belong. These higher hierarchy names were obtained largely through the ITIS biological name search site (see *http://sis.agr.gc.ca/pls/itisca/taxaget?p_ifx=cbif*) accessible through the Canadian Biodiversity Information Facility (CBIF) (see *http://www.cbif.gc.ca/home_e.php*).

The list of threatened species was obtained from the Internet version of the IUCN (1994; see *www.redlist.org*); the list of internationally protected species was obtained from CITES (see *www.unep-wcmc.org/index.html?http://www.unep-wcmc.org/CITES/redirect.htm~main*).

RESULTS AND DISCUSSION

Group-specific results

The following describe in some detail results obtained for each of the groups for which information is available. Note that marine turtles, microflagellates, bacteria, macroalgae and phytoplankton are not discussed in detail. The detailed list of species is available as an online searchable database at *www.seaaroundus.org*.

Birds. - Bianchi *et al*. (1999) reported that a total of 62 species of seabirds, including 20 rare visitors, have been recorded in Namibia. However, Bianchi *et al*. (1999) provides detailed information for only 19 commercially important species of seabirds, including 7 (guano producers) of the 12 seabird species which breed along the Namibian coast, the rest being pelagic seabirds most often encountered by fishers at sea. Branch *et al*. (1994) lists 30 coastal birds including the following shorebirds: greater flamingo (*Phoenicopterus ruber*), grey heron (*Ardea cinerea*), greenbacked heron (*Burorides striatus*), little egret (*Egretta garzetta*), curlew sandpiper (*Calidris ferruginea*), turnstone (*Arenaria interpres*), sanderling (*Calidris alba*), grey plover (*Pluvalis squatarola*), whitefronted plover (*Charadrius marginatus*), cape wagtail (*Motacilla capensis*), African black oystercatcher (*Haematopus moquini*), Caspian tern (*Hydroprogne caspia*), common tern (*Sterna hirundo*), Antarctic tern (*Sterna vittata*), Arctic tern (*Sterna paradisaea*), sandwich tern (*Sterna sandvicensis*), swift tern (*Sterna bergii*) and damara tern (*Sterna balaenarum*). Of the 25 endangered bird species listed in the Birdlife International species database for Namibia, 5 are seabirds and 4 are shorebirds.

The online database mentioned above lists 58 of the 62 seabird species from these different sources, including 3 species endemic to southern Africa, i.e. cape cormorant, *Phalacrocorax capensis*, cape gannet, *Morus capensis* and jackass penguin, *Spheniscus demersus*. The database also includes 4 commercially important guano-producing species, i.e. white pelican, *Pelecanus onocrotalus*, white-breasted cormorant, *Phalacrocorax carbo lucidus*, crowned cormorant, *Phalacrocorax coronatus* and bank cormorant, *Phalacrocorax neglectus*. These guano producers are included in the 11 IUCN listed species of seabirds in Namibia. Only 38 of those listed in the database are listed by CITES.

Marine mammals. - Jefferson *et al*. (1993) lists 36 species of cetaceans (8 baleen whales and 28 toothed whales, dolphins and porpoises) and 4 pinnipeds occurring between 20°S and 40°S. Bianchi *et al*. (1999) reported 31 species (8 baleen and 23 toothed whales, dolphins and porpoises) and 3 species of pinnipeds, but provides information on only 12 cetaceans and 2 pinnipeds. The

number of cetaceans occurring in Namibian waters represents a considerable 41% of the total number of species of cetaceans worldwide. Of these, only one is endemic, heaviside's dolphin, *Cephalorhynchus heavisidii*, which is a coastal shallow water species found only off southern Africa from about 17°S to the southern tip of Africa (Jefferson *et al.*, 1993). This species is common in Namibian waters and seen mostly about 5 miles from the shore in small groups of 2-7 individuals (Bianchi *et al.*, 1999).

Peddemors (1999), who reported 18 species of delphinids from Africa south of 17°S, concludes that there seems to be little human-induced threat to these species at present and only two inshore species are considered vulnerable, i.e. the Namibian population of heaviside's dolphin, and a localized Namibian population of bottlenose dolphin, *Tursiops truncatus,* which is reported as vulnerable to future coastal development and commercial fishery expansions. The offshore, less common southern right whale dolphin, *Lissodelphis peronii,* also forms a localized population, potentially vulnerable to fishing activities (Peddemors 1999).

The use of stranded marine mammals along the Namibian coast has been recorded since the time when the Khoikhoi, a group of nomadic cattle and sheep herders, occupied the western Namibian coast from 1800 to 1600 years ago, and consumed stranded whale meat and used whale bones to build huts (Boonzaier *et al.*, 1996). Early European visitors recorded an abundance of whales in these waters and 18th century records indicate the dominance of American whalers in the 'Coast of Guinea' in the 1760s and in Angola and Woolwich (Walvis) Bay before 1770 (Best and Ross, 1989). Extensive exploitation of whales in these regions developed rapidly, culminating in the 1930s when whales, notably sperm whales, humpback whales, fin whales and blue whales, were killed and processed in whaling stations along the Namibian coast (Bianchi *et al.*, 1999). Today, though all cetaceans are protected through international and national programmes, most of the once heavily exploited species in this region are still very rare and vulnerable (Bianchi *et al.*, 1999).

Cephalopods. - There are 55 species of cephalopods occurring in Namibia according to Nesis (1991), but Bianchi *et al.* (1999) include only 19 commercially important or potentially important species in 8 families, though they may be important mainly as bycatch. The database includes 66 species over 26 families and may include species found in South Africa as reported in Branch *et al.* (1994) and 13 species caught with bottom trawls or as bycatch of bottom trawls. None of the cephalopod species are listed in the IUCN or in the CITES Appendices.

Lobsters. - There are 11 species of lobsters occurring in Namibia (Bianchi *et al*., 1999) but we found information for only 10 (see database for more details) from 5 families. Four of these have commercial value or of potential commercial interest, i.e., Cape rock lobster, *Jasus lalandii*, royal spiny lobster, *Panulirus regius*, red slipper lobster, *Scyllarides herklotsii*, and scarlet lobsterette, *Nephropsis atlantica*. The most important of these is the Namibian Cape rock lobster stock, which was first exploited in the 1920s, with catches reaching up to 9,000 t in the mid 1960s, decreasing to 1000-3000 t in 1968-1969 with the abolition of the minimum legal size limit, and further decreasing in the 1980s perhaps owing to warm water intrusions from the south adding to the effect of overfishing. The biomass decreased further in 1992 when the TAC was set at 100 t (Grobler and Noli-Peard, 1997). This fishery is now protected by closed seasons (November-May) and size restriction (minimum of 65 mm carapace length; Bianchi *et al*., 1999).

Crabs. - Bianchi *et al*. (1999) reported 38 species of crabs occurring in Namibia, of which 9 are either caught by targeted fisheries or frequently occurring in bycatch. Branch *et al*. (1994) reported 300 species occurring in South Africa and reported a few more species which are known to occur in the southern border of Namibia with South Africa. These are integrated in the online database which lists 43 species, 58% of which are found at depths 0-1000 m.

Shrimps and prawns. - The lists of shrimps and prawns available indicate 54 (Macpherson, 1991) to 56 (Bianchi *et al*., 1999) species occurring in Namibia. We were able to reconstruct a list of 48 species, 40% of which are swimming and 60% benthic shrimps, and of which 50% are found at 200-1000 m depths, 15% at 0-200 m and about 1% are deepwater species occurring at depths >1000 m. Only a third of these species are of potential commercial interest.

Fishes. - Bianchi *et al*. (1999) listed a total of 492 fish species from 163 families, consisting of 2 species of jawless fishes from 1 family, 46 sharks from 15 families, 28 species belonging to 7 families of batoid fishes, skates and rays, 6 chimaerids from 3 families and 410 bony fishes from 137 families. Only about 40% of these are discussed in detail by Bianchi *et al*. (1999) because of their commercial or potential value as exploitable resources. However, the checklist obtained from FishBase (see *www.fishbase.org*) accounts for a total of 515 native and 1 endemic species. Almost 50% of these 516 species are bottom dwellers (20% demersals and 18 benthopelagic; Figure 2) while 36% are deepwater species (18% each bathypelagic and bathydemersals) and only 13% are truly pelagic species. This is not surprising given that the Na-

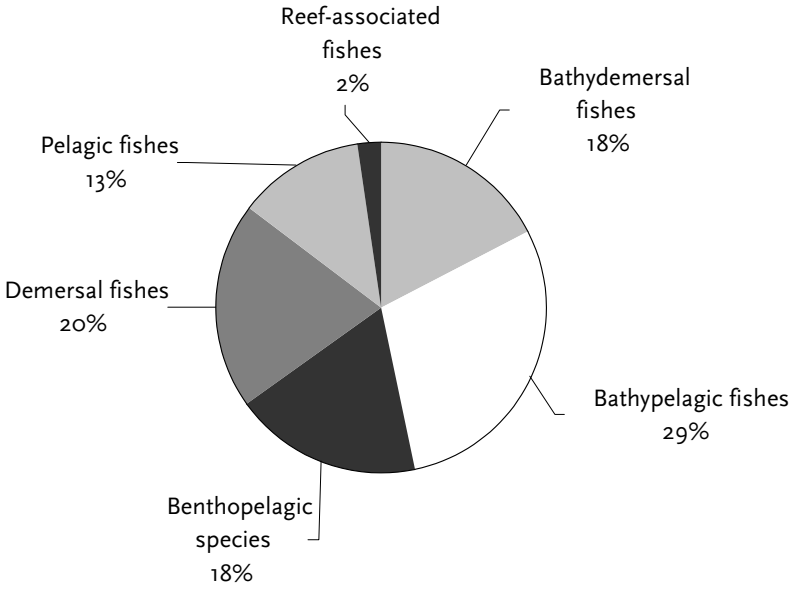

Figure **2**. Contribution of marine fish species by habitat in the Namibian marine ecosystem. Data from FishBase list of marine fishes of Namibia (Southeastern Atlantic, FAO Area **47**; see *www.fishbase.org*).

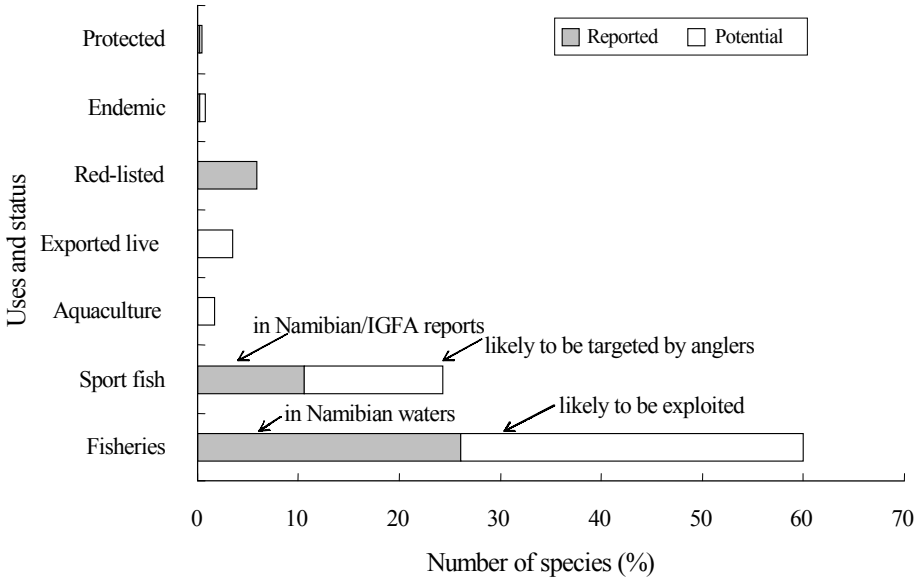

Figure **3**. Number of fish species (n=**407**) by commercial use, status of threat and protection in the list of marine fishes of Namibia (Southeastern Atlantic, FAO Area **47**) extracted from FishBase (see *www.fishbase.org*).

mibian EEZ comprises 64% of waters deeper than 1000 m, 24% between 200 and 1000 m, and 12% between 0 and 200 m (see the *Sea Around Us* Project database at *www.seaaroundus.org*).

The bulk of these fishes, about 65% of the species, are omnivores with trophic levels 3-4, and only about 33% can be considered true carnivores, with trophic levels 4-5. Only about 3% are herbivorous with trophic levels 2-3 (see Willemse and Pauly (this volume) for a trophic level definition and Bianchi *et al*. (this volume) for an analysis of Namibian fish communities). Further analyses of the FishBase data indicate about 34% have commercial use in Namibia and another 42% are reported to have potential commercial value. More than 60% are exploited by commercial and about 25% by the sport fisheries (Figure 3). Three species are currently under the IUCN list of threatened species, i.e. broadnose sevengill shark, *Notorynchus cepedianus* (Data Deficient), yellowspotted catshark, *Scyliorhinus capensis* (low risk/near threatened) and sharptooth houndshark, *Triakis megalopterus* (low risk/near threatened), while two appear in the CITES list of species, i.e., great white shark, *Carcharodon carcharias* (CITES Appendix III for Australian populations) and whaleshark, *Rhincodon typus* (CITES Appendix II).

We do not include in this analysis a discussion of the status of fish stocks and fisheries, as these will be found in other chapters of this book, notably Willemse and Pauly (this volume).

Benthic invertebrates. - Sakko (1998) reports about 200 benthic invertebrate species occurring in Namibia (see Table 1). Our database documents about 70% of these, including 1 Namibian endemic species, i.e. disc lamp shell, *Discinisca tenuis* and 1 endemic to the Benguela: Cape mantis shrimp, *Pterygosquilla armata capensis*. The disc lamp shell is a benthic filter feeder abundant at depths to 25 m off the southern coast of Namibia (Sakko 1998, p. 196). These can attach themselves on top of another to form rafts of shells that are frequently washed up along the driftline (Branch *et al*., 1994). The Cape mantis shrimp, a stomatopod burrowing in soft terrigenous sediments at depths <300 m, and which occurs between St. Helena Bay and the southern border of Namibia, appears to be endemic to that region (Griffiths and Blaine, 1988). It congregates near the surface in large swarms which are preyed upon by seals, hake and other fish (Branch *et al*., 1994).

The bulk of these benthic invertebrates occur in depths at 0-200 m; only the sea spider, *Pallenopsis bulbifera*, a species newly described from the Namibian coast by Munilla and Stock (1984) was taken during the cruise Benguela V of the Fisheries Research Institute at a depth of 260-269 m.

Jellyfishes. - The database includes 7 species of jellyfishes. The dominant jellyfish of the Benguela Current system, *Aequorea aequorea*, is a large medusa

found usually offshore and to the north of Namibia between 0 and 200 m (Sparks *et al.*, 2001). Another species which was abundant in phytoplankton samples obtained by staff of the University of Namibia from the coastal area off Swakopmund is the moon jelly, *Aurelia aurita* (Senn, 2001). Multi-frequency acoustic data collected by Brierley *et al.* (2001) indicate that the high densities of gelatinous macrozooplankton, predominantly the scyphozoan, *Chrysaora hysoscella* found in shallow inshore waters (3 individuals per 100 m^3) and *Aequorea aequorea* found in deeper offshore waters (168 individuals per 100 m^3) of the Benguela system off Namibia in 1999 have become a potentially important physical obstruction to pelagic fishing. Moreover, they may bias acoustic estimates of fish abundance.

Macrozooplankton. - Different krill species dominate the different regions of the Benguela current. The shelf region of the southern Benguela current is dominated by *Euphausia lucens* while that the outer shelf is dominated by *Euphausia hanseni*. The neritic region of the northern Benguela is dominated by *Nyctiphanes capensis* (Pillar *et al.*, 1991). These species have high turnover rates, as they reproduce throughout the year with multiple recruitment pulses and large numbers of eggs per brood. Northern Benguela euphausiids have twice as much biomass as those of the southwest Benguela. Adults are opportunistic omnivores, while juveniles are herbivorous. Pillar *et al.* (1991) report that euphausiids also have a minor impact on the phytoplankton biomass, but have a high predatory impact on other mesozooplankton species. Thus, euphausiids compete directly with various species of fish, which are also the major consumer of euphausiids in the Benguela ecosystem.

Ichthyoplankton. - The eggs and larvae of many fish species are distributed throughout the entire water column, from the surface to depths of 200 m when the upwelling is intense (Olivar *et al.*, 1991). However, ichthyoplankton distribution is clearly segregated between coastal and slope/oceanic areas in intense upwelling seasons in northern Benguela, i.e. the lanternfishes, *Lampanyctodes hectoris* and *Maurolicus muelleri* dominate oceanic areas while *Sufflogobius bibarbatus* dominates the coastal areas. Olivar and Barange (1989) reported that in the 1980s, the most abundant ichthyoplankton species on the Namibian continental shelf and slope were larvae of ringneck blenny, *Trachurus pilicornis*; lanternfishes, *Symbolophorus* sp., *Hygophum macrochir*; and pelagic goby, *Nematogobius bibarbatus* (synonym of *Sufflogobius bibarbatus*; see *www.fishbase.org*). Larval and egg abundance were different between the southern and northern coasts, i.e. the northern coast apparently acted as a nursery area for the majority of the species. Similarly, vertical distribution showed stratification with highest concentrations above the thermocline and upwelling affected the diurnal distribution of anchovy and

sardine eggs and larvae as well as those of king gar, *Scomberesox saurus scombroides* larvae which were most abundant at night. Based on another survey of the area 20-100 miles of the coast between 17°S and 25°S, Belyanina and Stejker (1988) reported that during the non-upwelling period of April-May 1985 and January 1986, ichthyoplankton was scarce with larval oceanic mesopelagic fishes, mainly myctophids, dominating the samples and that at depths shallower than 500 m, the average ichthyoplankton abundance increased with high concentrations of sardine, *Sardinops ocellatus* (synonym of *Sardinops sagax*, see *www.fishbase.org*) and horse mackerel, *Trachurus* spp.

General results

Reviewing the marine biodiversity of a country proved to be much more than assembling a checklist of species occurring in that country. We were able to assemble, from various sources and websites, a list consisting of 1,053 marine species, of which 47% are non-fish species from 212 families and 53% fish species from 163 families. This list includes roughly 70% of the species reported in Table 1. The list assembled in the online database is in no way complete, but all clearly add to existing databases on Namibian marine biodiversity.

Assuming that the data we used here are representative of the species occurring in the Namibian EEZ, one of the results probably reflecting the particular topography of the Namibian EEZ, i.e. narrow shallow shelf area and large oceanic zone with an upwelling area (Sakko 1998), is the predominance of deep-water fish groups, e.g. bathypelagic fishes (15%) closely followed by demersals (11%) and benthopelagic fishes (10%). The next most important groups are high trophic level groups, which include cephalopods, seabirds and marine mammals, together comprising 15%, while benthic invertebrates together cover 13% of the species composition. Figure 4 gives a bird's eye view of the contribution of each functional group, and implies a larger number of high trophic level species. This is biased however, as large, high trophic level and commercially important species are better documented than the small inconspicuous species that are not commercially exploited.

Table 2 summarizes species counts of endemic, commercial, threatened and protected species, and provides counts of the number of species by depth range and habitat. The number of endemic species accounts for 1% of the total number of species listed in the online database, confirming the relatively low level of endemicity reported in Sakko (1998). Commercially important species account for 14%, with fish groups making up 66% of those that are commercially important.

To compare our results with those that would be obtained by an unwary Internet user, we performed a search for 'Namibia' and 'Southeast Atlantic' area through the IUCN (*www.iucn.org*) species search. This resulted in 13

Functional group	Number	Endemic	Commer-cial	IUCN	CITES	0 - 200 m	200 - 1000 m	1000 - 4000 m	Pelagic	Demersal	Benthic
Seabirds	58	3	4	11	38	0	0	0	0	0	0
Marine mammals	35	1	4	13	35	16	30	23	0	0	0
Turtles	5	0	1	1	5	5	0	0	5	5	0
Bathydemersal fishes	97	0	17								
Bathypelagic fishes	160	0	4								
Benthopelagic fishes	102	1	24								
Demersal fishes	111	0	27								
Pelagic fishes	70	0	25								
Reef-associated fishes	12	0	3								
Cephalopods	66	0	8	0	0	27	28	5	30	9	5
Lobsters	10	0	4	0	1	3	3	0	0	0	5
Crabs	43	0	9	0	0	11	14	1	0	15	8
Shrimps and prawns	48	0	14	0	0	7	23	3	10	7	11
Invertebrates											
Ascidians	2	0	0	0	0	2	0	0	0	0	2
Brachiopods	1	1	0	0	0	1	0	0	0	0	1
Crustaceans, Cirripeds	3	0	0	0	0	3	0	0	0	0	3
Crustaceans, Amphipods	14	0	0	0	0	14	0	0	1	0	14
Crustaceans, Harpacticoids	2	0	0	0	0	2	0	0	0	0	2
Crustaceans, Isopods	20	0	0	0	0	20	0	0	0	0	19
Crustaceans, Mysids	1	0	0	0	0	1	0	0	1	0	1

Functional group	Number	Endemic	Commercial	IUCN	CITES	0 - 200 m	200 - 1000 m	1000 - 4000 m	Pelagic	Demersal	Benthic
Invertebrates											
Crustaceans, Stomatopods	1	1	0	0	0	1	0	0	0	0	1
Echinoderms	5	0	0	0	0	5	0	0	0	0	5
Hexacorals	1	0	0	0	0	1	0	0	0	0	1
Hydroids	7	0	0	0	0	7	0	0	0	0	7
Mollusks, Bivalves	11	0	3	0	0	11	0	0	0	0	11
Mollusks, Chitons	4	0	0	0	0	4	0	0	0	0	4
Mollusks, Gastropods	37	0	1	0	0	37	0	0	0	0	37
Polychaete worms	31	0	1	0	0	31	0	0	0	0	31
Pycnogonid	1	0	0	0	0	0	1	0	0	1	0
Zooplankton											
Crustaceans	10	0	0	0	0	3	3	0	10	0	0
Jellyfishes	7	0	0	0	0	7	2	1	7	0	0
Primary producers											
Macroalgae	41	2	3	0	1	10	0	0	0	0	41
Phytoplankton, Diatoms	26	0	0	0	0	0	0	0	26	0	0
Phytoplankton: Dinoflagellates	7	0	0	0	0	0	0	0	7	0	0
Plankton: Protozoa	3	0	0	0	0	0	0	0	3	0	0
Plankton: Bacteria	1	0	0	0	0	1	0	0	0	0	1
Sub-total: Non-fish groups	501	8	52	25	80	230	104	33	100	37	210

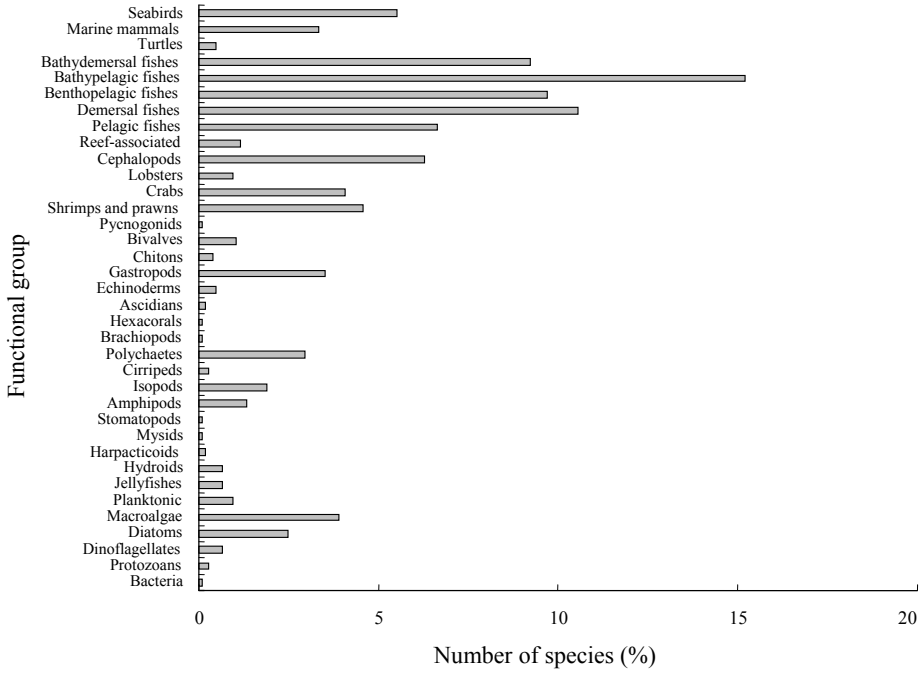

Figure **4**. Number of species (n=**1053**) by functional groups resulting from analysis of the data assembled in the online database for the Namibian marine ecosystem (Southeastern Atlantic, FAO Area **47**; see *www.seaaroundus.org*).

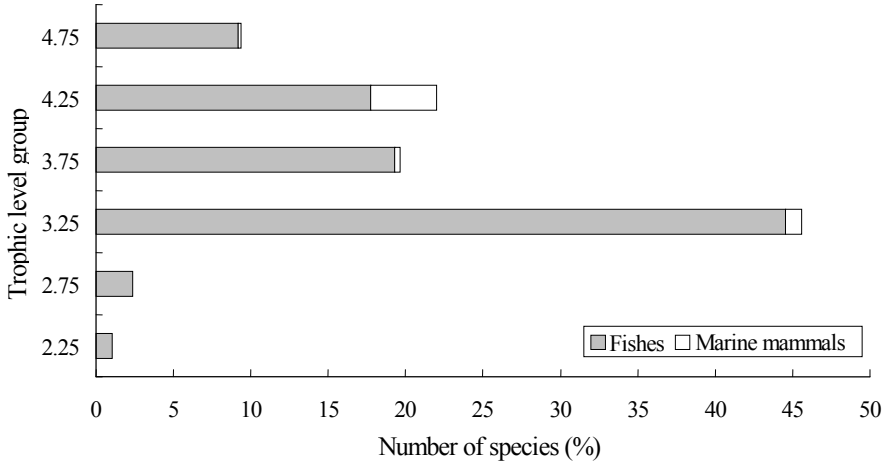

Figure **5**. Number of species (n=**586**) by trophic level groups of fishes (n=**552**) and mammals (n=**34**) in the Namibian marine ecosystem. Fish data from FishBase list of marine fishes from Namibia (Southeastern Atlantic, FAO Area **47**) (see *www.fishbase.org*) and the online database of Namibian marine biodiversity at *www.seaaroundus.org*.

marine species, 9 of which are marine mammals, 3 sharks and 1 turtle. The search did not find seabirds, which should actually have been marked for the Southeast Atlantic as well. Our list contains 28 marine species, i.e. 13 marine mammals, 11 seabirds, 3 sharks and 1 turtle.

A similar search for species listed in the UNEP-WCMC database for Namibia yielded 31 amphibians, 627 birds, 106 fishes, 232 invertebrates, 208 mammals, 216 reptiles, 7 orchids and 459 others. Here, again, habitats were not provided so we examined the list for distinctions by habitat. This yielded 76 species listed in the CITES Appendices I-III, ratified in February 13, 2003 and 6 more which are protected locally by the Namibian government. Of these, 38 are seabirds, 35 marine mammals, 5 turtles, 2 sharks, 1 lobster and 1 macroalga.

In Figure 5, we illustrate the trophic level structure of the Namibian EEZ ecosystem by plotting the number of species (% of total per group) by trophic level group of marine mammals and fishes, considered the top predators of the system. Most marine mammals have trophic levels above 4.0 while fishes tend to have lower trophic levels (see also *www.fishbase.org*).

Namibian legislature protects all marine mammals, marine turtles and seabirds. This contrasts to the level of protection (and research) focused on invertebrates, of which only few are protected, though many are subject to the direct or indirect effects of fishing. More than 33% of benthic invertebrate species in our checklist (see online database, *www.seaaround.org*) are potentially affected by commercial fisheries. However, none of them figure in the IUCN nor CITES lists nor appear to receive any specific protection in Namibia. This result, it must be stressed, is similar to the situation in other countries, which tend to protect vertebrate megafauna, but not 'ugly' invertebrates.

As mentioned earlier, a list such as presented here can never be complete and we will endeavor to update and keep this list available at the website of the *Sea Around Us* Project (see above).

- The first lesson was that online resources are still not sufficient to create acceptable marine biodiversity lists for developing countries such as Namibia. Thus, those attempting to create biodiversity lists to meet the requirement of the membership in the convention on biological diversity will generally have to rely on published sources. In this case, the key references were the early work of Bianchi *et al.* (1999), and gray literature with limited distribution.

- Second, confirming an experience already observed in the process of creating FishBase, we noted that it would be more straightforward for countries interested in creating marine biodiversity lists to team up re-

gionally in the creation of regional or global lists by taxonomic groups, as these can be more efficiently produced, and their species subsequently assigned to countries, than by working country by country.

- Third, the major deficiency and the major need, in this context, is for the creation of global marine invertebrate databases, of which only one so far, 'CephBase', has a global coverage.

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