OFFSHORE FISHERIES OF THE SOUTHWEST INDIAN OCEAN:

their status and the impact on vulnerable species







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Rudy van der Elst and Bernadine Everett (editors)

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SEABIRDS

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10. SEABIRDS

A review of status, distribution and interaction with fisheries in the Soutwest Indian Ocean

Ross M. Wanless[1]

Abstract

The SWIO region has globally significant seabird assemblages, including 11 seabird families, around ⅓ of the world's species, and at least nine endemic taxa. A high proportion of the endemic taxa are of conservation concern, with invasive species on islands and fisheries impacts contributing most to their poor conservation status. Biogeographically, the region's seabirds can best be divided into two main assemblages: the procellariiform-dominated southern waters, and the tuna-associated seabirds of tropical waters. By virtue of their extent and numbers of islands for seabirds to breed, the French territories and Seychelles have the highest seabird diversity, with South Africa's assemblage being both significant in numbers and diversity, and in terms of uniqueness for the SWIO region. Fisheries in the region can have very significant, negative impacts on seabirds, through direct mortality and through reducing food availability (direct competition with seabirds or through removing commensal species with which seabirds associate). Direct mortality can be overcome without major impacts on fishing activities in trawl and longline operations. However the scale and nature of impacts from gillnet fishing in the region remains unknown, and could be significant in areas where high gillnet fishing effort overlaps with the foraging ranges of diving seabirds such as shearwaters and cormorants. Over-exploitation of tuna stocks is expected to have significant impacts on tropical seabirds, and should be investigated. Coordinated monitoring of seabird colonies, if the results are made public, can become a very cost-effective means to track changes in the marine environment. Although identifying marine hotspots for seabirds is relatively new and requires significant new and ongoing research effort, BirdLife International's marine IBA programme offers a rigorous approach that could help fisheries and conservation managers to incorporate seabird considerations in management and spatial planning.

Seabird biodiversity in SWIO

Seabirds are defined as species that derive their sustenance primarily from the sea and which spend the bulk of their time (when not on land at breeding sites) at sea. This definition excludes shorebirds (waders, herons and egrets, ibises, etc.), which derive varying amounts of energy from marine sources but which are essentially terrestrial/freshwater/estuarine. Eleven seabird families occur within the geographical scope of the Soutwest Indian Ocean as breeding species. They are typically referred to as penguins (Spheniscidae), albatrosses (Diomedeidae), petrels and allies (Procellariidae), storm-petrels (Hydrobatidae), diving-petrels (Pelecanoididae), tropicbirds (Phaethonidae), gannets and boobies (Sulidae), cormorants (Phalacrocoracidae), frigatebirds (Fregatidae), skuas (Stercorariidae), gulls and terns (Laridae).

Taxonomic revisions make definitive statements about seabird diversity an invidious exercise. Globally there are ~350 species belonging to the 11 families (plus the alcids which are exclusively northern hemisphere seabirds) that occur in the SWIO region. Around a third of those (i.e. >100 species) either breed on islands in, or are at least occasional visitors to, the SWIO. To place this statistic in some perspective, this is similar to the diversity of seabird species in New Zealand's territorial waters. Most of the seabirds found in the SWIO region fall broadly into three categories: (a) Indo-Pacific or pan-tropical, (b) highly migratory Procellariiformes from high southern latitudes, and (c) predominantly Atlantic species with distributions that are relatively marginal to the SWIO. Consequently, levels of endemism are relatively low compared with other regions. There are, however, at least nine extant, breeding endemics (Table 1) of which five are listed

1. BirdLife South Africa & Percy FitzPatrick Institute, University of Cape Town. Email: rosswanless@gmail.com

as globally threatened, including two critically endangered species (BirdLife International 2008). Half of these are from sub-Antarctic islands, two from La Réunion Island and two from the Arabian seas. The procellariiforms dominate the SWIO endemic seabirds, represented by two albatrosses (Amsterdam *Diomedia amsterdamensis* and Indian Yellow-nosed *Thalassarche carteri*), three petrels (Jouanin's *Bulweria fallax,* Reunion *Pseudobulweria aterrima*, and Barau's *Pterodroma baraui*), the Persian Shearwater *Puffinus persicus* and Salvin's Prion *Pachyptilia salvini*.

Some popular literature considers the St Paul Island-endemic MacGillivray's Prion *Pachyptila macgillivrayi* a valid species (e.g. Onley and Scofield 2007). This awaits genetic analyses or a formal, modern taxonomic treatment. Other dubious taxa include the Round Island Petrel (Mauritius), which is now known to be an extraordinarily rare four-species hybrid complex of *Pterodroma* petrels (Brown *et al*. 2011). The Imperial/King/Blue-eyed Cormorant/Shag *Phalacrocorax atriceps* complex is frequently split into several species, some of which may result in valid, island-endemic taxa in the sub-Antarctic islands of the SWIO. Finally, from the taxonomic disarray that is the cryptic, super-species complex, formerly lumped into Audubon's Shearwater *Puffinus lherminieri*, arises the very doubtful Mascarene Shearwater *Puffinus atrodosalis* (sometimes considered to be part of the Tropical Shearwater *P. bailloni* group (e.g. Onley and Scofield 2007)) and even more doubtful Mohéli/Comoro Shearwater *Puffinus [persicus?] temptator*. More believable but still requiring adequate taxonomic treatment is the Arabian/Persian Shearwater *Puffinus persicus*. See Onley and Scofield (2007) for speculative details on this complex issue.

In addition to some endemic and very range-restricted species, the SWIO region is host to globally important numbers of more widespread seabird species. The Seychelles and French islands together hold significant proportions of tropical seabird populations, some of which have huge numbers of breeding species. The region has 25% of the world's Sooty Terns *Sterna fuscata*, with prodigious colonies at Juan de Nova (French- Mozambique Channel = 2 million pairs), Cosmoledo Atoll (Seychelles = 1.8 million), Bird Island (Seychelles = 1 million) and Europa Island (French- Mozambique Channel = 1 million) (Le Corre and Jaquemet 2005, BirdLife South Africa unpubl data). Aride Island, Seychelles, has >10% of the world's Tropical Shearwaters and Lesser Noddies *Anous tenuirostris*, and Seychelles holds roughly 15% of the global population of the latter (Fishpool and Evans 2001; BirdLife International 2012). Aldabra Atoll has the world's second-largest frigatebird colony, estimated to be 10,000 pairs in 2000, and is the only oceanic breeding site for the Caspian Tern *Sterna caspia* (Fishpool and Evans 2001). For two of the southern African endemic seabirds, the Nelson Mandela Bay area (where the city of Port Elizabeth is located, southeastern South Africa) has always been important for seabirds.

Table 1. Endemic seabirds of the SWIO region and their IUCN-listed conservation status. CR = Critically endangered; EN = Endangered; VU = Vulnerable; NT= Near threatened; LC= Least concern; ? indicates no threat assessment due to taxonomic uncertainty.

Species	*IUCN Status*	*Breeding islands*
Amsterdam Albatross *Diomedea amsterdamensis*	CR	Amsterdam
Indian Yellow-nosed Albatross *Thalassarche carter*	EN	Amsterdam, St Paul, Prince Edward Crozet and Kerguelen archipelagos
Barau's Petrel *Pterodroma baraui*	EN	La Réunion
Jouanin's Petrel *Bulweria fallax*	NT	Socotra Archipelago and islands off Oman
Reunion/Mascarene Petrel *Pseudobulweria aterrima*	CR	La Réunion
Salvin's Prion *Pachyptilia salvini*	LC	Prince Edward, Marion, and Crozet Archipelago
Persian Shearwater *Puffinus [bailloni] persicus*	?	Islands off Arabian peninsula
Socotra Cormorant *Phalacrocorax nigrogularis*	VU	Islands in Persian Gulf and Arabian Sea
Kerguelen Tern *Sterna virgata*	NT	Prince Edward, Marion, Crozet and Kerguelen archipelagos

Subsequent to the implosion of African Penguin (*Spheniscus demersus*) numbers at Atlantic colonies, the SWIO island of St Croix now hosts the largest colony (>8000 pairs in 2011) and ~50% of the global population (>11,000 pairs in 2011 out of an estimated ~23,000 pairs globally) breeds in the Bay (Crawford *et al*. 2011). Similarly, the near-total collapse of Namibia's Cape Gannet *Morus capensis* colonies has resulted in Bird Island, next to St Croix Island, now hosting 65% of the global population (~90,000 out of ~120,000 pairs in 2005/06) (Crawford *et al*. 2007).

For species breeding in the subAntarctic, the SWIO holds significant numbers of several Procellariforms: Wandering Albatross (*D. exulans* – 74% global breeding pairs), Sooty Albatross (*Phoebetria fusca* – 39% global breeding pairs), Light-mantled Albatross (*P. palpebrata* – 32% global breeding pairs), Grey-Headed Albatross (*T. chrysotoma* – 20% global breeding pairs) and Southern and Northern Giant-Petrels (*Macronectes giganteus* and *M. halli* – 30% and 26% global breeding pairs, respectively) (ACAP 2010).

Seabirds and trawler, South Africa. (Photo: Ross Wanless)

Distribution and migration patterns, including important bird areas

There is great variation, mixing and overlap of habitat types and seabird community composition in the SWIO. Nevertheless, broadly speaking one may identify three biogeographic zones with characteristic species assemblages. These are (a) tropical waters (north of ~25°S), (b) the temperate and sub-Antarctic, Procellariiform-dominated waters (south of ~25°S), and (c) the neritic waters of South Africa.

BirdLife International has embarked on a programme to identify marine Important Bird and Biodiversity Areas (IBAs) globally (Howgate and Lascelles 2007), including a strong focus on the SWIO (Derand *et al.* 2009; Kappes *et al.* 2010). At the time of writing no marine IBAs had been formally designated in the SWIO, but reference is made to areas that have been identified as being important to seabirds; it is likely that marine IBAs will coincide with many of the sites described below, and the term IBA is used accordingly.

Tropical waters

These waters are dominated numerically by the tropicbirds (two species), boobies (three species), frigatebirds (two species) and terns (>10 species), with *Puffinus* shearwaters also common, but less abundant and usually less visible than the other groups. None has substantial ranges during breeding. However, because there is not the marked seasonality in the tropics as there is further to the south, there tends to be less rigid periodicity to the breeding cycles, with some species' breeding cycles being less than 12 months. Indeed, it is not unusual to find seabirds present at breeding colonies year-round (Le Corre 2001). The main breeding grounds are the islands off Arabia and the Socotra Archipelago, Seychelles, the Mascarenes and the Mozambique Channel.

Migration patterns are not well understood for most tropical seabird species. With few exceptions, tropical seabirds associate very strongly with tuna, and feed in association with them (Le Corre 2001). As a consequence, their post-breeding dispersal is likely to be linked to broad-scale oceanic features (such as productive upwelling or mixing areas) to which forage fish, and consequently tunas, are attracted. Recent work using tracking technologies to identify foraging ranges of seabirds in La Réunion, Seychelles and other Southern Hemisphere tropical sites has identified five large-scale IBAs in the SWIO (Le Corre *et al.* in press). A sixth important site is located in the central Indian Ocean. The SWIO sites include (i) the Seychelles basin (east of the granitic Seychelles), (ii) the pelagic waters encompassing the Aldabra Group northwards and west of the Seychelles Basin, (iii) from La Réunion southwards, (iv) the area south of Madagascar and (v) the southern third of the Mozambique Channel and southwards to ~30°S. The principal species for which these areas are important are Wedge-tailed Shearwater (i), Greater Frigatebird (ii,v), Red-tailed Tropicbird *Phaethon rubricauda* (v) and Barau's Petrel (iii-v).

Temperate and sub-Antarctic waters

These pelagic waters, sub-Antarctic and cool-temperate islands and the highly productive South African continental shelf waters, are dominated by the procellariiform seabirds (albatrosses, petrels and allies, storm-petrels and diving-petrels) and a cameo role from the Southern Skua *Catharacta antarctica*. In addition, several species of near-shore-foraging larids and cormorants breed here, with only one breeding species (Antarctic Tern *Sterna vittata*) migrating northwards during the austral winter.

The procellariiform seabirds are amongst the most mobile birds on earth, and are capable of traveling prodigious distances, even when foraging to provision chicks (Weimerskirch *et al.* 1997; Croxall and Gales 1998; Baker *et al.* 2007; Rolland *et al.* 2009). Individuals of many species circumnavigate the globe repeatedly when not breeding, or as immatures (BirdLife International 2004). Consequently, efforts to identify 'hotspots', or marine IBAs, are complex and the results often encompass vast expanses of ocean (e.g. Delord and Weimerskirch 2009; 2011).

Many species which breed in the sub-Antarctic SWIO, as well as other Procellariiformes from colonies in both the Atlantic and Pacific oceans, migrate to the South African continental shelf and surrounding waters (BirdLife International 2011). In the austral summer, the numbers of Southern Ocean Procellariiformes in the area drop as adult birds leave to breed. They are replaced by migratory species from the northern hemisphere, including several Procellariiformes and larids (unpubl. data).

Neritic South African waters

The highly productive shelf waters, particularly the Benguela system south and west of South Africa (and north into Angola) have given rise to a suite of endemic seabirds, including Africa's only penguin, the African Penguin, the Cape Gannet, four cormorant species, a gull (Hartlaub's Gull *Larus hartlaubi*) and a tern (Damara Tern *Sterna baleanarum*) (Crawford *et al.* 2006). All disperse after breeding to some extent, and with minor exceptions, all remain in coastal waters. This zone is important for several non-endemic coastal species, primarily the Kelp Gull *Larus dominicanus* and several tern species, that also breed at coastal locations. Finally, a suite of northern hemisphere larids migrate to these waters in the austral summer.

Marine IBAs are likely to be focused on the breeding colonies, which in this part of the Indian Ocean include only St Croix and Bird islands near Port Elizabeth.

Features of seabirds in each of the SWIOFP countries

Of the eight SWIOFP countries, three hold exceptional diversity of breeding species. These are the French islands, Seychelles and South Africa. Between them they have all the major breeding sites in the SWIO, and all the endemic species of the SWIO aside from the two species from the islands of the far northwestern Indian Ocean. Nevertheless, all eight countries have terrestrial IBAs of global importance for seabirds, hosting >1% of the global population of at least one species, or congregations of >20 000 individuals (Fishpool and Evans 2001).

As tracking technology continues to miniaturise, and thereby bringing the technology within reach of researchers interested in smaller, tropical seabirds, we may well discover more pelagic sites that are globally significant. Climate change, and with it the profound, but as yet unpredictable consequences for the marine environment, may also add or subtract breeding and visiting species from the SWIOFP countries' national lists. Case in point is the distribution of the Flesh-footed Shearwater *Puffinus carneipes*, which migrates westward into the SWIO waters from the eastern Indian Ocean.

Field guides to the birds of the region from the 1990s reported this species as incidental from places like Mauritius or Comoros (see Sinclair and Langrand 1998; Onley and Scofield 2007). More recently sightings from both these locations (pers. obs.; V. Head pers. comm.), suggest a possible increased presence in the region. Also, the traditionally sedentary and highly natal philopatric Cape and Australasian *M. serrator* gannets have colonised St Paul Island relatively recently (Lequette *et al.* 1995). Similar changes in abundance or presence can be expected to continue as fishing and climate change continue to shape the distribution of marine biodiversity.

Common Noddy and Sooty Terns, Comoros. (Photo: Ross Wanless)

Comoros

Breeding seabirds in this archipelago are characterised by low numbers and low diversity, mostly common, pantropical species and confined (with two exceptions) to a single offshore stack close to the eastern extreme of Mohéli Island (pers. obs.). Small numbers of White-tailed Tropicbirds *Phaethon lepturus* and the Tropical/Persian/Comoro Shearwaters breed in forested uplands on Mohéli, the latter in sufficient numbers for the site to be declared an IBA by BirdLife International (Fishpool and Evans 2001, K. Green pers. comm.). All seabirds in the region associate strongly with feeding tunas (pers. obs.)

French islands

The French territories in the SWIO stretch from Mayotte in the north to the Kerguelen Archipelago in the deep south Indian Ocean, and include La Réunion, Mayotte, the Isles Esparses (Islands of Bassas da India, Europa, Glorieuses, Juan de Nova, Tromelin), Amsterdam Island, St Paul, and the Crozet and Kerguelen archipelagos. With such a vast biogeographic range, it is small wonder that the French territories encompass six of the SWIO-endemic species listed in Table 1. The territorial waters include virtually all the seabird species typically found south of the equator, with the exception of the coastal species in South African waters. The cool-temperate and sub-Antarctic islands have highly speciose breeding assemblages relative to anywhere else in the region. Although strict quantification has not been attempted, because of this vast biogeographic spread, the French territorial waters collectively are the most biodiverse in the SWIO for breeding seabirds.

Kenya and Tanzania (including Zanzibar)

Local oligotrophic coastal waters are notably depauperate in seabirds and only the small island of Latham, south of Dar es Salaam, has colonies of regional significance with large populations of Masked Boobies, Swift & Sooty terns and Brown Noddies (Crawford *et al.* 2006). Other breeding assemblages include the globally important Roseate Tern *Sterna dougali* (Fishpool & Evans 2001). Offshore, migratory movements of wide-ranging, tropical species add diversity, but small numbers of birds to the countries' seabird communities.

Madagascar

The few intact breeding colonies on offshore islands, in estuaries and remote beaches around Madagascar's coast, host reasonable numbers (globally unremarkable) of relatively common, widespread species – mostly near-shore-foraging terns (Fishpool and Evans 2001). However, the region's offshore islands have not been extensively surveyed (M. Le Corre pers. comm.) and may yet reveal some surprises.

Madagascar's EEZ is important for all the species breeding in, and migrating to, the Mozambique Channel (notably frigatebirds, tropicbirds and terns), and the southernmost waters are part of the IBA identified by Le Corre *et al.* (in press) for Barau's Petrel.

Mauritius

With the exception of the 'Round Island Petrel' hybrid complex, described above, Mauritius has low numbers of common, pantropical seabird species breeding. Southern Ocean Procellariiformes occasionally venture into Mauritian waters, and they are at some risk from tuna longline fishing effort. However, by virtue of its extensive EEZ, Mauritius' waters are assumed to be important for a wide diversity of tropical seabirds, including the endemics petrels of La Réunion.

Mozambique

Here, as in Kenya and Tanzania, there are few major seabird breeding colonies. This is probably due to the lack of suitably remote or inaccessible islands. However, as for Madagascar, the territorial waters of Mozambique are important for all the species breeding in and migrating to the Mozambique Channel (notably frigatebirds, tropicbirds and terns), and the southernmost waters are part of the IBA identified by Le Corre *et al*. (in press) for Barau's Petrel.

Seychelles

The Seychelles is arguably the most important country in the SWIO region for seabirds. Its ~155 far-flung islands combine to create an area of territorial waters that is staggeringly vast: ~1.4 million km². Although it hosts no endemic seabirds, it has the greatest diversity of breeding species in the tropical waters (18 species), and has globally important colonies of several species, with millions of seabirds in total. Several islands or island-groups are of exceptional importance. The assemblages and number of individuals at Cousin and Aride islands in the granitics, the astonishing numbers of Sooty Terns at Bird Island and Cosmoledo Atoll, and the Aldabra Group with both the diversity and numbers of seabirds (especially of large-bodied species such as boobies and frigatebirds) are all recognized internationally as sites of exceptional biodiversity and conservation value.

South Africa

By virtue of the extension into the SWIO, the ranges of all the endemic seabirds of the Benguela Ecosystem, essentially an Atlantic Ocean phenomenon, South Africa holds the most unique and distinctive seabird community. Added to its continental assemblage, being a mix of 'Benguela' endemics and huge diversity of migratory species, are the 26 species that breed at the sub-Antarctic Prince Edward islands in the South Indian Ocean.

Notable hotspots

The small body size of the larid-dominated seabird assemblages in SWIO tropical waters has hampered research into migratory behaviours. This is largely the result of weight constraints for tracking devices (Passos *et al*. 2010 and references therein), which until relatively recently could only be placed on larger species (e.g. Afanasyev 2004). A second constraint is, somewhat ironically, their good conservation status. Expensive remote sensing studies have necessarily focused on species of the highest conservation concern. However, enough is known about foraging ranges during breeding to identify the waters around important breeding colonies as *prima facie* marine IBAs (e.g. Kappes *et al*. 2010).

Le Corre (in press) has summarized current understanding of migratory behaviour of birds in the tropical SWIO. Frigatebirds from Aldabra and Europa range widely, primarily northwards, and into the Maldives area. White-tailed tropicbirds also range extremely widely outside the breeding season, with a hotspot that overlaps with the non-breeding distribution of Barau's Petrel, in the central tropical Indian Ocean.

BirdLife International has used tracking data in the Global Procellariiform Tracking Database to analyse the degree of overlap between tracked populations of procellariiform seabirds in the Indian Ocean and longline fishing effort (ACAP 2007). Subsequent analyses focusing on seabirds from the French islands (Delord and Weimerskirch 2009, 2010, 2011) have confirmed that the entire SWIO area from 25°S southwards is heavily utilized by a diversity of threatened seabirds. Attempts have been made to refine the areas into 'hotspots' for the purposes of identifying areas where species vulnerable to bycatch from tuna longline fishing are at highest risk (Inoue *et al*. 2011). However, scientists at the Indian Ocean Tuna Commission's 2011 meeting of the Working Party on Ecosystems and Bycatch concluded that no reasonable grounds existed for identifying any smaller area than south of 25˚S as a hotspot (IOTC-WPEB07 2011).

Most vulnerable species

None of the typical SWIO tropical species is currently of global conservation concern. However, the two Reunion-endemic petrel species are of high conservation concern, as are most of the larger procellariiform seabirds that breed in or visit the SWIO. The African Penguin and Cape Gannet are the most threatened coastal South African species in the SWIO region.

Interaction with fisheries and issues of bycatch

There are two general and a third very specific negative interactions between seabirds and fisheries in the SWIO. Incidental capture or entanglement with gear, including in longline, trawl and gillnet fisheries, have received a large amount of attention. This is in part due to the physical evidence of negative interactions, in the form of dead birds, which makes the connection between fishing and seabird mortality impossible to ignore. The second risk is more insidious: loss of foraging opportunities due to depleted tuna stocks (Dankwerts *et al.* 2014). The third, direct competition with fisheries targeting low trophic level fish, is difficult to quantify and globally there are few examples (Cury *et al.* 2011).

Fisheries can cause reductions in food through overfishing or competition for the same prey. While direct impacts of overfishing on seabirds can be difficult to prove, there is evidence of overfishing of tuna and tuna-like stocks in the SWIO region (numerous reports on the IOTC website www.iotc.org). Many terns, tropicbirds and noddies, common in tropical and subtropical regions, forage in association with large predatory fish such as tuna (Ramos 2000, Le Corre *et al.* 2012). The tunas drive small forage fish species to the surface, bringing them within the range of seabirds. If the abundance of tuna is reduced through overfishing, these and other seabird species will not be able to forage as successfully (Le Corre *et al.* 2012). The species in the Afrotropical region most likely to be affected by this are the tropicbirds, boobies, frigatebirds, noddies, and Bridled *Sterna anaethetus* and Sooty *S. fuscata* terns (Dankwerts *et al.* 2014).

Red-footed Booby, Seychelles. (Photo: Ross Wanless)

DIRECT SEABIRD MORTALITY FROM FISHERIES INTERACTIONS

Seabirds are characterised as being late to mature and slow to reproduce. For example, many albatrosses do not breed before they are ten years old (e.g. Weimerskirch 1992; Wanless *et al.* 2009). Most seabirds lay a single egg each year, few can lay replacement clutches, and some albatross species produce at most one chick every second year. To compensate for this unusually low fecundity, seabirds are amongst the most long-lived birds, with natural adult mortality typically very low. These traits make adult mortality from anthropogenic sources potentially damaging for population viability, as even small increases in mortality can result in population decreases (Weimerskirch and Jouventin 1987; Finkelstein *et al.* 2008; Wanless *et al.* 2009). To illustrate this, consider the case of the endemic Amsterdam Albatross *Diomedea amsterdamensis* population, which is currently listed as Critically Endangered and breeds only on Amsterdam Island, in the southern Indian Ocean. The population (estimated to a maximum of 180 adults in the world) will decrease if there is an additional mortality of just five adult birds per year (Weimerskirch *et al.* 1997; Weimerskirch 2009).

Fisheries bycatch is the single greatest threat facing many populations of seabirds which breed or visit the western Indian Ocean on a regular basis (Weimerskirch *et al.* 1997; Nel *et al.* 2002; Anderson *et al.* 2011). Longline fisheries globally are responsible for contributing to the poor conservation status of many Procellariiformes (Anderson *et al.* 2011). Albatrosses, in particular, are under extreme pressure with 15 of the 22 species threatened with some level of extinction (and the remaining five species listed as near-threatened). On the positive side, the rich and abundant seabird assemblages in the tropical waters of the SWIO region are largely immune to direct, incidental mortality from longline fishing (or other types of entanglement with fishing gear). The foraging strategy common to virtually all tropical seabirds is to pursue live prey, and so the dead, drifting bait on longline hooks is of no interest to them. This contrasts with the procellariiform foraging strategy, which involves scavenging of dead, floating items (e.g. post-spawning squid). This pre-adapts Procellariiformes to find baited longline hooks extremely effectively.

Seabird bycatch is unnecessary, unintentional and in most cases, largely preventable (Gilman *et al.* 2005). In fact, it not only has disastrous consequences for the birds, but may render certain fishing operations less efficient – for example in longline fishing, when bait loss to scavenging seabirds and seabird captures occupying hooks that would otherwise be available to catch the exceptionally high-value target fish (Brothers *et al.* 1999; Bull 2007). Several simple and effective solutions have been developed that can reduce seabird bycatch significantly in longline and trawl fisheries (Gilman *et al.* 2005; FAO 2009).

Evidence from areas where seabird bycatch was formerly high but has been reduced (e.g. CCAMLR and South Africa) has shown that currently there is no single measure that can effectively reduce seabird bycatch (Waugh *et al.* 2008; Petersen *et al.* 2009). It is important to employ, simultaneously, a suite of measures (Bull 2007; ACAP 2011). Best practice for

mitigation measures as recommended by ACAP (Agreement on the Conservation of Albatrosses and Petrels) includes night setting, appropriate deployment of well designed 'bird scaring lines', and properly weighted lines that ensure that baits sink below the reach of diving seabirds quickly (ACAP 2011). These recommendations apply to pelagic and demersal longlines, although the technical specifications for measures differ with gear type. Encouragingly, the Indian Ocean Tuna Commission (IOTC) followed recommendations from its Science Committee, and at their 2012 meeting adopted a binding resolution for all longline vessels operating south of 25°S to use two of the three measures.

Seabird fatalities in trawl fishing arise from three sources: net captures (diving birds swimming into the path of the open trawl net and being drowned), net entanglements (birds becoming entangled with the net) and cable strikes. Strikes against the net sonde, or sensor cable, were identified in the early 1990s (Bartle 1991), leading to the banning of the use of net sonde cables in several fisheries (e.g. CCAMLR 1998). Negative interactions with trawl net cables (or warps) have only been recognized and quantified relatively recently (Sullivan *et al*. 2006; Watkins *et al*. 2008). However, due to the sheer scale of the fishing effort of many trawl fisheries, comparatively low rates of fatal interaction can still multiply up to very substantial total mortalities. In South Africa, seabird mortalities were estimated to be 18,000 birds per year (Watkins *et al*. 2008). Bird scaring lines were introduced in 2006, and have proven to be almost completely effective in eliminating warp strikes in South Africa (Maree *et a*l. 2014). In sharp contrast, trawling operations in the tropical reaches of the SWIO have a negligible direct impact on seabirds. This is because trawling is mostly confined to shrimp trawling which seldom if ever records seabird bycatch and moreover, trawling is prohibited in all the small island states of Seychelles, French *Eparses* and the Mascarenes – all areas of high seabird abundance. However, the development of new trawl fisheries should be assessed for risks to seabirds before being authorised.

A third capture fishery technique that is of unknown scale and unquantified risk to seabirds in the region is gillnet fishing. Gillnet fishing is known to pose a huge risk to diving seabird species elsewhere (Melvin *et al*. 1999; Darby and Dawson 2000), and is assumed to pose similar risks within the SWIO. Large-scale driftnets (>2 km long) were banned by the United Nations from use on the high seas, but several coastal fishing nations in the northern Indian Ocean are known to fish in contravention of this ban (IOTC-WPEB07 2011), and any developments along this line in the SWIO region should be monitored and curtailed. That said, few breeding seabird species in the region have diving foraging behaviour that renders them highly susceptible to gillnet fishing.

Recommendations

Understanding where seabirds concentrate at sea is a precursor to implementing at-sea conservation actions and spatial protection. The Nairobi Convention has endorsed the concept of marine IBAs as a tool to assist in spatial conservation planning, and IBAs have been used extensively in defining the Convention on Biological Diversity's 'Ecologically or Biologically Significant Areas' (EBSA) programme.

***Recommendation*: Marine IBAs should be identified and integrated into national and regional fisheries planning (where appropriate, and without necessarily indicating no fishing in IBAs) and marine protected area networks. South West Indian Ocean Fisheries Commission (SWIOFC) should include EBSAs and marine IBAs (national and in the high seas) as sites of concern which require additional caution when considering fishing activities and possible fishing impacts on marine ecosystems and species.**

There is a widespread misperception that negative interactions between seabirds and fisheries are primarily the domain of longliners. Two other fishing impacts within the SWIOFP area are of concern. Gillnet fishing poses very significant risks to seabirds elsewhere (Zydelis *et al*. 2009) and should be investigated where diving birds (in particular Socotra Cormorant and all shearwaters) occur. The second is the risk of population decreases of tropical seabirds from reduced numbers of commensal species – primarily tunas and cetaceans (Dankwerts *et al*. 2014).

***Recommendation*: SWIOFC should collaborate with the IOTC secretariat to assess possible impacts of tuna stock depletions on tropical seabird species.**

Fairy Tern, Seychelles. (Photo: Ross Wanless)

REGIONAL OBSERVER SCHEMES

Independent, on-board fishery observer programmes are globally recognized as the best, and in many cases the only way to collect reliable information about fishing impacts on target and non-target stocks (e.g. Tuck 2011; Tuck *et al.* 2011). They are also crucial for collecting information about the degree of use and for assessing the effectiveness of various seabird bycatch mitigation measures. A shortcoming of some regional observer schemes is that they fail to require the submission of data to a centralized database (Wanless and Small 2011). This restricts the utility of such schemes in providing useful, region-wide, ecosystem-level data that fisheries managers and RFMOs can access readily for managing fisheries impacts. Elsewhere, such as within the CCAMLR region, all fishing vessels are required to carry at least one independent scientific observer at all times, and the observer data are centrally managed. This has allowed CCAMLR to respond quickly and effectively to a range of issues, including seabird bycatch, which has now been reduced to negligible levels thanks to 100% compliance with conservation measures (CCAMLR 1998; Waugh *et al.* 2008).

Recommendation: SWIOFC should initiate a regional scientific observer programme for all sizeable fisheries under its ambit.

ON-BOARD COLLECTION OF SEABIRD ABUNDANCE AND DISTRIBUTIONAL INFORMATION

Seabirds are frequently the most visible indicators of productive marine areas. At sea, fishermen commonly use seabird flocks to locate schools of target fish. Understanding seasonal and spatial patterns in seabird abundance, and how these might shift with climate change and altered fishing practices or fishing areas, is of great scientific interest. However, tracking studies are necessarily limited in scope due to financial and logistical constraints. At-sea atlas data from observers on board fishing vessels or research cruises is a valuable, relatively low-cost option for collection large volumes of coarse atlas data, and has been used already to identify marine IBAs elsewhere (e.g. Amorim *et al.* 2009). This would require dedicated training of a few observers, as at-sea identification of flying seabirds is a specialist skill. Nevertheless, the scale of fishing operations in the SWIO region affords tremendous potential for voluminous and valuable at-sea data collection.

Recommendation: Observer training courses should deliberately identify individuals with an aptitude for seabird identification and methodological rigour, and train them in AS@S data collection and accession systems – see databases section for a description of this project.

Conclusion

Most conservation efforts for seabirds relating to mitigating impacts from fisheries will require concerted and coordinated approaches. Seabirds are the most international of all birds, spending more time than any other bird group in international waters, which are by definition beyond national jurisdictions. Most species within the WIO are migratory or dispersive outside the breeding season to some extent, and can be expected to cross national boundaries and enter into international waters.

The meta-population dynamics of the more widespread and commoner seabirds in the WIO region are poorly understood, and losses of breeding colonies or subpopulations in one area cannot necessarily be compensated for by healthy colonies or subpopulations elsewhere. Fortunately, seabirds are the most conspicuous components of above-water marine biodiversity, making them easier to monitor than virtually any other group of marine animals. Secondly, they are obligate terrestrial breeders, returning predictably to colonies to lay eggs and raise their young. This facilitates more accurate counting and estimation of productivity (and other vital rates) than most marine species with which marine scientists and stock assessors are accustomed to working.

Coordinated monitoring of seabirds at colonies and at sea will serve multiple trans-boundary diagnostic analyses, providing that data are suitably reliable and accessible. It is incumbent on nations and intergovernmental organisations such as SWIOFC to monitor and assess the impacts of capture fisheries on non-target associated and dependent species, including seabirds. The known and likely impacts of fisheries on seabirds described above provide a *prima facie* case for contributing to regional/international seabird data collection protocols (see databases below). However, as already noted, seabirds are highly conspicuous, and are dependent on or indicators of many of the target species in SWIO fisheries. Therefore monitoring their patterns of abundance and distribution, as well as other parameters (such as breeding participation, adult body condition, chick provisioning rates, etc.) can provide important corroborative evidence or early warnings of adverse marine conditions that may impact negatively on important commercial or artisanal fisheries.

BirdLife International's Important Bird Areas programme, which includes marine IBAs, is listed as a key contributor to many objectives in the Strategic Action Plan (SAP). The IBA programme speaks to coastal zoning objectives, the identification of critical habitats and development of management approaches, regional monitoring of and evaluations for critical habitats, and through the various databases that BirdLife International runs, the management of regional information.

Known databases

- **BirdLife International Datazone**
  http://www.birdlife.org/datazone/home
  This searchable, online database contains information, maps and reports on the conservation status of all 10,000 of the world's bird species, as well as site descriptions of >10,000 Important Bird Areas. The marine atlas http://www.birdlife.org/marine is a work in progress, but has several hundred marine IBAs already identified.

- **The Global Procellariiform Tracking Database**
  http://www.seabirdtracking.org
  This is a central store for seabird tracking data from around the world. Data can be searched and viewed (subject to owner's permissions) within the site, but access to actual tracking data is restricted within a request process. There are plans to expand this to include tracking data from all seabirds, or to make the site fully interoperable with other seabird tracking and environmental/habitat (e.g. chlorophyll-a and SST) databases.

- **BirdLife International seabird foraging range database**
  http://seabird.wikispaces.com/home
  This is an online, database compilation of seabird ecology and foraging ranges. Its stated purpose is to use this information to help identify marine Important Bird Areas, inform Protected Area designation and input to marine spatial planning.

- **World Seabird Union**
  http://seabirds.net
  This site was under construction at the time of writing, but intends to become the central portal for seabird information, as well as the primary repository for some important databases, such as a seabird colony register, a seabird monitoring database and possibly a survey database. It also has an interactive map displaying seabird study metadata, with the intention that it becomes global and comprehensive.

- **Wetlands International/Ramsar sites database**
  http://ramsar.wetlands.org/Database
  This site provides information of all wetlands of international importance. It is a searchable database, fully accessible through the internet with a password protected data entry system, and a reporting system for public use. However, the quality of data publically available is generic, non-specific and of limited utility.

- **Indian Ocean Tuna Commission (IOTC)**
  http://www.iotc.org/English/data.php
  The Secretariat of this tuna commission maintains databases on nominal catch (from 1950), discards (not available for download), catch and effort (from 1998), and other statistics. All documents submitted to the various working parties and meeting reports are also available from this site.

- **The Agreement on the Conservation of Albatrosses and Petrels (ACAP)**
  http://www.acap.aq
  The data portal on this site links to comprehensive assessments of all the ACAP species, islands and breeding sites, Regional Fisheries Management Organisations and reference literature.

- **Atlas of Seabirds at Sea (AS@S)**
  http://seabirds.saeon.ac.za
  An open-access online database of at-sea survey data, including digitized records starting in the 1950s and continuing to the present. The protocols and data sheets are available online, and the system follows a simple and very flexible data collection principle. All data on this site are freely downloadable.

- **The Scientific Committee on Antarctic Research (SCAR)**
  http://www.scarmarbin.be
  This is a website containing data, including seabird distributional data, primarily of Antarctic relevance, but extending into the southern Indian Ocean.

White-tailed tropicbird, Seychelles. (Photo: Ross Wanless)

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