Seabird Conservation Handbook for West Africa

(for Mauritania, Senegal, The Gambia, Guinea-Bissau, Guinea, Sierra Leone & Cabo Verde)

BirdLife INTERNATIONAL

MAVA FONDATION POUR LA NATURE

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Front cover photo: Red-billed Tropicbird *Phaeton aethereus*, Cabo Verde. © BirdLife International.

Back cover photo: Great Cormorants *Phalacrocorax carbo*, Ile de Gorée, Senegal. © Tim Dodman

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Great White Pelicans in flight © Tim Dodman

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Introduction

WHO SHOULD USE THIS WORKBOOK?

Seabirds are in danger around the world. Over half (57%) of the world's 359 species are known to be in decline and almost a third (30%) are considered globally threatened (19 Critically Endangered, 34 Endangered and 58 Vulnerable), whilst a further 11% are listed as Near Threatened (BirdLife International 2022). Understanding their biology, the causes of their decline, conservation actions, and monitoring their populations are necessary to prevent their disappearance. The marine waters off West Africa are highly productive, supporting an array of seabirds. However, this productivity is under threat, and conservation of the region's seabirds is needed into the future.

This handbook aims to encourage and facilitate this process by providing an overview of the region and its seabirds and the key threats they face, and introducing conservation and monitoring measures to help to mitigate threats and improve conservation status. This handbook is thus intended for all actors and decision-makers motivated by and involved in the conservation of seabirds in West Africa, especially in countries between Mauritania and Sierra Leone and in Cabo Verde. It is particularly aimed at managers of protected areas of the coastal and marine zone of West Africa, and all sites where seabirds breed. Other key actors include researchers and staff and volunteers of environmental NGOs and networks. The handbook is especially relevant for students, notably those interested in the marine environment and/or ornithology. The handbook should further be useful for those engaged in managing, monitoring or researching the marine waters of West Africa for different purposes and in planning their utilisation, including for fisheries, industrial and energy developments.

This handbook refers to other works that provide further detail on certain aspects. For example, the reader may refer to Veen & Mullié (2015) in relation to monitoring colonial breeding gulls and terns of the West African coast, or to Rizk *et al.* (2011) for guidance in writing a management plan for Marine Protected Areas of West Africa.

ORGANISATION OF THIS BOOK

This handbook deals with the biology and ecological characteristics of seabirds in **part 1**, which also introduces seabirds that occur in West Africa and the region itself. In **part 2**, the main threats to seabirds and causes of their decline are discussed. **Part 3** focuses on conservation actions, especially to deal with the threats described. The strategies and the implementation of action plans as well as conservation tools such as a protected areas and other designations are highlighted in **part 4**. An introduction to monitoring seabird colonies and other areas necessary for the conservation of seabirds is given in **part 5**.

Words in blue in the text are defined in the Glossary. 'Toolboxes' provide useful and free tools for conservation and ornithology projects or studies.

Figure 1: Bridled Terns Onychoprion anaethetus, Parc National des Iles de la Madeleine, Senegal © N. Diop.

BirdLife's conservation efforts for seabirds in West Africa

The importance of West Africa for seabirds is highlighted by the designation of marine IBAs - areas that are essential for the persistence of seabirds and global biodiversity. A lack of up-to-date and accurate information hampers conservation efforts, as basic data on population trends and key feeding areas on which important conservation decisions can be built are limited. A concerted effort has been underway since the 2010s to collect essential information about the abundance and distribution of seabirds through initiatives such as BirdLife's West Africa Marine Conservation Programme. This programme, which has updated the network of marine IBAs, addresses some of the main threats to seabirds, including mortality in the fishing industry, emerging threats from oil and gas development, sources of disturbance, and direct impacts on seabird colonies. It started in 2013 with the regional Alcyon project for the conservation of seabirds in West Africa, with funding from the MAVA Foundation, which enabled identification of a network of 13 marine IBAs off West Africa, and development of a strategic document highlighting key threats and conservation actions. Further projects have focused on improved conservation of seabirds in the sub-region, including a seabird project in Cabo Verde, with continued support from MAVA and other partners.

Such regional efforts aim to contribute to a safer marine environment for seabirds. Effective seabird conservation requires a regional approach with strong coordination and cooperative efforts between countries. The development of various multinational conservation efforts and the existence of international agreements and treaties provide a platform to overcome this.

Part 1 Introducing seabirds and where they live in West Africa

1A. CHARACTERISTICS AND ORIGIN OF BIRDS

Currently, **11,147 species of birds** have been identified from the poles to the equator (http://datazone.birdlife.org/species; 11/2020). All birds are in the order Aves; they are diverse in size, appearance and behaviour, showing amazing adaptations to different habitats and climates. They can range in size from a few centimetres long to over 3 metres - 3.7m wingspan for large albatrosses of the *Diomedea* genus.

Birds are warm-blooded, egg-laying feathered animals with toothless beaks and largely air-filled (pneumatic) bones, which increase rigidity and which function well for flight. Most birds fly, but not all, including some seabirds, notably penguins, which are powerful swimmers. Birds are the last living representatives of dinosaurs, having evolved from feathered dinosaurs. Birds even coexisted with dinosaurs at the end of the Cretaceous period (> 66 million years ago). The oldest bird fossils date back 150 million years. Some birds survived the 5th (Cretaceous-Tertiary) extinction crisis 65 million years ago; their descendants evolved to the species we know today (Clarke *et al.* 2005).

Modern birds (Neornithes) evolved from a group of meat-eating dinosaurs known as theropods. Early groups to specialise in aquatic and marine environments include the extinct Hesperornithes, which were diving animals closely related to birds, and ancestors of two current orders of seabirds – the Procellariiformes (albatrosses, storm-petrels, petrels and shearwaters) and Pelecaniformes (pelicans). However, early seabirds could not have been diversified for a long time because marine ecological niches were largely dominated by pterosaurs in the air and by marine reptiles in water. The disappearance of most of these reptiles during the Cretaceous-Tertiary crisis probably favoured the diversification of seabirds in these environments when competition reduced. Today, BirdLife International recognises **359 species of bird**s as seabirds (Dias *et al.* 2019).

As birds are present in the vast majority of ecosystems, they serve as excellent bioindicators of the ecological health of the environment. Thus, population trends in bird species can reflect changes within an entire ecosystem. This is particularly true for seabirds, which are mostly predators at the top of the food chain.

1B. CHARACTERISTICS OF SEABIRD

What is a Seabird?

Seabirds are birds that spend part or all of their lives interacting with the marine environment. More precisely, a seabird is defined as a species for which a large proportion of the population rely on the marine environment for at least part of the year (Croxall *et al.* 2012). Seabirds do not represent a single taxonomic group, but are divided into nine orders of birds (), each representing a specific group of birds with their own characteristics.

The different orders of seabirds represented in West Africa are summarised below:

- **Anseriformes / ducks and geese:** There are several species of seaduck in the northern hemisphere, plus steamer-ducks in South America. Only one species of seaduck, the Common Scoter *Melanitta nigra* reaches coastal northern Mauritania.

- **Podicipediformes / Grebes:** Grebes are small to medium sized waterbirds, several of which spend the non-breeding season largely at sea. Only two species regularly occur in West Africa, only one of which is considered a seabird, the Black-necked Grebe *Podiceps nigricollis*, which has become regular in the Senegal Delta.

- **Charadriiformes:** This large order includes a number of bird families, some of which are considered as both waterbirds and seabirds. In Western Africa, the main family represented is the Laridae, which includes **gulls** and **terns**, which are especially well-represented in the coastal waters of West Africa, including some with important breeding colonies. Noddies are pelagic terns; two species occur in the Atlantic waters of Africa, but are only vagrant to the region. Skimmers are also members of the Laridae family, but are not considered as seabirds; the African Skimmer *Rynchops flavirostris* occurs in West African wetlands. The Charadriiformes order also includes the Stercorariidae (**skuas** and **jaegers**), some of which are passage migrants or non-breeding visitors to the marine waters of West Africa. The order also includes the Alcidae or auk family, which are not represented in West Africa. However, three species, Atlantic Puffin *Fratercula arctica*, Razorbill *Alca torda* and Common Murre or Common Guillemot *Uria aalge* all occur off Morocco, and vagrants may occur in West Africa at sea. The order also includes phalaropes, small shorebirds that spend the non-breeding season at sea; (these are not listed as seabirds however by BirdLife).

- **Phaethontiformes / Tropicbirds:** Tropicbirds are elegant mostly white seabirds with long tail streamers, with a largely tropical distribution. In West Africa, they are represented by Red-billed Tropicbird *Phaeton aethereus*, which breeds in Cabo Verde and at one site in Senegal and White-tailed Tropicbird *Phaethon lepturus*, recently found in Cabo Verde.

- **Procellariiformes:** This large order of seabirds includes albatrosses, storm-petrels, petrels and shearwaters. **Storm-petrels** are very small tube-nosed seabirds, with two families – the southern (Oceanitidae) and northern (Hydrobatidae) storm-petrels – both represented in Western Africa, with the latter including species that breed in Cabo Verde. Away from breeding, storm-petrels are exclusively marine. The Procellariidae family includes **petrels** and **shearwaters**, which occur in Western Africa as non-breeding visitors, whilst a few species also breed in Cabo Verde. They are strictly marine away from their breeding sites.

- **Suliformes:** This order includes **frigatebirds**, **gannets** and **boobies** and **cormorants** and shags. Frigatebirds (Fregatidae) are long-winged seabirds with forked tails, with only one species represented in the region, the Magnificent Frigatebird *Fregata magnificens*, which used to breed off Boavista, Cabo Verde. The Sulidae family are large long-winged seabirds, with four species occurring in Western Africa. There are two members of the Phalacrocoridae family in Western Africa, one of which, Great Cormorant *Phalacrocorax lucidus*, is considered as a seabird.

- **Pelecaniformes / pelicans:** Pelicans are large heavy birds of coastal and inland wetlands, with a large gular pouch. There are two species in Western Africa, one of which, Great White Pelican *Pelecanus onocrotalus*, is considered as a seabird. The Senegal Delta supports an important breeding population.

There are two orders illustrated in Figure 2 that are not represented in Western Africa – the **Gaviiformes** (divers or loons), which have a high latitude distribution, and the **Sphenisciformes** (penguins), which are restricted to the Southern Hemisphere.

Figure 2: Bridled Synthesis of seabird taxonomy. Seabirds are recognised to occur in the orders shown. Some orders contain many species that are not dependent upon marine resources and thus not considered seabirds, especially the order Charadriiformes, which includes all the waders or shorebirds.

Introducing Seabirds

Seabird habitats

Some seabirds are highly pelagic (inhabit the open sea) and only use land for breeding, often on islands. Most of these are masters of flight, and can cover extensive distances every day, such as albatrosses and shearwaters. Frigatebirds are supreme aeronauts, and rarely even rest on the water's surface. Other seabirds spend much of their time on and in the water, including cormorants and seaducks, surface diving for food. Some seabirds are more marine outside the breeding season, including skuas and terns. Many seabirds prefer coastal waters to the open sea (and are termed neritic feeders), for example shags, while others depend heavily on the land during all seasons, such as pelicans.

Foraging

Most seabirds feed predominantly on fish, and have adapted specialist behaviour to capture their prey. Some seabirds feed off the water's surface, including storm-petrels, which feed mostly on zooplankton. Most terns feed by surface-dipping, whereas gulls are opportunistic in their diet, and also feed away from the water. Petrels and shearwaters can detect food from long distances, and largely scavenge at sea using hook-tipped bills. Gannets and boobies plunge-dive for fish in a spectacular fashion, sometimes in groups, and many metres down. Cormorants chase fish underwater, propelled by their webbed feet, catching them with their hooked beaks. Great White Pelicans *Pelecanus onocrotalus* feed from the water's surface, often communally, scooping fish with their long beaks and gular pouches (Figure 3).

Breeding

A large number of seabirds breed in colonies, especially on islands. Most terns and gulls breed often in tight colonies on the open ground, especially on low sandy islets in West Africa, whilst other ground-nesting seabird colonies may be looser and spread-out. Some colonial seabirds, breed on coastal cliffs or ledges, including Brown Booby *Sula leucogaster* in Cabo Verde. Tropicbirds may also nest on cliffs or in crevasses. Most storm-petrels, shearwaters and petrels largely breed underground in burrows or in hollows in cliffs and under boulders. The White-faced Storm-petrel *Pelagodroma marina* nests in dense underground warrens on islets of Cabo Verde.

Figure 3: Group of Great White Pelicans *Pelecanus onocrotalus* fishing communally at Parc National des Oiseaux du Djoudj, Senegal. © Tim Dodman.

Adaptations of Seabirds

Seabirds are adapted to marine life and show several common characteristics, especially those imposed by the salty aquatic environment. These include:

Salt excretion

Salt, or sodium chloride (NaCl), is at a high level in seawater and can be abundant in the food of marine animals, which must develop strategies to excrete excess salt. Osmoregulation refers to the mechanisms to regulate water and electrolyte levels in their bodies; this is a key role of the kidneys. In addition, most seabirds have nasal or orbital salt glands located in cavities above their eyes, as an extra osmoregulatory system. When salt levels increase in their bloodstream, their salt glands are activated to extract salt from the blood and into a tube that empties through the birds' nostrils (Figure 4). Often, liquid can be seen dripping from a seabird's beak as a result of this process.

Seabird plumage

Some seabirds' plumage is adapted to provide camouflage in the marine environment. A pale ventral side is barely visible when viewed from below, with little contrast against a brighter sky background, whilst a black dorsal side blends with the dark background of the sea. However, not all seabirds show this kind of plumage pattern. Cormorants and skuas are largely all dark, as are many species that become largely nocturnal during breeding, such as storm-petrels. A lack of pigmentation can favour tightness of the plumage. However, melanin (a dark brown/black pigment) strengthens feathers subject to air friction, and this may explain dark plumage colours, notably at the leading edge of the remiges (the primary and secondary feathers of a bird's wing), which is most often black.

Sexual dichromatism - the colour differences between males and females - is almost absent in seabirds (Eliason & Shawkey 2011). However, ultraviolet colours may be present among some species, although these are invisible to the human eye.

Nesting habits

Most seabirds live predominantly at sea, but all need the terrestrial environment in order to lay eggs and raise their young. Breeding sites are often on islands, ideally those lacking or limited in predators. The limited space available on smaller islands has concentrated some seabird breeding populations into colonies. Such gatherings can confer advantages to birds on the exchange of information on fishing grounds (grouped departures) and on protection against certain predators (dilution effect). Around 95% of seabird species are colonial breeders (Coulson 2002). Seabirds are long-lived, becoming sexually mature relatively late, and they mostly lay few eggs (most often one to four per breeding season), whilst some species do not breed every year.

While there has been much debate about the origins of colony nesting, and the relative costs (e.g., parasite spread, competition for food nearby the colony) and benefits, several studies have demonstrated that young birds simply copy successful breeders and use social cues such as sound and breeding displays to help them learn the courtship and nesting rituals needed to succeed at breeding (Boulinier *et al.* 1996).

Seabirds that breed along coastlines have historically been more subject to predation than island-breeding birds, and therefore tend to produce more chicks. A bird's eggs can provide insights into breeding conditions and pressures. Seabirds that lay a number of often camouflaged eggs, such as terns, have largely coevolved with a risk from predators. Tern colonies of West Africa are mostly found on sandy islets, where they lay speckled eggs on the sand (Figure 5). Seabirds that nest in burrows tend to produce white eggs that are visible in the burrow for parents.

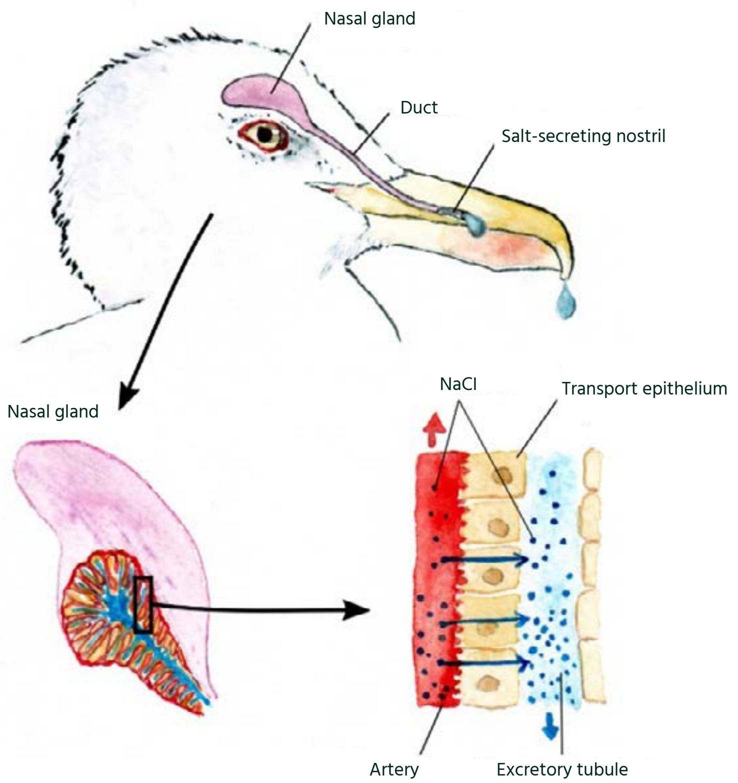


Figure 4: Osmoregulation in seabirds by salt glands, which help them to excrete salt.

Figure 5: Royal Tern *Thalasseus maximus* colony, Parc National du Delta du Saloum, Senegal. © Hanneke Dallmeijer-VEDA.

Feeding: seabirds as marine predators and scavengers

Seabirds are predators or scavengers that feed in the marine environment, either in the coastal zone or in the open sea. Most seabirds have developed abilities to move on or under the water, and have webbed feet. Their appearance helps to distinguish their different movement and feeding strategies, including surface feeding, dipping and plunge diving.

Penguins are so admirably adapted to diving that they are now unable to fly due to their massive hydrodynamic body and their fins. The Emperor Penguin *Aptenodytes forsteri* holds the diving record of 564m deep (Ropert-Coudert 2018). For flying seabirds, wing shape gives clues to their flight mode; the longer and narrower the wings, the better the adaptation to gliding (e.g., pelicans, albatrosses, frigates). Gliders feed at the water surface, their wings being difficult to manoeuvre underwater. Gannets and boobies (family Sulidae) can withstand impact of plunge diving at about 100 km/h thanks to air bags under the skin of the face and breast. Their nostrils are located at the corners of their mouth instead of on the beak to prevent violent entry of air or water as they enter the water.

Nocturnal habits

Some seabirds are largely nocturnal, including many petrels, shearwaters and diving-petrels (Procellariidae) and storm-petrels (Oceanitidae and Hydrobatidae). This could be an adaptation to reduce the risks from predators and/or diurnal parasitic birds or kleptoparasites, e.g., frigates, skuas and some gulls, which may steal their caught food. Most nocturnal species have developed a very acute sense of smell. Seabirds seem particularly sensitive to the odour of dimethyl sulphide (DMS), a molecule released when phytoplankton is browsed by predators (Nevitt 2008).

Breeding: a low fecundity

Most seabirds have a low annual reproduction and late sexual maturity (e.g., between five and thirteen years of age) and provide parental care for their young. This breeding strategy only succeeds under low levels of predation at breeding colonies, as well as under a generally stable breeding environment, not prone to significant or longer-term threats, such as climate change. Colonies are very often located on islands or isolated continental areas with few predators. Species specialised in feeding far offshore (pelagic seabirds) tend to have few chicks to raise per breeding season (usually one), whilst coastal breeding species subject to higher predation risk have higher fecundity and will try and raise two or more chicks. The main factors limiting seabird population growth are food resources and availability of nesting sites. However, the reproduction strategy of low fecundity has become risky due to increasing anthropogenic disturbances. Invasive alien species, pollution, overfishing, bycatch, climate change, among others, increase individual mortality and endanger the viability of populations (see part 2: Threats).

The ocean paradox

Planet Earth is predominantly oceanic, yet only 359 of 11,147 bird species, or 3%, are marine. This observation is explained mostly by:

1. The uniformity of ocean ecosystems. There are few ecological niches at sea, and competition for resources is intense; the species most suited to these niches supplant the others (competitive exclusion).

2. Seabirds are frequent travellers. The low isolation of populations limits the potential for evolution into new species.

3. Other organisms, notably carnivorous fish (sharks, tuna, etc.) and some marine mammals can evict seabirds from their ecological niche as marine predators by competition.

The diversity of seabird species is low in this vast oceanic system. Seabird endemicity is also limited compared to terrestrial species, although seabirds may often be endemic to specific breeding sites, such as the Cape Verde Petrel or Gon-gon *Pterodroma feae* and Cape Verde Shearwater *Calonectris edwardsii*, both of which only breed in Cabo Verde.

1C. SEABIRDS IN WEST AFRICA

The productive waters off West Africa are an important area for coastal and pelagic seabirds. The region is one of the richest upwelling systems on the planet, and thus attracts a diversity of ocean life as well as international fishing vessels. Local breeding and migrating seabird species depend on this area full of resources. Protecting these birds from marine and terrestrial threats is crucial for their conservation. Our knowledge of the distribution and abundance of seabirds is limited by the current availability of data, but it is clear that this region (coastal and offshore Mauritania to Sierra Leone and Cabo Verde) is home to some 56 species of seabirds (Table 1). The region includes a number of sites that are important for seabird reproduction, especially in Cabo Verde for birds breeding in burrows and on cliffs, and between Mauritania and Guinea for birds breeding on sandy islets. The region includes important feeding areas for resident and migratory birds.

In Table 1, conservation status is based on the IUCN Red List of Threatened Species (www.iucnredlist.org), which uses a set of standardized criteria to assess the threat of extinction of a species (see Toolbox: IUCN Red List).

Table 1: List of seabirds encountered in the coastal zone and marine waters of West Africa between Mauritania and Sierra Leone and in Cabo. B = breeding (current or recent). P = present during non-breeding season or on passage or probable passage, which may include some vagrant records. Sources http://www.birdlife.org/datazone/country/, BirdLife International (2020), Borrow & Demey (2014), Barlow & Dodman (2015).

Family	English name	Scientific name	Red List Category	Cabo Verde	Mauritania	Senegal	The Gambia	Guinea-Bissau	Guinea	Sierra Leone
Anatidae (Ducks, Geese, Swans)	Common Scoter	*Melanitta nigra*	LC		P					
Podicipedidae (Grebes)	Black-necked Grebe	*Podiceps nigricollis*	LC		P	P				
Phaethontidae (Tropicbirds)	Red-billed Tropicbird	*Phaethon aethereus*	LC	B	P	B	P	P	P	
	White-tailed Tropicbird	*Phaethon lepturus*	LC	B						
Oceanitidae (Southern Storm-petrels)	Wilson's Storm-petrel	*Oceanites oceanicus*	LC	P	P	P	P	P	P	P
	White-faced Storm-petrel	*Pelagodroma marina*	LC	B	P	P				
Hydrobatidae (Northern Storm-petrels)	European Storm-petrel	*Hydrobates pelagicus*	LC	P	P	P	P	P	P	P
	Cape Verde Storm-petrel	*Hydrobates jabejabe*	LC	B	P	P				
	Band-rumped Storm-petrel	*Hydrobates castro*	LC	P	P	P	P	P	P	P
	Leach's Storm-petrel	*Hydrobates leucorhous*	VU	P	P	P	P	P	P	P
Procellariidae (Petrels, Shearwaters)	Cape Verde Petrel	*Pterodroma feae*	NT	P	P	P				
	Desertas Petrel	*Pterodroma deserta*	VU	P						
	Zino's Petrel	*Pterodroma madeira*	EN	P						
	Sooty Shearwater	*Ardenna grisea*	NT	P	P	P	P	P	P	P
	Great Shearwater	*Ardenna gravis*	LC	P	P	P	P	P	P	P
	Scopoli's Shearwater	*Calonectris diomedea*	LC	P	P	P	P	P	P	P
	Cory's Shearwater	*Calonectris borealis*	LC	P	P	P				
	Cape Verde Shearwater	*Calonectris edwardsii*	NT	B	P	P	P			
	Manx Shearwater	*Puffinus puffinus*	LC	P	P	P	P	P	P	P
	Audubon's Shearwater	*Puffinus lherminieri*	LC	B	P	P	P	P	P	
	Bulwer's Petrel	*Bulweria bulwerii*	LC	B	P	P	P	P	P	P
Pelecanidae (Pelicans)	Great White Pelican	*Pelecanus onocrotalus*	LC		B	B	P	P	P	
Fregatidae (Frigates)	Magnificent Frigatebird	*Fregata magnificens*	LC	B						
Sulidae (Gannets, Boobies)	Northern Gannet	*Morus bassanus*	LC	P	P	P	P	P	P	P
	Red-footed Booby	*Sula sula*	LC	B						
	Brown Booby	*Sula leucogaster*	LC	B	P	P	P	P	B	P
	Masked Booby	*Sula dactylatra*	LC	P						
Phalacrocoracidae (Cormorants)	Great Cormorant	*Phalacrocorax carbo*	LC		B	B	P	P	B	
Laridae (Gulls, Terns, Skimmer)	Little Gull	*Hydrocoloeus minutus*	LC		P	P	P	P		
	Sabine's Gull	*Xema sabini*	LC	P	P	P	P	P	P	P
	Black-legged Kittiwake	*Rissa tridactyla*	VU	P	P	P	P			
	Slender-billed Gull	*Larus genei*	LC		B	B	B	P	P	
	Black-headed Gull	*Larus ridibundus*	LC	P	P	P	P	P	P	P
	Grey-headed Gull	*Larus cirrocephalus*	LC		B	B	B	B	P	P
	Mediterranean Gull	*Larus melanocephalus*	LC		P	P				
	Audouin's Gull	*Larus audouinii*	VU		P	P	P			
	Kelp Gull	*Larus dominicanus*	LC		B	B	P	P		
	Lesser Black-backed Gull	*Larus fuscus*	LC	P	P	P	P	P	P	P
	Yellow-legged Gull	*Larus michahellis*	LC	P	P	P	P			
	Sooty Tern	*Onychoprion fuscatus*	LC		P	B	P	P	P	P
	Bridled Tern	*Onychoprion anaethetus*	LC		B	B	P	P	P	P
	Little Tern	*Sternula albifrons*	LC	P	B	B	P	P	P	P
	Common Gull-billed Tern	*Gelochelidon nilotica*	LC	P	B	B	P	P	P	P
	Caspian Tern	*Hydroprogne caspia*	LC	P	B	B	B	B	B	P
	Black Tern	*Chlidonias niger*	LC		P	P	P	P	P	P
	Roseate Tern	*Sterna dougallii*	LC		P	P	P	P	P	P
	Common Tern	*Sterna hirundo*	LC	P	B	B	P	B	P	P
	Arctic Tern	*Sterna paradisaea*	LC	P	P	P	P	P	P	P
	Lesser Crested Tern	*Thalasseus bengalensis*	LC		P	P	P	P	P	
	Sandwich Tern	*Thalasseus sandvicensis*	LC	P	P	P	P	P	P	P
	Royal Tern	*Thalasseus maximus*	LC		B	B	B	B	B	P

Family	English name	Scientific name	Red List Category	Cabo Verde	Mauritania	Senegal	The Gambia	Guinea-Bissau	Guinea	Sierra Leone
Stercorariidae (Skuas)	Long-tailed Jaeger	*Stercorarius longicaudus*	LC		P	P				
	Arctic Jaeger	*Stercorarius parasiticus*	LC	P	P	P	P	P	P	P
	Pomarine Jaeger	*Stercorarius pomarinus*	LC	P	P	P	P	P	P	P
	Great Skua	*Catharacta skua*	LC	P	P	P				
	South Polar Skua	*Catharacta maccormicki*	LC		P	P				

Notes to Table 1

1. Royal Tern *Thalasseus maximus*. This species is now widely recognised as the West African Crested Tern *Thalasseus albididorsalis*.

2. Audubon's Shearwater *Puffinus lherminieri*. This species has three subspecies, which are widely considered as discrete species, two of which occur in West African waters: Barolo Shearwater *Puffinus (lherminieri) baroli*, which breeds in the Azores, Madeira, Salvage and Canary Islands, and Cape Verde Little (or Boyd's) Shearwater *Puffinus (lherminieri) boydi*, which breeds in Cabo Verde.

3. The following families have species that occur in West Africa but are not considered as seabirds by BirdLife International:

- Podicipedidae: Little Grebe *Tachybaptus ruficollis* is widespread along the coastal zone of West Africa between Mauritania and Sierra Leone, mainly in freshwater wetlands.
- Pelecanidae: Pink-backed Pelican *Pelecanus rufescens* occurs in coastal wetlands and offshore islands between southern Mauritania and Sierra Leone.
- Phalacrocoracidae: Long-tailed Cormorant *Microcarbo africanus* occurs widely in the coastal zone from Mauritania to Sierra Leone.
- Laridae: Two species of marsh tern - Whiskered Tern *Chlidonias hybrida* and White-winged Tern *Chlidonias hybridus* - occur widely in the coastal zone of West Africa from Mauritania to Sierra Leone during the northern winter. African Skimmer *Rynchops flavirostris* occurs from southern Mauritania to Sierra Leone, including in coastal wetlands.
- Scolopacidae: Phalaropes are migratory waders. Two species are marine and even pelagic during the non-breeding season, and both occur off West Africa. Red-necked Phalarope *Phalaropus lobatus* is vagrant, but Red Phalarope *Phalaropus fulicarius* is more regular off all countries from Mauritania to Sierra Leone (and occasionally inland) and in the waters of Cabo Verde.

4. Vagrant species. Laridae: Two species of noddy (pelagic terns) occur in the Atlantic waters of Africa, but are only vagrant to West Africa. Alcidae or auk family: Three members of the auk family, Atlantic Puffin *Fratercula arctica*, Common Guillemot *Uria aalge* and Razorbill *Alca torda* occur in the waters off Morocco during the northern winter, with vagrants occurring further south on occasion, especially in Mauritania. A vagrant Black Guillemot *Cepphus grylle* has also been recorded off Senegal.

Figure 6: Common Tern *Sterna hirundo*, a longevous marine predator. © Andrea Parisi.

1D. MARINE PRODUCTIVITY AND THE CANARY CURRENT LARGE MARINE ECOSYSTEM

The Canary Current Large Marine Ecosystem

Large Marine Ecosystems (LMEs) are management units aimed at promoting regional collaboration in assessment, monitoring and management of shared coastal marine resources. The 66 LMEs encompass the world's coastal waters and river basins and extend offshore, through the main ocean currents. LMEs are in general highly productive and often overexploited. Their geographic boundaries are defined using four interconnected ecological criteria: bathymetry (ocean water depth), hydrography, productivity and trophic relationships.

The Canary Current Large Marine Ecosystem (CCLME) is in the Atlantic Ocean along the northwest coast of Africa, extending from the Atlantic coast of Morocco in the north at the Straits of Gibraltar to the Bijagós Archipelago in Guinea-Bissau in the south, and the Canary Islands in the west (Figure 7). The countries included within its recognized limits are Spain (Canary Islands), Morocco, Mauritania, Senegal, The Gambia and Guinea-Bissau. The waters of Cabo Verde and Guinea are considered as adjacent and in the CCLME influence area. The CCLME contains various marine and coastal ecosystems within three distinct areas:

1. A zone of upwelling cold water in the northern and sub-tropical part centred off north Mauritania characterized by a minimal fluvial contribution.

2. A southern tropical zone extending from Senegal to Guinea dominated by the presence of estuaries and mangroves.

3. A subtropical to tropical oceanic zone in the west (including the Canaries and adjacent to the waters of Cabo Verde).

The CCLME is characterized by an upwelling recognized for its high biological productivity. The key productivity mechanisms of the CCLME are summarised in Annex 1. While the CCLME only covers 2-3% of the world's ocean surface, it generates 8% of the primary productivity of the world's oceans (Heileman & Tandstad 2008). Its waters are full of nutrients and induce a high seasonal primary productivity for the development of zooplankton and small pelagic organisms. This productivity attracts predators, and the CCLME region hosts large populations of small pelagic organisms, demersal fishes and tuna. Together, they represent 20% to 30% of global fisheries resources. Yearly production rate is the highest of African LMEs, with between 1.5 and 2.5 million tonnes of reported landings between 1970 and 2005 (Heileman & Tandstad 2008). Covering different climatic zones from temperate northern to southern tropical areas, the CCLME benefits a great diversity of coastal and marine habitats, particularly wetlands, estuaries, seagrass, mangroves and coral reefs. Characterized by high productivity, the CCLME hosts a wide variety of resident and migratory species other than fish (seabirds, sea turtles and cetaceans).

The upwelling and CCLME *enrichment mechanisms*

An upwelling is an oceanographic phenomenon that occurs when strong sea winds (usually seasonal winds) push the surface water of the oceans leaving a depression or a void, from which the bottom waters rise and with them a significant amount of nutrients. The upwelling phenomena are characterised by a cold sea rich in phytoplankton. Upwellings result in a significant increase in the number of fish.

The upwelling of cold coastal waters along the eastern border of the North Atlantic subtropical gyre increases productivity along the northwest African coast. The CCLME protects one of the four main areas of coastal upwelling of the world's oceans. Although the described hydrographic and climatic conditions play an important role in the productivity of this wide marine ecosystem, it is also believed that riverine inputs and wind dust contribute to the productivity of the system, through nutrient content, primary and secondary production inputs from land and wind inputs.

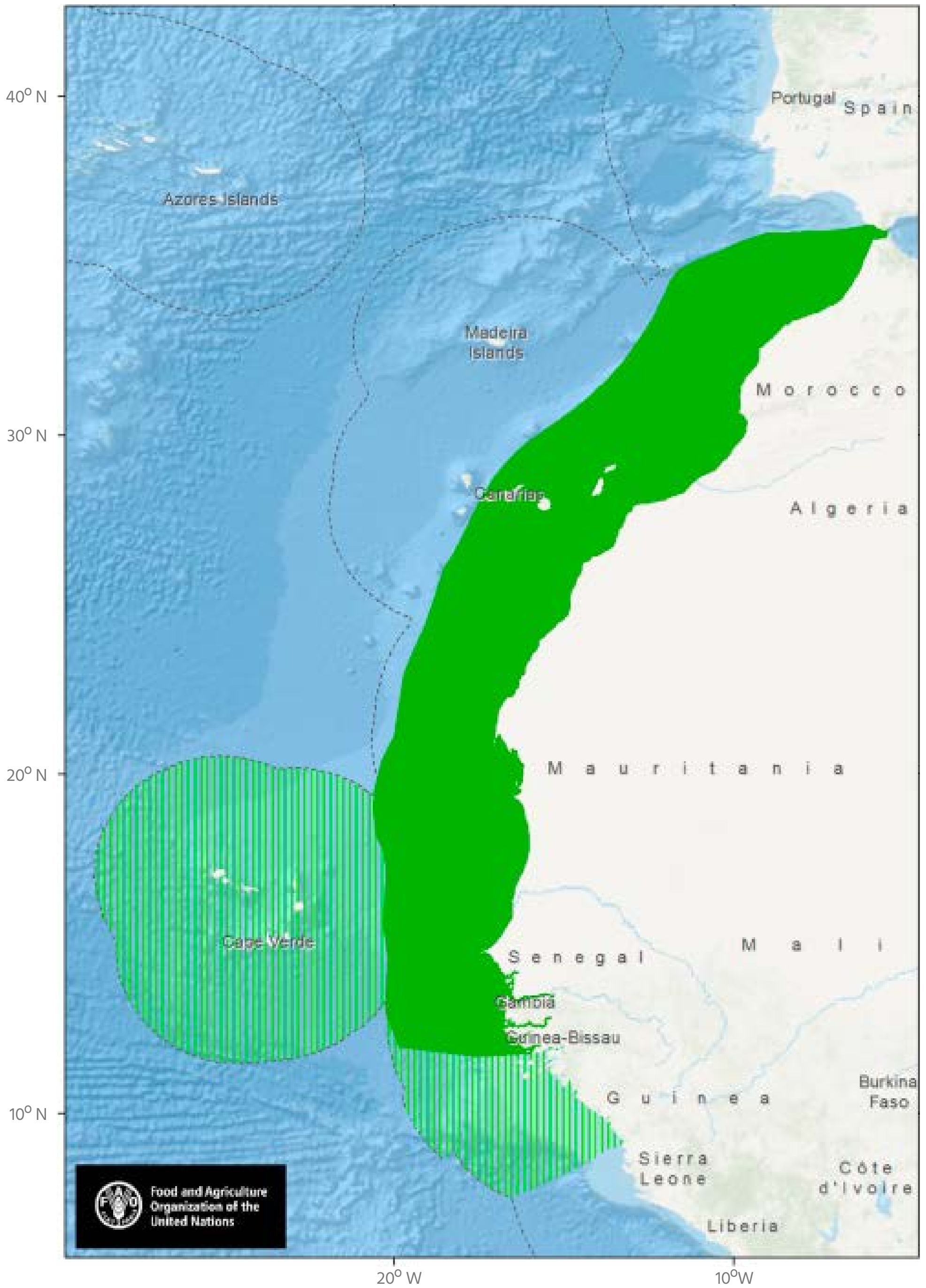


Figure 7: The CCLME in green, with adjacent waters shaded (Sambe *et al.* 2016).

1E. IMPORTANCE OF CCLME PRODUCTIVITY FOR MIGRATORY SEABIRDS

The high levels of marine productivity are essential for breeding seabirds of the region, but they also serve as a magnet for many migratory seabirds, many of which breed in northern latitudes. Movements of eight seabird species tracked by Grecian *et al.* (2016) indicate that the CCLME is a hotspot for migratory seabirds. The eight species tracked were: Cory's Shearwater *Calonectris borealis*, Scopoli's Shearwater *Calonectris diomedea*, Lesser Black-backed Gull *Larus fuscus*, Northern Gannet *Morus bassanus*, Great Skua *Stercorarius skua*, South Polar Skua *Stercorarius maccormicki*, Common Tern *Sterna hirundo* and Sabine's Gull *Xema sabini*. More than 70% of the individuals tracked used this upwelling region. By linking diversity to ocean productivity, this research reveals the importance of the CCLME for seabird populations across the Atlantic, making it a priority for conservation action (Grecian *et al.* 2016).

Connectivity between marine areas through migratory seabirds

Migratory seabirds link marine ecosystems in West Africa to distant ecosystems; if one is damaged, it can affect the health of others. Conservation strategies for seabirds must take this connectivity into account and have thematic resonance and relevance across different regions. Many seabirds are highly migratory, and some can travel hundreds of kilometres even during one trip in search of food. The nutrient-rich CCLME coastal waters are home to a wide variety of prey species, which constitute a rich source of food for seabirds. Many coastal migratory seabirds migrate south along the northwest coast of Africa from their breeding areas in Europe and the Mediterranean. They occur in West Africa especially between September-October and April-May. Coastal species are frequently affected by human disturbance, exploitation and damage to their habitat.

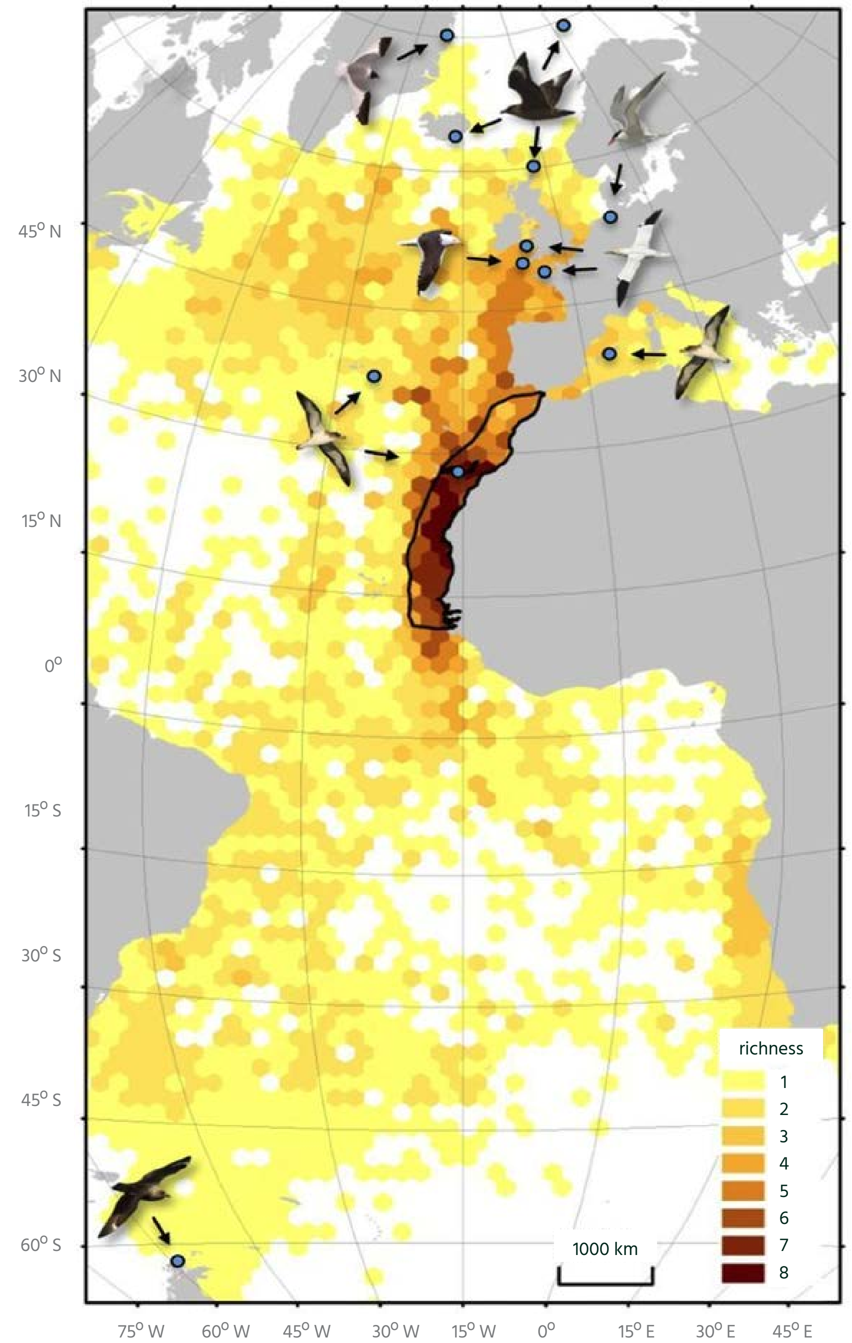


Figure 8: Relative richness of eight seabird species tracked from pan-Atlantic colonies between 2000 and 2011; the dark line represents the CCLME boundary, and blue dots represent colonies of origin for tracked birds, indicated by arrows (Grecian *et al.* 2016).

Many seabirds that breed in Europe and elsewhere spend part of their life off West Africa, especially during the northern winter. Conservation efforts at their breeding sites will only be effective if conservation efforts are also deployed off the West African coast. Many seabirds that breed in Europe, juveniles and adults, are dependent on marine resources off West Africa, where they are subject to risks linked to competition with fishing and bycatch, among others (Grémillet *et al.* 2015). These threats are in addition to damaging interactions between seabirds and fishing in Europe, which they may experience during their breeding season. Joint efforts are vital to improve marine conservation off the coast of West Africa, given the strong connectivity between many European breeding seabird colonies and their non-breeding areas of West Africa.

A good example is the Northern Gannet *Morus bassanus*, which breeds in northern Europe, with its largest colony being Bass Rock in Scotland (Figure 9). After breeding, some gannets stay in the North Sea, but most travel further south, with some migrating for the northern winter to West Africa (Figure 10, Kubetzki *et al.* 2009).

Figure 9: A section of the world's largest Northern Gannet *Morus bassanus* colony, Bass Rock, Scotland, UK. © Justine Dossa.

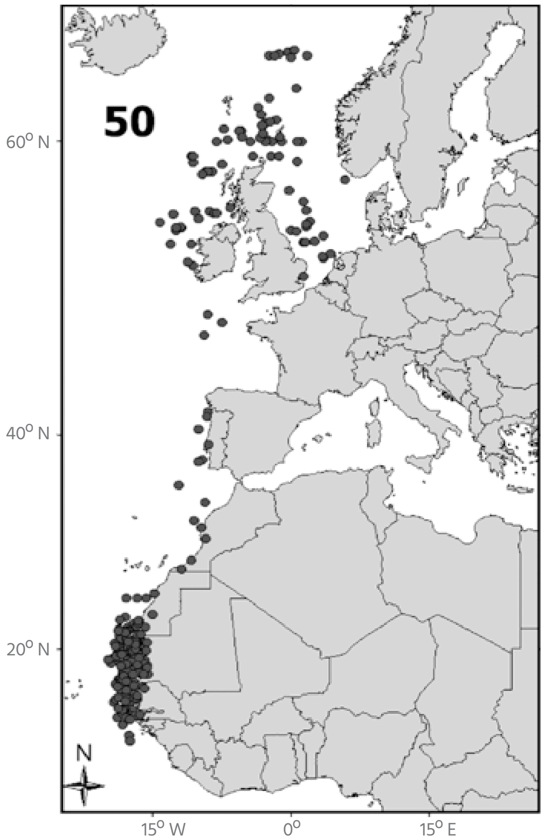


Figure 10: Movements of a Northern Gannet *Morus bassanus* between 4 October 2003 and 21 February 2004; the bird (Bird 50) was fitted with a geolocation logger at its breeding site in Scotland (Kubetzki *et al.* 2009).

Connectivity is also important at the regional (West Africa) scale between countries. A good illustrative example is the Cape Verde Shearwater *Calonectris edwardsii*, which breeds only in Cabo Verde. During the incubation period, Cape Verde Shearwaters mainly forage in the area off the West African continental shelf, making long trips between their breeding sites in Cabo Verde and the waters off West Africa known for their high productivity (Figure 11: Example of a three-day outward and return feeding trip for a Cape Verde Shearwater *Calonectris edwardsii* between its breeding site on Raso, Cabo Verde and its feeding areas during its incubation period; Cape Verde Shearwater breeding site. ©Biosfera). These waters are also widely used by other marine predators, notably migratory seabirds from Europe. However, seabirds feeding here also overlap strongly with international industrial fishing fleets (Paiva *et al.* 2015). Conservation actions for this endemic bird species of Cabo Verde therefore strongly depend on efforts made by West African countries such as Mauritania and Senegal to reduce the risks linked to the overexploitation of resources, bycatch and threats linked to gas and oil exploitation.

Figure 11: Example of a three-day outward and return feeding trip for a Cape Verde Shearwater *Calonectris edwardsii* between its breeding site on Raso, Cabo Verde and its feeding areas during its incubation period; Cape Verde Shearwater breeding site. ©Biosfera. Cape Verde Shearwater in flight. © BirdLife International.

1F. BREEDING SEABIRD COLONIES IN WEST AFRICA

Seabird colonies in the coastal zone of West Africa

The coastal zone of West Africa supports significant colonies of gulls and terns, as well as one breeding site for Red-billed Tropicbird *Phaeton aethereus* at Iles de la Madelaine off Dakar, Senegal, and one breeding colony of Brown Booby *Sula leucogaster* at Ile Alcatraz, Guinea (Figure 12). A network of low-lying coastal islands and islets between Mauritania and Guinea are key sites for breeding gulls and terns, as well as other birds. Great Cormorants *Phalacrocorax carbo* also breed on some islands, as well as at other sites, including in the Lower Senegal Delta. In addition, there are breeding colonies of Great White Pelican *Pelecanus onocrotalus* at the Banc d'Arguin and in the Senegal Delta.

The protection status of sites where colonies are located varies. Several colonies are found in national parks or reserves, whilst others, notably the islet of Bantambur off Jeta in Guinea-Bissau, are unprotected. Veen & Mullié (2015) present an overview of breeding gulls and terns based on data from annual counts between 1998 and 2013. A key feature of the breeding colonies of terns and gulls is that they form a network of sites, and numbers breeding at sites can vary considerably between years. For instance, the Bijol Islands of The Gambia have in the past supported breeding Royal Terns Thalasseus maximus, whilst a sandy islet of the Iles Tristao of Guinea used to support breeding terns before it was washed away. Some of these breeding islands, especially sandy islets, are quite dynamic and are prone to changes due to the influence of the sea, whilst some are also subject to disturbance.

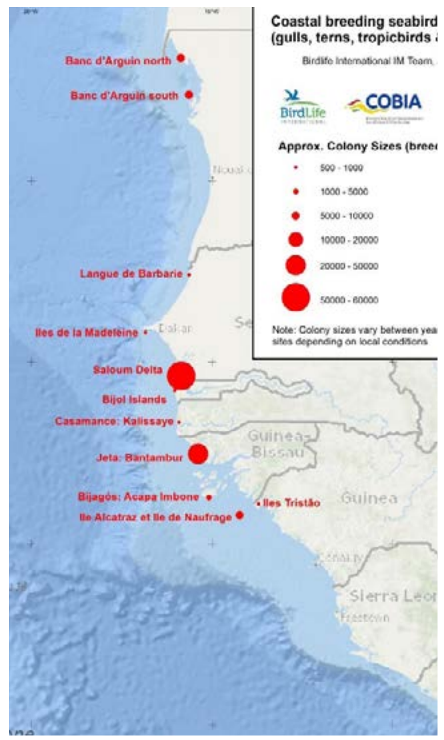


Figure 12: Coastal seabird colonies in West Africa (BirdLife International, 2021).

Breeding seabirds of Cabo Verde

Lying 500 km west of Senegal, the Cabo Verde archipelago comprises 10 main islands (ilhas) and several islets (ilhéus) of volcanic origin. This small island nation has a total land area of 4,033 km2 scattered over 58,000 km2 of Atlantic Ocean. The archipelago supports important terrestrial and marine biodiversity, and its coastal waters support over 300 fish species. The substantial marine area of Cabo Verde plays a crucial role in marine productivity, and its rocky coastlines and islets support numerous breeding seabirds, which utilise large areas of the Atlantic Ocean.

Important nesting habitats for breeding seabirds include loose soils of low-lying islands for burrow-nesting species, rocky crevices on islets and islands including in mountain ranges, cliff faces with ledges, and other features of uninhabited islets. The islets are of particular importance, especially the island groups of Ilhéus do Rombo (north of Brava) and Ilhas Desertas (in the northwest, Figure 13), whilst islets off Boavista and Maio are also important. The most substantial sea cliffs supporting breeding seabirds are at Baía do Inferno on Santiago. Cabo Verde has supported small colonies of Magnificent Frigatebird *Fregata magnificens* in the past. While this species is still recorded at Ilhéu de Curral Velho off Boavista, its last breeding site, its continued survival here seems unlikely.

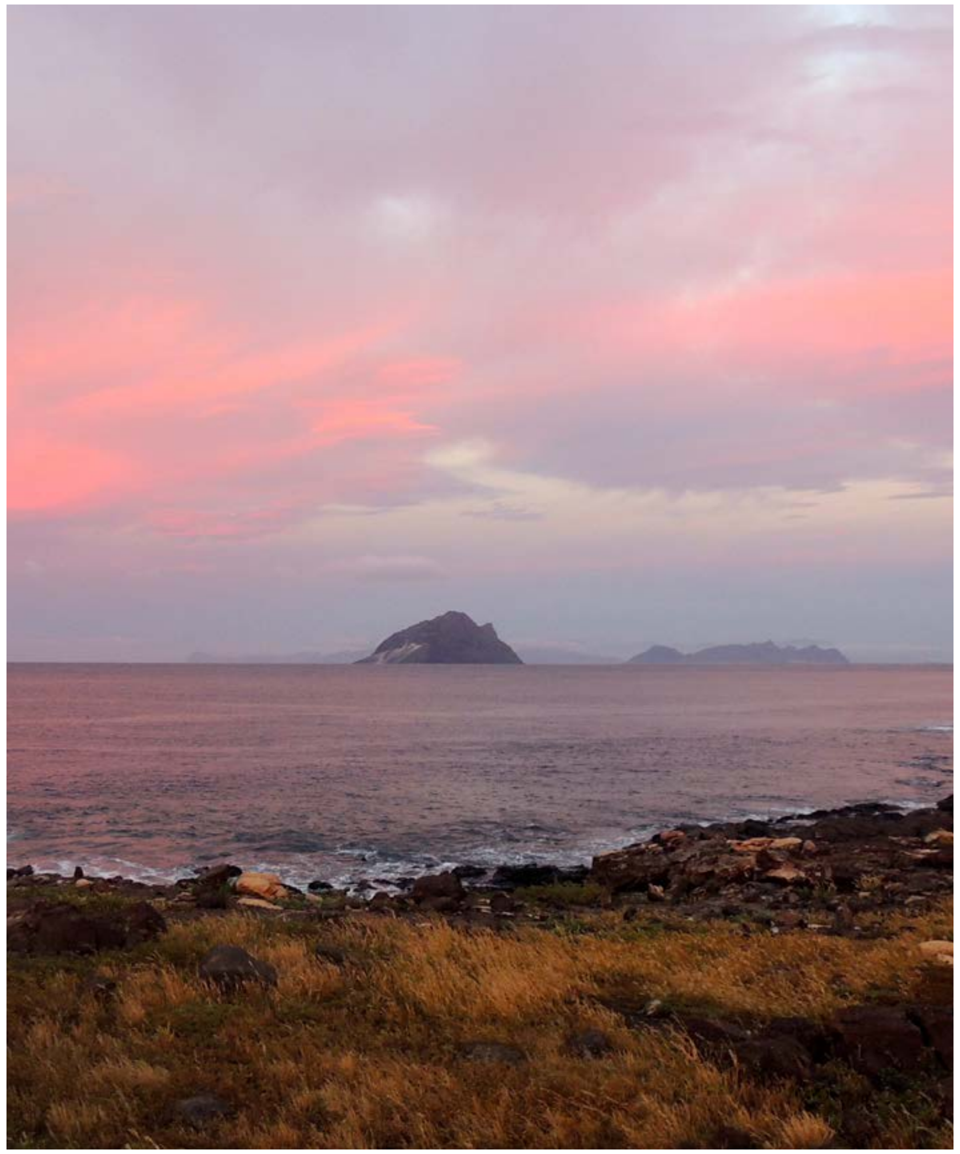


Figure 13: The islets Raso (foreground), Branco and Santa Luzia (distant) make up the Ilhas Desertas of Cabo Verde; Raso and Branco support important seabird colonies. © Tim Dodman.

1G. THE IMPORTANCE OF SEABIRDS, ESPECIALLY IN WEST AFRICA

Seabirds represent important links in the food webs of marine and coastal ecosystems. Their major roles in the functioning and stability of these ecosystems, upon which human societies depend, are captured by the concept of ecosystem services, which raises awareness of the value of biodiversity for humanity (Millennium Ecosystem Assessment 2005). They recall the need to maintain functioning ecosystems, such as the CCLME, in order to preserve the services rendered to human wellbeing. Although this concept is useful to justify the need to conserve key habitats and species, the conservation of species or ecosystems that provide few identified, or easily replaced, services also requires conservation strategies that value all biodiversity.

Some ecosystem services provided by seabirds include:

Support services

Seabird gatherings play a significant role in the nutrient cycle by locally concentrating nutrients provided by their marine food on land and in coastal marine environments. Guano, excrement accumulated over thousands of years by seabird colonies, has long been extracted by humans, and used as fertilizer for plants in agriculture. Guano used to be collected for phosphate from Ile Alcatraz off Guinea (Figure 14). Many fishing communities also observe gatherings of birds at sea to locate shoals of fish; this has been reported, for instance, in the Bijagós Archipelago, Guinea-Bissau. Djau (2020) reported from interviews with artisanal fishing communities in the Bijagós that seabirds, especially terns and pelicans, are used as indicators to locate schools of fish, thus contributing to fishing yields. Mollusc gatherers also used seabirds as indicators of productive areas and of tidal change, whilst seabirds were even valued as indicators during searches for people who had drowned.

Figure 14: Brown Boobies *Sula leucogaster* at Ile Alcatraz, Guinea. © Hanneke Dallmeijer-VEDA.

Supply services

Some seabird colonies provide food for island or coastal human populations, though these days this is rarely sustainable. Northern Gannets *Morus bassanus* from one colony in Scotland are locally consumed under special license, whilst the eggs and chicks of petrels and terns are consumed by certain communities in Polynesia, Africa and elsewhere. Seabirds have traditionally been collected in Cabo Verde for their meat, especially young birds from nests or colonies. Fishermen from Santo Antão used to collect young Cape Verde Shearwaters *Calonectris edwardsii* from Ilhéu de Raso for consumption, though this practice has now stopped.

Cultural services

Many myths and legends of island and coastal peoples depict species of seabirds, which are strong representatives of island and coastal habitats (Millennium Ecosystem Assessment 2005). The Red-billed Tropicbird *Phaeton aethereus* has an important cultural role for the Lébou and Layéne communities of Dakar, Senegal, who do not hunt it. Unusually, there are paintings and photos depicting a tropicbird seated on the shoulder or lap of local religious leaders (Figure 15).

As the ecology of birds is generally well known, they are more easily identifiable and appreciated by the public than some other animals, and can thus serve as ambassadors or umbrella species for the overall conservation of the ecosystems on which they depend. The establishment of a protected area structured around the conservation of a bird colony, for instance, enables the preservation of other organisms that share the same area. However, many seabirds are not so well known except by fishermen, especially those that breed in burrows or hollows and are largely nocturnal.

Figure 15: A religious leader in Senegal with a Red-billed Tropicbird *Phaeton aethereus* seated on his lap.

Tourism services

Tourism based on observing wildlife and immersion in exceptional ecosystems is today one of the most effective means for preserving them. Ecotourism, or nature tourism that contributes to nature conservation, including birdwatching, can contribute to financing conservation actions, such as building awareness of local communities, anti-poaching measures and site restoration. The large colony of Great White Pelicans *Pelecanus onocrotalus* at Djoudj National Park in Senegal is a key attraction of the park, bringing in important revenue for local boat operators (Figure 16).

Nevertheless, ecotourism is prone to impacts that prevent people visiting an area, such as diseases, security issues and economic influences, as exemplified by the COVID 19 (SARS-CoV-2 coronavirus), which impacted ecotourism economic activities across the world. It is thus essential that local people are fully involved in conservation and understand the benefits of a rich and intact ecosystems.

Figure 16: Boats ready to take visitors out at Djoudj National Park, Senegal, especially to view the Great White Pelican *Pelecanus onocrotalus* colony; 'Welcome to the Djoudj Jetty, where the Pelican is King'. © Tim Dodman.

© Tim Dodman

Part 2 Threats

2A. ANTHROPOCENE

For more than 200,000 years, *Homo sapiens* has altered the world's ecosystems. From the industrial era of the 19th century followed by the 'great acceleration' of the middle of the 20th century, the negative impacts on the entire planet are considerable and unprecedented. The effects on the planet's geology, climate, and biodiversity are tangible and measurable (Ripple *et al.* 2017). Many vertebrate species are being pushed to extinction by anthropogenic causes; a recent study showed that 32% of more than 27,000 vertebrate species have declining populations (Ceballos *et al.* 2017).

The IUCN Red List of Threatened Species™ shows that a quarter of all species are threatened with extinction. Human activity has seriously altered more than 75% of the Earth's freshwater and land, and 66% of the oceans (IUCN 2019). Climate change and political instability are exacerbating this crisis at all levels. At the current rate, the loss of species will lead to elimination of the vital ecological, economic, and cultural roles that they fulfil. A wide range of species are experiencing dramatic (often irreversible) population declines to a level that affects their future and our reservoir of resources. There is no doubt that our current lifestyle is not sustainable and that a change is vital (IUCN 2019).

Five seabird species have disappeared altogether - Labrador Duck *Camptorhynchus labradorius*, Great Auk *Pinguinus impennis*, Small St Helena Petrel *Bulweria bifax*, Large St Helena Petrel *Pterodroma rupinarum* and Spectacled Cormorant *Urile perspicillatus* (BirdLife International 2019). Extinction of both petrels occurred shortly after the discovery of Saint Helena by people in 1502. The prolonged overexploitation of the Great Auk leading to its disappearance during the 19th century was a major element in the awareness of the irreversibility of human actions, serving as a pioneer of conservation biology.

The current erosion of biodiversity is so extreme that the 6th species extinction crisis is already underway. In addition to the accelerated extinctions, many surviving species suffer drastic reductions in their populations and numbers. Thirty percent of seabird species are considered globally threatened, with 19 Critically Endangered, 34 Endangered and 58 Vulnerable, whilst 57% of seabird species are known to be in decline (BirdLife International 2022).

The harmful impacts of human activities on ecosystems can be grouped into five categories: Biological invasion by Invasive Alien Species (IAS), habitat destruction and degradation, pollution, overexploitation, and global warming (Millennium Ecosystem Assessment 2005).

Figure 17: Plastic and other waste dominates the beach waterfront at Tombo, an important fishing town in Sierra Leone. Rubbish and waste are some of the more visible signs of the human impact on the environment. © Momoh Bai Sesay.

Toolbox: The IUCN Red List

The International Union for Conservation of Nature (IUCN) Red List (https://www.iucnredlist.org) is the world's most comprehensive inventory on the conservation status of plant, fungus and animal species, and serves as a barometer of life. It is based on a series of precise criteria to assess the risk of extinction of thousands of species and subspecies: https://www.iucnredlist.org/resources/redlistguidelines. Founded on a solid scientific basis, the IUCN Red List is the most reliable reference tool for determining the level of threats to species. It guides scientific research, and is used to inform policy and conservation planning, influence resource allocation, improve decision-making and contribute to human health and livelihoods through education and public awareness.

These internationally recognized criteria are used around the world to inform about conservation, through the categories: Data Deficient (DD), Least Concern (LC), Near Threatened (NT), Vulnerable (VU), Endangered (EN), Critically Endangered (CR), Extinct in the Wild (EW) and Extinct (EX).

BirdLife International is the official authority for birds for the IUCN Red List, and coordinates the process of evaluating all of the world's bird species against the Red List categories and criteria. This process includes continually collating up-to-date information on Globally Threatened Birds from the published literature and from a worldwide network of experts, through Globally Threatened Bird Forums.

Seabird status is well documented, with only two species categorised as Data Deficient (DD): White-vented Storm-petrel *Oceanites gracilis* and Pincoya Storm-petrel *O. pincoyae*.

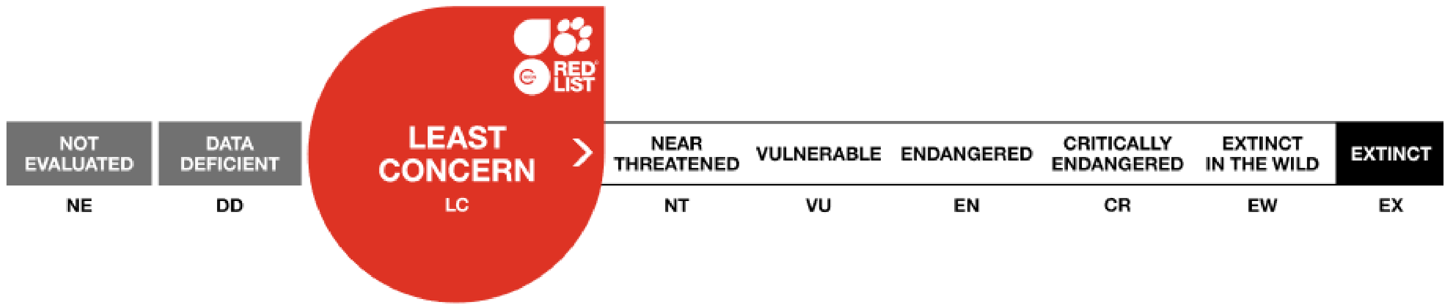


Figure 18: IUCN Red List categories. Here is an example of the status of Brown Booby Sula leucogaster classified as 'Least Concern'; https://www.iucnredlist.org/species/22696698/132590197.

2B. THE MAIN CLASSIFIED THREATS

The main causes of seabird decline and threats to their survival have been identified at a global level by Dias *et al.* (2019), who found that 84% of seabird species were impacted by at least one common threat among 18 identified, whilst 70% and 46% of species were impacted by a minimum of two and three threats respectively. IAS, bycatch, hunting or trapping, climate change and other disturbances represent by far the most important threats globally, which each affect more than 20% of all seabird species, or more than 170 million birds (Figure 19, Table 2).

Pollution, overfishing and interactions with problematic native species also impact more than 50 species each. The impact of hunting or trapping and disturbance remains moderate at the global scale of all marine seabird species. Diseases and alterations in natural systems impact relatively few species, although they can have considerable devastating effects (Dias *et al.* 2019).

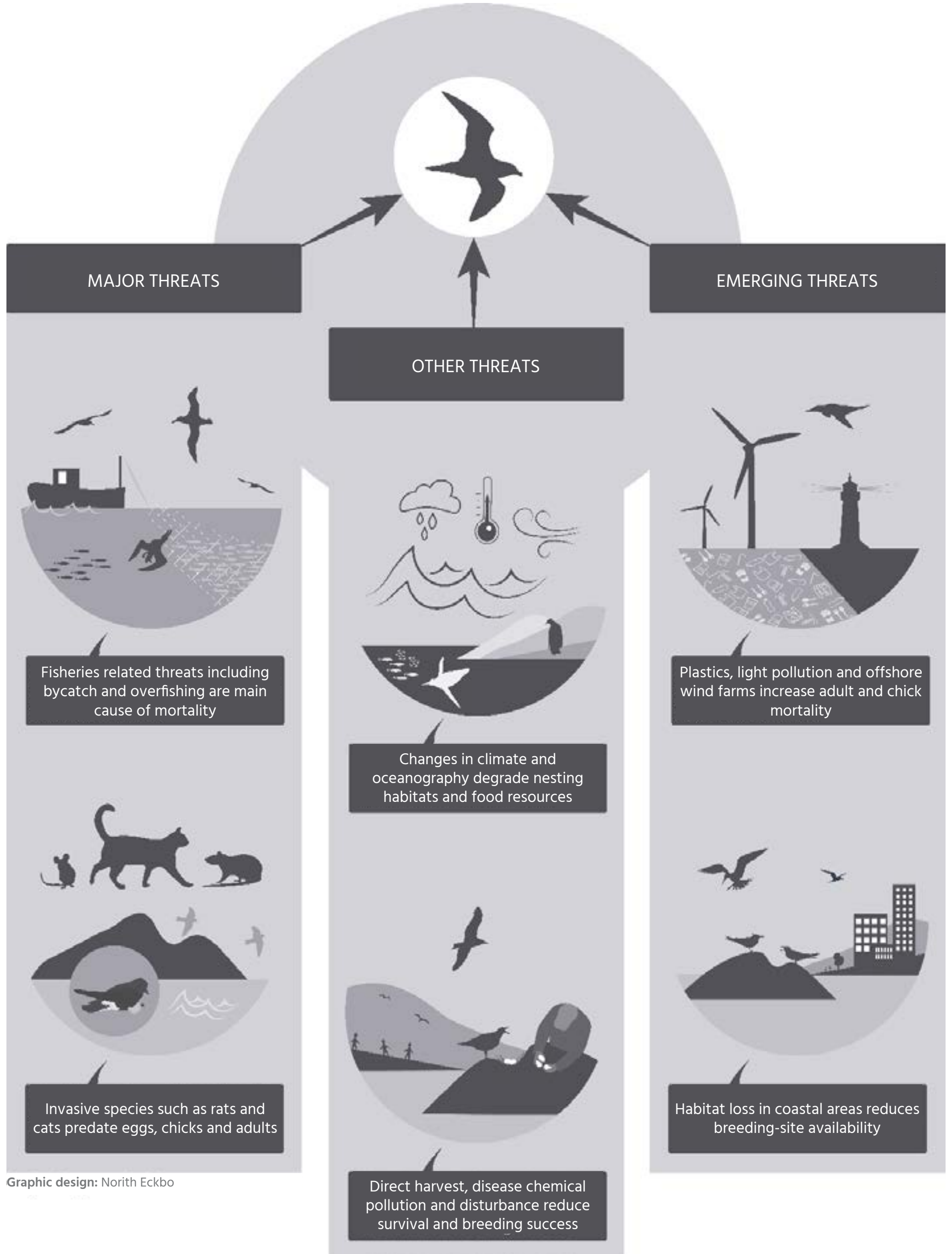


Figure 19: Current threats affecting all seabirds globally. These threats have different levels of severity in different regions, for example invasive mammalian predators are particularly problematic on islands such as in Cabo Verde, where they depredate ground nesting seabirds. Fishing related threats such as overfishing and diminution of forage fish, along with habitat loss and pollution by light, plastics and chemicals are more problematic in continental West Africa. Graphic: BirdLife International.

Table 2: Summary of the main threats (impacting more than 20% of species or having a high overall impact) affecting all species of seabirds and globally threatened species (Dias *et al.* 2019).

Threat	% of affected species (n = 359)	% of globally threatened species affected (n = 110)
Invasive Alien Species	46%	66%
Fishery Bycatch	28%	45%
Climate/weather change	27%	34%
Hunting/trapping	27%	25%
Human disturbances	20%	24%
Overfishing	15%	20%

2C. THREATS TO SEABIRDS IN WEST AFRICA

The CCLME: threats linked to its unique wealth

While the CCLME ecoregion contributes decisively to social and economic wellbeing, it faces a multitude of threats, especially overfishing. Many commercially important demersal resources are overexploited. Some of the underlying causes of the decline in fishery resources are attributable to the overcapacity of fishing fleets (both industrial and artisanal), to the complexity and variability of ecosystems, and to the lack of management, especially in terms of tracking, control and monitoring. There is also insufficient scientific and technical capacity supporting management, and stakeholder participation in management decisions is limited. Managing instruments for shared resources is problematic, and the growing demand for and rising prices of seafood products also contribute to the scarcity of resources.

The still poorly known extent of illegal, unreported and unregulated fishing (IUU fishing) constitutes a significant management challenge.

Meanwhile, the coastline of the CCLME region is under increasing pressure from growing coastal human populations. Urban growth, industrial development (including oil and gas), unplanned tourism development, the expansion of agricultural areas and other land-use changes cause degradation, fragmentation and loss of critical habitats, including estuaries, wetlands, mangroves and benthic habitats. An increase in both land-based and marine pollution also threatens biological diversity, including seabirds, cetaceans, Mediterranean Monk Seal *Monachus monachus*, marine turtles, sharks, sawfish and African Manatee *Trichechus senegalensis*. Climate change impacts pose further long-term challenges.

Threats to seabirds in West Africa

The most pressing threats identified by seven BirdLife Partners in West Africa include urbanisation, climate change, pollution by plastics and waste, human disturbance and habitat loss, and overfishing (BirdLife International 2022b). These are the types of threats resulting from human activity close to nesting sites and in the functional habitat of seabirds. The main threats to seabird populations in Cabo Verde range from predation by introduced predators, habitat alteration or destruction, and some residual human persecution (Semedo *et al.* 2020).

Urbanisation

Parts of the coastal zone of West Africa are subject to rapid urbanisation and development, with major cities such as Dakar supporting growing human populations. Conversion of coastal wetlands and other natural habitats threaten biodiversity. Seabirds most threatened are those that breed and feed in the coastal zone, especially terns.

Climate change

In coastal West Africa between Mauritania and Guinea, a number of islands and islets support breeding gulls and terns. Many of these islets are low and sandy, and prone to temporary or even permanent inundation by the sea. Rising sea levels due to climate change pose a clear threat to the long-term ability of these islands to support breeding seabirds and other birds. The islet of Pani Bankhi in Iles Tristao, Guinea, is one island that became engulfed by the sea, and no longer exists. Altenburg & Wymenga (1991) found Caspian Terns *Hydroprogne caspia* breeding here in 1988, with other terns and gulls also present. No breeding terns were found in the Iles Tristao during a survey in 2009, by when Pani Bankhi had already disappeared (Veen *et al.* 2009). The exact causes of the islet's disappearance are not well known, and coastal sandy islets are prone to change. However, rising sea levels undoubtedly will bring about more change, and will pose a risk to breeding seabird colonies dependent on these habitats.

Pollution by plastics and waste

Small waste particles, especially plastics, present a long-term problem for surface-feeding seabirds, which can ingest large quantities that clog up their stomachs and can lead to starvation. Marine pollution is a growing problem around the West African coastline and at sea. Plastic and other debris wash ashore every year around the coastline and at islands, such as Santa Luzia in Cabo Verde, threatening breeding sea turtles, as well as seabirds. The island of Acapa Imbone in the Bijagós Archipelago of Guinea-Bissau experiences heavy loads of plastic and other debris washed ashore, this being an important breeding site for Caspian Terns *Hydroprogne caspia* (Figure 20). Some breeding seabirds, such as Brown Booby *Sula leucogaster* commonly collect marine debris to use as nesting material (Figure 21), which can cause birds, especially chicks, to die through entanglement or ingestion.

Figure 20: Plastic and other waste washed ashore on Acapa Imbone, Guinea-Bissau. © Tim Dodman.

Figure 21: Brown Booby *Sula leucogaster* on nest comprised of collected marine waste, Raso, Cabo Verde. © Tim Dodman.

Human disturbance and habitat loss

Some breeding seabird islands are prone to human disturbance in Western Africa, both from fishermen and other visitors, including tourism. Burrowing colonies in soft sand are particularly vulnerable, such as at Ilhéu de Cima in Cabo Verde, as walking through the colony can destroy nests and potentially bury eggs or chicks. Disturbance of gull and tern colonies in coastal West Africa can cause birds to abandon their nests. Great White Pelicans *Pelecanus onocrotalus* are also prone to abandon colonies if heavily disturbed.

Overfishing

Overfishing is a major threat to the productivity of West Africa's marine waters and its future viability for fisheries and natural fish predators, including seabirds. The high coastal concentrations of fish seen in West African waters 1960 have nearly completely disappeared by 2000, whilst, conversely, the fishing intensity in the coastal zone has dramatically increased (Figure 22, Christensen *et al.* 2005). This figure shows clearly that fishing intensity is high when fish biomass is low. Unfortunately fishing pressure remains unsustainable in West African waters, and this is bound to impact the whole marine ecosystem.

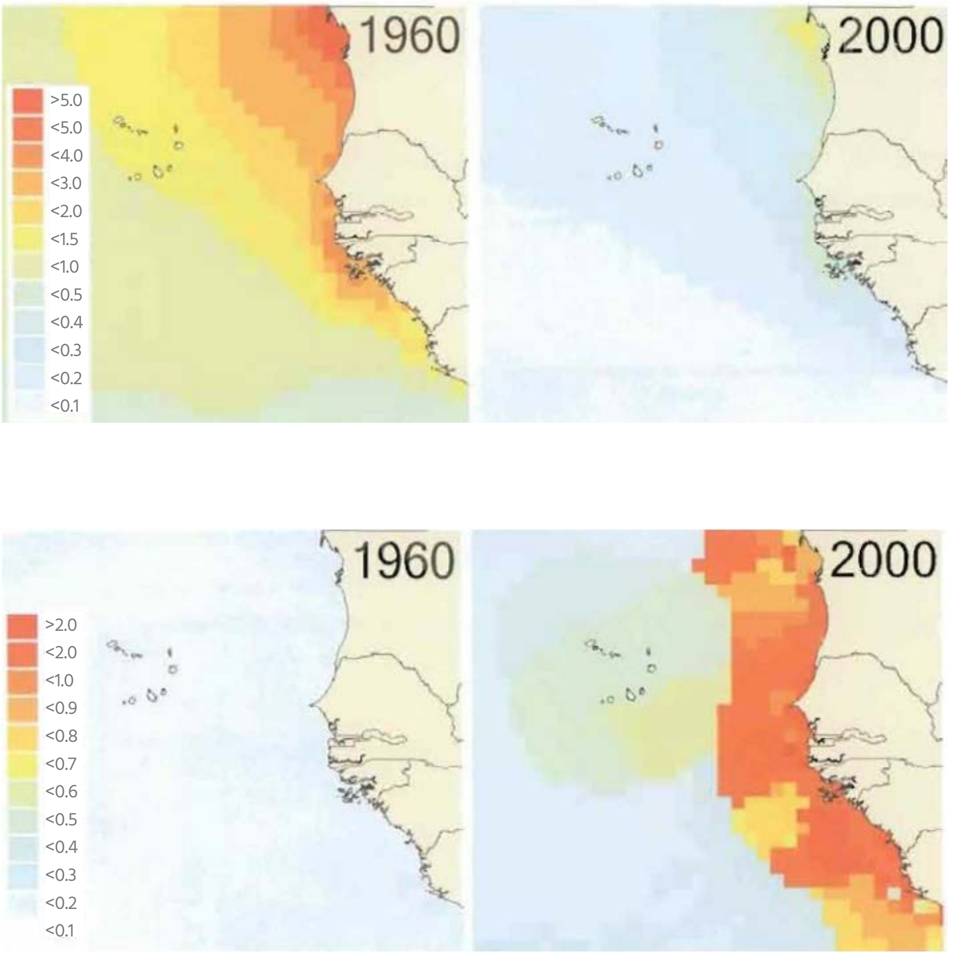


Figure 22: Top maps: Biomass distribution for fishes (excluding small pelagics) off West Africa in 1960 and 2000. Bottom maps: Fishing intensity (catch/biomass ratio) for fishes (excluding small pelagics) off West Africa in 1960 and 2000. Units in the legend are in tonnes per km2 (Christensen *et al.* 2005).

Bycatch

The extent of bycatch, or incidental capture, of seabirds in West African marine waters remains largely unknown, but is likely to be high given that significant fishing effort occurs in close proximity to important seabird breeding and foraging areas (Jabado 2021). Cape Verde Shearwaters *Calonectris edwardsii* were the most frequently reportedly bycaught species by artisanal, semi-industrial fishers and industrial fishers within Cabo Verde waters, followed by Brown Boobies *Sula leucogaster* and Red-billed Tropicbirds *Phaeton aethereus,* the majority caught by handlines (Montrond 2020).

Invasive Species

Invasive species mainly impact breeding seabirds. In coastal zone West Africa, invasive species are not known to impact breeding gull and tern colonies. The small offshore islets where most gulls and terns breed most likely offer good physical protection, whilst there are few opportunities for invasive species to subsist throughout the year on these islets, which are mostly dry with limited vegetation. The major pelican breeding colony in the Senegal Delta has been subject to predation pressure, though mainly from natural predators, such as warthogs and canids. Breeding seabirds in Cabo Verde, however, have faced pressure from invasive species historically and continue to do so. On larger islands where seabirds breed, domestic or feral cats present a problem, including to breeding Cape Verde Petrel *Pterodroma feae* on Fogo. Mice occur on Ilhéu de Cima, Ilhéus do Rombo, although the extent of their impact on breeding seabirds there has not been fully determined yet. However, mice are known to impact breeding seabirds in other Atlantic islands, such as Gough.

Direct exploitation

Breeding seabirds are highly susceptible to exploitation, especially chicks. Collection of breeding and young birds has been a major problem in Cabo Verde in the past. Human predation in Cabo Verde impacts seabirds on several islands, including Brown Booby *Sula leucogaster*, Red-billed Tropicbird *Phaeton aethereus,* Cape Verde Petrel *Pterodroma feae* and Cape Verde Shearwater *Calonectris edwardsii* (BirdLife International, 2019; Ratcliffe *et al.* 2000; Lopez-Suarez, 2012). In coastal zone West Africa, egg collection has been recorded in various gull and tern colonies, including at Ile de Senghor in the Saloum Delta, where a pirogue with 17 fishermen was found to have collected the majority of eggs from a mixed tern and gull colony during surveys in 1998 (Keijl *et al.* 2000).

2D. BIOINVASION

Invasive alien species (IAS) affect 165 out of 359 seabird species (Dias *et al.* 2019). 75% of threatened seabird species that nest on islands are declining due to IAS.

People have introduced and continue to introduce IAS deliberately (for agriculture, recreational species or for biomanipulation (the deliberate alteration of an ecosystem by introducing or removing species). Common IAS deliberately introduced are goats, dogs, pigs and cats, whilst IAS often introduced involuntarily include rats *Rattus spp.*, mice, snakes and insects, such as the aggressive Little Fire Ant or Electric Ant *Wasmannia auropunctata,* which impacts breeding seabirds and reptiles on Ilhéu do Raso, Cabo Verde.

Human movements of exploration, transport, and trade facilitate the movement of exotic organisms outside their distribution area, which can establish themselves, reproduce and proliferate according to the conditions of their new environment. These new naturalized species will interact with native organisms that have never known the bio-invader. Interactions can be negative if the exotic species is a parasite, predator or competitor or if it harms or kills another species through any kind of interaction, such as a plant that produces sticky seeds or rabbits or goats that destroy the habitat and nesting areas. Most seabirds that breed in colonies on islands are not familiar with predators and have no defensive behaviour, so introduced predators (cats, rats, dogs, pigs, etc.) can eradicate entire colonies of seabirds. In general, the appearance of an IAS will increase the mortality of threatened bird species, and decrease their breeding success, whilst their ecosystem will be degraded in most cases (BirdLife International 2018).

Probably the greatest threat to breeding seabirds of Cabo Verde is predation by IAS - dogs, cats, rats and mice, which can predate adults, young and eggs (Figure 23), depending on the IAS and seabird species, impacting breeding success of seabirds and population survival. Some seabird populations have already disappeared from some locations due to IAS pressure and others are in decline and at risk of local extinction. The introduction of cats and rats on Santa Luzia wiped out almost all seabird populations on this island. Illegal visits by fishermen and tourists on the few islets where IAS have not yet been introduced represent a significant threat to seabird conservation in Cabo Verde. Biosecurity measures are essential to minimise this threat.

Figure 23: Cape Verde Petrel *Pterodroma feae* chick predated by rat. © Adilson Fortes.

2E. HABITAT DESTRUCTION

For most vertebrates, the destruction of their habitat is the main threat endangering the maintenance of their populations, although for seabirds at the global level, this threat is secondary to bioinvasions (Dias *et al.* 2019). Although marine habitats are often altered significantly, they are rarely directly destroyed by human activity. The main impact of this threat for seabirds is through the destruction of habitats used during the breeding season, such as islets or coastal sandbanks where tern and gull colonies are established; this can have dramatic consequences for certain populations. Colonially nesting seabirds are particularly sensitive to the destruction of their breeding habitats. A single breeding site can support a considerable proportion of the population, so its destruction can have important consequences for the global conservation of the species.

A range of anthropogenic activities can lead to the destruction of breeding habitats, including the construction of infrastructure for industry (ports) or tourism (hotels, marinas). Other coastal zone developments, such as construction of dikes and dams, drainage of wetlands and conversion of salt marshes. Terns are particularly sensitive to these threats, being dependent on rare littoral (or shoreline) habitats for breeding and feeding. Some seabird species nest in forests, and deforestation threatens the disappearance of breeding colonies.

During infrastructural development, habitats can also be altered by domestic animals, especially livestock either through trampling or by soil erosion linked to grazing, both of which can cause the burrows of petrels, shearwaters, storm-petrels or puffins to collapse.

Habitat destruction in West Africa is occurring on an ongoing basis as urbanisation occurs in areas formerly with few inhabitants. This includes development of coastal areas for ports, towns or other infrastructure and industrial sites. In addition, pressure from communities harvesting natural resources in coastal area can lead to a reduction of the suitability of habitat for seabirds, for roosting or nesting.

The breeding colonies of gulls and terns in coastal West Africa occur within a dynamic network of mainly sandy islets between Mauritania and Guinea. These islets can be destroyed or impacted by the force of the sea, causing erosion and even disappearance of islets. Such impacts, however, become more likely and more prominent with the prospect of rising sea levels, a known result of a warming global climate. In the lower Senegal Delta, a 90cm sea level rise would result in the disappearance of 63.59 km, representing about 12.15% of the total area; serious coastal erosion is ongoing here with major environmental and economic consequences (Koulibaly 2021). The delta is further impacted by a breach that was dug in the Langue de Barbarie, a coastal sand spit between the delta and the Atlantic, and which rapidly grew, significantly altering flow of water in and out of the delta. The combined impact of climate change and the breach have caused significant erosion of Ile aux Oiseaux (Bird Islet) in the delta, an important breeding site for gulls and terns (Figure 24). This has resulted in a loss to date of around 5,000 pairs of breeding seabirds, with submersion of nesting areas, loss of eggs and chicks, increased competition for nesting sites and predation (Koulibaly 2022).

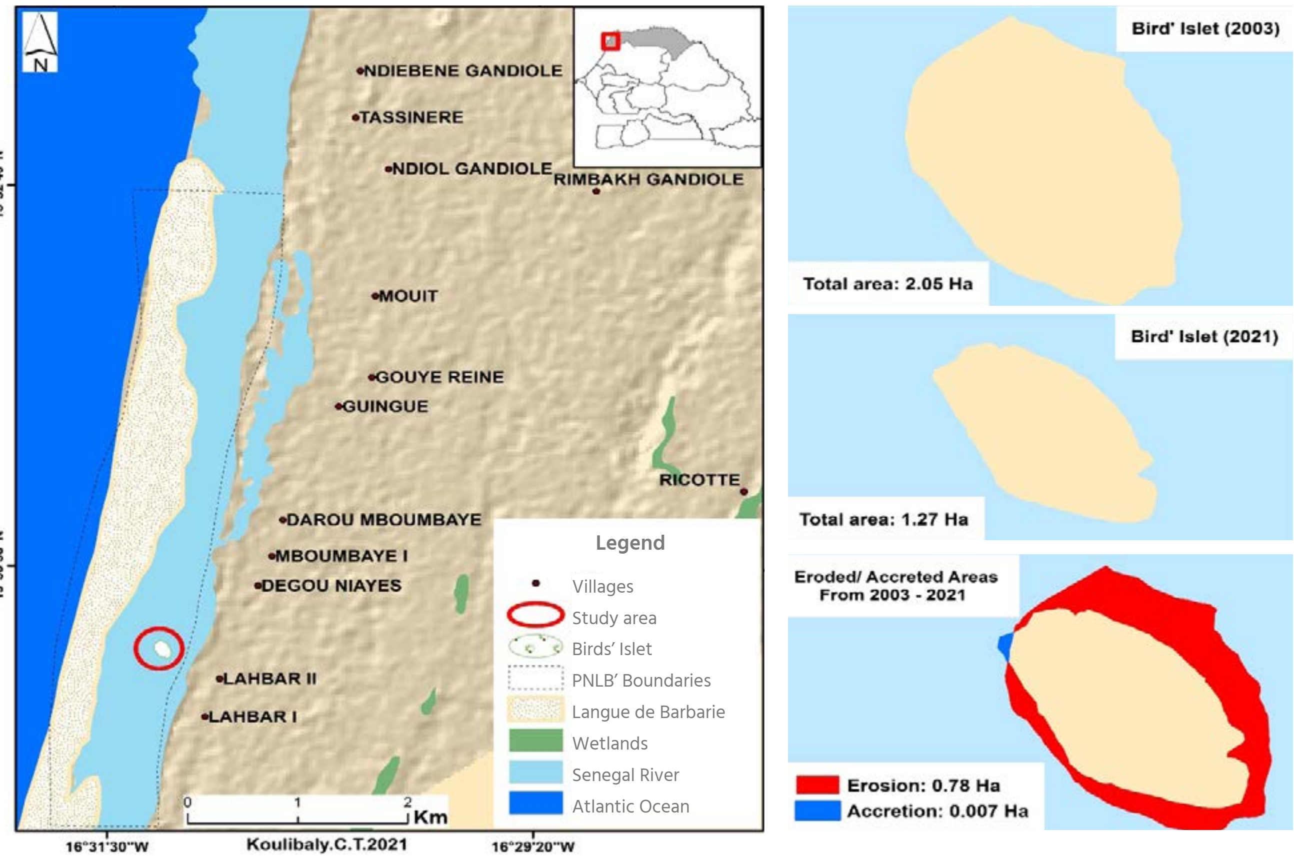


Figure 24: Erosion of a seabird breeding islet in the lower Senegal Delta caused by rising sea levels and a breach in a coastal sand spit (Koulibaly 2022).

2F. POLLUTION

1. Plastic, chemical and metallic pollution

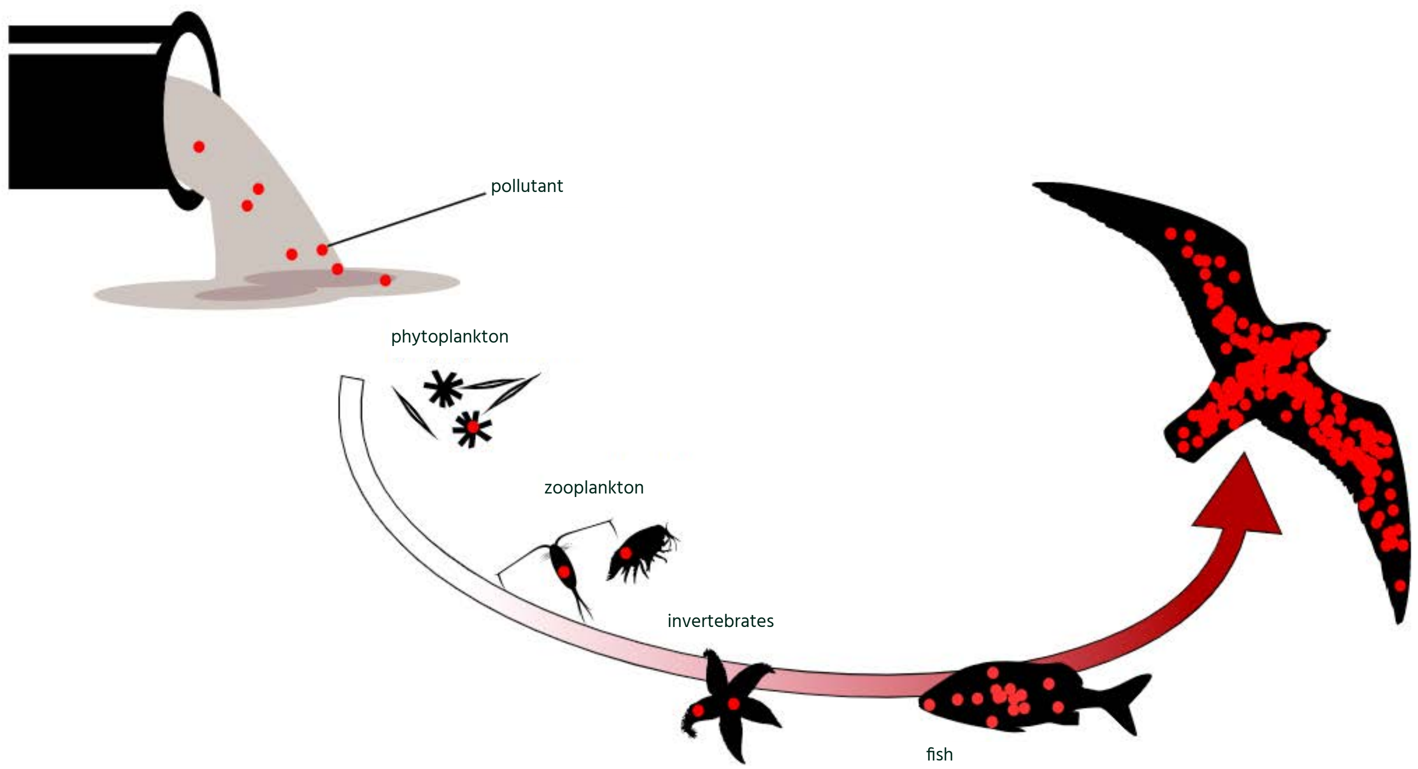


Figure 25: Bioaccumulation and biomagnification of a pollutant (red) among seabirds.

Releases of plastic, chemical and metallic substances have increased dramatically for several decades, intensely contaminating marine ecosystems (Burger & Gochfeld 2001). In 2019 global plastics production almost reached 370 million tonnes (Plastics Europe 2020), and plastics discharges into the sea have increased inexorably over past decades. Microplastics (pieces of plastic that measure less than 5mm) are of particular concern. Today more than 90% of seabird species have ingested plastic, and by 2050, 99% of seabirds will have plastic in their stomachs (Wilcox *et al.* 2015). Being mostly resistant to biodegradation, marine pollution can today be described as permanent (Bukola *et al.* 2015).

Seabirds, therefore, encounter these harmful substances throughout their lives. Being at the top of the food chain (top predators), they are particularly subject to bioaccumulation (Figure 25). As many seabird species are long-lived (sometimes living for more than 60 years), they can experience significant exposure to and accumulation of pollutants (Burger & Gochfeld 2001, 2004; Rowe 2008).

The negative impact of pollutants on the survival of seabirds has been proven (Goutte *et al.* 2014). Plastics, once ingested, diffuse substances (e.g., PBDE or bromide) toxic to birds (Tanaka *et al.* 2013), or kill directly by suffocation, tangling, strangulation, or obstruction of the digestive tract (Votier *et al.* 2011). Pollutants can also impact survival more indirectly, even at levels of contamination seen as non-lethal. For instance, some studies have shown that pollutants are responsible for increased levels of hormonal stress (Tartu *et al.* 2015) and oxidative stress (Costantini *et al.* 2019; Costantini *et al.* 2014). These physiological mechanisms are intricately linked to the immune system (Romero 2004), which, if inhibited or misdirected due to stress or directly from the pollutant then compromises survival (Wayland *et al.* 2002; Jara-Carrasco *et al.* 2015).

The impact of pollutants on breeding success can affect all stages of reproduction from the egg to feeding of young birds (Whitney & Cristol 2017; Barros *et al.* 2014; Burgess & Meyer 2008; Goutte *et al.* 2015; Tartu *et al.* 2015; Tartu *et al.* 2013). The fledgling mass and the growth rate of the chicks are also negatively impacted by pollution (Amélineau *et al.* 2019; Oudi *et al.* 2019), suggesting potential long-term effects of contamination.

Contamination during the chick stage can occur via food provided by parents (Nisbet *et al.* 2002; Paiva *et al.* 2008), or directly during the development phase. Indeed, pollutants present within adults can pass through feathers as a way for birds to reduce their level of contamination. Pollutants can also pass from females into their eggs, explaining the commonly observed pattern of higher contamination among males than females (Burger *et al.* 1994; Provencher *et al.* 2016; Robinson *et al.* 2012). This mechanism of 'depollution' can be beneficial for the female, but can also negatively impact her offspring. Some studies have shown correlations between the levels of pollution in the female (blood, feather) and in her chicks (shells, eggs, blood, feathers)

(Ackerman *et al.* 2016; Bearhop *et al.* 2000; Evers *et al.* 2003; Kenow *et al.* 2015).

Although the immediate effects of pollutants on seabirds are well known, the physiological mechanisms involved and the consequences of contamination in the long term have yet to be determined. In particular, the potential trans-generational effects of pollution suggest impacts redirected towards future generations, raising more questions about the adaptive capacity of populations to these large-scale anthropogenic disturbances.

Certain species of seabirds, such as boobies, cormorants and gulls, frequently use anthropogenic waste (synthetic ropes, fishing nets, pieces of plastic, etc.) as nest building materials (Battisti *et al.* 2019; Cadiou & Fortin 2015; O'Hanlon *et al.* 2019; Tavares, Moura & Merico 2019; Votier *et al.* 2011; Witteveen *et al.* 2017). Monitoring the presence and abundance of waste in the nests, and the mortality of adult and young birds due to entanglement in this waste, provides information on the impact of the oceans' pollution by plastics and other anthropogenic wastes. Such monitoring is relatively easy to carry out during census missions by prospecting seabird colonies.

Toolbox: Birds & Debris

An inventory of human waste related to birds

A dedicated website https://www.birdsanddebris.com allows you to report observations of bird nests containing anthropogenic waste, be it plastics or other types of waste, or observations of birds tangled in these different types of waste.

2. Light pollution

Light pollution can also affect seabirds, especially nocturnal species and more specifically burrowing species, notably petrels and storm-petrels (Rodríguez *et al.* 2017). Young birds can become disoriented by night lights at the coast or on islands and may run aground at the foot of the lights (Rodrigues *et al.* 2012). Affected individuals have difficulties relaunching and can be predated by animals (e.g., dogs, cats, pigs), or even killed by cars.

Seabirds are also attracted to the lights produced by offshore oil platforms (Wiese *et al.* 2001). Collisions or incinerations due to the flames produced have also been reported near the platforms. The global magnitude of this problem is potentially very high and likely causes the decline of many seabird populations, but it remains only poorly understood, especially in West Africa. Small pelagic seabirds are particularly sensitive to this, and any oil and gas platform in the region have the potential to represent a high risk for these species associated with the attraction effect, due in part to the large distances that they cover in a single trip (BirdLife International 2021).

Still little studied, light pollution could affect the migratory strategies of seabirds (Cabrera-Cruz *et al.* 2018; La Sorte *et al.* 2017), and therefore in the long term, compromise the sustainability of populations.

Light pollution is an emerging threat in West Africa, as awareness grows of its effects. Work is underway in Cabo Verde to increase community awareness of light pollution and to ensure there are networks in place to recover and re-release seabirds that are disoriented by light pollution. Work needs to continue to ensure that light sources, such as streetlights, lights in coastal installations and those from industry in coastal areas are reduced to have minimal effects. The turtle conservation networks working in West Africa are already working on light pollution due to its devastating effect on emerging turtle nestlings, causing them to be disoriented and lose their way to the sea.

Pollution: A pollutant is a biological, physical, or chemical alterant, which, beyond a certain threshold, and sometimes under certain conditions (potentiation), develops negative impacts on all or part of an ecosystem or the environment in general. In other words, when a substance - favourable at low doses (e.g., nitrate NO▯▯) - is too concentrated in an environment, it can negatively affect the environment and becomes a pollutant.

Bioaccumulation: Seabirds are predators at the top of the food chain. They therefore end up accumulating pollutants stored in the tissues of their prey (cf. Figure 25).

Biomagnification: The process by which the levels of certain substances increase at each stage of the food web. This process particularly affects end-of-chain predators such as seabirds (cf. Figure 25).

2G. INDUSTRIAL AND INFRASTRUCTURAL DEVELOPMENTS

The development of offshore oil and gas exploration and exploitation activities poses a direct threat to the conservation of biodiversity and the marine and coastal ecosystems. In West Africa, there are numerous activities underway or planned within both coastal (onshore) and marine (offshore) areas, and oil and gas concessions have been established for large areas at sea (Figure 26).

The principal risks to marine and coastal ecosystems from offshore oil and gas activities are from noise, damage to the seabed, spills of oil and other chemicals, gas flaring, infrastructure, waste and transport (BirdLife International 2021). Oil and gas activities represent a danger to birds through the presence of oil residues in the water which can contaminate plumage and food. The infrastructural developments also pose a risk of collisions, especially due to attraction to light, including from flaring. Ill-placed wind turbines at sea or in the coastal zone are also known to impact birds, including seabirds, although these are not well developed as yet in West Africa.

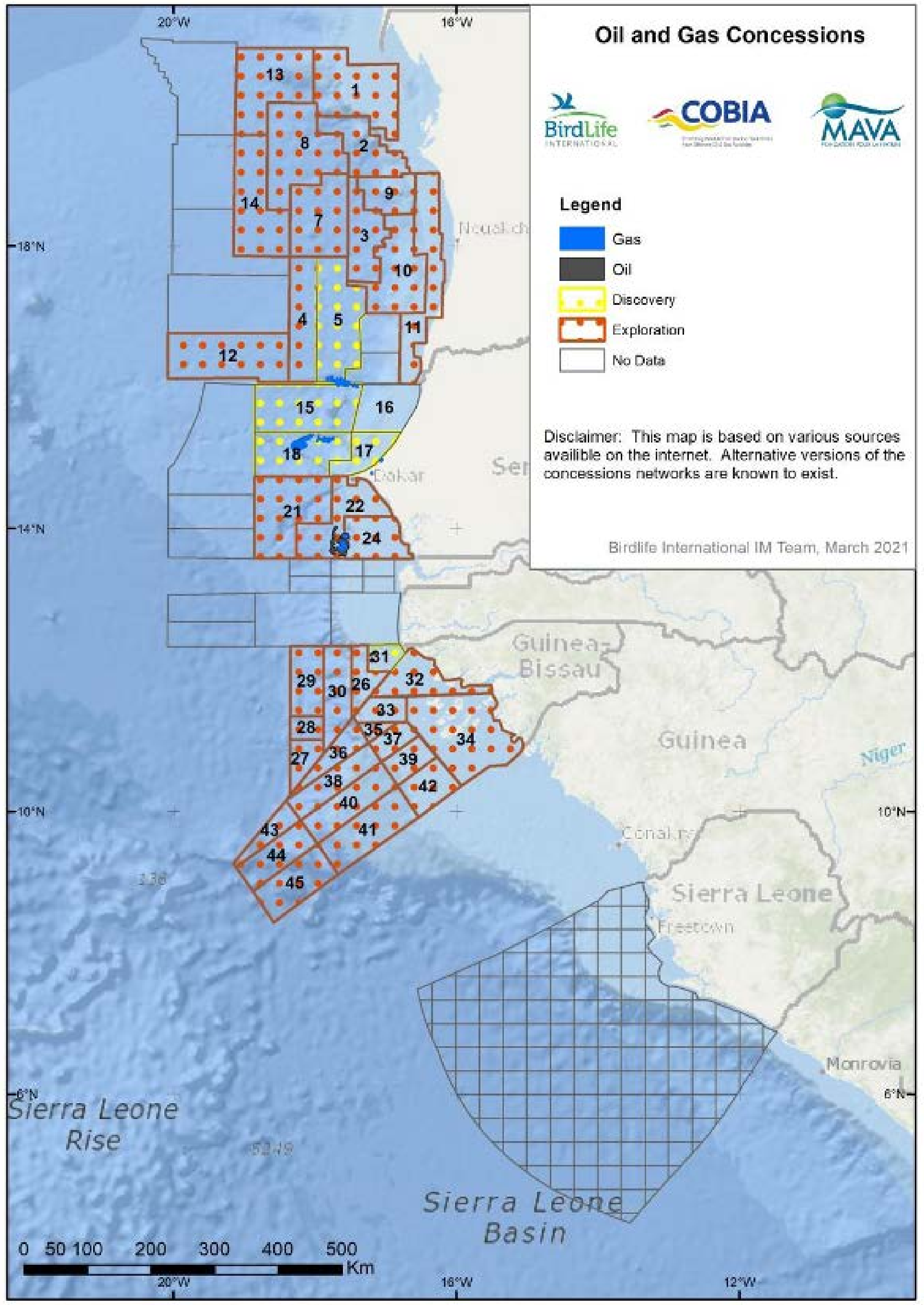


Figure 26: Oil and gas concessions between Mauritania and Sierra Leone (BirdLife International 2021).

1. Direct overexploitation of birds

Many seabird species have a slow rhythm of life characterized by a late sexual maturity and a long lifespan, making them particularly susceptible to threats directly affecting their survival, such as overexploitation. Historically, the overexploitation of seabirds by humans has had dramatic consequences, leading for example to the extinction of the Great Auk *Pinguinus impennis*, with the last pair killed in Iceland in 1844, or the Spectacled Cormorant *Urile perspicillatus*, former occupant of the Bering Strait which was hunted to extinction by the 1850s. Today, direct exploitation remains an important problem for seabirds, even if the protection of many species has helped to attenuate it.

In West Africa, the capture of terns has been reported from a number of countries, including Senegal, Ghana and Togo. In Ghana, terns are trapped by baited snares on beaches, mostly by young boys for food, money and recreation (Quartey *et al.* 2018); and such trapping could have had a role in reducing Roseate Tern *Sterna dougallii* numbers (Ntiamoa-Baidu *et al.* 1992). In coastal Senegal, Stienen *et al.* (1998) estimated that almost 10,000 terns were trapped in the 1990s, especially Sandwich Terns *Thalasseus sandvicensis*. Some rings of birds that had been banded at their European nesting areas were reused to make jewellery. Trapping of terns along the West African coast remains an important threat, although it is difficult to measure due to the lack of data.

In Cabo Verde, the Cape Verde Shearwater *Calonectris edwardsii*, was exploited heavily until recently on the islands of Raso and Branco, although this practice has now stopped through conservation programmes. Without the denunciation of these practices by civil society groups including Biosfera, the BirdLife Partner in Cabo Verde, and the intervention of the authorities, this illegal activity would probably still be practiced today. However, breeding seabirds are still hunted elsewhere in Cabo Verde for their meat. Further north, Cory's Shearwater *Calonectris borealis* has also been exploited in the Ilhas Selvagens (Madeira). Some seabirds are also targeted by fishing boats, not necessarily as (unused) bycatch. Northern Gannets *Morus bassanus* have been found packed in freezers on a fishing boat operating off West Africa.

Egg collecting can also have a significant impact, either for food or for private collections of eggs. In Great Britain, the collection of Roseate Tern Sterna dougallii eggs by rare bird egg collectors has been a threat affecting its survival there. Significant amounts of seabird eggs were also collected and consumed in the Caribbean. Indirectly, egg collecting inevitably causes disturbance of seabird colonies, which can lead to their abandonment. In West Africa, collection of seabird eggs has taken place in Cabo Verde, although this has been a greater threat for breeding sea turtles. Eggs have also been collected for consumption from tern and gull colonies off coastal West Africa, including in the Saloum Delta of Senegal.

2. Indirect overexploitation: overfishing

By transforming marine ecosystems (Beddington *et al.* 2005; Pauly *et al.* 1998) and entering directly into competition with predators, fisheries affect the ability of seabirds to feed, particularly impacting their reproductive success, in particular their ability to feed their young during the breeding season (Cury *et al.* 2011). Globally, overfishing, by reducing available prey, affects around 15% of seabird species (Dias *et al.* 2019). In a global study, Grémillet *et al.* (2018) showed that between the periods 1970 - 1989 and 1990 - 2010 the annual fisheries catch concerning prey that are also targeted by seabirds increased from 59 to 66 million tonnes. Despite a parallel reduction in seabird populations, competition between seabirds and fisheries has increased in 50% of marine regions (Grémillet *et al.* 2018).

Several species of seabirds have seen their populations decline sharply following the collapse of their main prey populations due to overfishing. Overfishing of sardines along the Namibian coast has caused a food shortage leading to a significant reduction in populations of Cape Gannets Morus capensis (Crawford *et al.* 2007; Crawford *et al.* 2014; Crawford *et al.* 2015). Similarly, the decline of African Penguin Spheniscus demersus populations in South Africa has been attributed to food shortages associated with overfishing (Crawford *et al.* 2011). On Robben Island, an increase in the survival of penguin chicks following the establishment of prohibited fishing zones around the island seems to confirm this hypothesis (Sherley *et al.* 2018; Sherley *et al.* 2015).

Understanding and estimating the effects of overfishing on the availability of prey for seabirds remains difficult, this effect being indirect. In the most obvious cases, fishing affects prey populations, which in turn affect bird populations (Grémillet *et al.* 2018). However, the effect of fisheries on ecosystems can be complex, with overfishing of a given species having very variable effects depending on the role of the species in the ecosystem. Thus, the overexploitation of species which are not part of the diet of seabirds, but which play a key role in marine ecosystems, can indirectly impact the prey of seabirds through a "cascading" effect. Thus, even the exploitation of species located low in the food web can have significant consequences on seabird populations (Smith *et al.* 2011). Understanding the regional and global effects of fisheries requires a detailed understanding of the functioning of ocean food webs, and of the consequences of disturbances linked to fisheries.

Not all species are equally affected by overfishing. Certain species, notably the Northern Gannet Morus bassanus, can modify their diet depending on the prey available, and theoretically, be less sensitive to the effects of fisheries. When mackerels are in shortage, a significant part of the Northern Gannets feeding in the English Channel thus modify their diet to exploit the discards of fisheries, i.e. the undesirable catches returned to the water, alive or not, by fishers (Enever *et al.* & Grant, 2007). This behavioural plasticity could even allow Northern Gannets to take advantage of fisheries, and facilitate their access to resources, rather than limit it. The use of discards from fisheries does not, however, compensate for the shortage of prey linked to overfishing, in particular Common Mackerel *Scomber scombrus* (Le Bot *et al.* 2019). In fact, Northern Gannets favouring the use of fisheries' discards have a lower breeding success and body condition than individuals who preferentially feed on natural prey. Overfishing therefore has a negative effect on Northern Gannet populations feeding in the English Channel, despite their foraging plasticity.

The degree of harm caused by overfishing of forage fish, and of seabirds' preferred prey species in West Africa is unknown. Concerns have been raised about the degree of removals of fish from coastal waters for fishmeal production in The Gambia (Urbina 2021). Further information on this growing problem for West Africa is needed.

3. Bycatch as a threat to seabirds

Each year, hundreds of thousands of seabirds are killed due to ever more intensive fishing. Surface-feeding seabirds, such as albatrosses are often attracted to bait on hooks or fish thrown around fishing boats. Plunge-diving birds can also be affected, such as the Northern Gannet Morus bassanus.

Common mechanisms for seabird bycatch are shown in Figure 28. a) Each year, more than 160,000 birds die from longline fisheries; a single tuna boat may have as many as 2,500 baited hooks, representing a significant hazard for seabirds. b) Around 10,000 birds are also trapped each year in trawler nets and drowned. c) Over 400,000 seabirds get trapped each year in static or drifting gillnets (BirdLife International 2013).

Figure 27: Northern Gannet *Morus bassanus* with a fishing hook caught in its throat © David Grémillet.

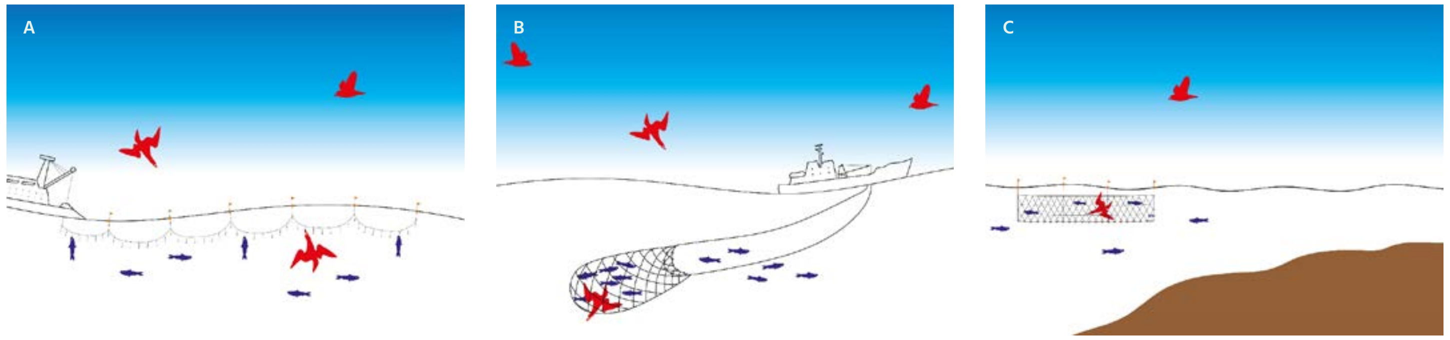


Figure 28: Each year, A) longline fisheries, B) trawl nets, and C) gillnets are responsible for the accidental death of hundreds of thousands of seabirds (BirdLife International 2013).

Fishery bycatch has been identified as the most important threat for seabirds in the marine space globally (Dias *et al.* 2019). However, without specific data gathering, such as through observer programmes, it often goes unnoticed. In sub-Saharan Africa, managing bycatch in artisanal and industrial fisheries continues to be a preoccupation for seabird conservation programmes. Recent successful bycatch mitigation work in Namibia has reduced seabird mortality by 98%, following the same highly successful interventions pioneered by BirdLife's Albatross Task Force in South Africa (Da Rocha 2021). Current information for the Mediterranean region of Africa indicates that little seabird bycatch is occurring in industrial longline fisheries, despite the existence of shearwater colonies in proximity to the coast and considerable fishing effort.

Bycatch, however, remains a persistent threat, with bycatch in new fisheries and new ways in which birds can be accidentally entangled described, as more information comes to light about the extent of bycatch in artisanal and semi-industrial fisheries. This reflects an ongoing challenge in fisheries – the lack of reliable data on effort and catch (including bycatch). The regions that are of high priority for reducing seabird bycatch in Africa are also pertinent for turtle bycatch and sharks, with a focus in West Africa, Southern and East Africa (Wallace *et al.* 2013).

Bycatch in West African fisheries has been studied in recent years with the deployment of observers. Between July 2019 and June 2021, BirdLife International trained over 50% of the government observers working in West Africa and collected data about 5,800 fishing sets, including in Cabo Verde (Figure 29). From these sets, bycatch of seabirds was only observed in four fishing events, three from trawl fisheries and one from purse seine fisheries, while sea turtle bycatch was more prevalent, with 115 turtles observed caught in the same fisheries (BirdLife International unpublished data). In addition to industrial or fisheries with large vessels, artisanal vessels can catch birds, turtles, sharks and rays and even marine mammals. Bycatch monitoring is continuing to be carried out in West Africa, with programmes ongoing to monitor fishing bycatch in artisanal fisheries where its occurrence is high, with 77% of fishers responding to questionnaires indicating they had caught seabirds during previous fishing trips (Montrond 2020). These problems are probably more widespread in West Africa than is currently evident, with a lack of data to describe the nature and extent of the problems.

Figure 29: Field technicians from Bios CV in Cabo Verde. © BirdLife International

2I. CLIMATE CHANGE

Climate change negatively affects most organisms on the planet, and even threatens the survival of some species. Seabirds, with a life cycle that takes place both on land and at sea, are threatened by climate change at several levels.

1. The warming of surface waters

The warming of ocean surface waters has a negative effect on primary production, notably phytoplankton, which is at the origin of the entire food chain. Warming surface water leads to a decrease in phytoplankton at the surface, and a weakening of the mixture with deeper waters.

When primary production decreases, the upper trophic level is negatively impacted by a lack of resources, and so on along all the levels of the food chain: this is a bottom-up control. Since seabirds are located at a high level in the marine food web, they are strongly affected by this control, which results in a decrease in the quantity of prey available. Although the birds' prey has adapted to climate change, most seabirds have not changed their phenology (Keogan *et al.* 2018). However, some species have adjusted their phenology to the new state of favoured prey, with some advancing their breeding and others delaying it.

2. The increase in intensity and frequency of exceptional events (tropical cyclones, storms)

Although storms and cyclones are not new events, the increase in their intensity will have important consequences on colonies, especially in tropical seabirds, which breed mostly on islands. These storms lead to an increased mortality and to a reduced breeding success, notably through the destruction of habitat and nests containing eggs or juveniles.

In addition, during these episodes, oceans become rough and prey becomes more widely dispersed, making it more difficult for seabirds to find food. Even if these phenomena have a short individual duration, the sudden lack of food and high winds may increase the mortality rate of seabird or their chicks.

3. Sea level rise

Sea level rise can have significant consequences for seabird colonies, especially those located on low islands, whose altitude is only slightly above current sea level, including the gull and tern colonies of coastal West Africa. Such islands could be partially or totally submerged, causing the disappearance of the breeding habitat and a significant mortality rate. A rise in sea level could even lead to the disappearance of the whole species or subspecies, for example the Europa Island population of Yellow-tailed Tropicbird *Phaeton lepturus* europae in the Mozambique Channel. Several gull and tern colonies on sand banks of the West African coast at sites such as Langue de Barbarie and the Saloum Delta in Senegal and Acapa Imbone and Bantambur in Guinea-Bissau are already impacted and may be submerged in the near future, with a current sea live rise rate of 3.3mm/year.

While global warming has many negative impacts on seabirds, it can have a beneficial effect on some populations; the increase in the number of Northern Gannets *Morus bassanus* in Newfoundland, Canada, can be directly attributed to the warming of surface temperatures, which has allowed a northward expansion of migrating mackerel in warm water in Newfoundland waters (Montevecchi & Veit 2006). It is however not possible to know whether this positive effect will last, or whether it will eventually become negative.

2J. DISEASE AND PARASITES

Disease

Disease has always played a role in natural mortality of birds, but the effects appear to have been more intense as a result of human interventions; for instance, a general increase in water temperature has in many countries caused more outbreaks of botulism (a paralytic disease caused by ingestion of a toxin produced by the bacteria *Clostridium botulinum*) which can kill hundreds of congregatory birds at the same time in a restricted area, including gulls (Dodman & Boere 2010). Avian influenza (AI) is an infectious disease caused by type A influenza viruses which commonly occurs in birds with little or no effect. The AI viruses are classified as low pathogenic (LPAI) or highly pathogenic (HPAI) depending on their virulence in domestic chickens. The HPAI virus subtype H5N1 of Asian lineage has been of great concern as it has spread rapidly across Asia, Africa and Europe and because of its unique pathogenicity (Dodman & Boere 2010).

HPAI has been long associated with waterbirds, including gulls, which are also considered as seabirds. In 2020 and 2021 HPAI outbreaks affected numerous species of seabirds in Western Europe, including birds that spend the northern winter in West African waters. Birds affected included Great Skua *Catharacta skua*, Sandwich Tern *Thalasseus sandvicensis* and Northern Gannet *Morus bassanus*, and many thousands of birds died at their breeding sites. The presence of HPAI in seabirds is of great conservation concern, given that most seabirds breed colonially, and the disease can spread quickly through breeding colonies.

HPAI outbreaks have been found in coastal seabirds in West Africa in 2023, with reports from Senegal, The Gambia and Guinea-Bissau, especially affecting Royal Terns *Thalasseus maximus*.

In West Africa, nearly 2,500 Great White Pelicans *Pelecanus onocrotalus* died in late January 2021 in the Senegal Delta in Djoudj and Diawling National Parks as a result of an HPAI outbreak. The vast majority of birds that died were chicks and juvenile birds. The park authorities and NGOs, including BirdLife Partners in Senegal and Mauritania, took quick action to dispose of corpses, close the parks and carry out surveillance measures (Figure 30).

Employing sound management options and precautions are essential when dealing with or investigating known or suspected cases of disease, especially HPAI. Annex 4 provides a summary of management guidelines based on recent experience of HPAI outbreaks in the Wadden Sea, notably of Sandwich Terns *Thalasseus sandvicensis* (Bregnballe et al. 2023).

Figure 30: A surveillance team operating at Djoudj National Park, Senegal, after a significant avian influenza outbreak within the Great White Pelican *Pelecanus onocrotalus* colony. © Direction des Parcs Nationaux, Senegal.

Parasites

Seabirds are victims of several parasites (ticks, mosquitoes, etc.) that transmit disease. Infestations by ticks can affect the health of hosts through blood loss, the injection of toxins, and the transmission of infectious agents, and has even been recorded causing blindness in petrels by the mechanical blocking of eyesight (Gamble *et al.* 2020).

Increase in zoonosis

With global warming, a need for larger foraging areas will lead to an increase in the transmission of ticks and pathogens in new areas, and to new species (Dietrich *et al.* 2011). For certain disease vectors, such as the mosquito, global warming can cause their distribution area to increase, accompanied by a higher transmission of diseases, and an increase in mortality rates. In certain species of seabirds, the loss of eggs and the desertion of nests by adults are greater when the quantity of mosquitoes increases. In addition, global warming can change the physiology of disease vectors, as can the phenology of birds, which could lead to changes in parasites and diseases (Montevecchi & Veit 2006).

2K. HUMAN DISTURBANCE

Human disturbance, unlike habitat destruction, does not necessarily imply a long-term alteration of the living areas of seabirds. However, it can have similar effects by preventing seabirds from using these habitats, and this threat is considered as one of the six main threats to seabird populations globally (Dias *et al.* 2019). Disturbance can be linked to all kinds of activities, especially tourism, transport, pets (dogs) and livestock (goats, sheep, cows). The level and frequency of disturbance can be particularly high in areas frequented by humans. The reasons for human presence in seabird colonies are numerous, from recreational reasons (for example beach walkers, tourism) to fisheries, farming, sand extraction and even scientific research (Folmer *et al.* 2018), whilst resources exploitation is widespread. These activities can have direct effects on the nesting success and survival of breeding birds, as well as long-term consequences for the persistence of colonies as a whole (BirdLife International 2012).

Ground-nesting seabirds, such as pelicans, gulls and terns, are particularly prone to human presence, which can cause nesting birds to fly up from their breeding colonies, injure nestlings and destroy eggs, leaving nests vulnerable to predation by birds such as gulls and corvids. This can also result in nest abandonment or, in the case of prospecting pairs, prevent them from settling in the first place (Carney & Sydeman 1999). Eggs and chicks may be trampled or may die because of heat stress when they are exposed to bright sunlight, even for relatively short periods of time (Veen *et al.* 2015). They are also vulnerable to predation, especially by gulls.

Seabirds breeding in coastal West African are particularly exposed to human disturbance. Whilst the coastal zone is an important area for migrating, foraging and breeding seabirds, it is also an area heavily utilised by people for fisheries and urban, agricultural and industrial development. Large numbers of seabirds occur in the Sahelian Upwelling Marine Ecoregion due to the high food abundance and suitable places for breeding. For coastal seabirds such as gulls and terns, the main suitable breeding sites are islands spread out along the coasts of Mauritania, Senegal, The Gambia, Guinea-Bissau and Guinea. Many of the sites are frequently visited by humans, including fishermen, tourists and other casual visitors. Any landings to these islands, including by researchers or protected area personnel, invariably causes disturbance (Figure 31).

Figure 31: Top: Disturbed gulls and terns rise up from their nests in the Saloum Delta. © BirdLife International.

Great White Pelican *Pelecanus onocrotalus* colonies are also very sensitive to disturbance. Fortunately, the only colonies in West Africa are in national parks, where disturbance is limited, although tourism impacts need to be carefully managed.

For burrow-nesting seabirds such as shearwaters, disturbance may have a limited effect on breeding adults, as they tend to be away, foraging at sea during the day. However, their burrows in soft substrate are especially vulnerable to disturbance, and easily cave in if walked over by people or larger domestic animals. This not only destroys their nests, but can also squash or trap eggs and chicks within the nests. White-faced Storm-petrels *Pelagodroma marina* on Ilhéu de Cima, Ilhéus do Rombo, Cabo Verde, are vulnerable to any landings by people (Figure 32). Habitually, fishermen land at the island, and may walk through the dense warrens of burrows, either unintentionally or on purpose.

In terms of research, handling incubating birds can result in a degree of nest abandonment (Carey 2011), and for older chicks within the burrows, human presence can cause stress, potentially leading to impaired immune system development (Brewer *et al.* 2008), or reduced body mass at fledging (Albores-Barajas *et al.* 2009). Since fledgling body mass and size are linked to sub-adult survival (Morrison *et al.* 2009; McClung *et al.* 2004), these effects on chicks in the nest may have long-term repercussions for the stability of the population.

Different species differ significantly in their sensitivity to human disturbance. Critical reaction distances and their associated behavioural responses vary by species and perceived threat, so conservation measures such as buffer zones and seasonal restrictions must be tailored to the species and human activity in question (Martínez-Abraín *et al.* 2008; Beale & Monaghan 2004).

For species nesting as infrequently as once every two years, the widespread failure of breeding attempts as a result of disturbance will have a large impact on productivity. For threatened seabirds this is a serious conservation problem, particularly where conservation areas are also managed for recreation.

Figure 32: Top: Fishermen land at Ilhéu de Cima, Ilhéus do Rombo, Cabo Verde. Bottom: Behind them are extensive burrows of White-faced Storm-petrel *Pelagodroma marina*. © Tim Dodman.

Part 3 Conservation of seabirds and their habitats

3A. REVIEWING THE SITUATION, AND A RESPONSE FRAMEWORK

Carrying out a review for conservation action

In carrying out conservation action, it is necessary to review what has already been done, both failures and successes, first at the intervention site(s) and then more broadly, at other scales, in other regions or for similar species.

Reviewing scientific and grey literature can be done freely on websites such as https://scholar.google.com or those that host scientific literature, such as https://www.researchgate.net. Nevertheless, access to certain articles is not always free and this can pose ethical problems of access to knowledge, for example through infringement of copyright. For publishing, peer-reviewed publications are preferable, and free and open access journals increase accessibility and readership. Peer Community In (PCI) offers peer review, recommendation and publication of scientific articles in open access for free, including in Ecology and Animal Science: https://peercommunityin.org). A number of journals specialise in publishing papers on birds and bird conservation in Africa, and provide free editorial support, including Malimbus (for West Africa – in English or French) and the Bulletin of the African Bird Club.

There is often a gap between research and application in the field, and therefore between scientists and managers in the field. This gap will tend to fill as awareness of the need to preserve biodiversity and improve the effectiveness of actions increases. However, technical reports produced by government workers or through conservation projects often hold detailed and important information, but may not be available online. Becoming acquainted with others working in similar fields and making reports available online improve links and make works accessible.

Toolbox: ResearchGate, the social network for publications of… uh… researchers

On https://www.researchgate.net/ you can create an account with an institutional address (a student email address for example), or with another address by being sponsored or by justifying a research activity. From then on, you will have access to publications and technical reports from conservation biologists (+11 million scientists from 192 countries announced on the site). It is also possible to ask questions and debate with your peers who are enlightened on specific subjects, and therefore useful for your conservation projects.

A review about effective and ineffective actions can be checked on a website that gathers evidence with references, namely: www.conservationevidence.com. This preliminary research makes it possible to clarify the paths of action to follow and can shed light on previous successful work to underpin a project. As an example, on entering the keywords 'seabirds bycatch', 21 actions are referenced, of which three appear to be beneficial and are supported by 22 published researches (website queried in October 2022).

A framework for response

The Driving Force – Pressures – State – Impacts - Responses framework (DPSIR) modified for the marine environment by Oesterwind *et al.* (2016) after Gabrielsen & Bosch (2003) presents well a conceptual framework in which monitoring and action or management decision-making can take place (Figure 33). Driving forces (e.g., the need for fish by humans) can result in pressures (e.g., overfishing), which may then change the state (e.g., reduced fish biomass as food for seabirds). This can then have consequences or impacts (e.g., low seabird breeding success) that require a management response. To be effective, management responses need to address not just the immediate impact (e.g., low seabird breeding success) but the driving forces – there may be several - that contribute to the impact. Effective responses should thus over time lessen the driving forces.

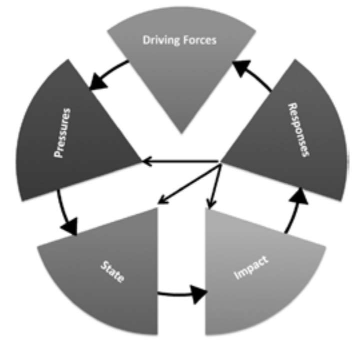


Figure 33: The Driving Force – Pressures – State – Impacts - Responses framework (DPSIR) modified for the marine environment by Oesterwind *et al.* (2016) after Gabrielsen & Bosch (2003).

3B. COMBATING INVASIVE ALIEN SPECIES

Invasive Alien Species (IAS) are known to threaten 165 out of 359 species of seabirds (Figure 19: Current threats affecting all seabirds globally. These threats have different levels of severity in different regions, for example invasive mammalian predators are particularly problematic on islands such as in Cabo Verde, where they depredate ground nesting seabirds. Fishing related threats such as overfishing and diminution of forage fish, along with habitat loss and pollution by light, plastics and chemicals are more problematic in continental West Africa. Graphic: BirdLife International.), mainly on islands. Combating them is therefore one of the main priorities related to the conservation of seabirds. Globally, more than a thousand eradication operations have been carried out on 967 islands with 1525 eradications of 67 different IAS (November 2020), as listed at http://diise.islandconservation.org. These eradication operations are carried out on islands or at other limited and controllable spaces because a low surface area and complexity of the environment to be treated are key factors of eradication success. The main taxa targeted for eradication are mammals, including rodents (57%), domestic goats Capra hircus (11%) and feral cats *Felis catus* (8%).

Is it beneficial? A bibliographic summary reveals that 236 insular terrestrial species, including 83 species of seabirds (596 populations) have benefited from the eradication of invasive alien mammals. Of these, 41 species (73 populations) have seen their numbers increase, 50 species (89 populations) have recolonized, and 22 species (28 populations) have recently colonized the islands cleared of invasive mammals. However, IAS eradication programmes can put at risk non-target species; 7 species on 6 islands were negatively affected (Jones *et al.* 2016) through poisoning with trapped baits or by consuming carcasses. However, the benefits in the medium and long term are usually favourable. For example, after the deaths of 320 Glaucous-winged Gull *Larus glaucescens* poisoned during a rat eradication campaign on Hawadax Island, Alaska, their population density increased a year after the eradication (Croll *et al.* 2016). Overall, the benefits of eradication operations are clear.

Note: Eradication of one IAS can trigger effects on other IAS through the release of pressure from a predator, such as an increase in the number of rabbits after the eradication of cats, or an increase in the number of a specific plant after the eradication of an invasive exotic herbivore (Courchamp *et al.* 2003). An action plan must consider the possible ecological scenarios before starting an eradication.

The main methods of eradication to date are: poisoning (anticoagulant, Brodifacoum type) for rodents, and shooting/trapping for herbivores, cats, dogs, pigs and others. These operations consume time and resources, so it is essential to avoid any new bioinvasion. Prevention with strict biosecurity measures is the best way to avoid ecological disasters linked to IAS. BirdLife International, the IUCN Invasive Species Specialist Group (http://www.issg.org) and Island Conservation (https://www.islandconservation.org/) all provide biosecurity advice.

Initiating, maintaining and enforcing biosecurity measures are essential procedures to prevent IAS reaching places, especially islands, where seabirds breed. To be effective, biosecurity measures need to be long-term and built into governmental and/or site management policy. These measures therefore require long-term resources and commitment. This can present a strain on NGOs and others, especially in remote island locations. Policing of biosecurity is particularly difficult, and requires strong government support, whilst biosecurity also needs to be built into legislation, and practiced by the communities using these areas.

In Cabo Verde, a number of efforts are underway to reduce and minimise the impact of IAS. Domestic cats were eradicated from Santa Luzia in 2020, where they had a significant impact on local fauna, although the House Mouse *Mus musculus* is still present there (Medina *et al.* 2021). This island is not known to support breeding seabirds, although Cape Verde Storm-petrels *Hydrobates jabejabe* have probably attempted to breed there; the discovery of wings of adult birds presumably depredated by cats were likely attracted by calling birds occupying nest crevices (Oliveira *et al.* 2014). With cats now eradicated, there is potential for this species to breed here.

A programme has been underway to monitor the impact of feral cats on Cape Verde Petrels *Pterodroma feae* on Fogo, where this species breeds on the slopes of the island's volcano caldera. Cats have been caught in live traps (Figure 34) and marked to follow their movements. The main activities in Cabo Verde proposed by Aves Marinhas de Cabo Verde (2019) to combat IAS include:

- Research and monitoring
- Training and capacity-building
- Conservation and management
- Environmental education and communication

Development of a Conservation Action Plan for the Seabirds of Cabo Verde is also planned to guide future conservation measures.

Well-designed artificial nests can afford improved protection against IAS and other predators, especially by limiting access to predators through their entrances, whilst they can also be placed in areas where IAS do not occur or frequent (SPEA 2022).

Figure 34: Checking a live mammal trap in a breeding area of Cape Verde Petrel *Pterodroma feae* on Fogo, Cabo Verde. © Tim Dodman.

3C. RESTORATION AND PROTECTION OF THE NESTING HABITAT

The destruction of seabird nesting habitat, when it is not caused by human transformation, is often due to IAS. For example, herbivores trample and destroy soils and therefore chambers of burrowing seabird species, or invasive plants can modify the seabird breeding grounds and prevent them from nesting. People may destroy burrows by walking over them, either on purpose or inadvertently. Climatic events, such as a cyclone on a tropical island, are also responsible for destruction of nests and burrows. In April 2014 a tropical cyclone caused widespread damage to indigenous forest in New Zealand, with windfall of canopy trees and landslips impacting the nesting areas of the Westland Petrel *Procellaria westlandica*, especially on steep slopes and ridges (Waugh *et al.* 2015).

Actions to restore the habitat can include the establishment of nests or artificial burrows to facilitate the resettlement of birds. The effectiveness is supported by at least eight studies where birds using artificial burrows have better reproduction rates than natural burrows (https://www.conservationevidence.com/actions/481).

SPEA (2022) produced a practical guide on designing, making and siting artificial nests for seabirds based on work conducted in Cabo Verde. The nests of burrowing seabirds often lack resistance and a prone to collapse. Artificial nests can thus provide protection against this, also against IAS. SPEA (2022) provide a range of designs for nests made of different materials for White-faced Storm-petrel *Pelagodroma marina* (Figure 35), Cape Verde Shearwater Calonectris edwardsii and Audubon's Shearwater *Puffinus lherminieri.*

Figure 36: Grey-headed Gulls *Larus cirrocephalus* and other seabirds behind an embankment that protects a part of Ile aux Oiseaux, Langue de Barbarie National Park, Lower Senegal Delta, Senegal. © Cheikh Koulibaly (2022).

Restoration of the vegetation or habitat structure should be considered if the new conditions, such as invasive alien plants covering important habitat, prevent birds from nesting. In this case, removing the invasive plants and replanting endemic or native species can improve nesting quality for seabirds. If the eradication of predatory IAS or native predation threatens the survival of the colony, the establishment of protection and shelters for chicks or barriers (including electrical barriers) are favourable actions (Williams *et al.* 2019).

Barriers may also protect nesting sites from human activities. For instance, on Cocos Island, Rodrigues, Indian Ocean, a barrier has been erected to separate the island in two parts. In one part, tourism is authorized, allowing birds to be observed in their natural environment and in a respectful setting. However, no tourist can access the other part of the island, where Brown Noddies *Anous stolidus* lay their eggs on the ground; the barrier protected their nesting habitat from potential destruction of eggs. In Cabo Verde, key breeding islands and islets, such as Raso, Branco and Cima may only be visited by conservation managers and researchers, the sea playing the role of a natural barrier to the whole island.

Protection against rising sea levels or forceful waves of low-lying sandy islets where gulls and terns breed along the West African coast presents significant challenges. Whilst sandbags have been used to surround and protect a nesting site of the Mauritanian subspecies of Eurasian Spoonbill *Platalea leucorodia* balsaci at Nair Islet in the Banc d'Arguin National Park in Mauritania (Diawara *et al.* 2020), this approach is more challenging for Royal Terns *Thalasseus maximus*, which may nest in high concentrations often very close to the sea. In the Lower Senegal Delta, attempts have been made to reduce erosion along the Langue de Barbarie National Park shoreline by planting casuarina trees, and to protect nesting tern and gull colonies at Ile aux Oiseaux through embankments (Figure 36). Koulibaly (2022) advocates that more attention should be given to nature-based solutions for rehabilitation of this site.

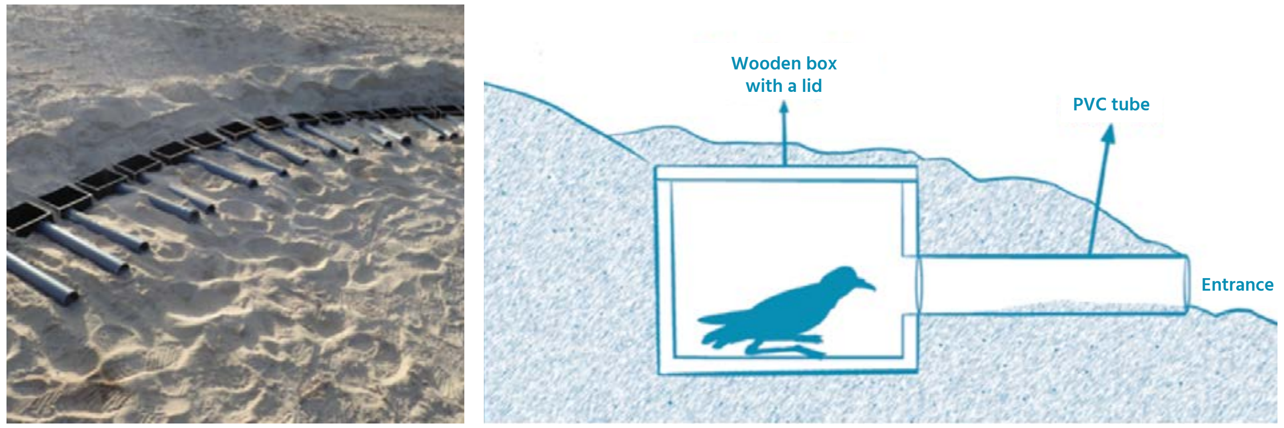


Figure 35: Recommended design of an artificial nest for White-faced Storm-petrel *Pelagodroma marina* (wooden box with lid, with entrance via a PVC tube) and photo of a series of nests being installed in situ. Image © Nathalie Melo/ Biosfera1. Photo © SPEA (2022).

3D. RESTORING COLONIES

Restoring seabird breeding colonies is an important process for the recovery of populations. Colonies may re-establish naturally at previously abandoned sites if conditions are right, whilst colonisation of new sites may also occur naturally. New breeding sites of Red-billed Tropicbird *Phaeton aethereus* and Brown Booby *Sula Leucogaster* were found on São Nicolau in Cabo Verde in 2016, an island where they had not been recorded before (Martins *et al.* 2017).

1. Restoration by behavioural manipulation through social attraction

The introduction of IAS which depredate adults or young or which destroy habitat can lead to the disappearance of a colony, as can other threats. After the removal of these IAS, it can however be difficult to bring back breeding birds. Seabirds are philopatric (return to their place of birth for breeding) but gauge the quality of a site according to 'public or social information'; i.e. the presence of many congeners, in reproduction, testifies to the quality and safety of the site and encourages them to settle, despite often intense competition for space.

After site restoration, the return of a colony can take several years. However, it is possible to speed up the recolonization of a site by encouraging birds to visit islands through a combination of attractants. Beaune *et al.* (2017) illustrate how an immigrant seabird may select a site based on 'public information' demonstrating site quality and can be attracted to a potential breeding site through artificial attraction (Figure 37: Attracting seabirds to a breeding island (Beaune *et al.* 2017): Natural social attraction (top left): Colonial birds are attracted to an island by the indications of the presence of congeners (birds of the same type / genus), e.g., the presence of burrows and calling birds. No attraction (top right): By contrast birds do not settle in the absence of congeners, even when no IAS are present. Artificial social attraction (bottom): Artificial clues can attract neo-reproductive individuals and accelerate colonization.). For example, the installation of lures (bird decoys, breeding colony sounds, artificial burrows and odours) can motivate the installation of young couples (Jones & Kress 2012).

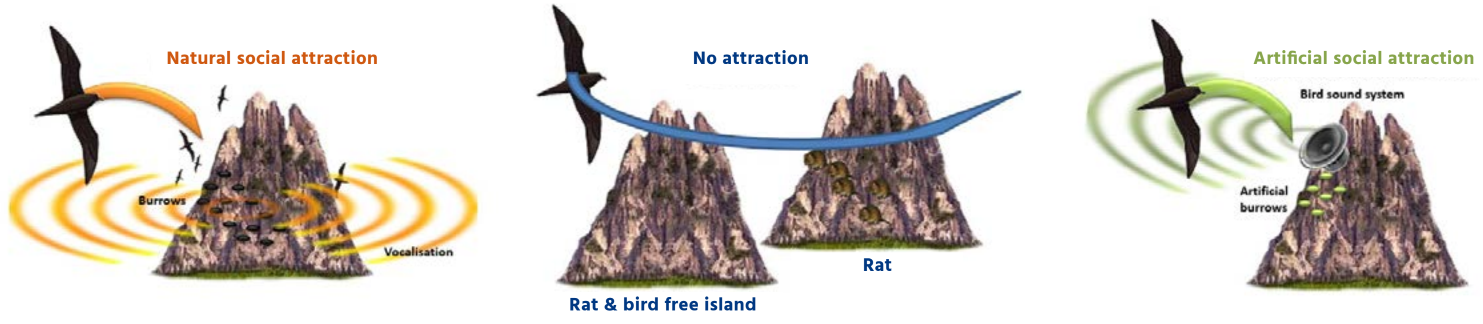


Figure 37: Attracting seabirds to a breeding island (Beaune *et al.* 2017): Natural social attraction (top left): Colonial birds are attracted to an island by the indications of the presence of congeners (birds of the same type / genus), e.g., the presence of burrows and calling birds. No attraction (top right): By contrast birds do not settle in the absence of congeners, even when no IAS are present. Artificial social attraction (bottom): Artificial clues can attract neo-reproductive individuals and accelerate colonization.

2. Restoration by translocation of chicks

The translocation of chicks is the active movement of chicks of philopatric species, which will return to reproduce at their native site. This technique can be used to restore a colony that has disappeared following a climatic, geological event (volcanic eruption), or biological invasion, and when the threat has disappeared (example: the eradication of rats and other IAS allowing a return of birds). Chicks of some species (especially burrowing birds) can be fed by hand with 100% fledging success for some species (Miskelly *et al.* 2009). Consequently, these chicks return to reproduce at their places of translocation or reintroduction (if the species was historically present there). Species that feed their young after fledging, such as terns, are poor candidates for this type of translocation. This method is cumbersome, but has been proven effective for several cases of restoration (Figure 3, Jones & Kress 2012).

In order to test the viability of reintroducing Cape Verde Shearwater Calonectris edwardsii to Santa Luzia in Cabo Verde, ten two-month-old chicks of nearby Raso islet were translocated to a different part of Raso, and compared to chicks that were not moved. There were no differences between groups in growth curves of offspring or in-flight success, which was 100% for both (Rodrigues *et al.* 2020). Carrying out such tests is an important stage in the translocation process.

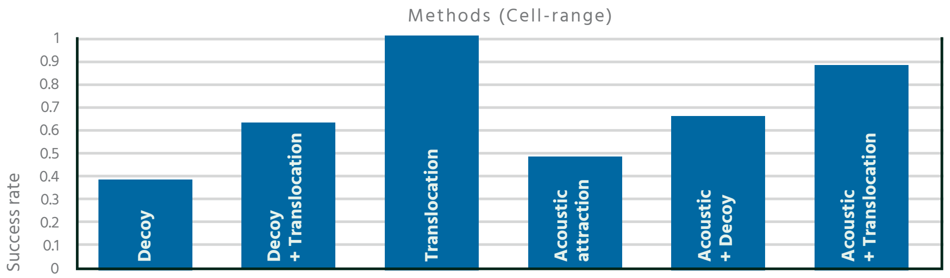


Figure 38: Success rate of seabird restoration projects according to the methodology used. The numbers above the bars indicate the total number of projects used to calculate success rates. After Jones & Kress (2012).

3E. ARTIFICIAL BREEDING OF YOUNG BEFORE RELEASE

When a seabird nesting site is highly threatened and therefore the risks of mortality of young birds is too high for the species to establish a growing or stable population, the incubation of eggs and/or the artificial breeding of young are possible. It is a costly method in financial and human means and is only feasible if a release habitat with feeding and a reproduction area is available. Effective protection of habitats and birds in the wild is always preferable. To artificially raise the young and release them effectively, the biology and behaviour of the species must be intimately known. This method can also be used to increase the reproductive potential of a population through replacement chicks or eggs. Some species have more than one chick at the start of the season although usually only one may survive, whilst others can quickly lay another egg if the first is predated (e.g., penguins). By artificially raising a replacement chick and letting the parents raise one of their offspring, there is a doubling potential for pair breeding. Five studies show that raising young seabirds is complex, but possible (https://www.conservationevidence.com/actions/604; Williams *et al.* 2019). For example, 30 artificially bred White-winged Petrels *Pterodroma leucoptera* had similar survival and biological conditions to other wild chicks (Priddel & Carlile 2001). One study in Spain found that one of five hand-reared Audouin's Gulls *Larus audouinii* went on to successfully breed in the wild (Martínez-Abraín *et al.* 2001).

Artificial incubation requires specific temperature and humidity control and rotation of the eggs for their development. Hand feeding should not disrupt the behaviour of young birds in the long term and create habituation to humans. Artificial breeding of young is a conservation technique that exists and works for certain species, but which is not always usable due to inadequate financial means and lack of knowledge of the species or its biology.

To protect seabirds, several conservation methods must therefore be considered and it is important to weight up the costs and benefits of a methodology before it is tried, along with seeking advice from experienced practitioners.

3F. LIMITING FISHERY-RELATED MORTALITY

Mortality caused by fisheries threatens long-lived marine species, and seabirds, sea turtles and marine mammals can all accidentally die at sea following interactions with fisheries. Bycatch, or accidental capture, is the catch of non-targeted species or individuals by fishing activities. The accidental capture of seabirds represents a danger to their conservation and a loss of fishery yield. Each fishing method poses risks for birds, whether it be longline, trawl, purse seine or fixed net fisheries (Figure 39: Numbers of observed seabird species interacting with different fishing gears. Source: BirdLife International (2018)39). Seabird mortality from fisheries is caused in different ways depending on the fishing method. To reduce (mitigate) these mortalities, it is important to understand how the mortality is occurring, and find ways to avoid these incidents:

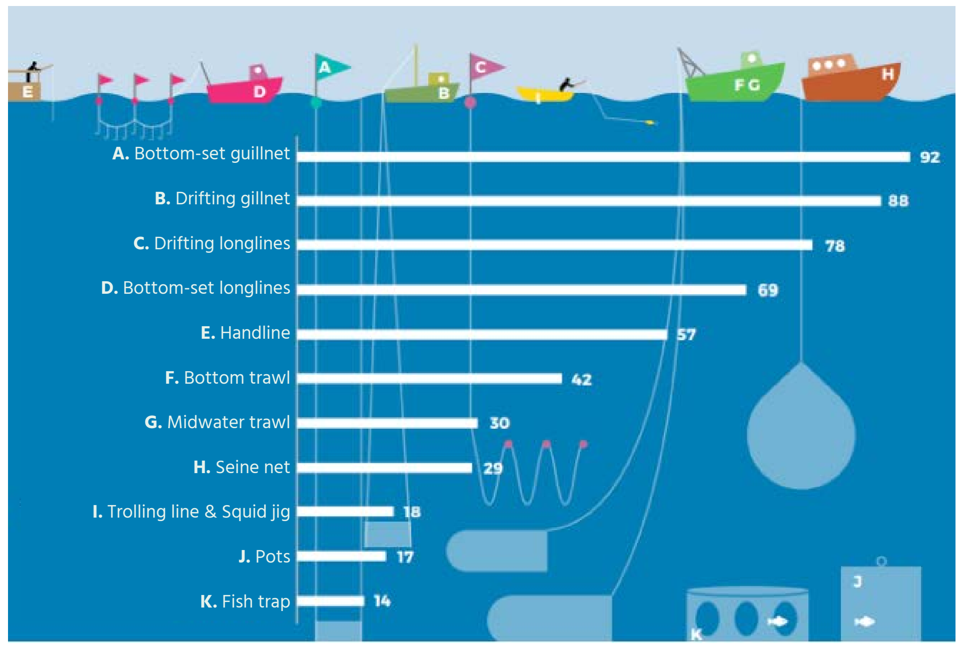


Figure 39: Numbers of observed seabird species interacting with different fishing gears. Source: BirdLife International (2018).

I. Longline fishery consists of a long submerged main line either set on the sea floor (demersal) or in the surface waters (pelagic), with short secondary lines attached that are fitted with baited hooks. Being attracted to the boat, birds can be fatally injured by the cables when longlines are or hauled in. In addition, when trying to catch bait, they can find themselves hooked, dragged into the water, and then drowned. Longlines do not present a danger to birds when they are submerged to a depth that is unreachable by them. Longline fisheries represent a potential danger for most seabirds foraging at the surface, and mortality in these fisheries is particularly prevalent for albatrosses, petrels, gulls and shearwaters.

II. The trawling fishery involves drawing a net (demersal, midwater or pelagic) behind the boat. The danger to seabirds comes from collision with the cables and becoming entangled in the net. Sulidae species (gannets and boobies) are particularly affected by trawling.

III. Purse seines and fixed nets (gillnets, entangling and trammel nets) pose a danger to diving birds seeking their prey in the water column, such as cormorants, seaducks, auks, penguins and shearwaters.

Bycatch Mitigation Measures

The Albatross Task Force (ATF), created in 2005, has the task to reduce the number of albatross caught in fisheries bycatch. In collaboration with BirdLife International and the Royal Society for the Protection of Birds (RSPB), the ATF demonstrated that it was possible to reduce the number of bycatches on albatrosses and petrels, with up to 85-90% reduction in mortalities of bycatch (Figure 40). In South Africa, albatross bycatches were reduced by 99% in six years. Likewise, in Chile, thanks to the modification of nets used, 98% of bycatch has been avoided (BirdLife International 2018). In Namibia, effective government regulation and dedicated grassroots engagement with the industry were essential steps in reducing seabird deaths in the Namibian demersal longline fishery by 98%.

To be effective, these programmes require collaboration between the fishing industry (e.g., fishery managers, fishing vessel captains and crew), government and NGOs. Advice from groups experienced in bycatch management helps the industry to develop and use best-practice methodologies, and working together the groups can implement, monitor and adjust the methods to ensure they work to best effect within the characteristics of the fishery in question.

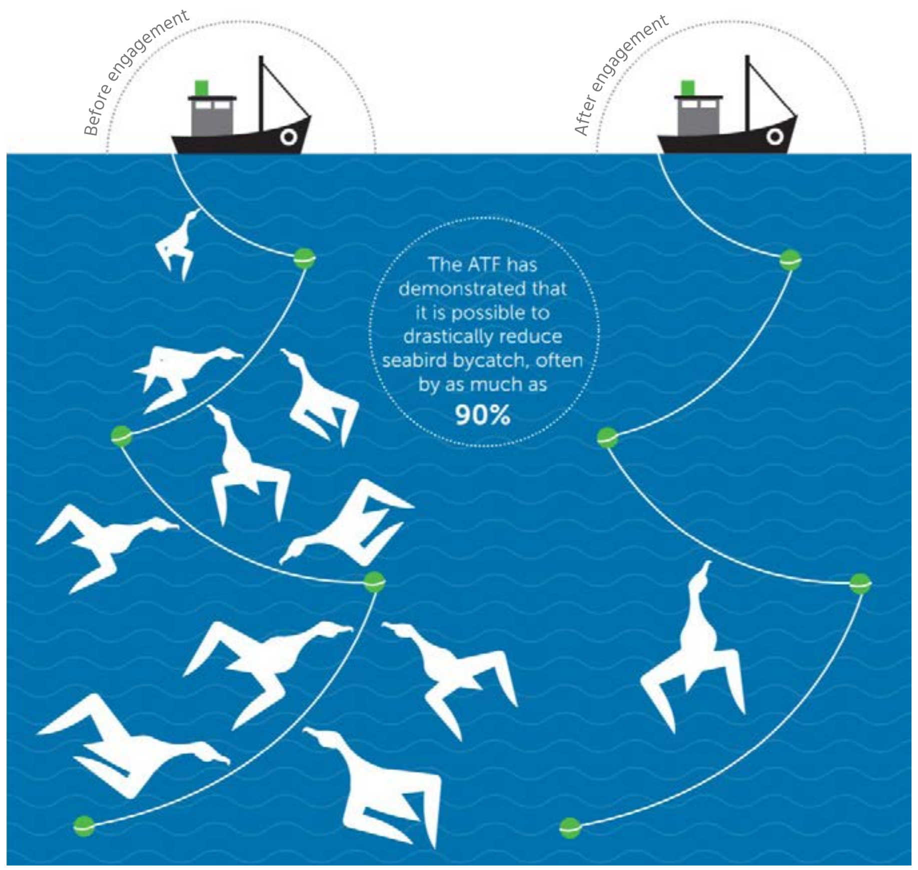


Figure 40: With successful engagement, seabird bycatch can be significantly reduced (BirdLife International 2018).

To overcome these issues, simple and inexpensive activities called bycatch mitigation measures are highly effective (RSPB 2019). Following are some measures that have been tested and recommended (Løkkeborg 2011):

Bird Scaring Lines, 'Tori Lines' or 'Streamer Lines'

A first priority is to reduce the attractiveness of the boat during risk phases, for example when hauling in the trawl or when setting the longlines. This can be achieved through employment of bird scaring lines, which have colourful banners that can be towed behind the boat to keep birds away from the lines or the net (Yokota *et al.* 2011, Figure 41). Streamer lines present a risk of entanglement with longlines, and their installation should be optimized to guarantee their efficiency and the operationality of fishing gear.

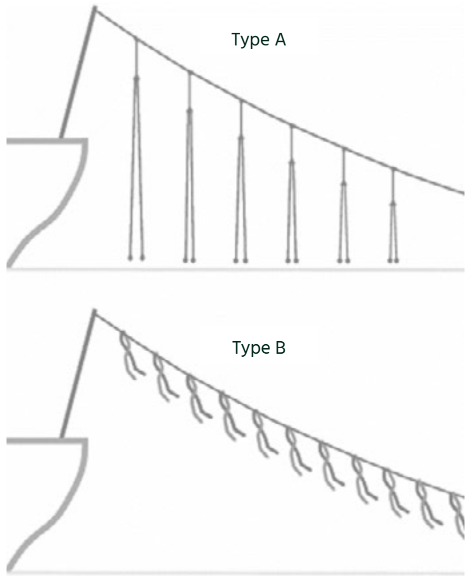


Figure 41: Example of two types of 'Tori Lines' or bird scaring lines. Type A, original design invented by Japanese fishers, made up of several long streamers made of nylon ropes. Type B with many short banners, made out of polypropylene packaging, braided on the main line. The latter is easier to use, presents fewer tangles and is lighter (Yokota *et al.* 2011).

For trawl fisheries, the management of fish waste discharges at sea is essential to avoid attracting birds around the boat. Preventing the discharge of waste at sea before release of nets, during fishing and when the nets are hauled is remarkably effective in reducing the risk of collisions. The key point here is to anticipate the management of fish offal storage by using storage tanks. Keeping fish whole until landed on shore also reduces the waste associated with fish processing at sea. Systematic cleaning of the nets from fish residues helps to reduce the attractiveness of the boat when the nets are set.

Adapting fishing practices

Adapting fishing practices involves modifying techniques that are used during the phases of fishing activity when birds are susceptible to be caught. For longlines, decreasing the time when hooks are exposed is possible by weighting the lines and hooks to hasten their descent in the water column (Robertson *et al.* 2013). Reducing the boat speed when setting and hauling in longlines decreases the angle of the main line and thus the length of line emerged. Setting fish hook protection devices (Sullivan *et al.* 2018) and thawing bait before setting have also been demonstrated to reduce bycatch. For the trawl or nets, it is a question of reducing the time when nets emerge at the surface and lowering them to a depth that is unreachable by birds. This depth depends on the ecology of the species, ranging from a few meters for albatrosses to several tens of meters for shearwaters and penguins. Increasing the depth of fixed nets can reduce their chance of catching diving birds such as cormorants.

Night Setting

Spatiotemporal avoidance reduces risks of interactions between birds and fisheries, such as fishing overnight when the activity of diurnal birds is almost zero.

Bycatch Mitigation policy approaches

As well as implementing practical measures, such as improved design and use of fishing gear in combination with bycatch mitigation devices, policy measures can also be taken to mitigate bycatch. Input and output controls are when countries or authorities place controls to limit capacity and effort in fisheries where bycatch occurs. This may include placing a cap on the numbers of vessel licenses issued or setting limits on allowable bycatch (Jabado 2021).

Spatial and temporal measures aim to avoid fishing in areas and at times when interactions between fishing vessels and seabirds are most likely to happen and most intense. Measures may include the declaration of Marine Protected Areas (MPAs) closed to fishing, as well as time or area closures and night setting (Jabado 2021). Information from Marine Important Bird and Biodiversity Areas (marine IBAs) and MPAs can help to identify critical sites for seabirds and interaction zones that may require closure. The deployment of transmitters on birds (e.g., GPS, Argos) can provide valuable information on key feeding areas, although these may vary depending on age, sex and season.

Providing incentives for fishers, such as promoting measures that maintain catch rates, and that improve revenues and catch quality all encourage fishers to comply with management measures and adopt fishing techniques designed to reduce bycatch.

Training and awareness

The Food and Agriculture Organization of the United Nations (FAO) has developed an International Seabird Action Plan to help States to manage bycatch resulting from fisheries. For the States involved, this plan includes the prescription of measures to limit bycatch, the establishment of research and development to reduce bycatch, training and awareness-raising among fishers, and the creation of information gathering programmes through the presence of observers on board fishing vessels. Observers can give advice to establish bycatch limitation measures and ensure training of the crew, in particular for the removal of living birds entangled in nets. The observer's role is especially important in providing empirical information on the number of individuals and species caught, as well as on the spatiotemporal overlaps of birds' areas of activity and fisheries.

Promoting communication, training, and fishers' awareness on methods of limiting bycatch are key elements. Emphasizing the reciprocal benefits for birds and fishers reinforces positive feelings about the measures indicated. Indeed, these measures allow both the life of seabirds to be preserved and a reduction in depredation and consumption of baits by birds, which improves the yield of the fishery. Increasing public awareness about bycatch and the need for bycatch mitigation is an important part of promoting adoption of mitigation methods. Tools, such as the 'Making fisheries safe for seabirds' animated video produced by BirdLife International and the British Antarctic Survey as part of a series highlighting threats to seabirds are very useful in this regard (Figure 42).

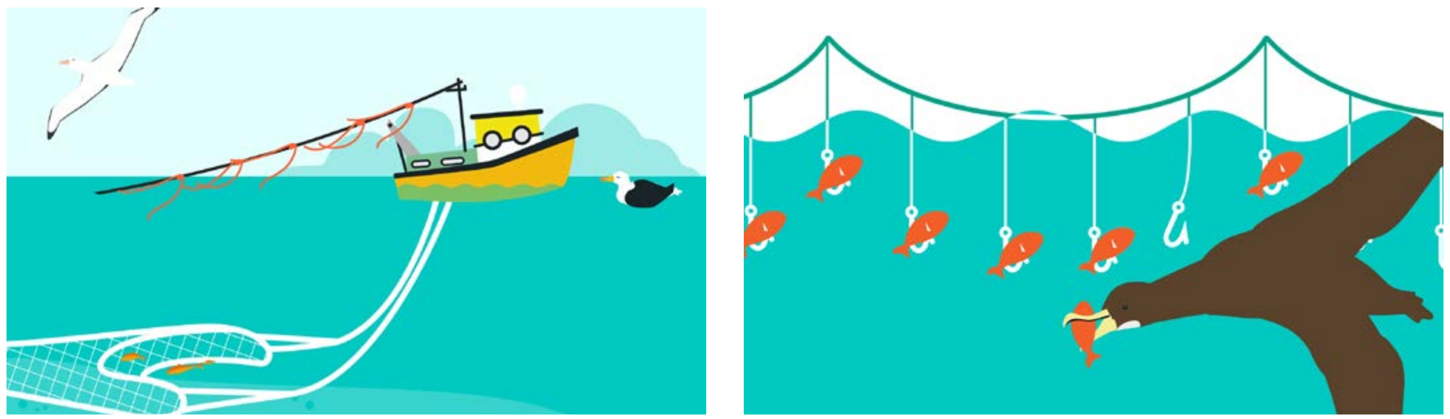


Figure 42: Stills from the animation video 'Making fisheries safe for seabirds'. © BirdLife International.

Illustrated guides and practical sheets are available on the FAO website (http://www.fao.org) and the Agreement on the Conservation of Albatrosses and Petrels (ACAP) website (available in several languages: https://www.acap.aq/resources/bycatch-mitigation/mitigation-fact-sheets), including recommendations classified by type of fishing and size of boat. A review of the effectiveness of several existing National Plans of Action for Seabird Bycatch was undertaken in 2020 (Good *et al.* 2020), setting out the key points covered above for an effective plan.

All these measures can reduce bycatch by 30-100% and must be used altogether to ensure maximum efficiency (Løkkeborg 2011). Mitigation measures that reduce bycatch also contribute to improved fishing results; in longline fishing before being caught on a hook, a seabird may catch more than 15 baits and therefore reduce the number of fish caught (Figure 43).

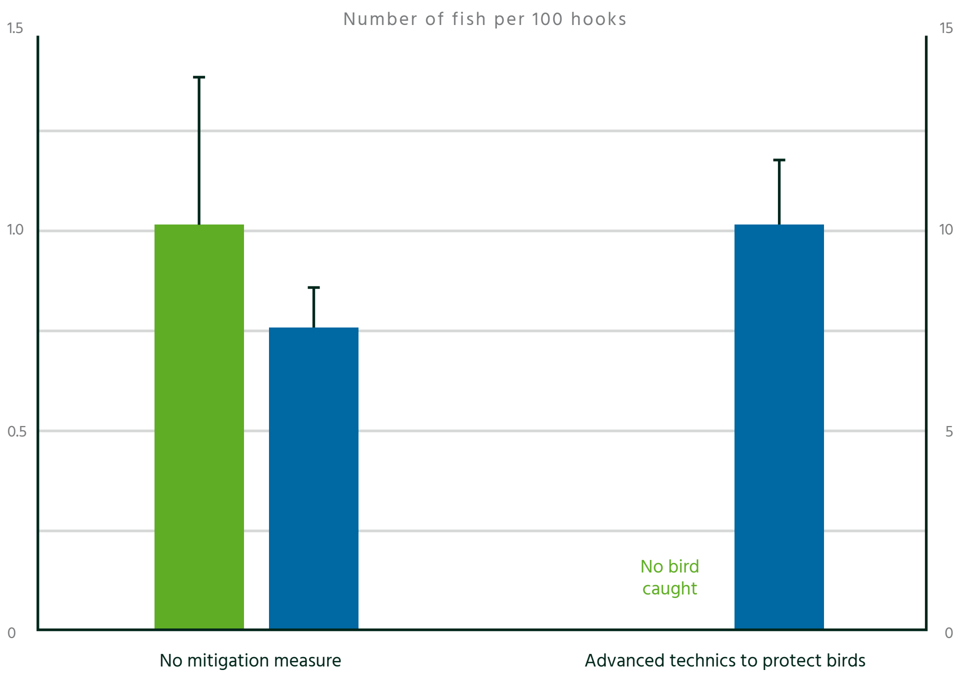


Figure 43: Mitigation measures are viable and allow bycatch to be reduced and the number of fish caught to be increased (BirdLife International, 2004). Bars match means with standard deviation.

Bycatch Mitigation in West Africa

The Bycatch Mitigation Roadmap for West Africa (Jabado 2021) aims to guide governments, fisheries managers and other stakeholders, including the fishing industry and conservation community, in understanding best practices for bycatch mitigation. The roadmap prescribes a range of measures for longline, trawl and purse seine fisheries, and identifies four key intervention areas:

1. Establish policies and regulations

2. Assess the magnitude of bycatch and monitor

3. Communicate and engage with stakeholders

4. Enforce.

BirdLife International has implemented a framework to minimise bycatch in West African industrial fisheries, which has included working with and supporting national observers to collect bycatch data. Kits including cameras, life jackets, field guides and equipment help to improve observers' operational and safety conditions. Observer training has also been carried out through training workshops and development of an identification guide to marine life that may be bycaught (Figure 44). Efforts are also underway to encourage fishers to safely release turtles and seabirds caught accidentally as bycatch.

Figure 44: New Cabo Verdean scientific onboard fisheries observers taking classes on seabird identification, using a new identification field guide. © Hortensio Lima, BirdLife International.

Fisheries management and conservation of seabirds in West Africa

There is clearly an urgent need to improve and strengthen the governance of the marine ecosystem of West Africa to prevent further overexploitation of fishery resources and the marine environment. It is increasingly important to consider the entire system, understand the cumulative impacts of activities in the marine environment and to set strict sustainability objectives for the recovery of marine stocks in the future.

Monitoring fish stocks, analysing data related to fisheries catches and efforts, and the implementation of an ecosystem approach to the fisheries management have been increasing over past years. The management of fishing stocks in the exclusive economic zones (EEZs) of some countries has improved, but the management and control of activities on the high seas or in areas beyond national jurisdiction are much more difficult to perform. The control of IUU fishing activities and the implementation of bycatch mitigation measures have started but still require much more sustained effort in many countries, particularly in West Africa.

Figure 45: Fisheries in West Africa have a diversity of sizes and ranges from industrial vessels to artisanal vessels, such as those seen off the coastal waters of Senegal. © BirdLife International.

3G. SECURING SEABIRD FOOD RESOURCES

Between 1950 and the 1980s, fishing catches increased from 20 million tonnes/year to more than 80 million tonnes/year. This increase is due to improved efficiency of fisheries, and not due to an increase in available stocks. With an increase in demand of 3.2% per year and a growth in the human population of 1.6% per year (FAO 2018), these catches are unlikely to decrease over time. Since seabirds also depend on marine resources, they can compete with human fisheries, and this competition, which has increased in 48% of fishing areas, is leading to a decline in seabird populations (Grémillet *et al.* 2018). In addition to the decrease in quantity, fish caught are also smaller and younger because the fishing effort is too great to enable the renewal of populations (Tasker *et al.* 2000). Productive fisheries are particularly important to seabirds during the breeding season, especially for colonial species that tend to forage close to their breeding sites during the breeding season, such as Royal Terns *Thalasseus maximus* (Figure 46).

To reduce the shortage of food for seabirds, there are projects that aim to secure bird food resources. These usually imply the establishment of MPAs that include the concept of conserving fish stocks in key feeding areas of targeted birds. Seabirds that are equipped with loggers (e.g., bio-loggers; see part 5G. RECORDING DEVICES FOR SEABIRDS) support the definition of these MPAs (cf. part 4B. PROTECTED AREAS, Figures 55, 56 and 57), by obtaining and analysing data relating to the foraging areas of seabirds. Once the zones where seabirds eat can be clearly delimited, it is possible to identify recommended areas for designation as MPAs, where restrictions on or a total prohibition of fishing may be implemented.

Figure 46: Parents and chicks of Royal Terns *Thalasseus maximus* during the breeding season in the Saloum Delta National Park. © Jan Veen-VEDA. The survival of thousands of chicks and their parents depends on the availability of fishery resources; breeding success (number of chicks reaching fledging) depends not only on the availability of fish, but also on the quality (species, good size etc.). Birds have to compete with fishing activities, especially if bad fishing practices are widespread in the area.

Fishing bans

If the establishment of an MPA is impossible due to the local or national context, it may be feasible to set a fishing ban during periods of fish reproduction in certain areas with lower restrictions for the rest of the year. For example, in California, seasonal protection of herring breeding areas enables a better survival of juvenile fish and increases the stock available for birds and fishers. As juvenile herrings are eaten by seabirds, prohibiting fishing to protect juveniles reduces interactions between birds and humans, ultimately reducing the risk of mortality for seabirds caught in nets.

Sustainable fishing practices

Another solution is the promotion of sustainable fishing practices, whereby fishing continues but exerts a low impact on the fishery resource. In California, artisanal fishers can market herring caught in an area where seabirds feed as 'fresh and local' at higher prices; as a result they take less fish, because they do not need it, and it is easier to reconcile fishing and availability on resources for seabirds. In Cabo Verde, the NGO (and BirdLife Partner) Biosfera has been managing a Sustainable Fisheries Project that promotes the consumption of fish of sustainable origin (Biosfera 2019). Fishermen who are partners of the project received fishing cool boxes to ensure that their fish was packaged well and reached the consumer as fresh as possible. In order to promote recovery of the most exploited fish stocks, the project also promoted consumption of alternative little-targeted fish of high gastronomic potential. Fish sold under the scheme bear a sustainability seal (Figure 47). Amongst other measures, awareness is also provided about fishing closed seasons.

Figure 47: Biosfera's Sustainable Fisheries Project 'from the sea to the plate' seal, Cabo Verde. © Biosfera.

Fostering the resilience of the marine environment is possible by creating and implementing MPAs and reducing fishing or by prohibiting fishing of juveniles. Consequently, the entire process allows bird populations to feed, and thus reduces mortality due to starvation.

3H. LIMITING DISTURBANCE AND PREDATION OF BREEDING SEABIRDS AND THEIR YOUNG

Human disturbance of breeding adult birds or their young can have very significant impacts: from the disturbance of an individual to an entire colony, sometimes resulting in mortality. Disturbance of seabirds, especially at colonies, must be limited or ideally avoided.

Education and awareness

Education, awareness and local engagement have an important role to play in changing behaviour and reducing disturbance (cf.: https://www.conservationevidence.com/actions/274), although education alone is not usually enough to effectively protect birds from human populations. If only a few people remain insensitive to arrangements to limit disturbance, or if such measures impact their livelihood or business, their actions can thwart protection measures, so other means will also be needed.

Local NGOs in Cabo Verde have carried out a range of education and awareness campaigns and other activities to sensitive local populations and decision-makers to the plight of seabirds and the importance of breeding sites. These have included the ECOSTAR project, a series of documentary films aired on television and available online in which Cabo Verdean artists and sports figures lent their image to environmental causes. For instance, Cabo Verdean musician Nuna de Pina was filmed visiting the environmental centre in Fogo Natural Park and breeding sites of Cape Verde Petrel Pterodroma feae. The centre itself plays an important role in promoting education and awareness, along with other centres and displays, such as the Cagarra EDU stand, a shearwater-shaped kiosk offering environmental games aimed for children. NGOs have also organised impressive murals of seabirds and other marine life on different islands, such as at Porto Mosquito, Santiago (Figure 48).

Figure 48: Mural showing seabirds, fish and dolphins at Porto Mosquito, Santiago, Cabo Verde. © Tim Dodman.

In Cabo Verde there are also strong efforts to actively engage communities in conservation activities. Success in behavioural change is demonstrated by past success in preventing annual harvest of Cape Verde Shearwaters *Calonectris edwardsii* from Raso islet. Environmental education and related activities also take place along the West African coastline, including at the Chami environmental education centre close to the Banc d'Arguin in Mauritania and the House of Environment on Bubaque, Bijagós Archipelago, Guinea-Bissau. In Senegal, people from local communities as eco-guards at and around protected areas, whilst there are also a number of community-led reserves, including in coastal areas important for seabirds.

Campaigns can play an important role in boosting awareness at different levels. Events to mark global campaign days, such as World Migratory Bird Day, are regularly organised in West African countries. On Réunion Island the Nuits sans Lumière (literally 'Night without Lights') are organized every year, corresponding to the season when juvenile petrels are fledging, when lights of all towns participating in the project are turned off at night. This action prevents young birds being attracted by urban lights and grounding themselves in towns and reduces the risk of adult birds stranding at the same time. The activity is designed to raise awareness, but to reduce bird stranding, it would need to be applied throughout the breeding season of the birds, and most particularly around the time that young birds fledge from their nests.

Protected areas

Key seabird breeding sites should be designated as protected areas, and equipped with a management plan devised with strong stakeholder participation that includes elements of environmental awareness and community engagement. Protected areas only tend to be effective when they are reasonably well staffed and well resourced. Important activities include monitoring and surveillance. In some protected areas, human presence may be prohibited, or zoning can be implemented, for instance to keep people a safe distance from sensitive breeding areas to avoid triggering a flight or stress reaction in birds. Zoning can also be introduced at sea, for instance to protect important seabird feeding areas. Most important seabird breeding colonies in West Africa, including Cabo Verde, are already designated as national parks or other forms of protection. A few sites, however, still remain unprotected, such as the islet of Bantambur, off Jeta island in Guinea-Bissau, which supports the largest seabird colonies in the country (Figure 49).

Figure 49: Grey-headed Gulls *Larus cirrocephalus* at Bantambur, off Jeta, Guinea-Bissau. © Tim Dodman.

A number of sites where seabirds breed in West Africa are also designated under international conventions. The Parc National du Banc d'Arguin, for instance, is a Wetland of International Importance under the Convention on Wetlands (or Ramsar Convention) as well as being a UNESCO World Heritage site. Such international designations can serve to strengthen site protection and recognition of a site's importance at a regional and international level. In West Africa, many important sites for breeding seabirds are members of RAMPAO – the West African Regional MPA network (www.rampao.org). RAMPAO aims to ensure maintenance of a coherent set of critical habitats for dynamic ecological functioning within the West African marine ecoregion, through network support, exchange, making MPAs operation and functional and building capacity.

Physical measures may also be needed to minimise disturbance of sensitive parts of protected areas. Appropriate signage is usually needed to ensure that visitors understand what activities can be carried out in different parts of a reserve, and which areas might be 'out of bounds'. Tourism can be very important in generating income at or around sites important for seabirds, but this invariably needs to be well managed. Usually, disturbance by tourists is unintentional. Physical barriers are also sometimes introduced to protect seabird colonies from disturbance or predators, whilst various measures can be taken to control IAS, including biosecurity measures (cf. 3B. COMBATING INVASIVE ALIEN SPECIES).

Policies and legislation

Developing and putting in place national or site-based policies are important steps in controlling access and disturbance to sensitive sites, as well as aiming to prevent their development for alternative uses. The policies related to protected areas should be strong enough to deter disturbance or more direct threats, such as the capture of young birds. However, legislation also needs to be strong enough to ensure that there is a genuine deterrence in place to illegal activities.

In order to mitigate the impacts of infrastructure developments on seabirds (and other biodiversity), it is essential to conduct independent Social and Environmental Impact Analyses before the developments are approved. In the coastal and offshore zone of West Africa, a range of developments can have potential impact on seabirds, especially the oil and gas sector. In some areas wind turbines and other energy systems, including wave power, can have important impacts. Assessments should be able to facilitate the modification of projects and the reduction of disturbance risks for bird populations.

3I. SUB-REGIONAL SEABIRD CONSERVATION INITIATIVES IN WEST AFRICA

Marine IBA data provide a solid scientific basis for existing or new MPAs, whilst the identification and protection of a site network for seabirds benefits other taxa and marine and coastal habitats. After the establishment of marine IBAs, advocacy work is needed to help actors understand their importance and to realise the efforts that have to be made by decision-makers for the creation or extension of MPAs. Advocacy carried out in West Africa has helped to take the protection of seabirds beyond their breeding sites better into account.

West African countries hosting important seabird colonies have also made efforts to improve the management plans of existing Protected Areas to better take account of seabirds in these plans. A regional strategy and action plan for the conservation of seabirds in the CCLME region developed in 2016 with local, national, regional and international actors helped to define clear strategic actions to deal with the risks and threats identified and to maintain momentum for the conservation of seabirds and marine biodiversity.

Further projects in the region have focused on reducing the pressure associated with over-exploitation of resources, understanding the level of threats from bycatch of seabirds and other species, and highlighting the emerging risks of oil and gas exploitation, which is gaining momentum in the subregion, and estimating the cumulative impact of specific threats. All ongoing efforts require effective marine spatial planning to better identify all the facets of seabird conservation and biodiversity.

Part 4 Conservation strategies and tools

A successful conservation strategy should guide the sustainable conservation management of natural resources and be adopted by all stakeholders. For the conservation of seabirds in West Africa, an important long-term strategy is sustainable fisheries management. Strategic plans are also needed to protect the network of breeding seabird colonies. All conservation actions should be integrated into a management plan for an area where it is possible to implement them, especially for protected areas. The presence of a seabird colony at a site may justify its establishment as a protected area, depending on its importance (size, density, rarity or threatened status). Site management plans are useful tools for guiding conservation actions; they should be reviewed and updated on a regular basis. Species action plans focus on particular species or groups of species, and may cover the whole of a species' range or a different area, such as a country.

4A. NEED FOR SUSTAINABLE FISHERIES MANAGEMENT

Characterized by high productivity and high biomass, the CCLME is globally important for seabirds and fishing. However, seabirds compete directly with fisheries due to decreasing fish stocks and are also vulnerable to bycatch mortality. These waters have suffered for many years from unsustainable fishing practices by both foreign and domestic fleets, and experience the highest levels of illegal, unreported and unregulated (IUU fishing) in the world (Agnew *et al.* 2009). IUU not only jeopardizes the economy and food security of West Africa, but it also makes it impossible to properly manage the impacts of fishing on ecosystems and untargeted impacts, such as seabird bycatch.

With low attention to marine conservation in the CCLME and weak understanding of models and processes of marine biodiversity, data on the distribution and movements of pelagic species are scarce, whilst high technology monitoring systems are largely absent. The level and efficacy of protection of marine species and habitats are negligible against heavy anthropogenic threats.

Fishing has a direct impact on ecosystems and their resources and should be subject to an ecosystem approach to fisheries management (EAF), which embraces ecosystem management. Historical or conventional fisheries have focused largely on a single fishing activity and a (unique) target fish species or fishery resource. This type of management does not consider other species or bycatch from fishing, nor the impact of other human activities or environmental factors.

The EAF takes all aspects of the ecosystem into account, involves multiple species and considers the social and economic aspects of sustainability. Maintaining a healthy ecosystem promotes social benefits and sustainable economic growth. Management decisions must be based on reliable scientific information for EAF to be effective. EAF implementation improves transparency and a broader and more inclusive engagement of stakeholders compared to conventional fisheries management, which usually only involved stakeholders within the fishery sector.

EAF is an extension of conventional fisheries management that explicitly recognizes the interdependence between human wellbeing and ecosystem health (Ward *et al.* 2002). Furthermore, it recognizes the need to maintain ecosystem productivity for present and future generations by conserving critical habitats, reducing pollution and degradation, minimizing waste, and protecting endangered species. Implementing sustainable fisheries policies including EAF is an essential strategy to minimize the impact of fisheries on marine biodiversity, including seabirds.

4B. PROTECTED AREAS

In 2008, IUCN proposed a definition for any type of protected area as 'a clearly defined geographical space, recognised, dedicated and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values'. Protected areas for seabirds are often key breeding sites, or they might be or might include resting grounds for migratory species, and marine feeding areas. Marine Protected Areas (MPAs), which are areas entirely or in part under marine influence, are key tools for seabird conservation. Protected area management plans should contextualize management actions, through planning and budgeting, and set goals to achieve in a measurable way, which can be evaluated.

1. Network of protected areas in the coastal zone of West Africa

Developing and putting in place national or site-based policies are important steps in controlling access and disturbance to sensitive sites, as well as aiming to prevent their development for alternative uses. The policies related to protected areas should be strong enough to deter disturbance or more direct threats, such as the capture of young birds. However, legislation also needs to be strong enough to ensure that there is a genuine deterrence in place to illegal activities.

In order to mitigate the impacts of infrastructure developments on seabirds (and other biodiversity), it is essential to conduct independent Social

Mauritania has two key national parks in the coastal zone, including the largest site of the region, the Banc d'Arguin, which supports breeding tern and gull colonies. Senegal has five national parks in the coastal zone, including Djoudj and Langue de Barbarie in the north, which support breeding gulls, terns and pelicans, Sine-Saloum further south, which has the largest tern and gull breeding colonies, and Iles de la Madelaine, where Red-billed Tropicbirds *Phaeton aethereus* breed. Maintaining strict and effective protection of the tropicbird breeding sites at Iles de la Madelaine is considered essential (Diop *et al.* 2019). Senegal also has quite a wide range of protected areas of different designations, including areas of local community heritage (APACs), and the Kalissaye Ornithological Reserve in the south, which supports breeding tern colonies.

There are five national parks or reserves in the coastal zone of The Gambia, which extends up the Gambia River. Guinea-Bissau also has five coastal zone national or natural parks, including two within the Bijagós Archipelago, both of which support breeding terns

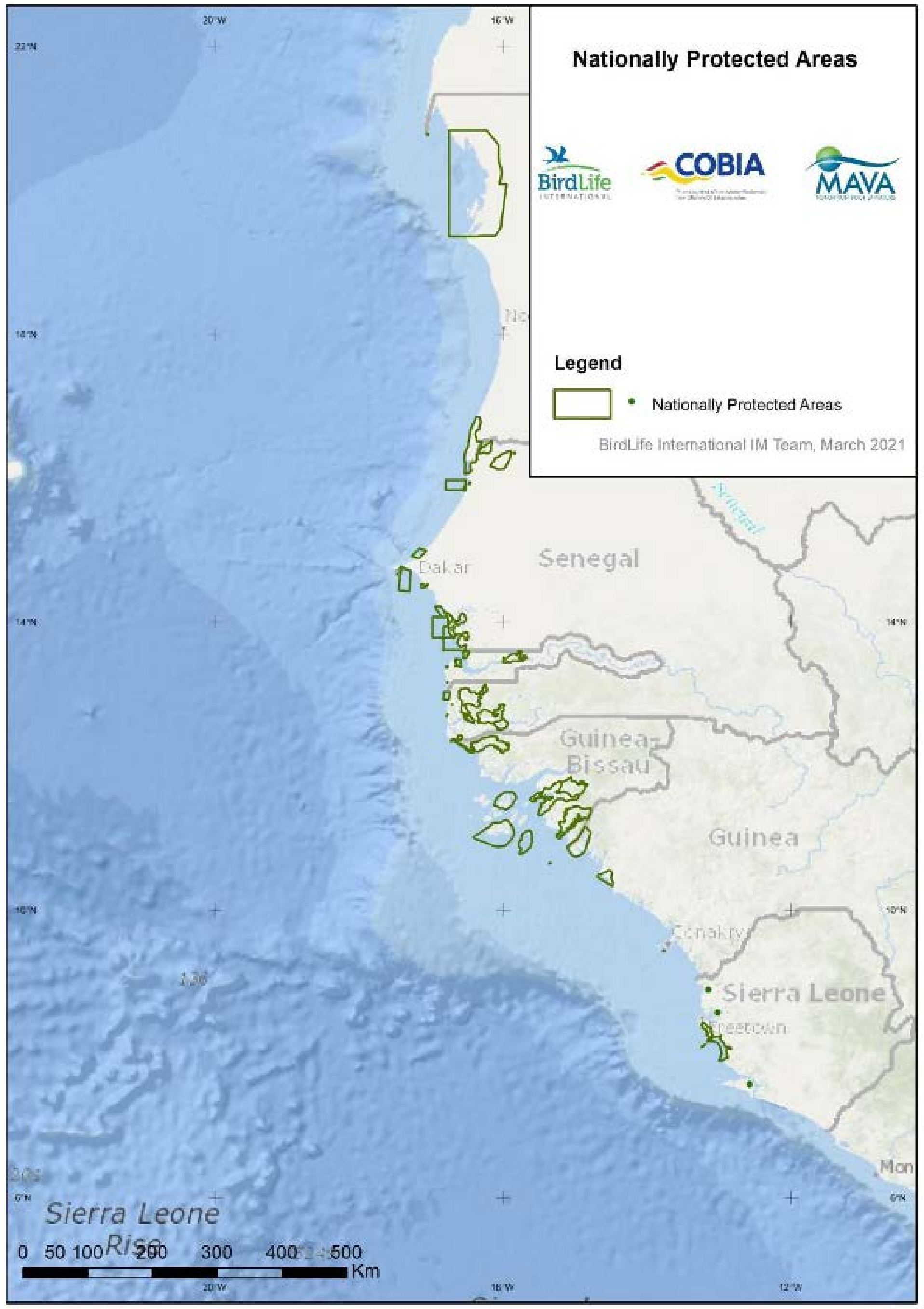


Figure 50: Networks of nationally Protected Areas in the coastal zone of West Africa (BirdLife International 2021).

and gulls. The only seabird breeding site in Guinea, Ile Alcatraz, is a Natural Reserve, whilst Iles Tristao (which used to support breeding terns) is a Faunal Reserve. Sierra Leone has four new MPAs, but there is only one national park in the coastal zone, which is essentially protected for its forest biodiversity.

Breeding sites for seabirds are well represented by the protected area network of Cabo Verde (Figure 51), although some gaps remain, notably the Ilhéus do Rombo just north of Brava. The Desertas Island group comprising Santa Luzia, Raso and Branco form a Natural Marine Reserve, for which a management plan has been proposed (Direcção Geral do Ambiente 2010). Designated marine protected areas include areas around the eastern islands of Sal, Boa Vista and Maio, including some offshore islets where seabirds breed. Some of the inland protected areas, especially on Fogo, are also important for breeding seabirds. There are ongoing developments to establish more extensive MPAs within Cabo Verde's marine territory.

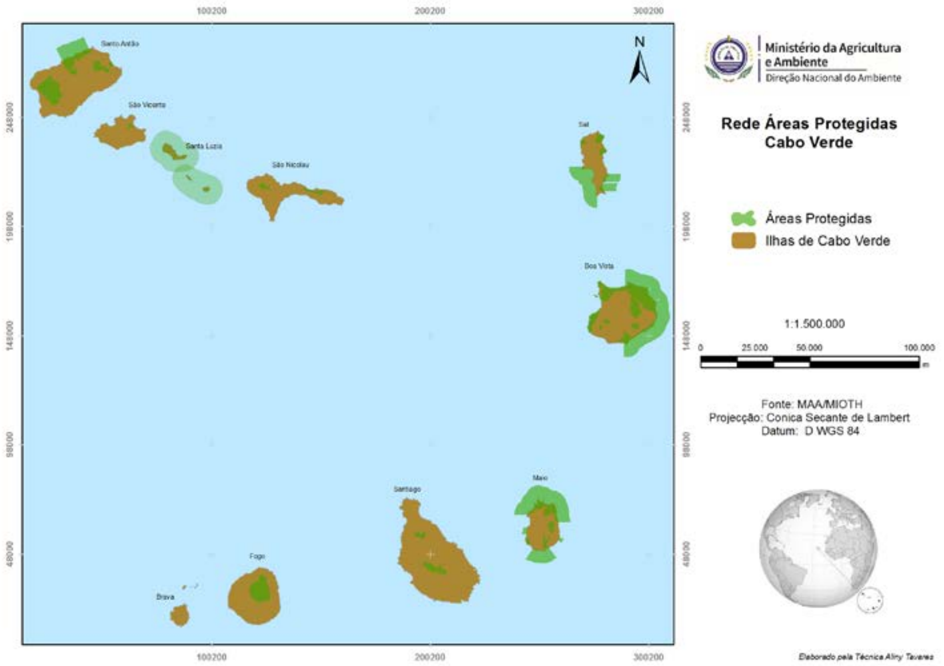


Figure 51: Network of nationally Protected Areas in Cabo Verde. © Ministério da Agricultura e Ambiente, Cabo Verde.

2. UNESCO World Heritage Sites and Biosphere Reserves

There are two key frameworks that recognise the global importance of sites under the United Nations Educational, Scientific and Cultural Organisation (UNESCO) – the World Heritage Convention (WHC) with the World Heritage List of sites, and the Man and Biosphere (MAB) Programme with the World Network of Biosphere Reserves. The WHC links the concepts of nature conservation and the preservation of cultural properties, recognising how people interact with nature, and the fundamental need to preserve the balance between the two. Its site network reflects the world's cultural and natural diversity of outstanding universal value, and the Convention promotes their protection, management, authenticity and integrity. Biosphere reserves promote solutions reconciling the conservation of biodiversity with sustainable use, as learning areas for sustainable development under diverse ecological, social and economic contexts.

There are two natural World Heritage sites in the West Africa coastal zone, the Parc National du Banc d'Arguin in Mauritania and the Parc National des Oiseaux du Djoudj in Senegal. Both sites are of high importance for seabirds, with the Banc d'Arguin supporting breeding colonies of gulls and terns and numerous seabirds on passage. Both sites support breeding colonies of Great (or White-breasted) Cormorant *Phalacrocorax carbo lucidus* and Great White Pelican *Pelecanus onocrotalus*.

The Senegal River Delta is an extensive Transboundary Biosphere Reserve of over 600,000 ha comprising a vast network of wetlands, and supporting numerous gulls, terns, cormorants and pelicans. It is also the only area in West Africa where Black-necked Grebe *Podiceps nigricollis* regularly occurs. The Saloum Delta in Senegal and the Bolama Bijagós Archipelago in Guinea-Bissau, both important for breeding and passage seabirds, are also designated Biosphere Reserves, whilst the Bijagós is in the process to apply for World Heritage status.

3. Ramsar Sites (or Wetlands of International Importance)

The Convention on Wetlands or Ramsar Convention (1971), ratified by 172 countries (October 2022), is an international treaty which promotes the conservation of wetlands and the wise use of their resources. Wetlands of International Importance or Ramsar Sites are designated under the Convention based on nine specific criteria, two of which are based on waterbirds, including seabirds (Appendix 1). Ramsar Sites are recognized as being of global importance, and designation of a site important for birds is favourable for its conservation (Kleijn *et al.* 2014). There are currently over 2,400 Ramsar Sites worldwide covering more than 2.5 million square kilometres. The Ramsar Convention only applies to wetlands whose depth is less than 6 meters at low tide, although adjustments for deeper areas, particularly near oceanic islands, are planned. Marine areas conventionally covered by the Convention are coastal wetlands such as estuaries, deltas and intertidal areas, mangroves, and coral reefs.

The Convention provides guidance to Contracting Parties on the management of Ramsar Sites and on the wise use of wetlands. Governments agree to take the necessary measures to guarantee the maintenance of the ecological character of Ramsar Sites, and the Convention has a range of measures to ensure that a site's ecological character is preserved. However, the Convention is not binding, as it does not provide for sanctions in case of degradation or improper use of resources. Ramsar Sites at risk may be placed on the record of Ramsar Sites where changes in ecological character have occurred, are occurring, or are likely to occur, the Montreux Record.

Sites that support over 20,000 seabirds that are also listed as waterbirds (e.g. all seaducks, grebes, pelicans, loons, cormorants, gulls and terns) or at least 1% of a biogeographic population or threatened birds of these families may be eligible for registration on the List of Wetlands of International Importance (the Ramsar List). The procedure established by the Convention for site designation must be followed, with completion of a Ramsar Information Sheet, including site characteristics, designation criteria and a map, which must be submitted by the administrative authorities to the Ramsar Secretariat. Refer to the designation and management guide on the Ramsar Convention website for more information (www.ramsar.org).

Ramsar Sites in West Africa

Mauritania, Senegal, The Gambia, Guinea-Bissau, Guinea, Sierra Leone and Cabo Verde are all Parties to the Convention on Wetlands (or Ramsar Convention). There are 24 Ramsar Sites (or Wetlands of International Importance) in the coastal zone between Mauritania and Sierra Leone: 3 in Mauritania, 8 in Senegal, 3 in The Gambia, 3 in Guinea-Bissau, 6 in Guinea and 1 in Sierra Leone (Figure 52). Most sites are important for gulls and terns, and some for pelicans. There are four Ramsar Sites in Cabo Verde, their main habitat being coastal lagoons and salt flats; they are not so important for seabirds.

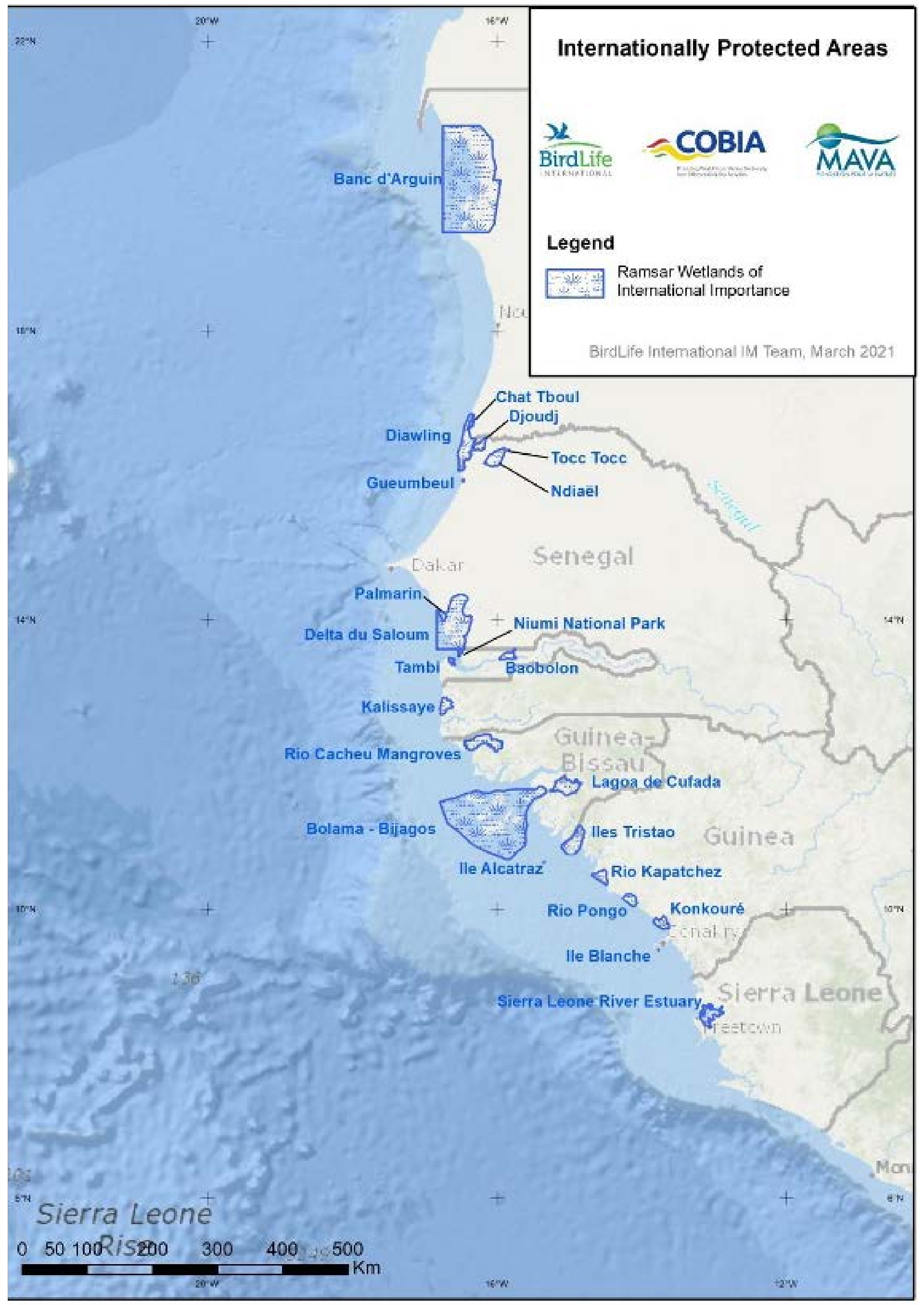


Figure 52: Ramsar sites from Mauritania to Sierra Leone (BirdLife International 2021).

4. Ecologically or Biologically Significant Marine Areas

Ecologically or Biologically Significant Marine Areas EBSAs are special marine areas that serve important purposes to support the healthy functioning of oceans and the many services that they provide, designated under the Convention on Biological Diversity. The combined impacts of numerous threats to the ocean, climate change and ocean acidification have impaired the structure, function, productivity and resilience of marine ecosystems. The designation of EBSAs can contribute to effective policy actions and to build a sound understanding of the most ecologically and biologically important ocean areas that support healthy marine ecosystems. The criteria adopted for the designation of EBSAs include uniqueness or rarity, importance for life history stages of species and threatened or declining species and/or habitats, vulnerability, productivity, diversity and naturalness.

There is an extensive network of EBSAs in West Africa (Figure 53), which include some key foraging areas for a high number of breeding and non-breeding seabirds. Improved awareness and recognition of these sites are needed to build their sustainable management into national and regional policies. There are three EBSAs in Cabo Verde – the Santa Luzia, Raso and Branco Complex, Boa Vista, and Santo Antão.

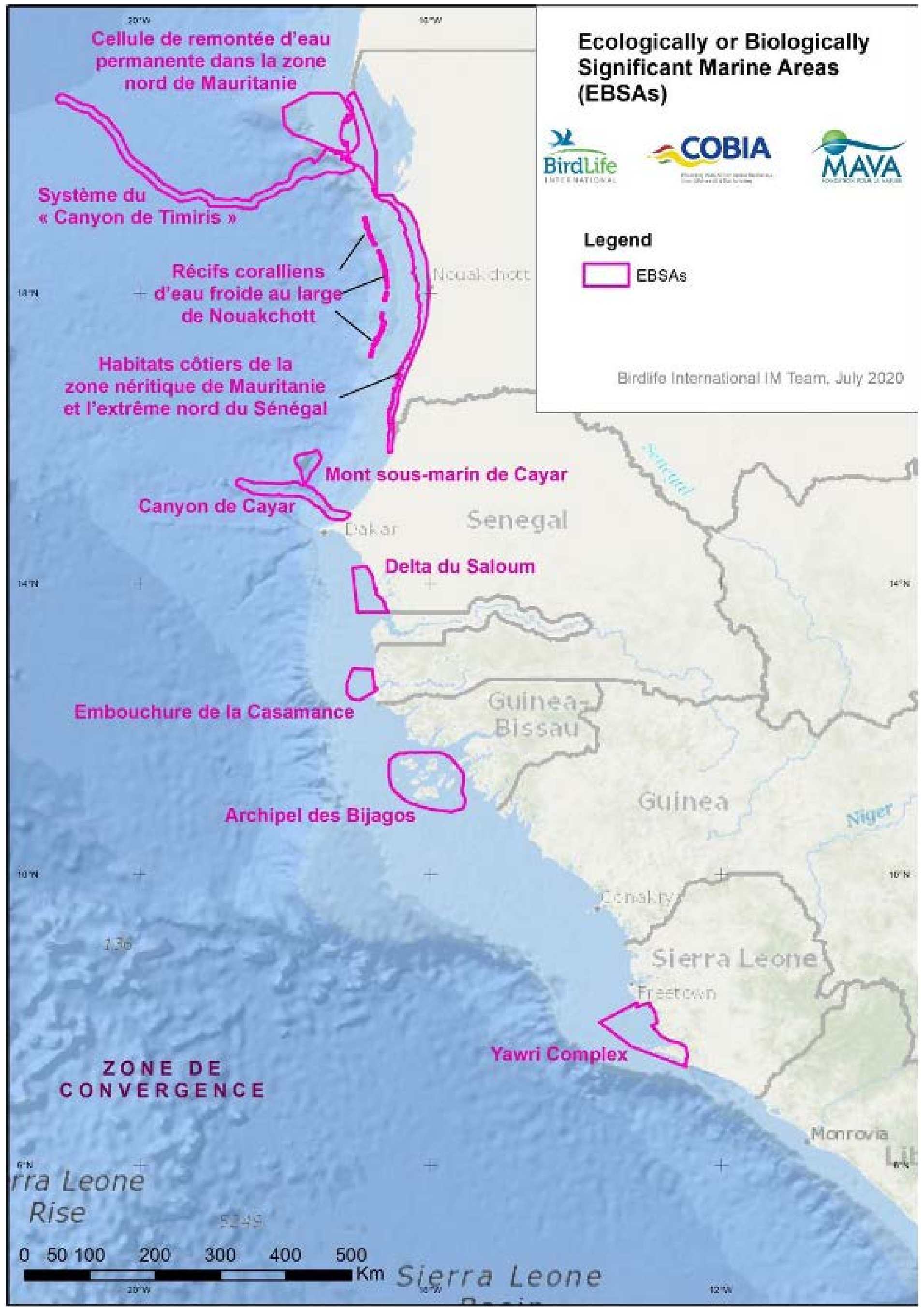


Figure 53: Ecologically or Biologically Significant Marine Areas (EBSAs) from Mauritania to Sierra Leone (BirdLife International 2021).

5. Key Biodiversity Areas (KBAs) and Important Bird and Biodiversity Areas (IBAs)

Key Biodiversity Areas (KBAs) are sites that contribute significantly to the overall persistence of biodiversity. KBAs extend to all taxa and ecosystems, whilst automatically including the criteria for Important Bird and Biodiversity Areas (see below). More details and criteria are available at: http://www.keybiodiversityareas.org. This classification tool can improve harmonisation between protected areas around the world and enable a better understanding of the importance of sites between countries.

Important Bird and Biodiversity Areas (IBAs) are key sites for birds and biodiversity identified through a set of simple but robust criteria that can be applied worldwide (Appendix 1). The selection criteria include quantified thresholds for some seabirds. Initially, IBAs were identified only for terrestrial and freshwater environments, but the IBA process and method has since been adapted and applied in the marine realm. IBAs are:

- Places of international significance for the conservation of birds and other biodiversity
- Recognised worldwide as practical tools for conservation
- Distinct areas amenable to practical conservation action
- Identified using robust, standardised criteria
- Sites that together form part of a wider integrated approach to the conservation and sustainable use of the natural environment

IBAs in West Africa

The coastal zone of West Africa supports a wide range of IBAs, including marine IBAs (Figure 54). Cabo Verde has 12 IBAs, eight of which are important for seabirds. This network of IBAs in West Africa includes some of the most important sites for birds associated with marine ecosystems, notably pelagic and coastal seabirds and waterbirds. The IBAs of the West African Marine Ecoregion serve as a key network for the conservation of birds and their habitats, as well as for many other taxa. IBA status is important in confirming the key role of sites for birds, and in supporting improved monitoring. Many marine and coastal birds occurring in the West African Marine Ecoregion are migratory, so it is vital that IBAs of the region are managed well, and present optimal conditions for birds to enable them to fulfil their annual life cycles.

Despite being recognised worldwide as a practical tool for conservation, IBAs are not always protected. However, designation of sites as Protected Areas does not necessarily infer protection, and many Protected Areas in the region receive insufficient resources to maintain adequate conservation measures; some have no management plans, whilst others have plans that are not implemented (BirdLife International 2021).

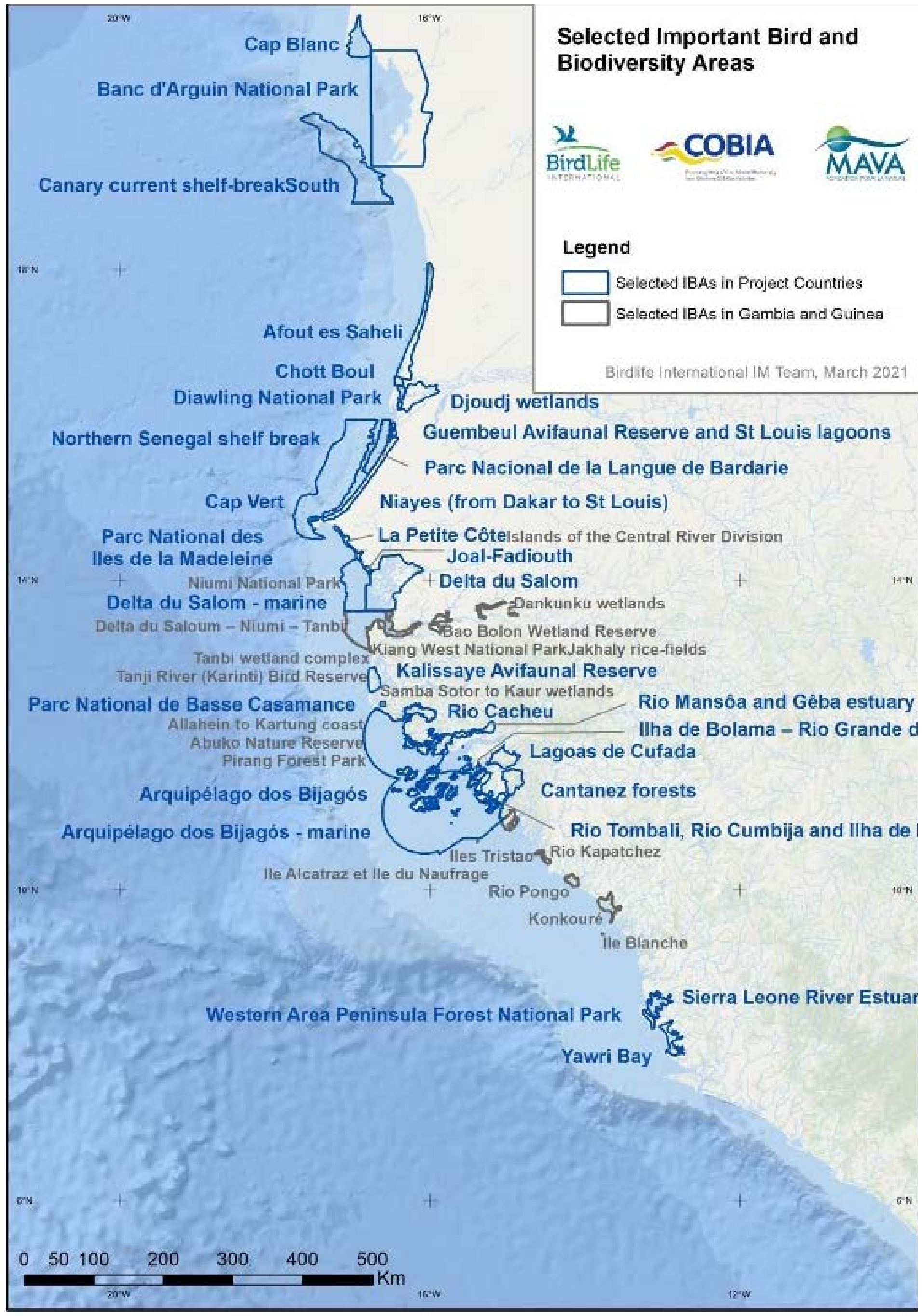
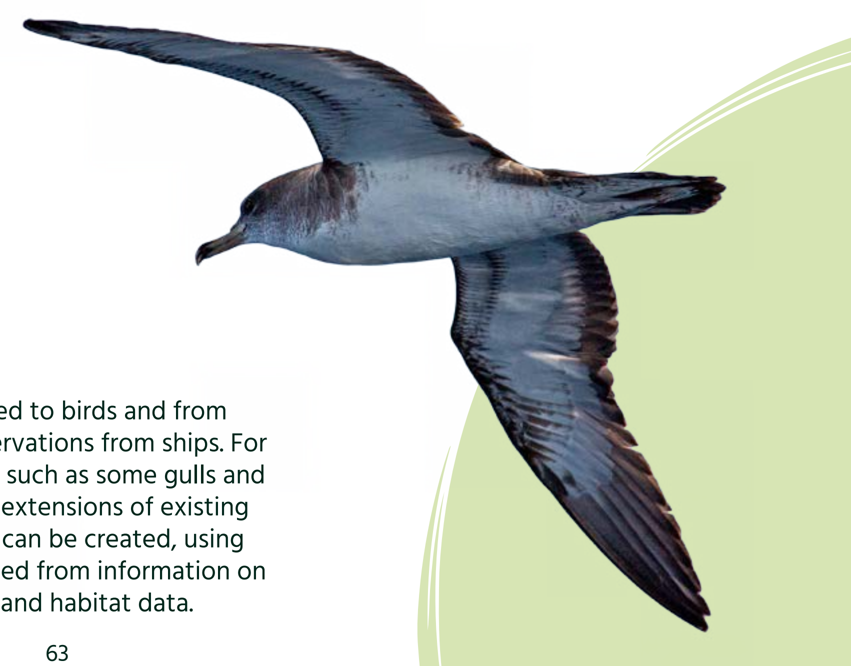


Figure 54: Important Bird and Biodiversity Areas (IBAs) of the coastal zone of West Africa from Mauritania to Sierra Leone (BirdLife International 2021).

The identification of marine IBAs in West Africa, an important step for the protection of species and sites

Seabirds are a key part of marine ecosystems and are recognized as important indicators of biodiversity and ecosystem health. BirdLife International has a programme to identify marine IBAs, especially areas where many species or individuals are concentrated, which includes creation of new databases and a range of analytical techniques. Results are available online (Marine IBA e-atlas: https://az-maps.birdlife.org/marineIBAs/) shows marine IBAs already identified for West Africa from southern Morocco / Mauritania to Guinea-Bissau, and in Cabo Verde. The data come mainly from GPS tracking devices attached to birds and from reports of observations from ships. For coastal species such as some gulls and terns, offshore extensions of existing terrestrial IBAs can be created, using heuristics derived from information on nutrition areas and habitat data.



A large set of historical and recent data on locally-breeding and migratory seabirds that use the West African region collected between 2013 and 2016 has been integrated into the central Seabird Tracking Database of BirdLife International. Ten years of historical data covering 32 species of seabirds from 21 colonies and nearly 1,000 individuals tracked with GPS devices has also been collected. An example of tracking results is shown for Royal Terns *Thalasseus maximus* from the Saloum Delta National Park in Senegal (Figure 56). Analysed data (see Dias *et al.* 2016) were used to improve the limits of existing marine IBAs, delimit new marine IBAs and update the international IBA database. The network of newly defined marine IBAs (Figure 55) takes better account of important areas at sea for the conservation of birds and other biodiversity thanks to this approach. Most Protected Areas that host breeding sites for seabirds are largely terrestrial and do not consider bird feeding areas. Marine IBAs can help to define or extend the boundaries of MPAs. The delimitation of marine IBAs off the coast of West Africa showcases some key sites for the conservation of seabirds and marine biodiversity.

In Guinea-Bissau, 20 Royal Terns *Thalasseus maximus* breeding at the Bantambur colony fitted with GPS devices were tracked in April-May 2021. The foraging trips recorded were deemed to be representative of the sampled population, i.e., the breeding colony. Therefore, the data could be used to identify the core areas on which the breeding colony depended and thus assess the suitability of marine areas designated as IBAs and/or for protection (Handley *et al.* 2021). Four key at-sea areas used on foraging trips which met IBA criteria were primarily inside of an already adopted IBA, and were located around the main breeding colony, with three additional areas found further north and close to the coastline (Figure 57). The data reaffirmed the importance of the previously identified global IBA for the region (Arquipélago dos Bijagós – marine) and reinforced how national and international efforts will be required to truly deliver effective conservation and management measures for species that span multiple jurisdictions. Correia *et al.* (submitted) further highlight the likely importance of suitable sandbanks and sand beaches up to 100 km away from the colony during the breeding season, and the need for their protection.

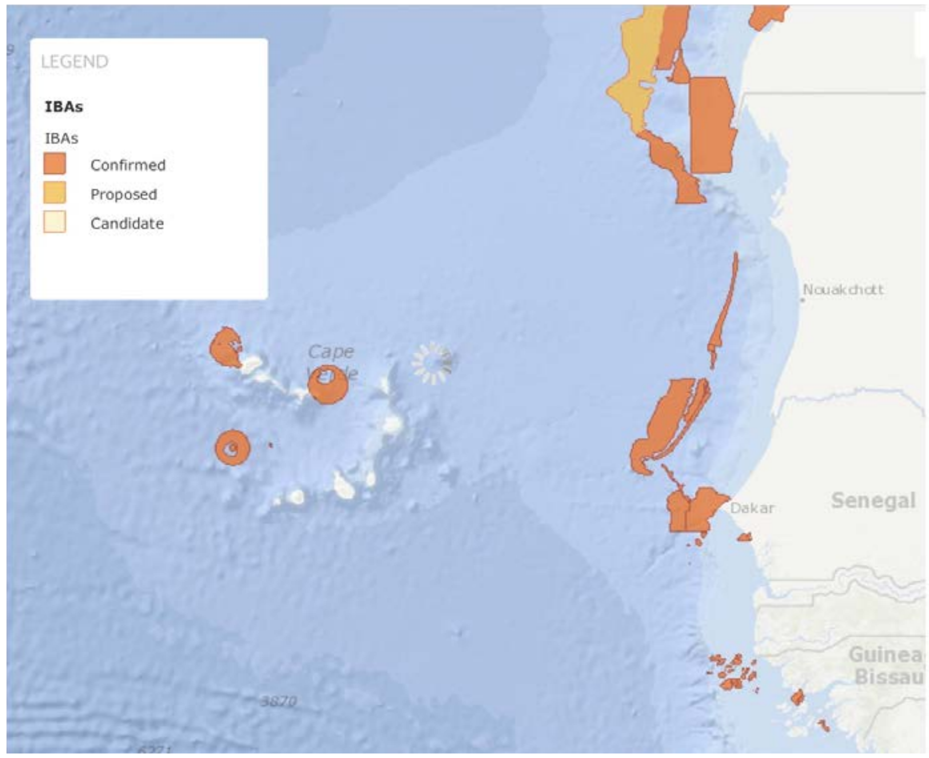


Figure 55: Marine IBAS identified (candidate and proposed areas) and confirmed in West African nations between southern Morocco and Guinea-Bissau (BirdLife International 2021).

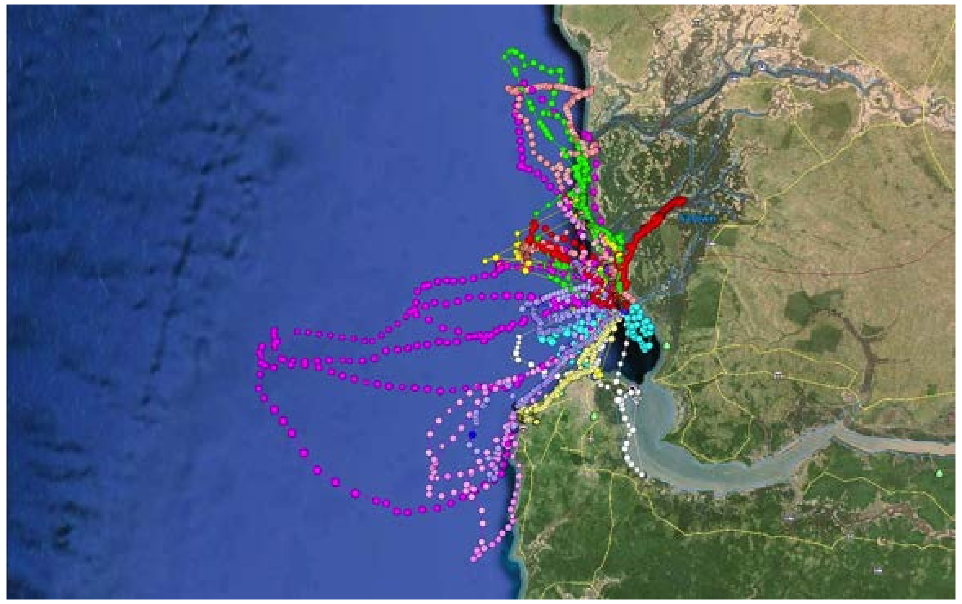


Figure 56: Example of routes used by tagged Royal Terns *Thalasseus maximus* between a colony in the Saloum Delta National Park (PNDS) and their feeding areas; analyses of data supported the definition of marine IBAs. The image shows a tagged tern with dye on its neck to identify it as a tagged bird. Photo: © Jan Veen-VEDA.

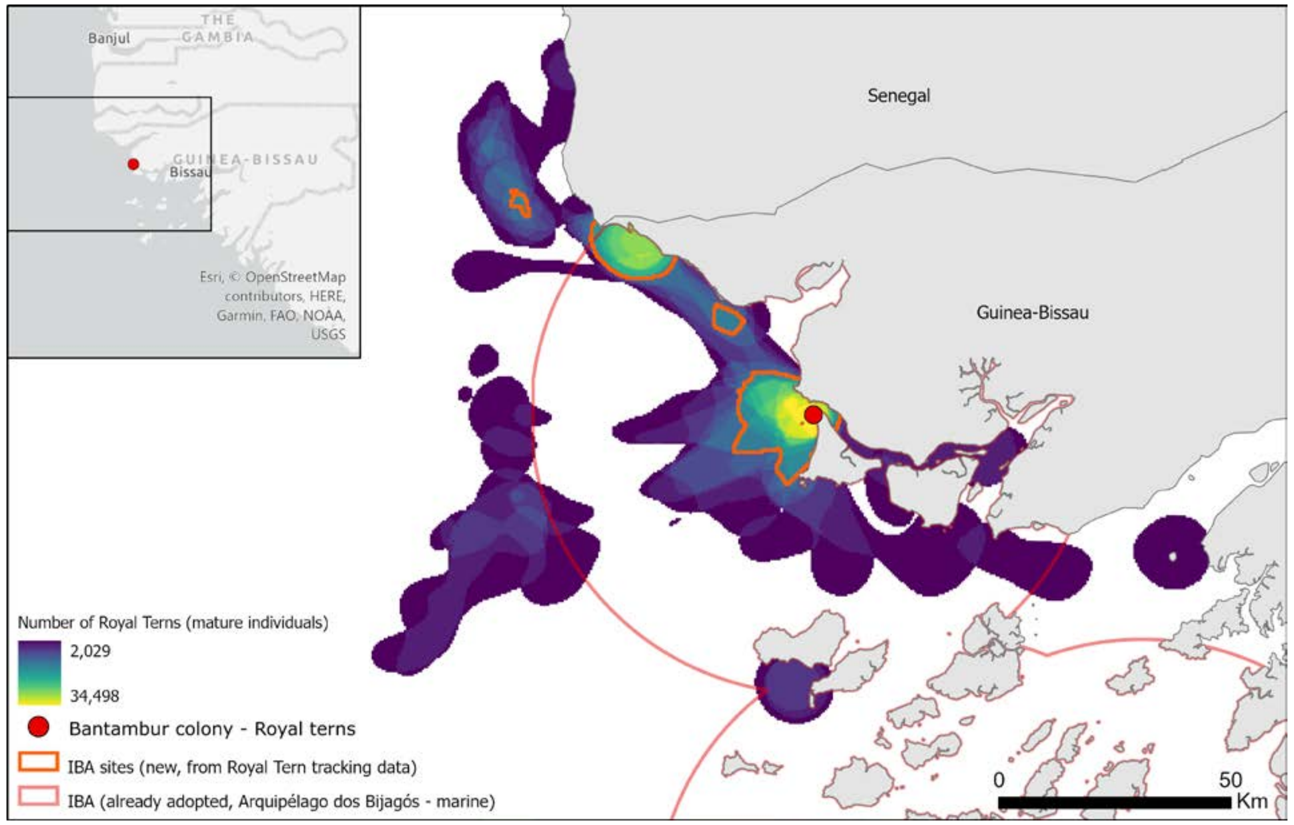
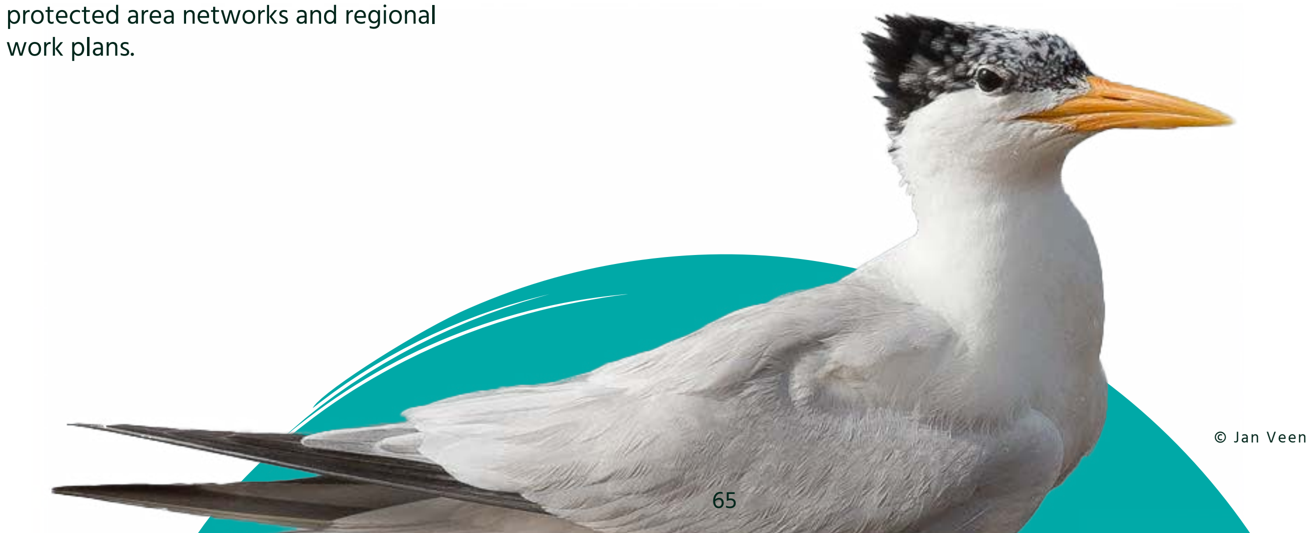


Figure 57: The core areas used by Royal Terns *Thalasseus maximus* (areas used by birds ≥50% of the time) breeding at Bantambur, Guinea-Bissau, based on tracking data of foraging trips in April-May 2021 of 20 terns tagged with GPS devices, including estimates of abundance, are highlighted in blue (less birds) to yellow (more birds) shading; new areas meeting IBA criteria based on the tracking data are shown in orange, with the existing global IBA (Arquipélago dos Bijagós – marine) is shown in red (Hadley *et al.* 2022).

For conservation to succeed, marine conservation efforts need to take full account of the ecosystem services provided. Thus, after defining marine IBAs, appropriate measures are needed to deal with identified threats, while deepening our knowledge of other risks that could hamper conservation of seabirds and marine biodiversity.

A preliminary proposal for marine IBAs for seabirds in Western Africa was presented at the IUCN Africa Protected Areas Congress (APAC) in July 2022 (Figure 58). Such actions build international awareness and can promote more formal adoption, such as integration of marine IBAs into national protected area networks and regional work plans.

Figure 58: Title slide from the preliminary proposal for marine IBAs for seabirds in Western Africa presented at the IUCN Africa Protected Areas Congress (APAC) in July 2022. © BirdLife International.



4C. MANAGEMENT PLANS

A management plan sets out the objectives of management and actions needed to respond to the purpose of a protected area. A business plan focuses on the financial and organisational dimensions and documents how to resource the delivery of the management plan (Worboys *et al.* 2015). Most manuals and guides on writing management plans follow the same logic for presentation of the plan: a) description of the site; b) a definition of management goals and activities; and c) the description of the plan's evaluation method. Site Management Plans are useful for establishing a framework of targets and actions over a prescribed period; they should enable the setting of objectives and time-bound targets, and a thought-out series of actions to meet these. Management plans should be practical and not cumbersome, and should be used regularly otherwise they are not serving a useful function (Dodman & Boere 2010).

Ramsar Handbook 18 (Ramsar Convention Secretariat 2010) identifies five main steps in the management planning process (Table 3), as summarised by Dodman & Boere (2010). These steps are useful within the context of seabird conservation in West Africa, especially as many important sites for seabirds are also Ramsar Sites.

In order to safeguard sites and their features, managers must adopt a flexible approach to allow them to respond to the legitimate interests of others, adapt to the ever-changing political climate, accommodate uncertain and variable resources, and survive the vagaries of the natural world, as illustrated in the adaptable management cycle (Figure 59). A key component of adaptable management is monitoring condition of features to determine the extent to which objectives have been met. If the objectives are not being met, then the management should be modified. Ongoing monitoring is needed to determine if the modified management meets the objectives and if further adjustments are needed.

Table 3: Five main steps in the management planning process for Ramsar Sites (Dodman & Boere 2010).

a. Preamble/policy:	A concise policy statement reflecting the broad terms, policies and/or practices concerned with the production and implementation of the management plan.
b. Description:	Collation and synthesis of existing data and information. The description should be regularly reviewed and updated.
c. Evaluation:	Evaluation of ecological character, socio-economic and cultural values and other features for management planning, employing the use of evaluation criteria. Ecological criteria are based on size, biological diversity, naturalness, rarity, fragility, typicalness, potential for improvement and/or restoration.
d. Objectives/ rationale:	Objectives must be measurable and achievable, and should present clear expressions of purpose. Three steps in preparing measurable objectives are to: i) describe the condition required for a feature; ii) identify factors that influence the feature, and consider how the feature may change as a consequence; and iii) identify and quantify a number of performance indicators for monitoring progress in achieving the objectives. The rationale section should outline the management considered necessary to maintain or restore the site features in/to a favourable status.
e. Action Plan:	The action plan should describe in detail the management work associated with each feature. The action plan may be considered as a management project, and should identify when and where the work will be carried out and by whom, priorities and expenditure. The action plan should include annual or short-term reviews, plus major reviews or audits to assess management effectiveness and efficiency and ensure that the site's features are being assessed.

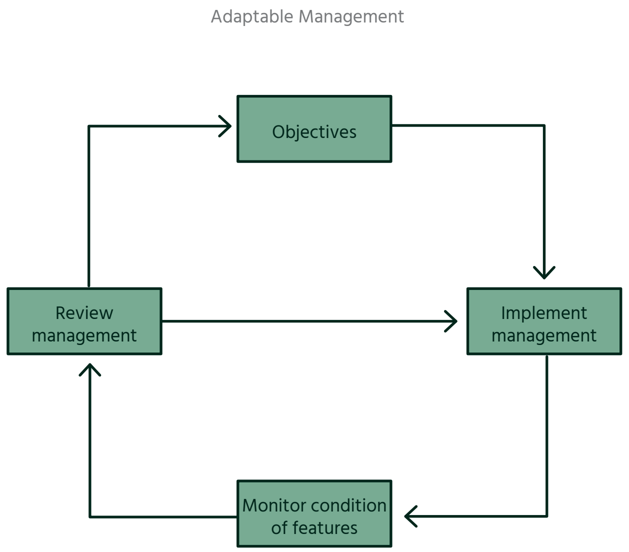


Figure 59: The adaptable management cycle (Ramsar Convention Secretariat 2010).

In terms of seabirds, a management objective might be to secure and increase a breeding colony of threatened seabirds. Proposed management may include actions such as control of IAS, disturbance and exploitation. If monitoring indicated that the colony was in decline, then management should be reviewed, probably through additional research. Perhaps, for instance, there is an issue related to bycatch that has not been accounted for. New management actions could then be applied, such as implementing bycatch mitigation measures. Ongoing monitoring will determine if the new actions contribute to achieving the objectives or not. It may take several years or breeding seasons to meet the objectives through the adaptable management cycle.

Several useful writing manuals are available, including the Methodological guide for developing management plans for Marine Protected Areas in West Africa (Rizk *et al.* 2011, Figure 60), currently only available in French: https://portals.iucn.org/library/node/28926).

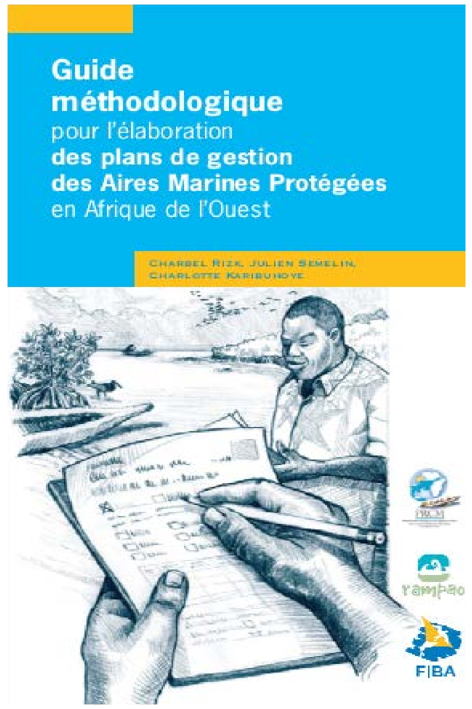


Figure 60: Methodological guide for the development of management plans for Marine Protected Areas in West Africa (Rizk *et al.* 2011).

4D. SPECIES ACTION PLANS

A Species Action Plan is a practical way to set out actions to improve a species' conservation status. Plans should be developed in consultation with stakeholders, e.g., through a participative workshop. Implementing the plan and monitoring its impact are essential steps that usually require fundraising efforts. Dodman & Boere (2010) summarise the following essential elements of a species action plan:

- Description of the available information on population status, trends (if available), distribution (per country), general ecology, threats and present conservation status.
- A framework for action, including aims and objectives of the plan, preferably with a timetable showing when described aims and objectives should be achieved.
- Description of the potential tools available for implementing the action plan, including policy instruments, national and international legislation and funding options.
- A realistic time schedule to achieve short-term, mid-term and long-term objectives.
- Time frame for monitoring, evaluation and communication, including public awareness activities and a schedule with regular intervals to review progress and, when needed, adjust goals, time schedules and funding.
- Clear structure for implementation and governing of the process, giving responsible bodies.

Species Action Plans may focus on one species or on a range of species, an example being the International Multi-species Action Plan for the Conservation of Benguela Upwelling System Coastal Seabirds (Hagen & Wanless 2015). Eight seabird species and one wader are covered by this plan, and the objectives are to manage fish stocks for their recovery and maintenance at agreed levels; reduce the number of seabird deaths due to pollution; minimise displacement and predation at colonies; and fill key knowledge gaps on the impacts of threats, especially those relating to mining impacts and gillnet mortalities. The plan identifies and ranks threats to each species, reviews polices and legislation, assesses monitoring and research and then prescribes a framework for action.

National Action Plan for Seabird Conservation in Cabo Verde

An action plan to conserve seabirds in Cabo Verde has been planned for several years, and a draft plan was first prepared in 2007. A workshop took place in 2014 to plan development of an action plan for the Cape Verde Shearwater Calonectris edwardsii. Development of the national action plan was put back to ensure that new information from an active phase of seabird research could be included within it. However, delays in the development of such plans can also be common, especially when a range of partners are involved.

The plan aims to outline the status and conservation needs of all seabirds breeding in Cabo Verde, with generic, species-specific and site-specific actions. Analyses will inform reviews of the threat status of all seabirds in Cabo Verde. The plan expects to focus initially on Ilhas Desertas, Ilhéus do Rombo and Cape Verde Petrel (Gon-gon) Pterodroma feae breeding areas. Production of this plan should be a key milestone in future conservation planning of Cabo Verde's seabirds and the sites on which they depend.

4E. CONSERVING GENETIC DIVERSITY OF SEABIRDS

To conserve a species, it is essential to preserve its genetic diversity and therefore its various populations and their gene pools. In conservation biology, the disappearance of a species is often the metric used to illustrate ecological degradation. However, before disappearing, a species usually undergoes local extinctions (disappearance of different breeding populations), and decreases in population density. Seabirds are often philopatric, that is, they return to the colony where they were born. Some colonies can represent discrete populations. Thus, if a seabird colony disappears, part of the genetic diversity of the species disappears with it. If, over time, a population is restored thanks to colonisers originating from another colony, their genetic background may be different. It is thus vital to conserve individual seabird colonies in order to maintain genetic diversity.

Pomarine Skua © BirdLife International

Part 5 Monitoring methods and research

5A. BIOLOGY OF POPULATION CONCEPT

Seabird Colony

A seabird colony is defined as a 'local' concentration of breeding seabirds (Walsh *et al.* 1995). It is a large congregation of individuals of one or more species of seabird that nest in proximity at a particular location. Some seabirds congregate at sea or at roosts often in large numbers, but a colony refers specifically to a breeding site comprising many birds.

Populations

A population can be defined as a distinct assemblage of individuals which does not experience significant emigration or immigration, in which the interchange of individuals between populations remains at a low level (Wetlands International 2006). This definition is used for waterbirds and applied by the Convention on Wetlands and AEWA, and is suitable for seabirds (many of which are also considered waterbirds).

Metapopulations

Seabird populations in some regions operate as metapopulations, i.e., a group of populations marked by immigration and emigration between colonies. Dispersal to other colonies is more common in young birds breeding for the first time than in more experienced breeders. The state of health of a metapopulation is regional as colonies interact with each other; breeding success in all colonies should be known. Some colonies may act as source populations, where high reproduction levels often lead to positive population growth rates, while other colonies act as sinks, where low breeding success leads to negative population growth rates. Demographic trends at one colony, especially a large colony, can affect breeding numbers of the metapopulation. Thus, cooperation and the sharing of information between managers from multiple sites is crucial.

Small populations issue

Seabirds can be stimulated by and benefit from a substantial number of congeners (birds of the same type/ genus). More birds can stimulate courtship displays and sexual availability, can dilute risks of predation, and may enable sharing of information on best fishing sites. Conversely, a low-density colony, following a decline in numbers, may never bounce back to its historical numbers. This is an Allee effect (Courchamp *et al.* 2008; Schippers *et al.* 2011), whereby there is a positive correlation between the density of a population and its growth rate. Abandoned colonies may also not experience recolonization despite conditions becoming favourable again (e.g., after rat eradication) and neighbouring colonies full of breeding pairs, without social attraction.

5B. MONITORING SEABIRD COLONIES

Key questions

Monitoring is a key component of site or population management, and is essential to gauge effectiveness of management actions and adapt them if necessary. It is not easy to monitor the status of seabirds at sea outside the breeding season, as birds tend to be widespread and often 'out of reach'. Thus, monitoring tends to focus on the breeding season and at seabird colonies. Key questions relating to an individual seabird colony are:

- What species of seabirds are present at the site(s)?
- How many pairs of each species are present?
- How do their numbers change over time?
- How to define the colony site?
- How important is the colony nationally, regionally or globally and for the population?
- What environmental factors (natural or anthropogenic) influence the colony?
- What conservation measures are necessary?
- Are conservation actions effective?

Attempting to answer these questions can help in the design of a monitoring plan for the colony and in justifying and adapting conservation plans and management actions:

- Determine which species of seabirds are present and monitor their relative distribution and abundance during the year.
- Measure the colony size and assess trends; monitor changes in numbers and density over time in response to environmental and other changes (e.g., variation in site conditions, direct threats affecting the site, indirect threats like climate change), and management actions.
- Estimate breeding success.
- Estimate the status of a threatened species (this may require following specific protocols).
- Justify conservation actions (e.g., proposing a site to be declared as a protected area).
- Assess the need for specific management or the implementation of conservation measures to improve the site for seabirds.
- Assess the effectiveness of management or conservation measures taken to improve the site for seabirds.
- Engage local communities to participate in citizen science activities and in the conservation of seabirds and their habitats.
- Assess the tourism potential based on nature (Veen & Mullié 2015).

Avoid impact to seabirds

It is vitally important that study methods such as those described below are undertaken in such a way that the behaviour of individual study animals and populations or other non-study species is not impacted adversely by the scientists or monitoring teams. Seabird colonies and other wildlife and flora at colony sites are fragile and sensitive to disturbance. Careless monitoring may have direct impacts on breeding seabirds, such as causing nest desertion, or causing undue stress to individuals that may change their subsequent behaviour. Most ecological studies are based on the assumption that the characteristics of the species or individuals studied are representative of the population as a whole, and adverse impacts on behaviour will bias these results. Thus, it is vital to minimise disturbance or other potential impacts, both for the wellbeing of seabirds and other wildlife and for the reliability of monitoring results.

Some indispensable references on the general methods of monitoring colonies of nesting seabirds are available, with variations adapted to various contexts, depending on region or species and habitats concerned (Bibby *et al.* 2000; Cadiou *et al.* 2009; Haynes-Sutton *et al.* 2014; Veen & Mullié 2015 (Figure 62); Walsh *et al.* 1995). These documents present the basic methods, which can be adapted on a case-by-case basis to the situations encountered in the field (Cadiou & Mahéo 2016; Monnat & Cadiou 2004).

Figure 61: Monitoring birds from a distance, including from a boat, is one option to minimise disturbance. © BirdLife International.

Toolbox: eBird, a useful birdwatching tool

Observations from the birdwatching community can provide valuable data on current and future seabird distribution, changes in population size over time, occurrence of invasive alien species, behaviours and emerging threats. Participatory science can be a useful and easy-to-use tool to collect data through motivated local observers.

eBird is a database developed by the Cornell Lab of Ornithology and the National Audubon Society (https://ebird.org). The platform allows you to store your observations, share them with the rest of the birdwatching community, and make preliminary research on your studied species.

The interventions described in these manuals require technical and scientific skills. Only trained personnel should carry out monitoring or research work in seabird colonies, whilst before any intervention, the necessary authorizations must be obtained from regulatory authorities.

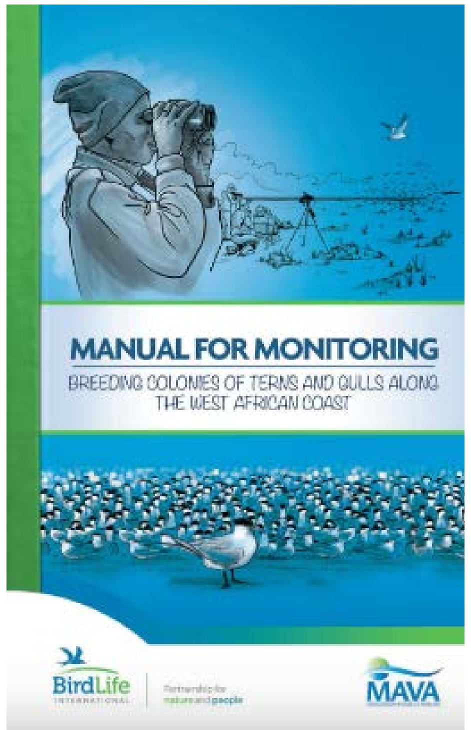


Figure 62: Manual for Monitoring breeding colonies of terns and gulls along the West African coast (Veen & Mullié 2015), https://www.birdlife.org/sites/default/files/attachments/FIB-Guide-suivi-oiseau-EN.pdf.

Why monitor nesting seabirds?

In marine conservation, the aim of monitoring seabird colonies is to acquire knowledge that can be used to help manage the species present, evaluate the conservation management underway and adapt / improve management. Through regular monitoring it is possible to assess the numerical and spatial trends of colonial nesting seabirds in the short, medium, and long term, and to evaluate the management actions implemented (cf. Haynes-Sutton *et al.* (2014) for a detailed review). Assessing population status is vital given the context of global changes and of anthropogenic and environmental factors influencing seabird populations. Monitoring can be done within the framework of protected area management plans, observatories or scientific research work. Data collection methods should be standardised in order to compare results between years.

Monitoring biological parameters

The first biological parameter conventionally monitored in a seabird colony is the size of the nesting population, which corresponds to a census of the number of breeding pairs. Second is productivity, which corresponds to the average number of fledged young per nesting pair and breeding success, or the percentage of pairs that have successfully raised at least one fledged offspring. It can be more difficult to monitor productivity in seabirds with mobile young, which leave the nest at a young age and may be difficult to locate again. Some birds form creches (groups of young birds) that may be some distance from the colony. Other parameters can also be monitored depending on the goals of the study, such as the clutch size or chick body condition (Veen *et al.* 2006). The monitoring should be organized according to the goals set; as well as the biological, logistical (material and human assets) and financial resources.

Monitoring the breeding population

A key objective of monitoring is to assess the numbers of birds present, ultimately to estimate the size and trend of a population. Monitoring needs to be carried out regularly if estimating population trends. In order to monitor a population, censuses need to be conducted at all or a sample of the colonies that make up that population. This is especially important for seabirds, such as terns, which may be highly mobile, and select different colonies between years.

In some countries, censuses are carried out every year, but this is not always feasible. Colonies can be monitored by whole-colony counts or by (sample) plot counts, which then require a means of extrapolating count results in order to estimate the population. However, if the key interest is to determine population trends, then plot counts may only be needed, and can be much more affordable if counting the whole colony is a daunting task that would involve equipment or resources that are not readily available.

Seabird colony censuses

For many seabird species, breeding birds (number of breeding pairs) tend to be the only ones 'accessible' when censusing a colony, as non-breeding birds generally remain at sea. Seabird colonies represent a concentration of breeding birds in well-defined areas (e.g., islands, islets), whilst other birds may also be present at other colonies and at sea. Pre-breeding individuals may prospect other areas in search of a future colony, site and partner (Danchin *et al.* 1991; Dittmann *et al.* 2005). Non-breeding adults, i.e. birds that may skip breeding for a year for several reasons such as poor bodily condition or the disappearance of their former partner, may also be absent from their usual colony (Aebischer & Wanless, 1992; Cam *et al.* 1998). Adult breeding birds that have undergone premature breeding failure will also usually desert their breeding site. Thus, certain parts of a population remain at sea during the breeding season, whether they are sexually immature young that spend their first years of life exclusively at sea, or non-breeding adults (in "sabbatical year"). In total, young pre-breeding individuals and non-breeding adults can represent more than 50% of the population (Nelson, 1980).

Some seabirds do not have a well-defined breeding season, which makes it difficult to determine the total breeding population size of a colony. This is more common in species nesting in tropical areas. In West Africa, Caspian Terns *Hydroprogne caspia* have an extended breeding season, and a single census carried out at a site will not represent all the Caspian Terns that breed at the colony.

When seabird colonies undergo significant disturbance or other threats, for instance, if they become inundated by storm surges, breeding birds may abandon their colony and move elsewhere to breed. In West Africa, this behaviour can happen with terns, especially those nesting on low sandy islets that are prone to flooding. It is thus important to monitor general movements of birds within an area and to relate the sudden disappearance of nests in one place with the appearance of nests elsewhere (Veen & Mullié 2005).

Timing a seabird census

The optimal period to census breeding seabirds and to monitor their productivity relates to seasonal and interannual (or phenological) influences (Cadiou *et al.* 2009; Cadiou & Vives 2006) and synchrony of reproduction. Some seabirds nest at the same time (highly synchronous), with the different breeding cycle phases (laying, hatching, fledging) each lasting a few weeks (Burr *et al.* 2016; MacDonald, 1980). In others, breeding phases can last up to several months and therefore show overlaps (Burr *et al.* 2016; Hamer *et al.* 2001). Some tropical seabirds can reproduce throughout the year (Haynes-Sutton *et al.* 2014; Kepler, 1978). The Sooty Tern's *Onychoprion fuscatus* breeding cycle can last less than a year, so the egg laying peak shifts from year to year (Reynolds *et al.* 2014). Some species show interannual changes in timing of breeding at the same colony or between distant colonies (Burr *et al.* 2016; Schreiber, 2001). Thus, phenology is an important factor for timing the census when birds are mid-incubation and stable in the colony. Disturbance of seabirds during the installation period risks abandonment of the colony. The best time to count terns is about three and a half weeks after the observation of first potential hatching.

Some seabird pairs fail in their breeding attempt for different reasons, such as poor coordination of partners, harsh weather and predation, either shortly after nest construction, or during incubation, hatching or chick-rearing (Monnat & Cadiou 2004). Breeding synchronization and failed breeding attempts mean that the number of breeding pairs found during a single visit is always lower than the total number of pairs (Monnat & Cadiou 2004). In West Africa, Caspian Tern *Hydroprogne caspia* shows a strong spread of reproduction, and the number of active nests detectable during a site visit does not represent the total number of breeding pairs during that season. Diagana *et al.* (2020) discovered nesting Caspian Terns at Aftout Es Saheli in Mauritania in January 2006, when several nesting stages were visible within the colony: nests with eggs in the brooding phase, nests with eggs in the hatching phase, nests with chicks; as well as large chicks accompanying adults. Young Caspian Terns may be fed by a parent bird for six to eight months after fledging (Urban *et al.* 1986); juvenile birds may also be seen around breeding colonies (Figure 63).

In some species, replacement laying can take place, most often when failure occurs soon after laying. A second reproduction attempt of terns can be made in another locality distant from the first. Such movements of breeders complicate estimation of breeding numbers, as the same pair may be counted as breeding in two separate places during the same season. Only coordinated counts carried out at regular intervals enable census bias to be limited (Cadiou *et al.* 2009).

Multispecies colonies

In multispecies colonies, the breeding seasons of each species present may differ (Cadiou *et al.* 2009; Haynes-Sutton *et al.* 2014; Monnat & Cadiou 2004), and a single visit may not necessarily coincide with the optimal census date for each species. This can result in an underestimation of numbers of some species, especially those that may have nearly finished breeding or only recently started. A second later visit to refine the counts is possible, though this may result in an increased risk of disturbance for the earlier-breeding species, whilst second counts may also include birds that have lost their first clutch and re-laid. It is important to decide the best compromise for the monitoring strategy.

Observers need to differentiate between each species present in a mixed colony, especially when monitoring is based on breeding bird censuses. Experienced observers should estimate the respective proportion of each species, which relates to the total number of pairs counted, and be able to recognize nests, eggs and chicks of distinct species. Criteria can refer to the nest itself, which may be bulky or located in a sheltered place, to the size and colour of eggs, or to the morphology and plumage of chicks. Some eggs cannot be easily differentiated, for instance in some mixed colonies of gulls.

Figure 63: Adult Caspian Tern *Hydroprogne caspia* with juvenile near Acapa Imbone, Bijagós Archipelago, Guinea-Bissau. ©Tim Dodman.

Determining the counting unit

The principal counting unit is the breeding pair, but the criteria to identify it vary according to the breeding biology of the species considered (Monnat & Cadiou 2004; Walsh *et al.* 1995). In most surveys carried out in West Africa, the counting unit relates to the birds themselves, i.e., individual birds or birds on eggs. However, it is also possible to use other units based on nests or breeding sites:

• Apparently Occupied Nests (AONs)

For some seabirds, such as gulls and cormorants, the counting unit corresponds to Apparently Occupied Nests (AONs), i.e., an elaborate nest with or without eggs or chicks. The empty nests observed during a count may correspond to pairs that have not yet laid eggs or that will ultimately not lay eggs, but also to couples that have already failed in their reproductive attempt (Monnat & Cadiou 2004). Observers should be able to correctly distinguish the various stages of nest construction, otherwise the counts may be under or over estimated.

The chronological succession of nest construction is: a site with droppings, without material input; material inputs; substantial but coarse draft platform of materials, without a clean cup nest; quite elaborate nest, platform of materials, with the beginning of a formed cup nest; and an elaborate / built nest, such as a platform of materials with a clean cup nest (Jones *et al.* 2008). In the field, these stages can be listed using abbreviations or numerical scores. The distinction between a quasi-developed nest and an elaborate nest is not always easy to make for less experienced observers.

After a nest failure while incubating or soon after hatching, the state of the nest will regress quickly, whilst an occupied nest regresses progressively as the young grow and become more active, firstly to that of a platform without a cup nest, then to the presence of materials as at the beginning of the season, lastly to a site covered in droppings, with no plant material present. These natural developments mean that the number of identifiable elaborate nests on a given date is not equal to the total number of developed nests built by the nesting pairs of the colony studied. Only nest-by-nest monitoring during the breeding season provides a high level of precision, but in the vast majority of cases, counting is done through a single visit during the season. In some seabirds the base of the nest may remain from season to season, and only nests with new material inputs should be considered as AONs. This can be the case with cormorants nesting on the ground (Figure 64), although in West Africa they often breed in shrubs or mangroves.

Figure 64: Nest of a Great (White-breasted) Cormorant *Phalacrocorax carbo lucidus* breeding at Parc National des Iles de la Madeleine, Dakar, Senegal, showing nesting material present. © Ngoné Diop.

• Apparently Occupied Sites (AOSs)

For seabird species that do not build ground, the census unit is the Apparently Occupied Site (AOS). In the absence of nests (as in fulmars), or in the case of an extremely basic nest or simply a slight depression in the substrate (as in terns), an observer counting from a distance should identify adults in an apparent incubation position. With a little experience, these breeding birds can be distinguished from individuals at rest by their different postures, i.e. lower position closer to the ground (Cadiou *et al.* 2009), and in some cases by their regular dispersion. It can require an extended period of observation (e.g., more than 15 minutes, or up to several hours) to observe whether apparently nesting birds stand up and can be classified. Instantaneous counts can be efficient to undertaken timewise, but require very experienced observers to discern the difference between birds with active nests and those without. An incubating tern may be partly hidden if sitting on eggs in a hollow or scrape and the tail will usually point upwards at an angle (Walsh *et al.* 1995, Figure 65).

Figure 65: Arctic Tern *Sterna paradisaea*. © Christophe Mueller.

Apparently Occupied Burrows (AOBs)

For seabird species that breed underground, the census unit is the Apparently Occupied Burrow (AOB). In birds that breed in burrows or holes in rocks (e.g., storm-petrels and shearwaters), it is a matter of prospecting the colony and looking for indications of burrow or hole occupation. This can include signs of burrow extension, as well as egg shells, chick down, the calls of an adult or a chick, and, in some cases, the presence of droppings. However, prospecting burrows in sandy or loose soil, such as the dense colonies of White-faced Storm-petrel *Pelagodroma marina* on Cabo Verde, is risky, as walking through a colony can easily cause earth to collapse in on burrows and possibly bury any occupants. Audio playback for small burrowing seabirds and manual burrow inspections for larger burrowing seabirds are widely used occupancy detection methods, but playback requires calibration to account for non-responsive birds, whilst it is also an invasive and time-consuming process (Bird *et al.* 2021). Birds can be extracted from burrows for specific purposes, including ringing, fitting trackers or collecting measurements and samples (Figure 66).

Figure 66: A Cape Verde Little Shearwater Puffinus *lherminieri boydi* (a subspecies of Audubon's Shearwater endemic to Cabo Verde) taken briefly from its burrow by a research and monitoring team. © Tim Dodman.

Thus, non-invasive methods of monitoring are advisable or monitoring small sample plots following strict precautions to minimise disturbance. Camera traps have proved to be effective at recording nest-level activity and breeding success, with cameras placed at burrow entrances, though camera type and positioning can influence effectiveness (Bird *et al.* 2021). Camera traps and videocams have been used in Cabo Verde to observe and monitor activity at seabird burrows; livecam video recordings of Cape Verde Petrels *Pterodroma feae* are even available to view online (https://avesmarinhasdecaboverde.info/livecam/). Drones are being used commonly now in wildlife research, and can also be useful in prospecting areas for burrow colonies, for instance, recording through photographs the extent of a colony. Images can be used to define the extent of colonies or to classify habitat into likely areas for later prospection by on-the-ground observers.

Burrowing species can be estimated by assessing the density of burrows and the occupancy of those burrows by breeding birds, e.g., using burrow scopes or playback to solicit bird calls from occupants. The number of nesting pairs in a colony may be estimated by first working out an average density of burrows per unit area (m²), then multiplying this figure by the total area of the colony (in m²).

Census modalities

The census of a colony can be done by different means depending on a range of factors, such as the species concerned, the configuration of the breeding site or island, the size of the colony, and the human resources available (Haynes-Sutton *et al.* 2014; Veen *et al.* 2006; Walsh *et al.* 1995).

Exhaustive census of ground-nesting seabirds

For censusing colonies of ground-nesting seabirds, various methods are available, and the preferred ones are always those that are non-invasive and cause minimal disturbance. With equipment such as drones and handheld GPS becoming more affordable, there is high potential for future non-invasive monitoring of seabirds. However, if specific detailed information needs to be collected by directly prospecting a colony, this may be possible for some species, notably terns and gulls, providing it is not during too sensitive a stage in breeding. Survey methods include flush-counts, transect counts and counts from vantage points and drones. Flush-counts are when adult birds are flushed from their nests during late incubation and counted rapidly.

In transect counts a small colony can be walked by one or more people, but larger colonies require a large and experienced team, who must work quickly and efficiently to minimise time spent in the colony (Figure 67). All nests found and considered active should be counted, noting also the content of each nest (empty or number of eggs and chicks). Data on nest content are useful for long-term studies, to highlight developments related to climate change and to consider variations in prey resources. Observers should advance head on, with each counter prospecting a strip of variable width according to the topography, the vegetation, and the density of the nests (Veen *et al.* 2006). If necessary, stakes or ropes can be used to mark the boundaries of transects. Human resources mobilized are adapted to the size of the colony to minimize prospecting time as much as possible, and therefore the disturbance of birds.

It is equally important to define (or estimate) the area surveyed, so that future counts can be conducted in the same area, and that the surface area of the zone can be localised to assess the growth of the colony area through time. This can be done with GPS points around the edges of the colonies, and plotted in a Geographic Information System. Likewise, the location of transects can be defined using handheld GPS, and plotted to ensure that future counts are undertaken in similar or overlapping areas.

Figure 67: Conducting a census in a tern colony in Senegal. © Hanneke Dallmeijer-VEDA.

It is preferable to conduct a census of ground-nesting seabirds by distance counting if there are one or more favourable observation or vantage points, preferably located high up to have a good overview of the colony. If several counts are made from different observation points, visual cues (topography, vegetation, etc.) must be found to identify separate sub-colonies or portions of the colony and thus avoid double counting. However, vantage points are not always available, especially at the low-lying sandy islets of West Africa. Some colonies may also be surveyed by boat, if access by land is not feasible. It is important to take note of the location of vantage points, so that future surveys can be taken from the same point(s) to ensure the repeatability of the surveys.

A newer method is using a drone to fly over the colony and take aerial photos which are then analysed to locate birds in an incubating position on nests (Chabot *et al.* 2015). This method reduces disturbance, provided that the

overflight height is sufficient, but there must necessarily be a calibration step that allows the results obtained from sample areas to be compared with the conventional method of prospecting on foot and through photos. This technique seems to be the most effective and efficient (Hodgson *et al.* 2018, Figure 68), although it can entail some training for the drone pilots. In some areas, permits are required to fly drones.

Figure 68: Royal Tern *Thalasseus maximus* colony in the Saloum Delta National Park in Senegal. This image was taken using a drone, which can be a useful tool to census seabird colonies whilst minimising disturbance. © Hanneke Dallmeijer-VEDA.

Sampled census of ground-nesting seabirds

If the colony is large, as in the case of several Royal Tern *Thalasseus maximus* colonies in West Africa, with sometimes several thousand pairs, a sampling method may be used by making counts of sample plots of variable surface (circles, quadrats, strip transects) then by extrapolating the results to obtain an overall estimation (Hughes *et al.* 2017; Valle *et al.* 2016; Wilkinson *et al.* 2012). Care always needs to be taken when extrapolating results, especially when distribution of birds is uneven. Sample plots are distributed randomly in diverse types of habitats or in sectors of different topography; this reduces bias. Results may be used to calculate densities for different areas and the average density of nests, which can be used with the total surface of the colony to obtain an overall estimation of the number of birds breeding (Haynes-Sutton *et al.* 2014). Again, defining the areas surveyed using GPS on the ground to map the areas sampled is useful to ensure the same areas are sampled in future counts.

Another sampling method is based on 'distance sampling', which consists of traversing the colony along linear transects, by listing the distance between the line in question and the nests detected on either side of this line. Data is then analysed with a specific software. The results obtained make it possible to calculate an average density of nests, which can be related to the total area of the colony to obtain an overall estimation of the number breeding (Barbraud *et al.* 2014; Buckland *et al.* 2015).

Census of ground-nesting seabirds in flight

An alternative but more approximate method can be used for terns whose colonies are difficult to access or hardly visible at distance. This involves counting the number of birds of each species present when in flight. This can be done by waiting for birds to fly due to predators, disturbance or another behavioural response. Alternatively, it is possible to encourage or trigger the colony to fly (flush-counts), although great care should be taken to minimise disturbance time, and to avoid this approach during extreme weather, especially high temperature or rain. Afterwards, a correction factor is applied to estimate the number of breeding pairs (Cadiou *et al.* 2009; Walsh *et al.* 1995). For terns, the correction factor conventionally used is 1.5 individuals present for 1 nest, and the estimated number of nests is therefore obtained by dividing the number of individuals in flight by this factor of 1.5.

Census of cliff-nesting seabirds

For seabirds that nest on cliffs, safe access clearly presents an issue, whether by counting from land (high cliffs) or from sea (potential for rough weather). Sample sections may be counted by land from safe vantage points each season to monitor the colony and estimate trends. However, it is rare to find a suitable access point or combination of access points for counting the whole colony. Photos and mapping or GPS coordinates can be used to identify the colony sample plots.

The use of drones is also useful for censusing cliff-nesting birds, again taking care to minimise disturbance. Obtaining photos of cliff faces not visible from any vantage point with a drone offers can be very beneficial. Drone use has been trialled at the cliff-nesting seabird colony at Baía do Inferno, Santiago, Cabo Verde. Loureiro *et al.* (2021) used drone surveys to study booby population size and phenology at this site, generating photographic records from the cliff face, impossible to achieve by other methods (Figure 69).

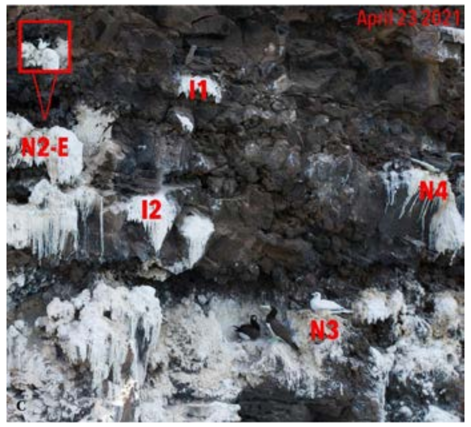


Figure 69: Photograph from April 2021 showing cliff-nesting Brown Booby *Sula leucogaster* and Red-footed Booby *Sula sula* (Loureiro *et al.* 2021). The codes refer to different individual birds and nests of Red-footed Booby; I1 and I2 are immature birds, N2-E shows an egg on a nest (with insert of an adult photographed earlier), and N3 and N4 show adults on nests. © Nuno Loureiro.

Monitoring breeding success or productivity

The methods of monitoring productivity, i.e., the average number of young fledging per breeding pair, vary according to the biology of the species and the topography of the colonies (e.g., on the ground, on cliffs, in burrows), and associated observation conditions (Cadiou *et al.* 2009; Veen *et al.* 2006; Walsh *et al.* 1995). The chicks of many seabirds remain strongly associated with their nest until they fledge. However, in some species, chicks leave their nest to regroup in nurseries or 'crèches, which may be overseen, sometimes alternately, by breeding adults. Other chicks, such as terns, may also leave their nest, but remain in the area.

Monitoring productivity can be done individually nest-by-nest or through overall monitoring of the whole colony or sub-colony. In some ground-nesting seabirds, an enclosure can be set up around a sample of nests to prevent chicks escaping and to enable fledging success to be monitored; this should only be done by professional researchers. In the first case, results show that each nest or breeding pair has produced a certain number of young fledging or has failed to reproduce. In the second case, results show that a group of a certain number of nests produced a certain number of young fledging. Nest by nest monitoring involves having a precise map of the location of the nests, associated or not with a distinct mark positioned in the colony (for example a numbered stake). Monitoring productivity of burrow-nesting seabirds usually involves reaching into sampled burrows; for long or deep burrows a tool, such as a stick, may be needed. For cliff-nesting birds, visual comparisons (photos may be used) are usually made of the same nests early, during and late in the breeding season.

Monitoring productivity requires repeated visits during the breeding season, first to obtain an estimation of the number of breeding pairs, and then an estimation of the number of young fledging. The estimation of productivity requires that observers learn to identify different age classes of chicks, and can tell when young birds have reached a sufficient age to be able to fly. In a simplified way, in the absence of detailed criteria to distinguish specific age classes, it is a matter of being able to distinguish small chicks (all in down), medium-sized chicks (feathered), large chicks (well feathered) and young flying birds (able to fly or flying). Then productivity is calculated as follows:

$$\text{minimum productivity} = \frac{\text{minimum number of counted young flying}}{\text{maximum number of counted nesting pairs}}$$

$$\text{maximum productivity} = \frac{\text{maximum number of counted young flying}}{\text{minimum number of counted nesting pairs}}$$

Estimating productivity can be more difficult to carry out in species with an extended laying period, which results in an extended fledging period, increasing the difficulty in counting young birds considered able to fly.

In individual nest-by-nest monitoring, it is also possible to obtain results on various parameters such as the hatching rate, i.e., the percentage of eggs laid that have hatched, or the rate of fledging, i.e., the percentage of young fledging relative to the number of chicks hatched. Another result is the success rate (or conversely the failure rate), i.e., percentage of pairs (nests) that have successfully raised at least one young to flight. Massive reproductive failures in seabirds, with 100% or almost 100% failure, are often linked to cases of heavy predation (on eggs or chicks), food shortage, human disturbance, or a combination of these factors.

5C. STUDY OF SEABIRD DIET

Studies of seabird diet can provide valuable information to understand trophic interactions within marine food webs, as well as for the assessment of ocean resources. Trophic ecology, the study of feeding relationships within an ecosystem, is an important part of the ecological niche of populations. Seabirds must cope with unpredictable and often patchily distributed marine resources at sea. Ceia *et al.* (2022) provide an updated synthesis to guide the application of modern approaches, including the stable isotope method, lipids as trophic markers and DNA metabarcoding, discussing the pros and cons of each method, and providing a case study focused on storm-petrels. This review summarizes recent progress, taking into consideration conventional diet analyses.

The methods of analysing the diet of seabirds vary according to the food ecology of the species studied, such as types of prey consumed and feeding methods of chicks (Barrett *et al.* 2007; Karnovsky *et al.* 2012). The different methods are based on the direct identification of prey or on the identification of trophic biomarkers.

The oldest method of analysis consists of collecting stomach contents, from adults or chicks, obtained by spontaneous regurgitation of birds during handling, by stomach washing, and by stomach sampling from dead birds. The harvesting of regurgitated pellets from breeding colonies or resting areas is also a method extensively used in species that spit out undigested remains of consumed food, including cormorants, gulls and terns (Correia *et al.* 2018; Dyer *et al.* 2019; Robinson *et al.* 2019; Veen *et al.* 2019; Veen *et al.* 2018; Veen *et al.* 2003). Similarly, it is possible to collect droppings around nests because they also contain undigested remains, as in terns (Courtens *et al.* 2017; Veen *et al.* 2019; Veen *et al.* 2018; Veen *et al.* 2003). In West Africa, Slender-billed Gulls Larus genei, Royal Terns *Thalassa maximus* and Caspian Terns *Hydroprogne caspia* defecate and deposit regurgitated pellets around the nest (Veen & Mullié 2015), which can be collected for analyses. Samples may then be sorted out and later examined using a binocular microscope to identify whole preys or to search for hard undigested elements and identify them (e.g., otoliths, endoskeleton elements of fish or crustacean exoskeletons, cephalopod beaks, Figure 70). In the context of this type of analysis, it is important to gradually build up a reference collection from the elements collected.

For seabirds that carry their entire prey across the bill, such as terns, the study of the diet can also be done either by direct observation of the prey caught when the birds return to the colonies, or by taking snapshot photos of the prey for later analysis (Gaglio *et al.* 2017; Larson & Craig 2006). Observers can also record the size and frequency of fish brought to chicks and also measure chick growth (Figure 71).

Stable isotope analysis is the most common biochemical method for studying seabird diet (Barrett *et al.* 2007; Karnovsky *et al.* 2012). Analyses can be done on blood samples, which provide information on current nutrition (during the previous month), or on feather samples, which provide indications on nutrition when the feathers were growing during the moult, either at breeding or non-breeding areas (Gatto & Yorio 2016; Morera-Pujol *et al.* 2018). Most often, analyses are based on the isotopic ratios of carbon (13C/12C) and nitrogen (15N/14N). The isotopic ratio of carbon does not vary much from one trophic level to another but varies according to the origin of the organisms (terrestrial, coastal, pelagic) and therefore makes it possible to characterize the feeding zones exploited by the species studied. The isotopic ratio of nitrogen increases with the trophic level.

The most recent methods for studying seabird diet use the analysis of fatty acids or DNA research in stomach contents, in regurgitated pellets or in droppings (Alonso *et al.* 2014; Bowser *et al.* 2013; Iverson *et al.* 2007; Williams & Buck 2010). For interpreting the results, it is necessary to have a database on fatty acids or on the DNA of different prey potentially exploited by the species of seabird studied.

The combination of several investigation methods improves the quality of the results, since each method has its own advantages and disadvantages (Alonso *et al.* 2014; Gatto & Yorio, 2016; King *et al.* 2017; Oehm *et al.* 2017; Weiser & Powell, 2011).

Figure 70: Training Senegalese scientists in faeces analysis and otolith identification at CRODT, Dakar, Senegal. © Hanneke Dallmeijer-VEDA.

Figure 71: Royal Tern *Thalasseus maximus* feeding its chick. The size of fish and frequency of feeding can be measured by such observations and photography. Saloum Delta National Park, Senegal. © Jan Veen-VEDA.

5D. SAFETY OF BIRDS AND OBSERVERS

Safety of seabirds

The presence of observers within a colony of seabirds involves risks for the species studied. The first risk is the crushing of eggs or chicks, especially when the nests are remarkably close to each other; some tern colonies, for instance, have less than half a metre between nests. Vegetation may also mask the presence of nests during movement through the colony (as in gull colonies for instance). The second risk is predation, interspecific or even intraspecific. The presence of observers may cause adults to leave the nests, eggs or small chicks uncovered and unattended, and therefore render them easily accessible to predators (gulls in particular). In the absence of predators, this departure of adults from the nest can expose eggs and chicks to cooling or, conversely, to sunstroke. Small cormorant chicks, born naked, are particularly vulnerable to thermal environment variations. It is thus important to utilise the most suitable time slot of the day for monitoring, and to secure suitable human resources to minimize the disturbance time of the colony (Haynes-Sutton *et al.* 2014; Veen *et al.* 2006).

The precipitated flight of an incubating adult at the approach of the observer can lead to the ejection of an egg or a chick from the nest. An observer's approach can also involve a risk of falling, or of premature departure on the water for more mobile chicks, which may be doomed to an early death, especially on steep islets or in colonies without shelter of vegetation or rock where chicks can hide. Disturbance may also cause mobile chicks to move away from their parents' territory and be violently attacked, or even killed, by neighbouring pairs (for example, gulls or certain species of tern (Brown & Morris, 1995; Veen *et al.* 2006). For burrow-nesting seabirds, the risk during a researcher's movement in the colony is to crush the burrows while walking, especially if the substrate is soft (Kennedy & Pachlatko 2012).

Research or monitoring within a seabird colony should therefore only be carried out when it is important with clear goals for the work. It is essential for observers to take great care when advancing on foot within a seabird colony and to be particularly attentive to what is happening around them to minimize the risk of mortality of eggs and chicks. Observers must consequently be informed beforehand by the census coordinator to do their work knowing the risks of collateral damage that their intrusion into the colony generates on the species studied, and by doing everything to reduce them but without ever ignoring them.

Figure 72: Observers conduct a rapid survey within a colony of terns in Guinea-Bissau, with disturbance time restricted to a few minutes. © Tim Dodman.

Observer safety

Given the often inhospitable or remote location of seabird colonies, the safety of observers should be thoroughly assessed and measures taken before, during and after visits to colonies to minimise risk to observers. Risks include falling during progression through a colony in a perilous environment (e.g., cliffs, steep islets or roofs for urban gull colonies), falling on slippery substrates (wet soil, areas covered with droppings, landing and boarding manoeuvres of a boat on an islet and vice versa). There can even be risks of attack by breeding birds acting defensively or other animals, or the potential for conflicting situations with people, such as those carrying out illegal activities at a protected site. Observers should also be made aware of the risks of being bitten by ticks endemic to seabirds, which can be vectors of pathogens (Dietrich *et al.* 2011).

Observers must therefore wear appropriate clothing and personal protection equipment according to the type of colony (suitable shoes, self-inflating lifejacket, helmet, harness, etc.). They should also be trained in first aid (and have access to a suitable first aid kit), and be given other specific training as required, including nautical training, harness use and safe use of climbing ropes. A means of reliable communication is also important, with procedures in place should communication channels fail or replies go unanswered. Emergency locator beacons are recommended where services to pick up and respond to distress calls exist.

5E. BEWARE OF BIAS

Sampling and reducing bias are important aspects of monitoring. Sampling involves taking samples when it not possible to count an entire community of birds (such as a seabird colony), and extrapolate the results to produce estimations of the size and diversity of species present. However, sampling practices can be biased in many ways. For example, samples taken at different times of day cannot be reliably compared, as differences may only be because birds were easier to see and hear at one time of day compared to another. Such bias can thus affect the results of a bird census exercise. Understanding the causes of bias and correctly managing them is the most important part of planning a study (Bibby *et al.* 1998). Not accounting for it can discredit the value and credibility of a study and follow-up work. Recommended ways to reduce bias include:

- Ensure that key areas of a site or key habitats are sampled,
- Standardise studies according to observers, the time of day, weather condition, tide state, moon phase, area covered, and according to the time spent counting,
- Use standardized methods,
- Ensuring that there are no major differences in the skills of observers working on the same project.

Bibby *et al.* (1998) offer a detailed discussion of bias and how to reduce it.

Sources of bias when counting seabirds

During counting of above-ground colonies, whether to determine nesting population or productivity, three main sources of bias can be identified:

- Counting date: This should coincide with the optimal period of the breeding season, when most birds are involved in reproduction or when most young are close to fledging. A badly chosen date leads to an underestimate of results.
- The capacity to detect nests or young birds: The ability to detect nests or young birds depends on the topography of the colony, plant cover, breeding biology of the species (ground nesting vs burrowing species) and experience of the observer, and is also a potential source of underestimating results. In the case of distance observations, several successive counts should be carried out, by visually scanning the colony with binoculars or using a telescope, and recording the maximum figure obtained.
- Burrowing seabirds: There are biases inherent in sampling burrowing birds due to the difficulty of identifying active burrows, and the fact that burrows can be hidden under vegetation. In addition, discerning where the edge of a colony is can be more of an art than a science.
- Determining the status of birds, whether breeders or young flying, can be a source of underestimation or overestimation of results.

It is important to set criteria for identifying the census unit used in the field, which could include an elaborate nest, an active nest, or a bird in apparent incubation position. Identifying eggs and age classes of chicks is also part of the skill set to acquire. Furthermore, it is important to take time to observe a colony from a distance before entering it and triggering birds to fly away. Some surveys may be achievable only be distance counts, which also enable observers to detect the possible presence of a few pairs of one species among the many pairs of another species (e.g., in mixed gull and tern colonies). Observation of birds landing back on their nests, or listening to a difference in calls, can also help to validate the presence of these few pairs of another species.

As far as possible, tasking a team entirely made up of inexperienced observers to count must be avoided. An inexperienced observer can participate in counting a monospecific colony or a mixed colony with very distinct species, but adequate supervision by experienced observers should be provided for more complex surveys.

5F RINGING AND MARKING OF SEABIRDS

Ringing consists of placing a unique individual ring on a bird so that it can be identified later. It is usually a metal ring placed on a bird's leg, which is uniquely numbered, carrying also the name of the ringing centre that issued the ring. The goals of ringing are in particular to obtain data on migration, survivorship, distribution (including natal and breeding dispersal), age at first reproduction, longevity and philopatry (Breton *et al.* 2014; Coulson & Nève de Mévergnies 1992; Greenwood & Harvey 1982; Harris & Tasker 1999; Naves *et al.* 2006; Veen *et al.* 2006). Natal dispersal corresponds to the movement of an individual between its place of birth and place of first reproduction. Philopatry refers to the return of a young bird to its birth colony to reproduce, which is frequent in many seabirds (Coulson 2016). Breeding dispersal corresponds to changes in the breeding location of adults, which occur in some seabirds, especially after a repeated or massive breeding failure, which can be at the scale of the whole colony (Fernández-Chacón *et al.* 2013).

The mark and recapture method requires a subsequent observation effort to recapture individuals or to identify them from a distance (Kendall *et al.* 2009). Data can also be obtained through the recovery of rings, for instance from accidental capture in fishing gear or oil spills. The information thus collected contributes to the assessment of the demographic impact on seabird populations by enabling the identification of the geographic origin and age of the birds killed (Belda & Sanchez 2001; Cadiou *et al.* 2004; Lewison *et al.* 2012).

Other marks can be used in addition, to facilitate distance identification by telescope, binoculars or camera. Coloured plastic rings are commonly used for marking seabirds, which can be placed on one or both legs. Combinations of coloured rings can constitute a unique colour code. Alternatively, rings can carry an engraved alphanumeric code that is readable from a distance, without any need to disturb the bird. Coloured plastic wing marks with an engraved code can also be used for soaring seabirds, such as frigates, when the wing marks can be seen from below.

Birds can be captured and ringed as chicks, which provides a sample of birds of known age and geographic origin. Birds ringed as adults will usually be of unknown age and geographic origin. The capture of birds in a colony employs different methods depending on the biology of the species and topography of the colony; it may sometimes be done using vertical nets stretched over the colony.

Figure 73: A young White-faced Storm-petrel *Pelagodroma marina* is caught for ringing and measuring on Ilhéu de Cima, Cabo Verde. © Tim Dodman.

5G RECORDING DEVICES FOR SEABIRDS

External attachment or implantation of electronic devices on / in wild animals - to determine their location, monitor their biology, measure the physical characteristics of their environment, or simply identify them - are relatively recent approaches that are now well embedded in wildlife conservation research methodologies.

Biotelemetry: This concerns the transmission of information, in distance and in real time, from a living organism, widely used for the spatial monitoring of wildlife by radio telemetry or by satellite link. Such monitoring only requires a single capture to fit a bird with a tag, from which data are transmitted to receivers in near real time. This differs from bio-logging, which requires recapture of the animal over a period to retrieve the device and access data. Bio-recorders or bio-loggers are electronic devices recording a parameter as a function of time. They were developed in the mid-1960s but only became common tools for researchers in the mid-1990s (Ropert-Coudert & Wilson 2005), when memory cards became available. More recently, the summary data recorded in bio-recorders' memory may sometimes be transmitted to fixed or mobile reception stations, merging the pros and cons of the two approaches of bio-logging and biotelemetry.

Being able to record information from a marked animal without locating it in the wild via active (satellite) or passive (alteration of radar signals) systems has opened new ways of classified research in ultrasound, infrared and radio telemetry. Biotelemetry monitoring applies particularly well to birds that are highly sensitive to capture, such as cormorants and to species suffering from high mortalities at sea. It is also useful for birds that do not return frequently, if at all, to the capture site, such as juvenile seabirds, which tend to disperse over long distances and durations after fledging. Although biotelemetric approaches are essential for such cases, they are more expensive than bio-logging approaches.

Bio-logging: The underlying principle of recapturing birds to retrieve data means that the parameters are almost measured without interruption, regardless of the subject's location. The idea of equipping animals with sensors to collect lifestyle data was born in the 1960s. In 1964, pioneering oceanographer Gerald Kooyman fitted a Weddell Seal Leptonychotes weddellii with a recording device to measure the depth, duration and trajectory of its plunge diving. Bio-logging is at a crossroads between various sciences such as behavioural ecology and physiology. Technological advances in recent years, particularly in mobile telephony, have opened bio-logging to a vast horizon of possibilities.

The shape, weight and size of a bio-logger depend on:

I) the specifics of the seabird being studied (e.g., bird that plunge-dives or swims) and its size (ranging from a few grams for storm-petrels to several kilogrammes for gannets);

II) the research objectives and therefore the type of parameters concerned (are these parameters internal such as heart rate, or external such as sea water temperature?);

III) the frequency with which the parameters must be recorded (e.g. several hundred points per second or one point per day) and for how long (from a few hours to a full year).

Based on these parameters, research goals and practical issues, the memory and the battery size and therefore the size and weight of the device can be determined. According to the models deployed, bio-loggers make it possible to measure an entire range of parameters, such as the animal's biology, its movements, the number of wing beats and its internal body temperature. New devices even allow the sounds produced by the animal or its environment to be filmed or recorded.

A distinctive feature of bio-logging is the ability to provide information on the characteristics of a seabird's immediate environment. Bio-loggers at the forefront of technology and animals that carry them should be seen more as environmental sensors expanded in the environment, and as oceanographic, and even atmospheric aids for scientists. It is possible, for instance, to measure salinity, oxygen content, intensity of bioluminescence, atmospheric and marine thermals, and a complete set of parameters which then feed international databases and strengthen / improve meteorological models and global climatology.

Figure 74: Slender-billed Gull *Larus genei* equipped with a bio-logger in a colony on Ile aux Oiseaux in the Saloum Delta National Park, Senegal. Birds were equipped for monitoring their movements between colonies and feeding areas with a view to defining marine IBAs. ©Hanneke Dallmeijer-VEDA.

Operating principles: From the size of an eraser down to a few millimetres for the smallest, these recorders are encapsulated in silicone or corrosion-free titanium to ensure their watertightness and to withstand the high pressures and low temperatures in deep waters. They integrate several components that enable the capture and storage of data, through digital conversion and compression, whilst saving data on a memory device capable of preserving them without a power supply or transmitting data. They also have a battery and an internal clock providing the essential hourly reference to the nearest thousandth of a second. A computer interface allows the recorded data to be transferred to a computer once the device has been recovered to analyse its content or enables connection to satellite collection systems that centralize data relayed by satellites for biotelemetric monitoring.

Example of use for conservation: Recent signs of progress in miniaturization and in the recording capacities of bio-loggers have made it possible to develop a tool particularly suitable for monitoring over long distances and extended periods. Ultra-miniaturized geolocators or GLS (Global Location Sensors) weigh only a few grams and can record the intensity of ambient light, whilst some can even record external pressure and temperature. Through their use it is possible to determine the hours of sunrise and sunset and light intensity to deduce the longitude and latitude at which a bird is located, providing information on seasonal movements of migratory birds. The measures of water temperatures made by the loggers also enable improvement of the localization's accuracy. However, this system does not work when day and night lengths are the same. Using bio-loggers, researchers followed the movements of Adélie Penguins *Pygoscelis adeliae* at a colony in Eastern Antarctica that suffered from two episodes of massive chick mortality (Ropert-Coudert *et al.* 2018), with their results contributing to conservation planning and relations to an MPA.

In West Africa, bio-loggers have been applied to several seabird species, including Slender-billed Gull *Larus genei* in Senegal (Figure 75), and a range of seabirds breeding in Cabo Verde. Results generating valuable records of bird movements, which are helping, among other results, to identify key foraging areas at sea. Paiva *et al.* (2015) used GPS-loggers and stable isotope analysis to study spatial and trophic ecology of the Cape Verde Shearwater *Calonectris edwardsii* during both the incubation and the chick-rearing periods. They found inter-annual consistency in their spatial, foraging and trophic ecology, but a strong alteration in foraging strategies of adult breeders, with birds mostly targeted a discrete and highly productive region off West Africa during incubation, but remaining close to Cabo Verde during chick-rearing. Cerveira *et al.* (2020) further found that Cape Verde Shearwaters engaged in longer trips to West Africa during years of poor oceanographic conditions around the colony, whilst they foraged more on their colony surroundings during years of good oceanographic conditions.

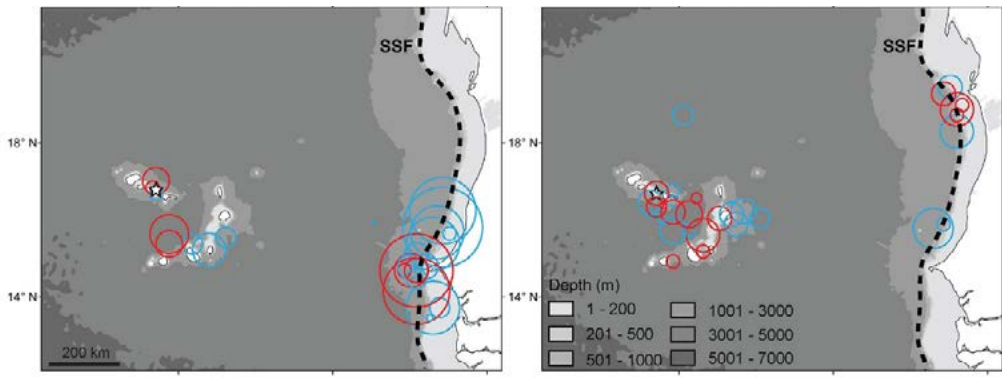


Figure 75: Home range and core foraging areas of Cape Verde Shearwaters *Calonectris edwardsii* from Raso Islet (white star) in 2013 (blue) and 2014 (red); 1: Cap Blanc; 2: Southernmost area of the Parc National du Banc D'Arguin; 3: Cap-Vert, Dakar, Senegal (Paiva *et al.* 2015).

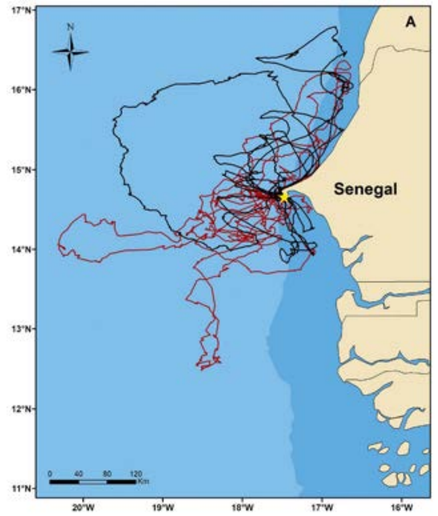
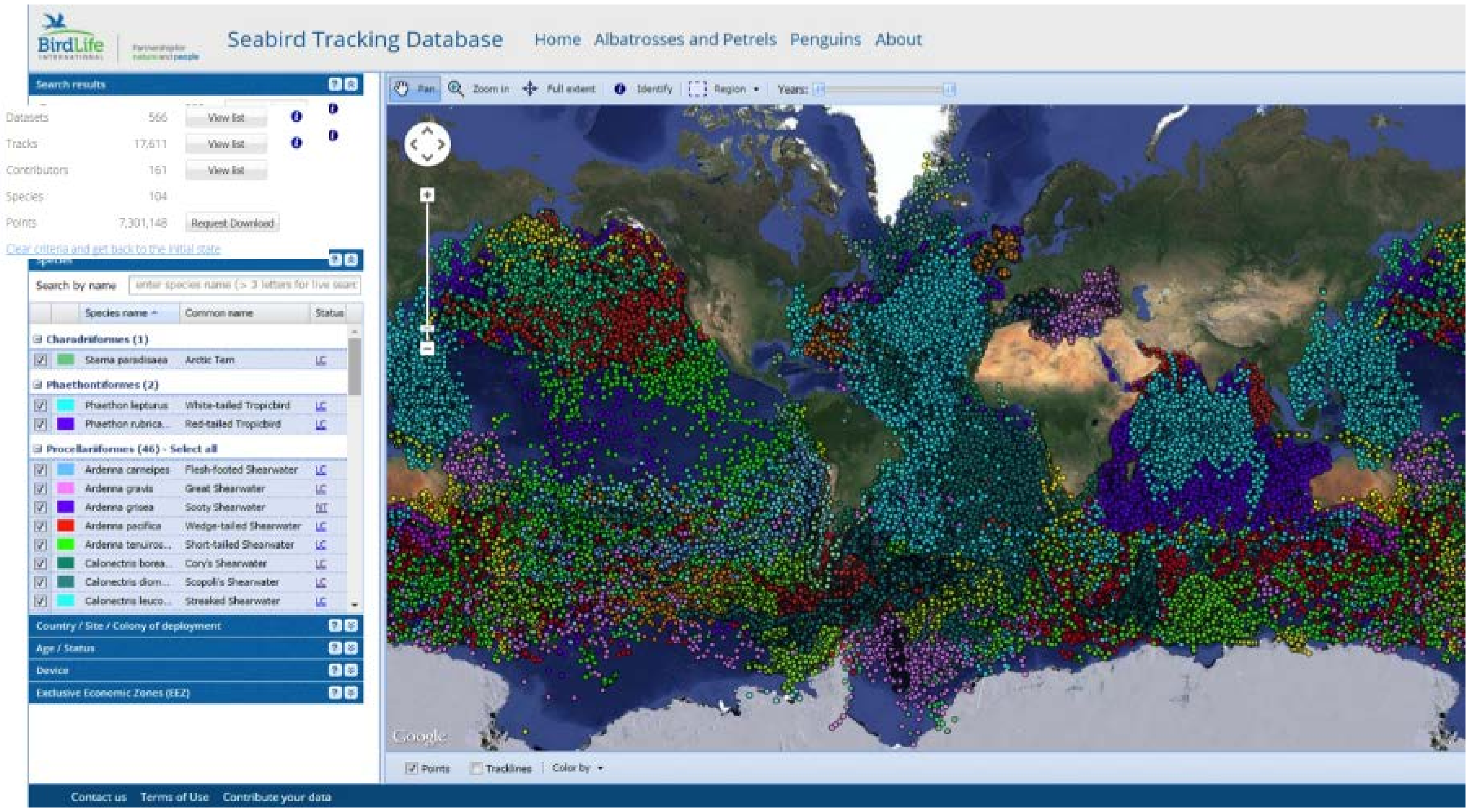


Figure 76: Red-billed Tropicbird *Phaeton aethereus* foraging trips during incubation and brooding periods in Iles de la Madeleine breeding colony (yellow star), Senegal; red lines indicate incubating trips, black lines indicate brooding trips, dark blue shows the isobath at 200m (Diop *et al.* 2018).

In Senegal, Diop *et al.* (2018) found that Red-billed Tropicbirds *Phaeton aethereus* ranged far beyond the extension of the protected area around their colony at Iles de la Madelaine, indicating that current protected areas are insufficient for this population. The tropicbirds mainly foraged at and beyond the continental shelf break (Figure 76), often exploiting the same foraging grounds as Cape Verde Shearwater *Calonectris edwardsii* during their incubation period, as demonstrated by Paiva *et al.* (2015, Figure 75).

BirdLife Seabird Tracking Database

The BirdLife Seabird Tracking Database is a data repository to enable collaboration between scientists and policy makers to progress powerful scientific approaches to conservation and sustainable management. Currently contributions by 273 scientists and their 27 million datapoints are managed through the database (Figure 77); each dot on the map represents a single location of a GPS tracking device, satellite logger or light intensity logger.



5H EXPLOITATION AND VALUATION OF MONITORING RESULTS

Once monitoring has been carried out in the field and data entered on a computer, the compilation, verification and grooming of raw data is required before starting analyses and diffusion. Tools used to record data in the field should be retained; there are now mobile tools for field use from which georeferenced data can be downloaded (Tornos *et al.* 2014). Annual and other reports should be archived in a standardized manner to enable transmission within the framework of other regional or national reports (Birolleau *et al.* 2019; Debaive & Touzé 2013), and data associated with a GIS to facilitate cartographic exploitation.

Reports obtained at the local or site level can contribute to site management and to wider analyses. Results of the numerical evolution of populations, the success of reproduction or other parameters can be used as indicators of the state of health of seabird populations, or of the quality of the marine environment (Veen *et al.* 2003; Velarde *et al.* 2019). Some seabirds (and other marine predators) can be considered as 'sentinel species' as they react quickly to changing conditions of the marine environment (Hazen *et al.* 2019).

5I COLLECTING STATISTICS FOR CONSERVATION

Statistics is the science of collecting, analysing, presenting, and interpreting data. Statistical tests are used to identify the strength and significance of different factors on a biological parameter. There are several statistical tests available, and researchers need to determine which test is appropriate for their data. The goal is not to be acquainted with all the tests that exist, but to know which test(s) is (are) the right one(s) to answer questions according to the data collected. A decision tree of statistical tests can be helpful to select the right test. There are several decision trees or interactive applications available online to guide users, including at https://biostatgv.sentiweb.fr (in French), where it is also possible to make online tests. The Handbook of Biological Statistics is a useful resource (in English), available freely through the link provided (McDonald 2014).

After determining the desired test, it will invariably be carried out using statistical software. The R software (R Project for Statistical Computing: https://www.r-project.org) is a free resource that is widely used by scientists. R is a free and cross-platform software that compiles a wide variety of tests and modelling. Statisticians and scientists continually enrich the extension software ('packages') that they have developed for their needs. Search for the test in the R online guide, in the R book (Crawley 2012) or by searching online with the test keyword to make the test correctly. It is always recommended to discuss methods and options with a statistician or a colleague.

Toolbox: R, your new friend for statistics

R is a programming language and free software for statistics and data science supported by the R Foundation for Statistical Computing. R is part of the GNU 3 list of packages and is written in C language Fortran and R.

GNU R is a free software available under GNU/Linux4, FreeBSD5, NetBSD6, OpenBSD7, Mac OS X8 and Windows9. The R language is widely used by statisticians, data miners, data scientists and used for the development of statistical software and data analysis.

The latest version can be downloaded here: https://www.r-project.org

5J GEOGRAPHIC INFORMATION SYSTEMS FOR CONSERVATION

A Geographic Information System (GIS) is a system designed to capture, store, manipulate, analyse, manage, and present all types of spatial or geographical data. In conservation, geographic information is frequent: distribution areas, distance from disturbances, food trips, etc. To process this type of data, you can again use the R software, as well as the free and cross-platform software, QGIS. This programme will map colonies, habitats, tracked animals, trips and other GPS and geographic data. There is even an application (QField) made to use a recent telephone as a GPS that collects data with attributes, for example, to record the position of a stranded bird + the identity of the observer + the state of the bird + all pre-recorded information (=attributes) in a QGIS project.

Toolbox: QGIS and QField

QGIS is a GIS software (Geographic Information System) free to use cross-platform published under the GPL license https://www.qgis.org. It manages raster graphics image formats and vectors, as well as databases.

The software is recommended by various states, used in almost all the scientific fields. In the field, it is possible to use a free QGIS interface: QField. QField is an application for geo-locatable phones and tablets (Android) https://qfield.org.

References

Ackerman, J. T., Eagles-Smith, C. A., Herzog, M. P., & Hartman, C. A. (2016). Maternal transfer of contaminants in birds: mercury and selenium concentrations in parents and their eggs. Environmental pollution, 210, 145-154.

Aebischer, N., & Wanless, S. (1992). Relationships between colony size, adult non-breeding and environmental conditions for Shags *Phalacrocorax aristotelis* on the Isle of May, Scotland. Bird Study, 39(1), 43-52.

Agnew, D. J., Pearce, J., Pramod, G., Peatman, T., & Watson, R. (2009). Estimating the Worldwide Extent of Illegal Fishing. PLOS One, 4, 1932-6203.

Alonso, H., Granadeiro, J. P., Waap, S., Xavier, J., Symondson, W. O., Ramos, J. A., & Catry, P. (2014). An holistic ecological analysis of the diet of Cory's shearwaters using prey morphological characters and DNA barcoding. Molecular ecology, 23(15), 3719-3733.

Altenburg, W. & van de Kamp, J. (1991). Ornithological Importance of Coastal Wetlands in Guinea. ICBP study report no. 47 / WIWO report no. 35, Cambridge/Zeist.

Amélineau, F., Grémillet, D., Harding, A. M., Walkusz, W., Choquet, R., & Fort, J. (2019). Arctic climate change and pollution impact little auk foraging and fitness across a decade. Scientific reports, 9(1), 1014.

Assessment, M. E. (2005). Ecosystems and Human Well-being: Synthesis. Retrieved from Washington, DC:

Ballard, G., Toniolo, V., Ainley, D. G., Parkinson, C. L., Arrigo, K. R., & Trathan, P. N. (2010). Responding to climate change: Adélie penguins confront astronomical and ocean boundaries. Ecology, 91(7), 2056-2069.

Barbraud, C., Fortin, M., Charbonnier, Y., Delord, K., Gadennne, H., Thiebot, J.-B., & Gélinaud, G. (2014). A comparison of direct and distance sampling methods to estimate abundance of nesting gulls. Ardeola, 61(2), 367-378.

Barlow, C. & Dodman, T. (2015). African East Atlantic Flyway Guide - Photographic Fieldguide to Waterbirds and Seabirds of Africa's Western Coastline. Common Wadden Sea Secretariat, Wilhelmshaven, Germany; BirdLife International, Cambrudge, United Kingdon; Programme Rich Wadden Sea, Leeuwarden, The Netherlands.

Barrett, R. T., Camphuysen, K., Anker-Nilssen, T., Chardine, J. W., Furness, R. W., Garthe, S., . . . Veit, R. R. (2007). Diet studies of seabirds: a review and recommendations. ICES Journal of Marine Science, 64(9), 1675-1691.

Barros, Á., Álvarez, D., & Velando, A. (2014). Long-term reproductive impairment in a seabird after the Prestige oil spill. Biology letters, 10(4), 20131041.

Battisti, C., Staffieri, E., Poeta, G., Sorace, A., Luiselli, L., & Amori, G. (2019). Interactions between anthropogenic litter and birds: a global review with a 'black-list' of species. Marine pollution bulletin, 138, 93-114.

Bearhop, S., Waldron, S., Thompson, D., & Furness, R. (2000). Bioamplification of mercury in great skua *Catharacta skua* chicks: the influence of trophic status as determined by stable isotope signatures of blood and feathers. Marine pollution bulletin, 40(2), 181-185.

Beaune, D., Ghestemme, T. & Cranwell, S. 2017. Petrel Social Attraction on Gamblier Islands for colonies restoration (French Polynesia). Technical report. SPO Manu, Taravao, Tahiti FP. 26p.

Beddington, J. R., Kirkwood, G. P., Pauly, D., Watson, R., & Alder, J. (2005). Global trends in world fisheries: impacts on marine ecosystems and food security. Philosophical Transactions of the Royal Society B: Biological Sciences, 360(1453), 5-12. doi:doi:10.1098/rstb.2004.1574

Belda, E. J. & Sanchez, A. (2001). Seabird mortality on longline fisheries in the western Mediterranean: factors affecting bycatch and proposed mitigating measures. Biological Conservation, 98(3), 357-363.

Bibby, C. J., Burgess, N. D., Hill, D. A. & Mustoe, S. (2000). Bird census techniques: Elsevier.

Bibby, C. J., Martin, J. & Marsden, S. (1998). Expedition Field Techniques: Bird Surveys: The Expedition Advisory Centre.

Biosfera. (2019). FISHING: Sustainable from sea to plate. Retrieved from https://www.biosfera1.com/projects/cepf-project/.

Bird, J.P., Fuller, R.A., Pascoe, P.P. & Shaw, J.D.S. (2021). Using camera traps to determine occupancy and breeding in burrowing seabirds. *Remote Sensing in Ecology and Conservation* doi: 10.1002/rse2.235.

BirdLife International. (2004). State of the world's birds 2004: indicators for our changing world: Cambridge, UK: BirdLife International. Retrieved from http://www.birdlife.org

BirdLife International. (2013). State of the world's birds: indicators for our changing world: Cambridge, UK: BirdLife International. Retrieved from http://www.birdlife.org

BirdLife International. (2013). Collecte de fonds auprès des institutions pour les projets de conservation, Nairobi, Kenya: Secrétariat de Partenariat In ternational de BirdLife en Afrique. Retrieved from http://www.birdlife.org

BirdLife International. (2017). Many albatross species are in alarming slow decline. Retrieved from http://www.birdlife.org

BirdLife International. (2018). State of the world's birds: taking the pulse of the planet: Cambridge, UK: BirdLife International. Retrieved from http://www.birdlife.org

BirdLife International. (2019). IUCN Red List for Birds. Retrieved from http://www.birdlife.org.

BirdLife International. (2020). Datazone. http://datazone.birdlife.org/home.

BirdLife International. (2021). Atlas of ecological and biological sensitivity in coastal and offshore areas of West Africa, especially Mauritania, Senegal, Guinea-Bissau and Sierra Leone, with particular reference to the development of oil and gas in the region. BirdLife International: Cambridge U.K.

BirdLife International. (2022). State of the World's Birds 2022. Insights and solutions for the biodiversity crisis. Retrieved from http://www.birdlife.org.

BirdLife International. (2022b). Africa Marine Strategy 2023 - 2027. August 2022.

Birolleau, A., Boudet, C., Gamp, E., Gailhard-Rocher, I., Lefeuvre, C., Mahier, M., & Nelz-Moreau, S. (2019). Guide pour la gestion des données «milieu marin». De l'acquisition à la diffusion.: Agence française pour la biodiversité.

Boulinier, T., Danchin, E. Monnat J-Y., Doutrelant, C. & Cadiou, B. (1996). Timing of prospecting and the value of information in a colonial breeding bird. *Journal of Avian Biology*. 27: 252-256.

Borrow, N. & demey, R. (2014). Birds of Western Africa. Second edition. Bloomsbury Publishing, London.

Bowser, A. K., Diamond, A. W., & Addison, J. A. (2013). From puffins to plankton: a DNA-based analysis of a seabird food chain in the northern Gulf of Maine. PLoS One, 8(12), e83152.

Boyd, I. L., Kato, A., & Ropert-Coudert, Y. (2004). Bio-logging science: sensing beyond the boundaries.

Bregnballe, T., Meise, K., Packmor, F. (2023) Management guidelines - Mitigation and data collection strategies for avian influenza in bird colonies in the Wadden Sea. Common Wadden Sea Secretariat, Wilhelmshaven, Germany.

Breton, A. R., Nisbet, I. C., Mostello, C. S., & Hatch, J. J. (2014). Age-dependent breeding dispersal and adult survival within a metapopulation of Common Terns Sterna hirundo. Ibis, 156(3), 534-547.

Brown, K. M., & Morris, R. D. (1995). Investigator disturbance, chick movement, and aggressive behavior in Ring-billed Gulls. The Wilson Bulletin, 107, 140-152.

Buckland, S. T., Rexstad, E. A., Marques, T. A., & Oedekoven, C. S. (2015). Distance sampling: methods and applications: New York, NY, USA: Springer.

Bukola, D., Zaid, A., Olalekan, E. I., & Falilu, A. (2015). Consequences of anthropogenic activities on fish and the aquatic environment. Poultry, Fisheries & Wildlife Sciences, 3(2), 138.

Burger, J., & Gochfeld, M. (2001). Effects of chemicals and pollution on seabirds. In Schreiber, E. A., Burger J. (eds), Biology of Marine Birds (pp. 485-525): CRC Press.

Burger, J., & Gochfeld, M. (2004). Marine birds as sentinels of environmental pollution. EcoHealth, 1(3), 263-274.

Burger, J., Pokras, M., Chafel, R., & Gochfeld, M. (1994). Heavy metal concentrations in feathers of Common Loons (*Gavia immer*) in the northeastern United States and age differences in mercury levels. Environmental Monitoring and Assessment, 30(1), 1-7.

Burgess, N. M., & Meyer, M. W. (2008). Methylmercury exposure associated with reduced productivity in common loons. Ecotoxicology, 17(2), 83-91.

Burr, Z. M., Varpe, Ø., Anker-Nilssen, T., Erikstad, K. E., Descamps, S., Barrett, R. T., . . . Moe, B. (2016). Later at higher latitudes: large-scale variability in seabird breeding timing and synchronicity. Ecosphere, 7(5), e01283.

Cabrera-Cruz, S. A., Smolinsky, J. A., & Buler, J. J. (2018). Light pollution is greatest within migration passage areas for nocturnally-migrating birds around the world. Scientific reports, 8(1), 3261.

Cadiou, B., Barbraud, C., Camberlein, P., Debout, G., Deniau, A., Fortin, M., . . . Yésou, P. (2009). Méthodes de suivi des colonies d'oiseaux marins: dénombrement de l'effectif nicheur et suivi de la production en jeunes. Document de travail GISOM (non publié), 97 p.

Cadiou, B., & Fortin, M. (2015). Utilisation des macrodéchets comme matériaux de nids par les cormorans huppés en Bretagne, en Normandie et en Corse: proposition d'un indicateur «macrodéchets» pour la DCSMM. In (pp. 8 p.): Rapport Bretagne Vivante, Ifremer, Brest.

Cadiou, B., & Mahéo, H. (2016). Recueil méthodologique des suivis ornithologiques réalisés sur la Réserve Naturelle Nationale d'Iroise. In (pp. 47 p.): Rapport Bretagne Vivante, RNN Iroise, PNMI.

Cadiou, B., Riffaut, L., McCoy, K. D., Cabelguen, J., Fortin, M., Gélinaud, G., . . . Boulinier, T. (2004). Ecological impact of the "Erika" oil spill: Determination of the geographic origin of the affected common guillemots. Aquatic Living Resources, 17(3), 369-377.

Cadiou, B., & Vives, G. (2006). Concevoir un planning opérationnel pour optimiser un suivi ornithologique…. In (Vol. 16, pp. 16-17): Espaces Naturels.

Cam, E., Hines, J. E., Monnat, J.-Y., Nichols, J. D., & Danchin, E. (1998). Are adult nonbreeders prudent parents? The kittiwake model. Ecology, 79(8), 2917-2930.

Carey, M. (2011). Investigator disturbance reduces reproductive success in Short-tailed Shearwaters Puffinus tenuirostris. Ibis 153(2): 363-372. https://doi.org/10.1111/j.1474-919X.2011.01109.x.

Ceballos, G., Ehrlich, P. R., & Dirzo, R. (2017). Biological annihilation via the ongoing sixth mass extinction signaled by vertebrate population losses and declines. Proceedings of the national academy of sciences, 114(30), E6089-E6096.

Ceia, F., Xavier, J., Carreiro, A., Santos, I. & Cherel, Y. (2022). Conventional and Modern Approaches to Study Seabird Trophic Ecology and Diet. 10.1201/9781003047520-3.

Cerveira, L.R., Ramos, J.A., Rodrigues, I., Almeida, N., Araújo, P.M., dos Santos, I., Vieira, C., Pereira, J.M., Ceia, F.R., Geraldes, P., Melo, T. & Paiva, V.H. (2020). Inter-annual changes in oceanic conditions drives spatial and trophic consistency of a tropical marine predator. Marine Environmental Research 162 (2020) 105165.

Chabot, D., Craik, S. R., & Bird, D. M. (2015). Population census of a large common tern colony with a small unmanned aircraft. PloS one, 10(4), e0122588.

Clarke, J., Kerry, K., Fowler, C., Lawless, R., Eberhard, S., & Murphy, R. (2003). Post-fledging and winter migration of Adélie penguins Pygoscelis adeliae in the Mawson region of East Antarctica. Marine Ecology Progress Series, 248, 267-278.

Clarke, J. A., Tambussi, C. P., Noriega, J. I., Erickson, G. M., & Ketcham, R. A. (2005). Definitive fossil evidence for the extant avian radiation in the Cretaceous. Nature, 433(7023), 305.

Correia, E., Granadeiro, J. P., Regalla, A., Monteiro, H., & Catry, P. (2018). The diet of two opportunistic seabirds (Caspian and Royal Terns) confirms the importance of *Sardinella spp.* in West African coastal food webs. Marine Biology Research, 14(9-10), 961-972.

Correia, E., Beal, M., Gomes, N., Diop, N., Wambar, F., Dias, M.P., Hernandez-Rios, A., Catry, T. (submitted). Foraging movements and important sites for conservation of the West Africa Crested Tern (*Thalasseus albididorsalis*) breeding in Guinea-Bissau.

Costantini, D., Blévin, P., Herzke, D., Moe, B., Gabrielsen, G. W., Bustnes, J. O., & Chastel, O. (2019). Higher plasma oxidative damage and lower plasma antioxidant defences in an Arctic seabird exposed to longer perfluoroalkyl acids. Environmental research, 168, 278-285.

Costantini, D., Meillère, A., Carravieri, A., Lecomte, V., Sorci, G., Faivre, B., . . . Budzinski, H. (2014). Oxidative stress in relation to reproduction, contaminants, gender and age in a long-lived seabird. Oecologia, 175(4), 1107-1116.

Coulson, J., & Nève de Mévergnies, G. (1992). Where do young kittiwakes *Rissa tridactyla* breed, philopatry or dispersal. Ardea, 80, 187-197.

Coulson, J. C. (2002). Colonial breeding in seabirds. In Schreiber, E. A., Burger J. (eds), Biology of Marine Birds (pp. 197-234): CRC Press.

Coulson, J. C. (2016). A review of philopatry in seabirds and comparisons with other waterbird species. Waterbirds, 39(3), 229-241.

Courchamp, F., Berec, L., & Gascoigne, J. (2008). Allee Effects in Ecology and Conservation. In (pp. 272). New York: Oxford University Press, New York.

Courchamp, F., Chapuis, J.-L., & Pascal, M. (2003). Mammal invaders on islands: impact, control and control impact. Biological Reviews, 78(3), 347-383.

Courtens, W., Verstraete, H., Vanermen, N., & Stienen, E. (2017). Faecal samples reveal the diet of breeding adult Sandwich terns *Thalasseus sandvicensis* in Belgium and the southern part of the Netherlands. Journal of Sea Research, 127, 182-193.

Crawford, R. J. M., Altwegg, R., Barham, B. J., Barham, P. J., Durant, J. M., Dyer, B. M., . . . Ryan, P. G. (2011). Collapse of South Africa's penguins in the early 21st century. African Journal of Marine Science, 33(1), 139-156.

Crawford, R. J. M., Dundee, B. L., Dyer, B. M., Klages, N. T. W., Meÿer, M. A., & Upfold, L. (2007). Trends in numbers of Cape gannets (*Morus capensis*), 1956/1957–2005/2006, with a consideration of the influence of food and other factors. ICES Journal of Marine Science, 64(1), 169-177.

Crawford, R. J. M., & Dyer, B. M. (2006). Breeding numbers and success of Eudyptes penguins at Marion Island, and the influence of mass and time of arrival of adults. CCAMLR Science, 13, 175-190.

Crawford, R. J. M., Makhado, A. B., Waller, L. J., & Whittington, P. A. (2014). Winners and losers – responses to recent environmental change by South African seabirds that compete with purse-seine fisheries for food. Ostrich, 85(2), 111-117.

Crawford, R. J. M., Makhado, A. B., Whittington, P. A., Randall, R. M., Oosthuizen, W. H., & Waller, L. J. (2015). A changing distribution of seabirds in South Africa - the possible impact of climate and its consequences. Frontiers in Ecology and Evolution, 3(10). doi:10.3389/fevo.2015.00010.

Crawley, M. J. (2012). The R book: John Wiley & Sons.

Croll, D. A., Newton, K. M., McKown, M., Holmes, N., Williams, J. C., Young, H. S., . . . Bock, M. F. (2016). Passive recovery of an island bird community after rodent eradication. Biological invasions, 18(3), 703-715.

Croxall, J.P., Butchart, S.H.M., Lascelles, B., Stattersfield, A.J., Sullivan, B., Symes, A., Taylor, P., 2012. Seabird conservation status, threats and priority actions: a global assessment. Bird Conservation International 22, 1–34. https://doi.org/10.1017/S0959270912000020.

Cury, P. M., Boyd, I. L., Bonhommeau, S., Anker-Nilssen, T., Crawford, R. J., Furness, R. W., . . . Paleczny, M. (2011). Global seabird response to forage fish depletion—one-third for the birds. Science, 334(6063), 1703-1706.

Da Rocha, N., Oppel, S., Prince, S., Matjila, S., Shaanika, T.M., Naomab, C., Yates, O., Paterson, J.R.B., Shimooshili, K., Frans, E., Kashava, S. & Crawford, R. (2021). Reduction in seabird mortality in Namibian fisheries following the introduction of bycatch regulation. Biological Conservation 253. https://doi.org/10.1016/j.biocon.2020.108915.

Danchin, E., Cadiou, B., Monnat, J., & Rodriguez Estrella, R. (1991). Recruitment in long-lived birds: conceptual framework and behavioural mechanisms. Paper presented at the Proceedings of the International Ornithological Congress.

Debaive, N., & Touzé, A. (2013). Donnez toutes les chances de réussite à votre suivi. Espaces naturels, 41, 26.

Del Hoyo, J., Collar, N. J., Christie, D. A., Elliott, A., & Fishpool, L. (2014). HBW and BirdLife International Illustrated Checklist of the Birds of the World: non-passerines (Vol. 1): Lynx, BirdLife International.

Diagana, C.H., Ould Sidaty, Z.E.A., Diawara, Y. & Ould Daddah, M. (2020). Nouvelles données sur la nidification de la sterne caspienne *Sterna caspia* au Parc National du Diawling (Mauritanie). Nature Mauritanie.

Dias, M.P., Martin, R., Pearmain, E. J., Burfield, I. J., Small, C., Phillips, R. A., . . . Croxall, J. P. (2019). Threats to seabirds: a global assessment. Biological Conservation, 13 p.

Diawara, Y., Araujo, A., Diagana, C.H. & Meriaux. (2020). Réhabilitation du site de reproduction des spatules à Nair, Parc National du Banc d'Arguin. Nature Mauritanie.

Dietrich, M., Gomez-Diaz, E., & McCoy, K. D. (2011). Worldwide distribution and diversity of seabird ticks: implications for the ecology and epidemiology of tick-borne pathogens. Vector-Borne and Zoonotic Diseases, 11(5), 453-470.

Diouf, S., Neiss, T., Rode, C., Schwöppe, W., Schmidt, A., Sylla, S.I., Terlutter, H. & Woike, M. 1995. Le Parc National des Oiseaux du Djoudj. Ministère de l'Environnement et de la Protection de la Nature, Dakar, Senegal.

Diop, N., Zango, L., Beard, A., Tidiane Ba, C., Ndiaye, P.I., Henry, L., Clingham, E., Oppel, S. & González-Solís, J. (2018). Foraging ecology of tropicbirds breeding in two contrasting marine environments in the tropical Atlantic. *Mar Ecol Prog Ser* 607: 221–236.

Diop, N. , Ba, C.T., Ndiaye, P.I., Militão, T. & González-Solís, J. (2019). Population Size and Breeding Phenology of Red-billed Tropicbirds (*Phaethon aethereus*) on Iles de la Madeleine, Senegal. *Waterbirds* 42(1): 100-106.

Direcção Geral do Ambiente. (2010). Proposta do Plano de Gestão da Reserva Natural de Santa Luzia, ilhéus Branco e Raso. Ministério do Ambiente, Desenvolvimento Rural e Recursos Marinhos, Cabo Verde.

Dittmann, T., Zinsmeister, D., & Becker, P. H. (2005). Dispersal decisions: common terns, Sterna hirundo, choose between colonies during prospecting.

Animal behaviour 70(1), 13-20.

Djau, A. (2020). Importância socioeconómica e ambiental das aves marinhas na costa ocidental de África: O caso da Ilha de Bubaque na Guiné-Bissau. Thesis submission, Universidade Lusófona da Guiné-Bissau.

Dodman, T. & Boere, G.C. (eds.). (2010). The Flyway Approach to the Conservation and Wise Use of Waterbirds and Wetlands: A Training Kit. Wings Over Wetlands Project, Wetlands International and BirdLife International, Ede, The Netherlands.

Dunn, M. J., Silk, J. R. D., & Trathan, P. N. (2011). Post-breeding dispersal of Adélie penguins (*Pygoscelis adeliae*) nesting at Signy Island, South Orkney Islands. Polar biology, 34(2), 205-214.

Dyer, B. M., Cooper, J., Crawford, R. J. M., Sherley, R. B., Somhlaba, S., Cockcroft, A., . . . Makhado, A. B. (2019). Geographical and temporal variation in the diet of Bank Cormorants *Phalacrocorax neglectus* in South Africa. Ostrich, 90(4), 373-390.

Eliason, C. M., & Shawkey, M. D. (2011). Decreased hydrophobicity of iridescent feathers: a potential cost of shiny plumage. Journal of Experimental Biology, 214(13), 2157-2163.

Enever, R., Revill, A., & Grant, A. (2007). Discarding in the English Channel, Western approaches, Celtic and Irish seas (ICES subarea VII). Fisheries Research, 86(2-3), 143-152.

Evers, D., Taylor, K., Major, A., Taylor, R., Poppenga, R. H., & Scheuhammer, A. (2003). Common loon eggs as indicators of methylmercury availability in North America. Ecotoxicology, 12(1-4), 69-81.

Fernández-Chacón, A., Genovart, M., Pradel, R., Tavecchia, G., Bertolero, A., Piccardo, J., . . . Oro, D. (2013). When to stay, when to disperse and where to go: survival and dispersal patterns in a spatially structured seabird population. Ecography, 36(10), 1117-1126.

Gabrielsen P. & Bosch P. (2003). Environmental indicators: typology and use in reporting. European Environment Agency, Brussels.

Gaglio, D., Cook, T. R., Connan, M., Ryan, P. G., & Sherley, R. B. (2017). Dietary studies in birds: testing a non-invasive method using digital photography in seabirds. Methods in Ecology and Evolution, 8(2), 214-222.

Gamble, A., Boulinier, T. & Weimerskirch, H. (2020). Seabirds blinded by ticks. Frontiers in Ecology and the Environment. DOI: 10.1002/fee.2237

Gatto, A. J., & Yorio, P. (2016). Assessing the trophic niche of South American Terns integrating conventional and isotopie methods. Emu-Austral Ornithology, 116(3), 230-240.

Good, S.D., Baker, G.B., Gummery, M., Votier, S.C. & Phillips, R.A. (2020). National Plans of Action (NPOAs) for reducing seabird bycatch: Developing best practice for assessing and managing fisheries impacts. Biological Conservation 247. https://www.sciencedirect.com/science/article/pii/S0006320719314545.

Goutte, A., Barbraud, C., Herzke, D., Bustamante, P., Angelier, F., Tartu, S., . . . Gabrielsen, G. W. (2015). Survival rate and breeding outputs in a high Arctic seabird exposed to legacy persistent organic pollutants and mercury. Environmental Pollution, 200, 1-9.

Goutte, A., Barbraud, C., Meillère, A., Carravieri, A., Bustamante, P., Labadie, P., . . . Weimerskirch, H. (2014). Demographic consequences of heavy metals and persistent organic pollutants in a vulnerable long-lived bird, the wandering albatross. Proceedings of the Royal Society B: Biological Sciences, 281(1787), 20133313.

Goutte, A., Bustamante, P., Barbraud, C., Delord, K., Weimerskirch, H., & Chastel, O. (2014). Demographic responses to mercury exposure in two closely related Antarctic top predators. Ecology, 95(4), 1075-1086.

Grecian, W. J., Witt, M. J., Attrill, M. J., Bearhop, S., Becker, P. H., Egevang, C., . . . Grémillet, D. (2016). Seabird diversity hotspot linked to ocean productivity in the Canary Current Large Marine Ecosystem. Biology letters, 12(8), 20160024.

Greenwood, P. J., & Harvey, P. H. (1982). The natal and breeding dispersal of birds. Annual review of ecology and systematics, 13(1), 1-21.

Grémillet, D., Peron, C., Provost, P., & Lescroel, A. (2015). Adult and juvenile European seabirds at risk from marine plundering off West Africa. Biological Conservation, 182, 143-147.

Grémillet, D., Ponchon, A., Paleczny, M., Palomares, M.-L. D., Karpouzi, V., & Pauly, D. (2018). Persisting worldwide seabird-fishery competition despite seabird community decline. Current Biology, 28(24), 4009-4013. e4002.

Hagen, C. & Wanless, R. (2015). International Multi-species Action Plan for the Conservation of Benguela Upwelling System Coastal Seabirds. AEWA Technical Series No. 60. Bonn, Germany.

Hamer, K. C., Schreiber, E. A., & Burger, J. (2001). Breeding biology, life histories, and life history–environment interactions in seabirds. In Schreiber, E. A., Burger J. (eds), Biology of Marine Birds (pp. 235-280): CRC Press.

Handley, J., Beal, M., Correia, E., Gomez, N. & Dias, M.P. (2022). Alcyon Programme: Conservation of coastal seabirds and their key sites along the West African coast. Unpublished report, BirdLife International.

Harris, M., & Tasker, M. (1999). Conservation value of ringing seabirds in Britain and Ireland. Ringing & Migration, 19(S1), 95-106.

Haynes-Sutton, A. M., Sorenson, L. G., Mackin, W. A., Haney, C., & Wheeler, J. (2014). Manuel de suivi des oiseaux marins des Caraïbes: le suivi écologique pour promouvoir la conservation des oiseaux marins nicheurs et de leurs habitats dans la région Caraïbes (Vol. 2). Arlington, VA: BirdsCaribbean.

Hazen, E. L., Abrahms, B., Brodie, S., Carroll, G., Jacox, M. G., Savoca, M. S., . . . Bograd, S. J. (2019). Marine top predators as climate and ecosystem sentinels. Frontiers in Ecology and the Environment, 17(10), 565-574.

Heileman, S. & Tandstad, M., (2008). Canary Current LME, p.131-141. In: The UNEP Large Marine Ecosystem Report: A perspective on changing conditions in LMEs of the world's Regional Seas. UNEP Regional Seas Report and Studies No.182. United Nations Environment Program. Nairobi, Kenya.

Hodgson, J. C., Mott, R., Baylis, S. M., Pham, T. T., Wotherspoon, S., Kilpatrick, A. D., . . . Koh, L. P. (2018). Drones count wildlife more accurately and precisely than humans. Methods in Ecology and Evolution, 9(5), 1160-1167.

Hughes, B. J., Martin, G. R., Giles, A. D., & Reynolds, S. J. (2017). Long-term population trends of Sooty Terns Onychoprion fuscatus: implications for conservation status. Population ecology, 59(3), 213-224.

IUCN. (2019). The Abu Dhabi Call for Global Species Conservation Action. Retrieved from https://www.iucn.org/species/about/species-survival-commission/ssc-leadership-and-steering-committee/ssc-leaders-meeting-2019/abu-dhabi-call-global-species-conservation-action

Iverson, S. J., Springer, A. M., & Kitaysky, A. S. (2007). Seabirds as indicators of food web structure and ecosystem variability: qualitative and quantitative diet analyses using fatty acids. Marine Ecology Progress Series, 352, 235-244.

Jabado, R.W. (2021). Bycatch Mitigation Roadmap - west African Industrial Fisheries. Convention on the Conservation of Migratory Species of Wild Animals, Bonn, Germany. 52pp.

Jara-Carrasco, S., González, M., González-Acuña, D., Chiang, G., Celis, J., Espejo, W., . . . Barra, R. (2015). Potential immunohaematological effects of persistent organic pollutants on chinstrap penguin. Antarctic Science, 27(4), 373-381.

Jones, H. P., Holmes, N. D., Butchart, S. H., Tershy, B. R., Kappes, P. J., Corkery, I., . . . Burbidge, A. A. (2016). Invasive mammal eradication on islands results in substantial conservation gains. Proceedings of the National Academy of Sciences, 113(15), 4033-4038.

Jones, H. P., & Kress, S. W. (2012). A review of the world's active seabird restoration projects. The Journal of Wildlife Management, 76(1), 2-9.

Jones, N. M., McChesney, G. J., Parker, M. W., Yee, J. L., Carter, H. R., & Golightly, R. T. (2008). Breeding phenology and reproductive success of the Brandt's Cormorant at three nearshore colonies in central California, 1997-2001. Waterbirds, 31(4), 505-520.

Karnovsky, N. J., Hobson, K. A., & Iverson, S. J. (2012). From lavage to lipids: estimating diets of seabirds. Marine Ecology Progress Series, 451, 263-284.

Keijl, G.O., Brenninkmeijer, A., Schepers, F.J., Brasseur, R.E., Ndiaye, A., Stienen, E.W.M. & Veen, J. 2000. Oiseaux nicherus sur les côtes du Parc National Langue de Barbarie et du Parc National du Sine-Saloum, Sénégal, 1998. Rapport-WIWO68, rapport IBN-DLO 99/6, Zeist, The Netherlands.

Kendall, W. L., Converse, S. J., Doherty Jr, P. F., Naughton, M. B., Anders, A., Hines, J. E., & Flint, E. (2009). Sampling design considerations for demographic studies: a case of colonial seabirds. Ecological Applications, 19(1), 55-68.

Kennedy, E. S., & Pachlatko, T. (2012). Footwear to allow researchers to cross densely burrowed terrain without damage to seabird habitat. Marine Ornithology, 40, 53-56.

Kenow, K. P., Meyer, M. W., Rossmann, R., Gray, B. R., & Arts, M. T. (2015). Influence of in ovo mercury exposure, lake acidity, and other factors on common loon egg and chick quality in Wisconsin. Environmental toxicology and chemistry, 34(8), 1870-1880.

Keogan, K., Daunt, F., Wanless, S., Phillips, R. A., Walling, C. A., Agnew, P., . . . Barrett, R. T. (2018). Global phenological insensitivity to shifting ocean temperatures among seabirds. Nature Climate Change, 8(4), 313-318.

Kepler, C. B. (1978). The breeding ecology of seabirds on Monito Island, Puerto Rico. The Condor, 80(1), 72-87.

King, L., de Solla, S., Marentette, J., Lavoie, R., Kyser, T., Campbell, L., . . . Quinn, J. (2017). Fatty acids, stable isotopes, and regurgitate reveal diet differences between Lake Ontario and Lake Erie double-crested cormorants (*Phalacrocorax auritus*). Journal of Great Lakes Research, 43(3), 132-140.

Kleijn, D., Cherkaoui, I., Goedhart, P. W., van der Hout, J., & Lammertsma, D. (2014). Waterbirds increase more rapidly in Ramsar-designated wetlands than in unprotected wetlands. Journal of Applied Ecology, 51(2), 289-298.

Koulibaly, C.T. (2022). How environmental changes due to anthropogenic factors and a changing climate are affecting waterbirds in the Senegal River Delta. Abstracts booklet, Pan-African Ornithological Congress (PAOC15), p.40.

Koulibaly, C.T. (2021). A comparative analysis of the vulnerability of selected areas of Senegal to coastline retreat. A Thesis Submitted to Pan African University of Life and Earth Sciences Institute (Including Health and Agriculture), Ibadan, Nigeria.

Kubetzki, U., Garthe, S., Fifield, D., Mendel, B. & Furness, R. W. (2009) Individual migratory schedules and wintering areas of northern gannets. Marine Ecology Progress Series. 391, 257-265.

La Sorte, F. A., Fink, D., Buler, J. J., Farnsworth, A., & Cabrera-Cruz, S. A. (2017). Seasonal associations with urban light pollution for nocturnally migrating bird populations. Global change biology, 23(11), 4609-4619.

Larson, K., & Craig, D. (2006). Digiscoping vouchers for diet studies in bill-load holding birds. Waterbirds, 29(2), 198-202.

Le Bot, T., Lescroël, A., Fort, J., Péron, C., Gimenez, O., Provost, P., & Grémillet, D. (2019). Fishery discards do not compensate natural prey shortage in Northern gannets from the English Channel. Biological conservation, 236, 375-384.

Lewison, R., Oro, D., Godley, B., Underhill, L., Bearhop, S., Wilson, R., . . . Borboroglu, P. (2012). Research priorities for seabirds: improving conservation and management in the 21st century. Endangered Species Research, 17(2), 93-121.

Løkkeberg, S. (2011). Best practices to mitigate seabird bycatch in longline, trawl and gillnet fisheries—efficiency and practical applicability. Marine Ecology Progress Series, 435, 285-303.

López Suárez, P. 2012. Bird population monitoring report: Ospreys and Red-billed tropicbirds on Boa Vista island (December 2011-May 2012). Unpublished report submitted to Cabeólica.

Loureiro, N.S., Reis, E., Dias, D. & Veiga, A. (2021). Is Sula sula breeding in the cliffs of Baía do Inferno, Santiago Island, Cabo Verde? *Zoologia Caboverdiana,* 9(1): 14–16.

MacDonald, M. (1980). The winter attendance of fulmars at land in NE Scotland. Ornis scandinavica, 11, 23-29.

Martínez-Abraín, A., Viedma, C., Ramón, N., & Oro, D. (2001). A note on the potential role of philopatry and conspecific attraction as conservation tools in Audouin's Gull *Larus audouinii.* Bird Conservation International, 11(2), 143-147.

Martins, S., Fortes, R. & Palma, L. 2017. New breeding sites of the red-billed tropicbird *Phaeton aethereus* and the brown booby *Sula leucogaster* on São Nicolau Island, Cabo Verde. *Zoologia Caboverdiana*, 6: 5–8.

McDonald, J.H. (2014). Handbook of Biological Statistics - Third Edition. University of Delaware. Sparky House Publishing, Baltimore, Maryland, U.S.A.

Medina, F.M., Melo, T., Oliveira, P., Nogales, M. & Geraldes, P. (2021). Trophic ecology of an introduced top predator (Felis catus) on a small African oceanic islet (Santa Luzia, Cabo Verde Islands). African Journal of Ecology, 59, 88–98.

Mittelstaedt, E. (1991). The ocean boundary along the northwest African coast: Circulation and oceanographic properties at the sea surface. Progress in Oceanography, 26(4), 307-355.

Miskelly, C. M., Taylor, G. A., Gummer, H., & Williams, R. (2009). Translocations of eight species of burrow-nesting seabirds (genera Pterodroma, Pelecanoides, Pachyptila and Puffinus: Family Procellariidae). Biological conservation, 142(10), 1965-1980.

Monnat, J.-Y., & Cadiou, B. (2004). Techniques de recensement. In Cadiou, B., Pons, J.-M., & Yésou, P. (eds), Oiseaux marins nicheurs de France métropolitaine 1960-2000: Biotope.

Montevecchi, W., & Veit, R. (2006). The influences of global climate change on marine birds. Zoologica Sinica, 52.

Montrond, G. (2020). Assessing Sea Turtle, Seabird and Shark bycatch in Artisanal, Semi-industrial and Industrial Fisheries in the Cabo Verde Archipelago. Thesis, University of Cape Town, South Africa.

Morera-Pujol, V., Ramos, R., Pérez-Méndez, N., Cerdà-Cuéllar, M., & González-Solís, J. (2018). Multi-isotopic assessments of spatio-temporal diet variability: the case of two sympatric gulls in the western Mediterranean. Marine Ecology Progress Series, 606, 201-214.

Naves, L. C., Yves Monnat, J., & Cam, E. (2006). Breeding performance, mate fidelity, and nest site fidelity in a long-lived seabird: behaving against the current? Oikos, 115(2), 263-276.

Nelson, B. (1980). Seabirds: their biology and ecology: Hamlyn.

Nevitt, G. A. (2008). Sensory ecology on the high seas: the odor world of the procellariiform seabirds. Journal of Experimental Biology, 211(11), 1706-1713.

Nisbet, I. C., Montoya, J. P., Burger, J., & Hatch, J. J. (2002). Use of stable isotopes to investigate individual differences in diets and mercury exposures among common terns *Sterna hirundo* in breeding and wintering grounds. Marine Ecology Progress Series, 242, 267-274.

Ntiamoa-Baidu, Y., Nyame, S. K., & Nuoh, A. A. (1992). Preliminary report on tern trapping in coastal Ghana. Proceedings of the Roseate Tern Workshop (ed Rolland, G.), 47-52.

O'Hanlon, N. J., Bond, A. L., Lavers, J. L., Masden, E. A., & James, N. A. (2019). Monitoring nest incorporation of anthropogenic debris by Northern Gannets across their range. Environmental Pollution, 255, 113152.

Oehm, J., Thalinger, B., Eisenkölbl, S., & Traugott, M. (2017). Diet analysis in piscivorous birds: What can the addition of molecular tools offer? Ecology and evolution, 7(6), 1984-1995.

Oesterwind D., Rau A. & Aiko A. (2016). Drivers and pressures: untangling the terms commonly used in marine science and policy. *Journal of Environmental Management* 181: 8-15.

Oliveira, N., Geraldes, P.L., Oliveira, J., Melo, T. & Melo, J. 2014. Possible breeding of Cape Verde storm-petrel *Oceanodroma jabejabe* (Bocage, 1875) on Santa Luzia, Cape Verde Islands *Zoologia Caboverdiana* 4 (1): 17-20.

Oudi, A., Chokri, M. A., Hammouda, A., Chaabane, R., Badraoui, R., Besnard, A., & Santos, R. (2019). Physiological impacts of pollution exposure in seabird's progeny nesting in a Mediterranean contaminated area. Marine pollution bulletin, 142, 196-205.

Paiva, V. H., Tavares, P. C., Ramos, J. A., Pereira, E., Antunes, S., & Duarte, A. C. (2008). The influence of diet on mercury intake by Little Tern chicks. Archives of environmental contamination and toxicology, 55(2), 317-328.

Paiva, V. H., Geraldes, P., Rodrigues, I., Melo, T., Melo, J. & Ramos, J. A. (2015). The foraging ecology of the endangered Cape Verde shearwater, a sentinel species for marine conservation off West Africa, PloS one, 10(10).

Pauly, D., Christensen, V., Dalsgaard, J., Froese, R., & Torres, F. (1998). Fishing down marine food webs. Science, 279(5352), 860-863.

Plastics Europe. (2020). Plastics - The Facts 2013: An Analysis of European Plastics Production, Demand, and Waste Data. Retrieved from https://plasticseurope.org/wp-content/uploads/2021/09/Plastics_the_facts-WEB-2020_versionJun21_final.pdf.

Prentice, E. F., Flagg, T. A., McCutcheon, C. S., & Brastow, D. F. (1990, 1990). PIT-tag monitoring systems for hydroelectric dams and fish hatcheries.

Priddel, D., & Carlile, N. (2001). A trial translocation of Gould's petrel (Pterodroma leucoptera leucoptera). Emu, 101(1), 79-88.

Provencher, J., Gilchrist, H., Mallory, M., Mitchell, G., & Forbes, M. (2016). Direct and indirect causes of sex differences in mercury concentrations and parasitic infections in a marine bird. Science of the Total Environment, 551-552, 506-512.

Quartey, J.K., Nuoh, A.A., Taye, E. & Ntiamoa-Baidu, Y. (2018). Assessment of the wintering population, conservation requirements and priority actions for Roseate tern (*Sterna dougallii*) in Ghana. Centre for African Wetlands, Accra, Ghana / RSPB, Sandy, UK.

Ratcliffe, N., Zino, F. J., Oliveira, P., Vasconcelos, A., Hazevoet, C. J., Neves, H. C., Monteiro, R. L. & Zino, E. (2000). The status and distribution of Fea's Petrel *Pterodroma feae* in the Cape Verde islands. *Atlantic Seabirds* 2: 73–86.

Reynolds, S. J., Martin, G. R., Dawson, A., Wearn, C. P., & Hughes, B. J. (2014). The sub-annual breeding cycle of a tropical seabird. PloS one, 9(4), e93582.

Ripple, W. J., Wolf, C., Newsome, T. M., Galetti, M., Alamgir, M., Crist, E., . . . 15, s. s. f. c. (2017). World scientists' warning to humanity: a second notice. BioScience, 67(12), 1026-1028.

Rizk, C., Semelin, J., & Karibuhoye, C. (2011). Guide méthodologique pour l'élaboration des plans de gestion des Aires Marines Protégées en Afrique de l'Ouest.

Ropert-Coudert Y., Kato A., Robbins A. & Humphries, G.R.W. (2018). The Penguiness book. World Wide Web electronic publication (http://www.penguiness.net), version 3.0, October 2018. DOI:10.13140/RG.2.2.32289.66406

Robertson, G., Candy, S. G., & Hall, S. (2013). New branch line weighting regimes to reduce the risk of seabird mortality in pelagic longline fisheries without affecting fish catch. Aquatic Conservation: Marine and Freshwater Ecosystems, 23(6), 885 - 900.

Robinson, H. J., Seher, V. L., & Thayer, J. A. (2019). Novel vs. Traditional Approaches to Sampling Seabird Diet: Nest and Pellet Analysis of Brandt's Cormorants (*Phalacrocorax penicillatus*). Waterbirds, 42(3), 282-293.

Robinson, S. A., Lajeunesse, M. J., & Forbes, M. R. (2012). Sex differences in mercury contamination of birds: testing multiple hypotheses with meta-analysis. Environmental science & technology, 46(13), 7094-7101.

Rodrigues, I., Monteiro, C., Almeida, N., Delgado, K., Geraldes, P. & Melo, T. 2020. Translocation test of Cabo Verde shearwater *Calonectris edwardsii* on Raso Islet. *Zoologia Caboverdiana* 8, 3, 58–65.

Rodrigues, P., Aubrecht, C., Gil, A., Longcore, T., & Elvidge, C. (2012). Remote sensing to map influence of light pollution on Cory's shearwater in São Miguel Island, Azores Archipelago. European journal of wildlife research, 58(1), 147-155.

Rodríguez, A., Holmes, N. D., Ryan, P. G., Wilson, K. J., Faulquier, L., Murillo, Y., . . . Rodríguez, B. (2017). Seabird mortality induced by land-based artificial lights. Conservation Biology, 31(5), 986-1001.

Romero, L. M. (2004). Physiological stress in ecology: lessons from biomedical research. Trends in ecology & evolution, 19(5), 249-255.

Ropert-Coudert, Y., Kato, A., Shiomi, K., Barbraud, C., Angelier, F., Delord, K., . . . Raclot, T. (2018). Two Recent Massive Breeding Failures in an Adélie Penguin Colony Call for the Creation of a Marine Protected Area in D'Urville Sea/Mertz. Frontiers in Marine Science, 5, 264.

Ropert-Coudert, Y., & Wilson, R. P. (2005). Trends and perspectives in animal-attached remote sensing. Frontiers in Ecology and the Environment, 3(8), 437-444.

Rowe, C. L. (2008). "The calamity of so long life": life histories, contaminants, and potential emerging threats to long-lived vertebrates. Bioscience, 58(7), 623-631.

RSPB (2019). The Albatross Task Force. Retrieved from https://www.rspb.org.uk/our-work/our-positions-and-casework/our-positions/marine-and-coastal/saving-seabirds-globally/the-albatross-task-force/

Sambe, B., Tandstad, M., Caramelo, A. M. and Brown, B. E. (2016) Variations in productivity of the Canary Current Large Marine Ecosystem and their effects on small pelagic fish stocks. Environmental Development, 17, 105-117.

Schippers, P., Stienen, E. W., Schotman, A. G., Snep, R. P., & Slim, P. A. (2011). The consequences of being colonial: Allee effects in metapopulations of seabirds. Ecological Modelling, 222, 3061-3070.

Schreiber, E. A. (2001). Climate and weather effects on seabirds. In Schreiber, E. A., Burger J. (eds), Biology of Marine Birds (pp. 197-234): CRC Press.

Semedo, G., Paiva, V.H., Militão,T., Rodrigues, I., Dinis, H.A., Pereira, J., Matos, D., Ceia, F.R., Almeida. N.M., Geraldes, P., Saldanha, S., Barbosa, N., Hernández-Monteiro, M., Fernandes, C., González-Sólis, J. & Ramos, J.A. 2021. *Bird Conservation International* 31,1: 53 - 76. DOI: https://doi.org/10.1017/S0959270920000428.

Sherley, R. B., Barham, B. J., Barham, P. J., Campbell, K. J., Crawford, R. J., Grigg, J., . . . Pichegru, L. (2018). Bayesian inference reveals positive but subtle effects of experimental fishery closures on marine predator demographics. *Proceedings of the Royal Society B: Biological Sciences*, 285(1871), 20172443.

Sherley, R. B., Winker, H., Altwegg, R., van der Lingen, C. D., Votier, S. C., & Crawford, R. J. (2015). Bottom-up effects of a no-take zone on endangered penguin demographics. Biology letters, 11(7), 20150237.

Smith, A. D., Brown, C. J., Bulman, C. M., Fulton, E. A., Johnson, P., Kaplan, I. C., . . . Shannon, L. J. (2011). Impacts of fishing low–trophic level species on marine ecosystems. Science, 333(6046), 1147-1150.

SPEA. (2022). Ninhos artificiais para aves marinhas. Guia Prático Ilustrado. SPEA, Lisboa. https://spea.pt/projetos/protecao-das-aves-marinhas-de-cabo-verde/.

Stienen, E. W., Jonard, A., & Brenninkmeijer, A. (1998). Tern trapping along the Senegalese coast. Sula, 12(1), 19-26.

Sullivan, B., Kibel, B., Kibel, P., Yates, O., Potts, J., Ingham, B., . . . Lebepe, B. (2018). At-sea trialling of the Hookpod: a 'one-stop'mitigation solution for seabird bycatch in pelagic longline fisheries. Animal Conservation, 21(2), 159-167.

Tanaka, K., Takada, H., Yamashita, R., Mizukawa, K., Fukuwaka, M.-a., & Watanuki, Y. (2013). Accumulation of plastic-derived chemicals in tissues of seabirds ingesting marine plastics. Marine pollution bulletin, 69(1-2), 219-222.

Tartu, S., Angelier, F., Wingfield, J. C., Bustamante, P., Labadie, P., Budzinski, H., . . . Chastel, O. (2015). Corticosterone, prolactin and egg neglect behavior in relation to mercury and legacy POPs in a long-lived Antarctic bird. Science of the Total Environment, 505, 180-188.

Tartu, S., Goutte, A., Bustamante, P., Angelier, F., Moe, B., Clément-Chastel, C., . . . Chastel, O. (2013). To breed or not to breed: endocrine response to mercury contamination by an Arctic seabird. Biology Letters, 9.

Tartu, S., Lendvai, Á. Z., Blévin, P., Herzke, D., Bustamante, P., Moe, B., . . . Chastel, O. (2015). Increased adrenal responsiveness and delayed hatching date in relation to polychlorinated biphenyl exposure in Arctic-breeding black-legged kittiwakes (Rissa tridactyla). General and comparative endocrinology, 219, 165-172.

Tasker, M. L., Camphuysen, C., Cooper, J., Garthe, S., Montevecchi, W. A., & Blaber, S. J. (2000). The impacts of fishing on marine birds. ICES journal of Marine Science, 57(3), 531-547.

Tavares, D. C., Moura, J. F., & Merico, A. (2019). Anthropogenic debris accumulated in nests of seabirds in an uninhabited island in West Africa. Biological conservation, 236, 586-592.

Thiebot, J.-B., Ropert-Coudert, Y., Raclot, T., Poupart, T., Kato, A., & Takahashi, A. (2019). Adélie penguins' extensive seasonal migration supports dynamic Marine Protected Area planning in Antarctica. Marine Policy, 109, 103692.

Tornos, J., Prud'dhomme, O., Boulinier, T., Ponchon, A. & Quidoz, M. C. (2014). Utilisation de QGis comme outil nomade de saisie - 1re partie, Géomatique Expert, 101, 32-42.

Urbina, I. (2021). The factories turning West Africa's fish into powder. BBC Future: https://www.bbc.com/future/article/20210323-the-factories-turning-west-africas-fish-into-powder.

Valle, S., Barros, N., Ramírez, I., & Wanless, R. M. (2016). Population estimates of the breeding birds of the Tinhosas islands (Gulf of Guinea), the only major seabird colony of the eastern tropical Atlantic. Ostrich, 87(3), 209-215.

Veen, J., Dallmeijer, H., Schlaich, A. E., Veen, T., & Mullié, W. C. (2019). Diet and foraging range of Slender-billed Gulls Chroicocephalus genei breeding in the Saloum Delta, Senegal. Ardea, 107(1), 33-46.

Veen, J., Dallmeijer, H., & Veen, T. (2018). Selecting piscivorous bird species for monitoring environmental change in the Banc d'Arguin, Mauritania. Ardea, 106(1), 5-18.

Veen, J., & Mullié, W. (2015). Manuel de terrain pour le suivi des colonies d'oiseaux marins en Afrique de l'Ouest: Dakar, Sénégal: BirdLife International.

Veen, J., Keïta, N., Dallmeijer, H. & Gbansara, M.S. (2009). Colonies d'oiseaux piscivores nidifiant le long des côtes de Guinée. Etude prospective effectuée du 14 au 30 mai 2009. VEDA consultancy, Wenum-Wiesel, The Netherlands / Ministère de l'Environnement et du Développement Durable, Conakry, Republique de Guinée.

Veen, J., Peeters, J., Leopold, M. F., Van Damme, C. J. G., & Veen, T. (2003). Les oiseaux piscivores comme indicateurs de la qualité de l'environnement marin: suivi des effets de la plche littorale en Afrique du Nord-Ouest (1566-7197). Retrieved from

Veen, J., Peeters, J., Mullié, W. C., Diagana, C. H., & Hoedemakers, K. (2006). Manuel pour le suivi des colonies de nidification d'oiseaux marins en Afrique de l'Ouest / Manual for monitoring seabirds colonies in West Africa. Synopsis iconographique des otolithes de quelques espèces de poissons des côtes ouest africaines. Wetlands International, Dakar.

Velarde, E., Anderson, D. W., & Ezcurra, E. (2019). Seabird clues to ecosystem health. Science, 365(6449), 116-117.

Votier, S.C., Archibald, K., Morgan, G., & Morgan, L. (2011). The use of plastic debris as nesting material by a colonial seabird and associated entanglement mortality. Marine Pollution Bulletin, 62(1), 168-172.

Wallace, B.P., Kot, C.Y., DiMatteo, A.D., Lee, T., Crowder, L.B. & Lewison, R.L. 2013. Impacts of fisheries bycatch on marine turtle populations worldwide: toward conservation and research priorities. Ecosphere 4(3):40. https://doi.org/10.1890/ES12-00388.1.

Walsh, P., Halley, D., Harris, M., Del Nevo, A., Sim, I., & Tasker, M. (1995). Seabird monitoring handbook for Britain and Ireland: a compilation of methods for survey and monitoring of breeding seabirds: JNCC/RSPB/ITE/Seabird Group.

Ward, T., Tarte, D., Hegerl, E. & Short, K. (2002) Policy proposals and operational guidance for ecosystem-based management of marine capture fisheries', World Wide Fund for Nature Australia, Sydney.

Waugh, S.M., Poupart, T. & Wilson, K-J. (2015). Storm damage to Westland petrel colonies in 2014 from cyclone *Ita*. *Notornis* 62: 165-168.

Wayland, M., Gilchrist, H., Marchant, T., Keating, J., & Smits, J. (2002). Immune function, stress response, and body condition in arctic-breeding common eiders in relation to cadmium, mercury, and selenium concentrations. Environmental Research, 90(1), 47-60.

Weiser, E. L., & Powell, A. N. (2011). Evaluating gull diets: a comparison of conventional methods and stable isotope analysis. Journal of Field Ornithology, 82(3), 297-310.

Wetlands International. (2006). Waterbird Population Estimates - Fourth Edition. Wetlands International, Wageningen, The Netherlands.

Whitney, M. C., & Cristol, D. A. (2017). Impacts of sublethal mercury exposure on birds: a detailed review. In de Voogt, P., (eds), Reviews of environmental contamination and toxicology (2018) (Vol. 244, pp. 113-163): Springer.

Wiese, F. K., Montevecchi, W., Davoren, G., Huettmann, F., Diamond, A., & Linke, J. (2001). Seabirds at risk around offshore oil platforms in the North-west Atlantic. Marine Pollution Bulletin, 42(12), 1285-1290.

Wilcox, C., Van Sebille, E., & Hardesty, B. D. (2015). Threat of plastic pollution to seabirds is global, pervasive, and increasing. Proceedings of the National Academy of Sciences, 112(38), 11899-11904.

Wilkinson, C., Pollard, M., Hilton, G., & Geraldes, P. (2012). A survey of breeding seabirds on Anguilla. Airo, 22, 56-69.

Williams, C. T., & Buck, C. L. (2010). Using fatty acids as dietary tracers in seabird trophic ecology: theory, application and limitations. Journal of Ornithology, 151(3), 531-543.

Williams, D. R., Child, M. F., Dicks, L. V., Ockendon, N., Pople, R. G., Showler, D. A., . . . Sutherland, W. J. (2019). Bird Conservation. In Sutherland, W.J., Dicks, L.V., Ockendon, N., Petrovan, S.O., Smith, R.K. (eds), What Works in Conservation (pp. 141-290): Open Book Publishers, Cambridge, UK.

Witteveen, M., Brown, M., & Ryan, P. G. (2017). Anthropogenic debris in the nests of kelp gulls in South Africa. Marine pollution bulletin, 114(2), 699-704.

Worboys, G.L., Lockwood, M., Kothari, A., Feary, S. & Pulsford, I. (eds). (2015). Protected Area Governance and Management, ANU Press, Canberra.

Yokota, K., Minami, H., & Kiyota, M. (2011). Effectiveness of tori-lines for further reduction of incidental catch of seabirds in pelagic longline fisheries. Fisheries Science, 77(4), 479-485.

Glossary

Allee effect: Positive dependence of populations on the number of individuals (positive correlation between the density of a population and its growth rate). It occurs among certain species with low numbers which causes a population to collapse.

Amensalism: Association between organisms of two different species in which one is inhibited or destroyed and the other is unaffected.

Biosecurity: Preventive and regulatory measures whose goal is to reduce the risks of the spread of exotic organisms (IAS).

Bycatch: Untargeted animals caught in fisheries, such as a seabird caught on a fish hook and drowned on longlines.

Ecological / ecosystem services: The benefits that humans derive from the ecosystem. Benefits include supply services (e.g., food, water); regulatory services linked to ecosystem processes (e.g., buffer effect on floods, climatic inertia); cultural services; support services for conditions favourable to life on earth; carbon sink.

Food web: A set of food chains linked together within an ecosystem and through which energy and biomass circulate.

Guano: A fertilizing substance composed of excrement from seabirds (or bats).

IBA: Important Bird and Biodiversity Area.

Infratidal or subtidal zone: A coastal area below the intertidal zone that is always submerged (often includes seagrass).

Intertidal: A coastal area between the extreme limits reached by the tide. Also called foreshore or tidal zone.

Invasive alien species (IAS): An organism outside its distribution area, which has become established or naturalized, and which proliferates with negative effects on the ecosystem and its functions.

IUU fishing: Illegal, unreported and unregulated fishing (IUU).

Kleptoparasitism: A form of resource acquisition where one animal takes resources from another, especially food. Some seabirds are kleptoparasites, especially skuas and frigatebirds.

Philopatric: An organism that tends to return to its birthplace for breeding.

Pneumatization: Formation of alveoli or air-filled cavities in a tissue, especially in the bones.

Ramsar: A city of Iran where the Convention on Wetlands was signed; Ramsar Sites are recognized Wetlands of International Importance under the Convention.

Reintroduction: The movement of an organism back into the wild in a natural habitat where it was historically present, either from the captive environment or relocated from another area.

PRCM: Regional Partnership for Coastal and Marine Conservation of West Africa. PRCM covers the coastal and marine area of Mauritania, Cabo Verde, Senegal, The Gambia, Guinea-Bissau, Guinea and Sierra Leone.

Spp.: Abbreviation of species.

Strategy K: Reproductive strategy adopted by organisms living in stable environments, with a low rate of reproduction, which produce a small number of descendants to whom they offer parental care, leading to a reduction of their mortality to a minimum.

Systematics: The science of classification of taxa.

Translocation: The capture, transport, and release/introduction of an organism from one place to another.

Umbrella species: A species whose extent of territory or ecological niche enables the protection of a large number of organisms when it is protected.

Waders: Shorebirds belonging to the order Charadriiformes (sub-order of Charadrii).

Annexes

Annex 1: The unique productivity of the CCLME: favourable factors and enrichment mechanisms

The Canary Current is a surface wind-driven current that flows continuously from north to south and connects countries bordering the northwest coast of Africa. By blowing parallel to the coast, trade winds lead to coastal upwellings while bringing up cooler nutrient-laden bottom waters that enrich the surface ecosystem. These interactions and seasonal changes in ocean-atmospheric dynamics stimulate CCLME productivity. There is a permanent upwelling zone of cool water between Morocco and Senegal. The Canary Current is usually cold (18°C during the northern summer) because it is powered by waters from northern latitudes and by the resurgence of cold deep waters loaded with nutrients. These colder waters that flow up alongside the Atlantic coast of northwest Africa are carried in the current and transported towards the equator, contributing to displace productivity towards the south (Mittelstaedt 1991). Colder waters mix with warmer water bodies as they move along the Mauritanian and Senegalese coasts.

The Canary Islands and Cabo Verde divert the currents, hence a variability in the productivity regime around the islands. The estuaries and coastal waters from Senegal to Guinea provide additional nutrients from terrestrial sources through coastal processes. The surface circulation remains a favourable factor. The Canary Current flows south along the African coast, moving away from the Cap Blanc coast near latitude 21°N to join the Atlantic North Equatorial current. It is powered in the north by the low intensity Portugal Current, which flows south, and the Azores Current, which flows east and brings it masses of water from the North Atlantic Central Water. The southern branch joins the Guinea Current, bringing warm tropical waters to the east. The flow of the northern branch is situated below the southern branch and its intensity decreases sharply because of depth.

Finally, seasonal variability also contributes to the CCLME. The changes observed in oceanographic conditions and productivity result from the change of seasons combined with movements of intertropical convergence and the trade winds of the region, namely:

• The cold season (January to May): Northeast trade winds blow during the dry season, and colder northern waters develop and flow south. The winds, deflected by the Coriolis force, push coastal surface waters offshore, creating an upwelling bringing cooler bottom waters to the surface, which spread south along the Mauritanian and Senegalese coasts to the Bijagós Archipelago in Guinea-Bissau.

• A transition period (May to June): Intercontinental convergence shifts to the north and the trade winds weaken. With the decrease of the winds, the expanse of cold water is gradually covered by the warm salty tropical waters of the North Equatorial Current.

• The warm season (July to October): The more variable and weaker monsoon winds start to blow from the southwest. The influence of the North Equatorial Counter Current intensifies during the wet season, when the Canary Current does not penetrate beyond 15°N in the south and 20°W in the east. The warm waters reach their limit in the north. In September and October, the upwelling process of the Cap Blanc begins and cools the surface waters.

• A second transition period (November to December): The warm waters continue to recede to the south and upwellings of coastal waters occur (Cap Blanc, Cap Timiris, Cabo Verde) with the return of the trade winds.

Annex 2: The global criteria for Important Bird and Biodiversity Areas (IBAs)

http://datazone.birdlife.org/site/ibacritglob

A1. Globally threatened species

Criterion: The site is known or thought regularly to hold significant numbers of a globally threatened species.

Notes: The site qualifies if it is known, estimated or thought to hold a population of a species categorized by the IUCN Red List as Critically Endangered, Endangered or Vulnerable. Specific thresholds are set for species within each of the threat categories that need to be exceeded at a particular IBA. The list of globally threatened species is maintained and updated annually for IUCN by BirdLife International (www.birdlife.org/datazone/species).

A2. Restricted-range species

Criterion: The site is known or thought to hold a significant population of at least two range-restricted species.

Notes: Restricted-range bird species are those having a global range size less than or equal to 50,000 km^2. 'Significant population': it is recommended that site-level populations of at least two restricted-range species should be equal to or exceed 1% of their global population. This criterion can be applied to species both within their breeding and non-breeding ranges.

A3. Biome-restricted species

Criterion: The site is known or thought to hold a significant component of the group of species whose distributions are largely or wholly confined to one biome-realm.

Notes: Bioregion-restricted assemblages are groups of species with largely shared distributions which occur (breed) mostly or entirely within all or part of a particular bioregion. Bioregions are defined by the WWF classification of biome-realms. Many biome-realms hold large numbers of species restricted to them, often across a variety of different habitat types; networks of sites must be chosen to ensure, as far as possible, adequate representation of all relevant species. In data-poor areas, knowledge of the quality and representativeness of the habitat types within sites alongside incomplete knowledge of the presence of bioregion-restricted species can be used to inform site selection. Under 'significant component' it is recommended to use 30% of the number of bioregion-restricted species within a biome-realm within a country or five bioregion-restricted species, whichever is greatest.

A4. Congregations

Criterion: The site is known or thought to hold congregations of ≥1% of the global population of one or more species on a regular or predictable basis.

Notes: Sites can qualify whether thresholds are exceeded simultaneously or cumulatively, within a limited period. In this way, the criterion covers situations where a rapid turnover of birds takes place (including, for example, for migratory land birds).

Annex 3: The Ramsar Sites Criteria

The nine criteria for identifying Wetlands of International Importance; https://www.ramsar.org

Group A of the Criteria. Sites containing representative, rare or unique wetland types

Criterion 1: A wetland should be considered internationally important if it contains a representative, rare, or unique example of a natural or near-natural wetland type found within the appropriate biogeographic region.

Group B of the Criteria. Sites of international importance for conserving biological diversity

Criteria based on species and ecological communities

Criterion 2: A wetland should be considered internationally important if it supports vulnerable, endangered, or critically endangered species or threatened ecological communities.

Criterion 3: A wetland should be considered internationally important if it supports populations of plant and/or animal species important for maintaining the biological diversity of a particular biogeographic region.

Criterion 4: A wetland should be considered internationally important if it supports plant and/or animal species at a critical stage in their life cycles, or provides refuge during adverse conditions.

Specific criteria based on waterbirds

Criterion 5: A wetland should be considered internationally important if it regularly supports 20,000 or more waterbirds.

Criterion 6: A wetland should be considered internationally important if it regularly supports 1% of the individuals in a population of one species or subspecies of waterbird.

Specific criteria based on fish

Criterion 7: A wetland should be considered internationally important if it supports a significant proportion of indigenous fish subspecies, species or families, life-history stages, species interactions and/or populations that are representative of wetland benefits and/or values and thereby contributes to global biological diversity.

Criterion 8: A wetland should be considered internationally important if it is an important source of food for fishes, spawning ground, nursery and/or migration path on which fish stocks, either within the wetland or elsewhere, depend.

Specific criteria based on other taxa

Criterion 9: A wetland should be considered internationally important if it regularly supports 1% of the individuals in a population of one species or subspecies of wetland-dependent non-avian animal species.

Annex 4: Guidelines for managing avian influenza in seabird colonies

Avian influenza is an infectious disease caused by type A influenza viruses, classified as low pathogenic (LPAI) or highly pathogenic (HPAI); HPAI H5N1 was first identified in domestic poultry in 1996. AI viruses are transmitted via direct contact with an infected bird or indirectly via close exposure to contaminated materials; persistence in the environment depends on moisture, temperature and salinity (Dodman & Boere 2010). HPAI may be transmitted between regions or continents via trade in live poultry or by migratory wild birds.

As many seabirds are congregatory or breed colonially, they are particularly vulnerable to disease spread, so it is important to follow proper management procedures. Various guidelines are available, especially within the poultry sector, where good biosecurity measures are essential. Bregnballe *et al.* (2023) developed mitigation and data collection strategies for avian influenza in wild bird colonies in the Wadden Sea, related to cases of HPAI in Sandwich Terns *Thalasseus sandvicensis* in 2022. These have been used as the basis for the following short guidelines for seabird colonies in West Africa.

Guidelines to minimise entry of HPAI into seabird colonies and to reduce transmission within colonies, based on Bregnballe *et al.* (2023)

1. Prevention. Personnel entering a breeding colony should be trained in the proper use and disposal of Personal Protective Equipment (PPE, e.g., disposable overalls, masks and rubber gloves, rubber boots, safety goggles), and should follow established precautions and safety measures. Clean and disinfect footwear and all equipment used when entering or leaving each colony or sub-colony; clean by spraying with disinfectant solution until it runs off.

2. Early detection and monitoring. Monitor active breeding colonies to detect the presence of sick or dead birds (e.g., physical visits, live cameras, drones). Photos are helpful for later descriptions. Monitor mortality rates to determine when measures may be stopped to minimise disturbance. Note the presence of other bird species within or in the vicinity of a breeding colony.

3. Sick bird surveillance. Note the location of sick birds with clear clinical signs of HPAI for removal of potential carcasses the following day and to monitor disease development.

4. Detection of HPAI. Be familiar with HPAI clinical signs, which include closed/watery eyes, lethargy, loss of balance, head/body tremors, drooping wings and twisting of head and neck.

5. Carcass removal. Remove fresh carcasses from active and potential breeding colonies regularly (every day, or as often as possible), especially in early stages of an outbreak. Areas where carcass are removed may be treated with salt to reduce viral load.

6. Carcass disposal. Keep dead birds in secure containers and ensure their proper and safe disposal or deep burial in collaboration with national veterinary authorities.

7. Testing. Test at least five carcasses of each species from each colony for AI. Trained personnel should take oropharyngeal and cloacal swab samples for analysis by a designated laboratory. Conduct rapid influenza virus tests if kits are available.

8. Communication. Share information on any confirmed and potential HPAI cases near breeding colonies immediately with site managers.

9. Environmental risks. Monitor freshwater ponds near colonies for their potential role in viral spread; remove carcasses from ponds and pond edges.

10. Alternative breeding sites. Colonial breeding seabirds may be actively attracted to alternative sites through social attraction methods (e.g., decoys, sounds).

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This handbook brings together tools and concepts for seabird conservation in West Africa, including their biology, their status in and an introduction to the region, current threats, conservation and monitoring and research. The handbook applies to the coastal zone and marine waters of Mauritania, Senegal, The Gambia, Guinea-Bissau, Guinea, Sierra Leone and Cabo Verde, with a particular focus on seabird breeding areas between Mauritania and Guinea-Bissau and in Cabo Verde. The handbook was written and compiled by field biologists, ornithologists and conservationists who would have liked this type of handbook to be available at the start of their conservation projects. The handbook is dedicated to naturalists, ornithologists, conservationists, decision makers, students and everyone else who loves nature, especially those working in West Africa.