East Atlantic Flyway assessment 2020

The status of coastal waterbird populations and their sites

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East Atlantic Flyway Assessment 2020

The status of coastal waterbird populations and their sites

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9. The Bijagós Archipelago: a key area for waterbirds of the East Atlantic Flyway

Mohamed Henriques, João R. Belo, Joãozinho Sá, Hamilton Monteiro, José A. Alves, Theunis Piersma, Tim Dodman & Marc van Roomen

Summary

The Bijagós Archipelago is a group of 88 islands and islets off the coast of Guinea-Bissau in W Africa. It is a site with an undisputable ecological value, recognized nationally by the implementation of three marine protected areas, and internationally by its classification as a Biosphere Reserve and Ramsar Site. Its relatively pristine ecosystem mostly arises from local community cultural traits that have limited the overexploitation of resources until recently. Among the diverse set of habitats, its extensive mangrove forests, totalling 524 km^2, cover c. 30% of the area of the archipelago, and provide crucial ecosystem services, including nursery for several fish species, safe roosting areas for waterbirds, and organic matter input to adjacent habitats. The Bijagós Archipelago also features ca. 450 km^2 of intertidal flats, among the largest in the world, which sustain highly diverse benthic communities. This site holds an important part of the regional populations of several waterbird species, especially migratory shorebirds. It is the third most important site on the East Atlantic Flyway for Palearctic migratory shorebirds during their non-breeding period, and second in Africa, after the Banc d'Arguin in Mauritania. Nevertheless, very steep declines in most shorebird species are being observed in the Bijagós Archipelago, in accordance with overall declines along the flyway, and in other important sites like the Banc d'Arguin. The reasons for these declines are not fully known. Conservation, research and monitoring efforts have been increasing in the area, in an attempt to gather baseline knowledge on different aspects of relevance to waterbirds, their habitats and the ecological processes they depend upon, ultimately aiming at protecting the extraordinary biodiversity value of the Bijagós Archipelago.

Resumé

L'archipel des Bijagós est un groupe de 88 îles et îlots au large de la Guinée-Bissau, en Afrique de l'Ouest. C'est un site dont la valeur écologique est indiscutable, reconnue au niveau national par la mise en place de trois aires marines protégées, et au niveau international par son classement en tant que réserve de biosphère et site Ramsar. Son écosystème relativement vierge résulte principalement des traits culturels des communautés locales qui ont limité la surexploitation des ressources jusqu'à récemment. Parmi les divers habitats, ses vastes forêts de mangroves, d'une superficie totale de 524 km2, couvrent environ 30 % de la superficie de l'archipel et fournissent des services écosystémiques cruciaux, notamment des nurseries pour plusieurs espèces de poissons, des aires de repos sûres pour les oiseaux aquatiques et un apport en matière organique aux habitats adjacents. L'archipel des Bijagós compte également environ 450 km2 de plaines intertidales, parmi les plus grandes du monde, qui abritent des communautés benthiques très diverses. Ce site abrite une part importante des populations régionales de plusieurs espèces d'oiseaux d'eau, notamment les limicoles migrateurs. C'est le troisième site le plus important sur la voie de migration de l'Atlantique Est pour les limicoles migrateurs du Paléarctique pendant la saison de non-reproduction, et le deuxième en Afrique, après le Banc d'Arguin en Mauritanie. Néanmoins, des déclins très marqués de la plupart des espèces d'oiseaux limicoles sont observés dans l'archipel des Bijagós, conformément aux déclins généraux le long de la voie de migration, et dans d'autres sites importants comme le Banc d'Arguin. Les raisons de ces déclins ne sont pas entièrement connues. Les efforts de conservation, de recherche et de suivi se sont multipliés dans la région, afin de rassembler des connaissances de base sur différents aspects concernant les oiseaux d'eau, leurs habitats et les processus écologiques dont ils dépendent, dans le but ultime de protéger l'extraordinaire valeur de biodiversité de l'archipel des Bijagós.

9.1 The Bijagós Archipelago

The Bijagós Archipelago, off the coast of Guinea-Bissau in W Africa, is composed of 88 islands and islets with very low human presence (Fig. 9.1). This archipelago has a triangular shape, typical of estuarine delta archipelagos (Pennober 1999). The tide regime is semi-diurnal, with spring tides reaching amplitudes of 4.5 m (Campredon & Catry 2017). The Bijagós Archipelago comprises a relatively diverse range of habitats, including a set of wetland ecosystems: channels and shallow reefs, intertidal flats, and mangroves, which are ubiquitous there and cover as much as 30% of its surface area (Cardoso 2017, Temudo & Cabral 2017). This mosaic of habitats support high levels of biodiversity, including internationally important populations of Green Turtle *Chelonia mydas* (Barbosa *et al.* 2018, Catry *et al.* 2010), Timneh Parrot *Psittacus timneh* (Lopes *et al.* 2018, 2019), African Manatee *Trichechus senegalensis* (Silva & Araujo 2001), and Atlantic Humpbacked Dolphin *Sousa teuszii* (van Waerebeek *et al.* 2004). There are

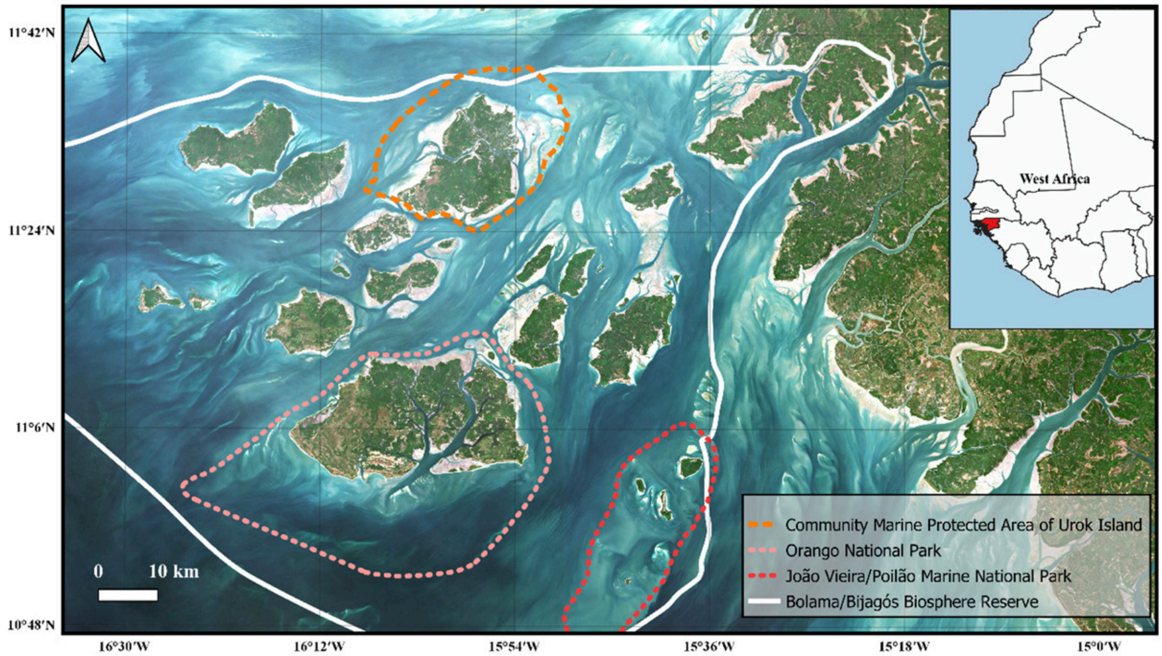

Figure 9.1. Satellite image of a low-tide moment (tide height: 1.04 m) in the Bijagós Archipelago, Guinea-Bissau. The limits of the Biosphere Reserve and of the three marine protected areas are represented in the map. Satellite image (taken 21 November 2019) from Copernicus' Sentinel-2B, courtesy of the European Space Agency.

also important sites for colonial breeding waterbirds (Birdlife International 2013, Zwarts *et al.* 2009) and the second most important assemblage of wintering shorebirds in W Africa (Delany *et al.* 2009, Dodman & Sá 2005, Salvig *et al.* 1997, 1994, Zwarts 1988). The undisputable ecological value of this site led to its recognition as a Biosphere Reserve by UNESCO in 1996 (Biai 2015), followed by classification as an Important Bird & Biodiversity Area (IBA) in 2001. Three marine protected areas (MPAs) of different management levels have been established within the Bijagós: Orango National Park, João Vieira and Poilão Marine National Park, and the Marine Community Protected Area of the Islands of Formosa, Nago & Chediã (Urok) (Biai *et al.* 2003, Daniel Suleimane Embalo *et al.* 2008, Embalo *et al.* 2008, INEP 2006, Fig. 9.1). In 2014, in recognition of the importance of the Bijagós Archipelago for numerous wetlands values, including waterbirds, it was also designated as a Ramsar Site (Campredon & Catry 2017). An application for an inscription of the archipelago as a World Heritage Site is currently under preparation.

9.2 The Importance of the Bijagós Archipelago for Waterbirds

Key ecological features

There are several ecological features that likely contribute to the large numbers of waterbirds found in the Bijagós Archipelago. The ecosystem in this archipelago is considered to still be relatively pristine, mostly as a result of the local community cultural traits, whose beliefs include animist-based religious regulations that have kept the resources and the environment from being overexploited until recently (Campredon *et al.* 2010, Campredon & Catry 2017, Maretti 2015, Rachid *et al.* 2011). Moreover, there is no large-scale industry and coastal development, whilst hardly any infrastructure has thus far been built. There are still low levels of pollutants in the environment (Catry *et al.* 2021, 2017, Coelho *et al.* 2016, Mullié 2017). Tourism is underdeveloped, with low long-term visible impacts on the environment (Polet 2011). Fishing areas around the MPAs are only used by the local communities, for local consumption. All these features combined result in quite small levels of human disturbance in this area.

The Bijagós Archipelago constitutes a relatively productive system, with high levels of organic matter, but presents low levels of chlorophyll due to relatively low nutrient content in the water (Campredon & Catry 2017). This is partly compensated by the fact that this archipelago is situated south of a large upwelling zone, benefiting also from the seasonal influence of upwellings linked to the Canary currents during the dry season, from small-scale coastal upwellings formed through trade winds and contributions of organic matter from continental run-off (Campredon & Catry 2017, Pennober 1999). The extensive mangrove forests occupy 524 km^2 (Temudo & Cabral 2017) and constitute a very productive ecosystem that may play an important role for intertidal invertebrates, on which several shorebird species rely for food.

A recent study by Henriques *et al.* (2021) assessed the role of mangrove forests as a direct carbon source to benthic macroinvertebrates living in adjacent intertidal flats of the Bijagós Archipelago. While no overall evidence of a direct contribution to several groups of benthic invertebrates was found, a significantly higher contribution of mangrove carbon to the sediment organic matter of intertidal flats adjacent to mangrove forest was detected, when compared to intertidal flats without mangrove. However, mangrove carbon was present only in benthic macroinvertebrates within the first 50 m from the mangrove edge, with this contribution fading away rapidly with increasing distance. The authors suggested that the contribution of mangrove forests to the productivity of intertidal flats could occur mostly indirectly, with mangrove organic matter being transformed in nutrients like inorganic carbon and processed nitrogen (through mineralization), which may then be assimilated by other primary producers (like algae) and fuel intertidal food webs.

Complementary to this, Meijer *et al.* (2021) also assessed the importance of mangrove forests to benthic macroinvertebrates in the Bijagós Archipelago, but taking a landscape-scale approach and comparing the benthic macroinvertebrate community composition and abundance between tidal basins with different levels of connectivity to mangroves. They found that the configuration and types of mangrove basin had a significant effect on the structure and composition of the benthic macroinvertebrate community. In fact, intertidal flats with higher influence of mangrove forests (larger mangrove areas) had higher levels of organic matter and suspended materials, and consequently also had richer and more abundant benthic macroinvertebrate communities. These ecological processes at the base of the food webs contribute to the productivity of this system, creating a set of specific features that are important for waterbirds.

The Bijagós Archipelago features one of the very large intertidal flats worldwide, estimated at over 450 km2 (Henriques *et al.* unpublished data; Hill *et al.* 2021), where shorebirds find vast foraging areas. Within these intertidal flats there is a very high diversity of benthic macroinvertebrate prey (contrasting with low abundances) when compared to temperate intertidal flats, which in turn results in competition avoidance due to low overlap between the trophic niches of the different shorebird species (Catry *et al.* 2016, Hickey *et al.* 2015, Lourenço *et al.* 2017, Lourenço *et al.* 2018, Piersma *et al.* 1993). This has a structuring effect on the community of shorebirds along the different areas of the intertidal flats of the Bijagós Archipelago, promoting habitat partitioning. An extreme example of this effect is the case of the widespread West African Fiddler Crab *Afruca tangeri*, a known ecosystem engineer in intertidal flats. Areas colonized by this crab constitute a very different sub-habitat for shorebirds and their prey (Fig. 9.2), presenting significantly lower biomass of all other

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Figure 9.2. Intertidal flats in the bay of Adonga, Orango National Park, Bijagós Archipelago.

Species	1986/87 1992/93	2014 - 2020	
		mean	s.d.
Flamingos, Pelicans and Herons			
Greater Flamingo *Phoenicopterus roseus**	2,438	550	130
Pink-backed Pelican *Pelecanus rufescens***	N/A	1,300	110
Great Cormorant *Phalacrocorax carbo*	N/A	400	70
Western Reef Heron *Egretta gularis*	1,800	1,500	390
Western Cattle Heron *Bubulcus ibis**	50,000	130	50
Black Heron *Egretta ardesiaca**	2,200	20	10
Gulls and Terns			
Grey-headed Gull *Larus cirrocephalus***	170	600	370
Slender-billed Gull *Chroicocephalus genei*	N/A	400	110
Gull-billed Tern *Gelochelidon nilotica*	10,130	7,600	5,350
Caspian Tern *Hydroprogne caspia*	1,456	4,600	1,830
Sandwich Tern *Thalasseus sandvicensis*	2.952	10,000	3,650
Royal Tern *Thalasseus maximus*	2,078	4,200	1,630
Lesser Crested Tern *Thalasseus bengalensis*	384	500	310
Common Tern *Sterna hirundo*	5,988	12,000	8,150
Little Tern *Sternula albifrons*	6,348	5,700	2,000
Black Tern *Chlidonias niger*	4,295	3,200	4,300
Palearctic migratory shorebirds			
Common Ringed Plover *Charadrius hiaticula*	26,300	17,000	3,600
Kentish Plover *Charadrius alexandrinus*	5,000	600	270
Grey Plover *Pluvialis squatarola*	39,100	9,900	1,350
Red Knot *Calidris canutus*	31,300	38,000	22,000
Sanderling *Calidris alba*	24,300	20,000	6,000
Curlew Sandpiper *Calidris ferruginea*	326,500	59,000	27,900
Bar-Tailed Godwit *Limosa lapponica*	108,700	56,000	28,600
Eurasian Whimbrel *Numenius phaeopus*	22,000	23,000	3,280
Eurasian Curlew *Numenius arquata**	9,300	3,400	1,000
Common Redshank *Tringa totanus*	2,920	17,000	3,270
Common Greenshank *Tringa nebularia*	1,400	1,700	540
Ruddy Turnstone *Arenaria interpres*	7,900	2,300	610
Little Stint *Calidris minuta**	59,700	1,600	1,550

Table 9.1. List of waterbird species for which the estimated number of individuals based on several counts conducted during the non-breeding period meets the Ramsar Convention's 1% criterion. 1% thresholds were calculated from the Waterbird Population Estimates 5th Edition for the estimates of 1986/87-1992/93 (Wetlands International 2012), and from the Agreement on African-Eurasian Migratory Waterbirds Conservation Status Report (AEWA CSR8) for the 2020 estimates, both available at wpe.wetlands.org. Data for 1986/87-1992/93 were retrieved from Dodman & Sá 2005. Data for 2014-2020 are means and standard deviation of three estimates based on sample counts in January 2014, 2017 and 2020 (GPC/IBAP/WSFI unpublished data, see van Roomen *et al.* 2021 for details of the counts and extrapolation) . * Species for which estimates in 2020 would not qualify for the Ramsar 1% criterion. ** Species for which estimates in 1986/87-1992/93 did not qualify for the Ramsar 1% criterion, but that currently qualify based on the estimate for 2020.

Species	Year	N breeding pairs
African Sacred Ibis *Threskiornis aethiopicus*	1994	742
African Spoonbill *Platalea alba**	1992	1,000
Black-crowned Night-heron *Nycticorax nycticorax*	1994	168
Squacco Heron *Ardeola ralloides*	1994	318
Green-backed Heron *Butorides striata**	1994	513
Cattle Egret *Bubulcus ibis*	1994	270
Great White Egret *Ardea alba**	1994	925
Little Egret *Egretta garzetta*	1994	553
Western Reef-egret *Egretta gularis**	1994	870
Grey-headed Gull *Larus cirrocephalus**	1994	800
Caspian Tern *Hydroprogne caspia**	1987	300
	1997	594*
	2019	259
Royal Tern *Thalasseus maximus**	1994	1,867*
	2015	335
	2019	475

Table 9.2. List of notable waterbird species breeding in the Bijagós Archipelago with estimates of the number of breeding pairs. Data from Dodman & Sá 2005, Folmer *et al.* 2019 and Veen *et al.* 2004, 2015. * Species for which the number of breeding pairs has qualified for Ramsar 1% criterion. When estimates for more than one year are given, * marks the estimate that qualified for Ramsar 1% criterion.

benthic macroinvertebrates than areas without fiddler crabs (Paulino *et al.* 2021, Zwarts 1988). On the other hand, fiddler crabs themselves are key prey for many shorebird species in the Bijagós Archipelago (Carneiro *et al.* 2021, Lourenço *et al.* 2017, Zwarts 1985). This results in very different shorebird species assemblages between these two sub-habitats (Paulino *et al.* 2021, Zwarts 1988).

The availability of many undisturbed high-tide roost locations and resting places for waterbirds, within dense mangrove forests, on open and vast beaches or around elevated sand banks, is another important trait of the Bijagós Archipelago. Here, as elsewhere, shorebirds have been noted to display high fidelity to foraging areas (NIOZ & University of Aveiro, unpublished data; Bom *et al.* 2020; www.globalflywaynetwork.org), and therefore the availability of suitable roosting sites in the vicinity of their foraging grounds will be advantageous. Shorebird feeding patterns also depend on the balance between the availability of food resources and energetic requirements. During the non-breeding season, it is expected that species specific diet and the trophic network will vary across different periods (wintering and migration) accompanying shorebird's energetic demands (Carneiro *et al.* 2021). For instance, just before migrating northwards to their breeding grounds, shorebirds need to fuel up and either increase their prey intake rate and/or shift their diet to more energetically profitable prey, in order to store fat for their long migration. However, this is only possible if the wintering areas provide adequate conditions. In the Bijagós Archipelago, preliminary results of ongoing studies indicate that prey availability and size increase from the northern winter to the fuelling period, and the main consumed prey becomes increasingly important throughout the fuelling period (Coelho *et al.* unpublished data). Thus, the demanding energetic requirements of shorebirds in order to fuel up for migration seems to be met by the productivity of the intertidal flats of the Bijagós Archipelago.

The Bijagós Archipelago also has an abundant and diverse small pelagic fish community (Campredon & Cuq 2001; Correia *et al.* 2017). This is important for several piscivorous waterbirds, particularly terns, which are very efficient fish predators and represent the bulk of the seabird numbers along the W African coasts (Correia *et al.* 2018, Veen *et al.* 2004).

Waterbird populations

Waterbirds in the Bijagós Archipelago comprise about 105 species, totalling 37% of the 287 bird species reported for this IBA (Carneiro *et al.* 2017, Dodman *et al.* 2004, Dodman & Sá 2005). This includes 53 Afrotropical resident species (from 18 families) and 50 Palearctic and intra-African migrants (from 19 families). Because of their numerical importance at the Bijagós Archipelago, most attention is given to Palearctic (migratory) shorebirds, which may spend more than half of their year in the Bijagós (Dodman & Sá 2005, Frikke *et al.* 2002, van de Kam *et al.* 2004). Also important are the populations of terns and gulls, with over 33,000 terns estimated in the Bijagós Archipelago in 1992/1993 (Salvig *et al.* 1997 in Dodman & Sá, 2005).

From an international importance perspective, many sites in the Bijagós Archipelago counted during the northern winter between 1986/87 and 1992/93 have been found to meet the Ramsar Convention's 1% criterion (Ramsar Convention 2014, criterium A6). This was the case for 12 shorebird species, eight species of terns, two species of gulls, three species of herons and the Greater Flamingo *Phoenicopterus roseus* (Dodman *et al.* 2004; Table 9.1). Likewise, breeding estimates obtained in the 1990s revealed Ramsar designating numbers for several of these species (Dodman *et al.* 2004, Veen *et al.* 2015; Table 9.2).

More recent estimates of numbers of non-breeding birds conducted during the northern winter, in 2014, 2017 and 2020, highlighted contrasting numbers for some Ramsar-triggering species when compared to the 1986/87-1992/93 period, with those of species like Greater Flamingo, Little Stint *Calidris minuta* and Eurasian Curlew *Numenius arquata* no longer qualifying for the Ramsar 1% criterion (Table 9.1). On the other hand, new estimates for two additional species in 2020 are considered to meet the criterion, for Pink-backed Pelican *Pelecanus rufescens* and Grey-headed Gull *Larus cirrocephalus*. Despite these changes, recent data undoubtedly supports the claims of the Bijagós Archipelago holding one of the very important waterbird assemblages in the world (van de Kam *et al.* 2004).

9.3 Colonial breeding waterbirds

Several colonial breeding waterbird species occur in the Bijagós Archipelago, distributed across a large range among the islands. These include herons and egrets, African Sacred Ibis *Threskiornis aethiopicus*, African Spoonbill *Platalea alba* and several species of gulls and terns (Table 9.2).

Terns are among the most abundant in W Africa, and have been the focus of studies, especially Caspian Tern *Hydroprogne caspia* and Royal Tern *Thalasseus maximus*, which present quite large breeding populations in near shore islands of Guinea-Bissau and (at least in the past) in the Bijagós Archipelago (Fig. 9.3). Waterbird counts conducted in the 1990s by Altenburg *et al.* (1992), Quade (1994), Schmanns *et al.* (1997) and Brenninkmeier *et al.* (1998), summarized in Dodman & Sá 2005, reported internationally important breeding colonies of these two species. Outside

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Figure 9.3. Caspian Tern breeding colony on the sand islet of Acapa-Imbone, in Orango National Park, Bijagós Archipelago.

Year	Period of count	Areas covered	Area covered (%)	Count method	Estimation method	Global estimate	Literature source
1982-1983 1986-1987	December-February	Bubaque, Bolama, Bijagós	25	In situ low-tide counts	Density extrapolation	699,120	Poorter & Zwarts 1984 Zwarts 1988
1992-1993	October-May	16 areas in 14 islands	64	In situ low-tide counts	Density extrapolation	710,000	Salvig et al. 1994
1994	December	Full coverage	54	Aerial survey & ground counts	Detection Rate	750,000	Salvig et al. 1997
1994 1995 1997	February-November April-September January-March	Bubaque, Soga	N/A	In situ low-tide counts	Total count	15,000*	Salvig et al. 1997
2001	January-February	44 areas in 18 islands	64	In situ low-tide counts	Density extrapolation	871,750	Frikke et al. 2002 Dodman & Sá 2005
2009	May, July September, December	9 counts in 2 marine protected areas	N/A	In situ low-tide counts	Total count	23,241*	Monteiro 2011
2010	August, October, December	9 counts in 2 marine protected areas	N/A	In situ low-tide counts	Total count	31,092*	Monteiro 2011
2011	August, October, December	9 counts in 2 marine protected areas	N/A	In situ low-tide counts	Total count	17,979*	Monteiro 2011
2014	January	56 sample plots in all Bijagós	69	In situ low-tide counts	Density extrapolation & total count	352,000	van Roomen et al. 2015
2017	January	77 sample plots in all Bijagós	14	In situ low-tide counts	Density extrapolation	231,000	Sa & Regalla 2017
2020	January	62 sample plots in all Bijagós	14	In situ low tide-counts	Density extrapolation	193,000	Sá et al. 2020

Table 9.3. Summary of historical and recent shorebird counts conducted in the Bijagós Archipelago, with distinction between count method, areas covered, estimation method and the source of information. * Counts did not produce a global estimate.

the breeding season, terns, and specifically Royal Terns, are known to disperse along the W African coast from Morocco in the north to Namibia in the south (Veen *et al.* 2015). During the northern winter months, numbers of terns fluctuate markedly due to the arrival of non-breeding birds from other parts of W Africa and from the Northern hemisphere (Brenninkmeijer *et al.* 2002, van Roomen *et al.* 2015, Veen *et al.* 2015). Little is known on Caspian Tern movements within the Bijagós Archipelago or in the region.

Caspian and Royal Tern populations have been increasing in W Africa over the past 20 years (van Roomen *et al.* 2015). However, these trends are to be interpreted with caution, as data are scarce and few studies have been conducted on these species across the region, especially away from their main breeding sites.

9.4 Migratory shorebirds

The Bijagós Archipelago receives annually large numbers of shorebirds of Palearctic breeding origins during their non-breeding period (Alves *et al.* 2021, Dodman & Sá 2005, Zwarts 1988) and it is among the most important wintering sites along the East Atlantic Flyway (EAF) (Delany *et al.* 2009). Shorebird species assemblages are diverse in the Bijagós Archipelago, with the counts conducted during the non-breeding period typically yielding 16 to 19 migratory species. These birds spend the high tide essentially hidden inside the mangrove forests, and are only visible during the low tide, while foraging on the intertidal flats. The extensive nature of these flats makes it challenging to conduct counts and assess the total numbers of shorebirds using them (Fig. 9.4). After trying a number of different approaches, the best results appear to have been

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Figure 9.4. Palearctic migratory shorebirds feeding on intertidal flats partially covered by fiddler crab burrows, in the Bay of Adonga, Orango National Park, Bijagós Archipelago.

obtained by determining shorebird densities during low tide at a number of smaller sampling sites distributed across the entire area, and then extrapolating based on the total surface of available feeding habitat (Zwarts 1988; see Table 9.3). Results so far suggest a rather low density of foraging shorebirds, especially when compared to the numbers and densities in the Banc d'Arguin (Lourenço *et al.* 2016, van de Kam *et al.* 2004, Wolff *et al.* 1993, Zwarts 1988). This may be related to several factors, including a lower density of prey items, but this is currently unknown.

Some studies have unveiled a markedly low density of benthic invertebrates on which shorebirds feed on in the Bijagós Archipelago (Larénie & Anne-Laure 2009, Pedro M. Lourenço *et al.* 2018, Zwarts 1988), which may be structuring the distribution patterns observed in wintering shorebirds. As shorebird prey items are distributed in low densities across the mudflats of the archipelago, shorebirds may also follow these patterns, occurring in low densities during low tide (Lourenço *et al.* 2017). Nonetheless, previous shorebird counts have shown important low tide densities in the intertidal flats around the islands of Bubaque and Soga, as well as in the mudflats around Orango National Park and the Community Marine Protected Area of Urok - two of the three MPAs of the Biosphere Reserve (Dodman *et al.* 2004, Dodman & Sá 2005, Monteiro 2011). Recent ongoing studies have unveiled marked spatial variations in the density and biomass of benthic macroinvertebrates throughout the Bijagós Archipelago's intertidal flats (Coelho *et al.* unpublished data), which may be a process driving differential distributions of shorebird species according to their preferred prey type.

Overview of historical and current counts

Over the last four decades there have been several counts aiming at estimating the total shorebird numbers in the Bijagós Archipelago. The first population estimates were produced in 1982-83 (Zwarts & Poorter 1984 in Dodman & Sá 2005), but only in 1986-87 was the low-tide density extrapolation method established (Zwarts 1988). Since then, two other complete estimates were produced with this method, in 1992 (Salvig *et al.* 1994) and in 2001 (Frikke *et al.* (2002) in Dodman & Sá 2005), with counts using different methods or targeting smaller areas of the Bijagós Archipelago also taking place (Table 9.3). In 2014, 2017 and 2020, total complete estimates based on sample counts were again obtained in the framework of the Wadden Sea Flyway Initiative, Wetlands International and BirdLife International cooperation as a contribution to the International Waterbird Census (IWC; Agblonon *et al.* 2017, van Roomen *et al.* 2020, van Roomen *et al.* 2015). An overview of the data available from historical and recent counts is presented in Table 9.3.

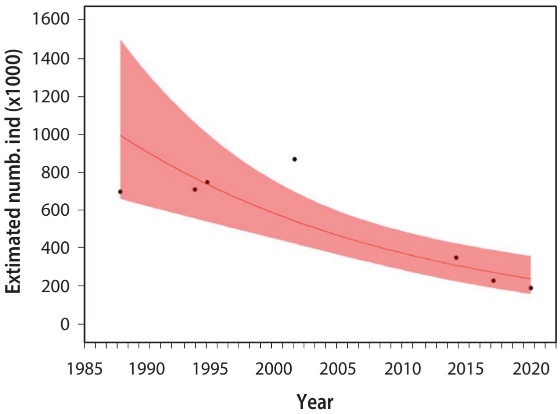

Figure 9.5. Estimates (represented by black dots) of the total number of migratory shorebirds spending the non-breeding period at the Bijagós Archipelago in 1987, 1993, 1994, 2001, 2014, 2017 and 2020 (estimated using different methods, see Table 9.3). Data retrieved from Zwarts *et al.* (1988), Salvig *et al.* (1994, 1997), Frikke *et al.* (2002) and GPC/IBAP/WSFI unpublished data (2014, 2017, 2020, see Van Roomen *et al.* 2021). The trend line was fitted using a generalized linear model with negative binomial distribution and log link. The coloured area around the line represents the 95% confidence interval. The analysis shows a significant decline over time (P <0.001).

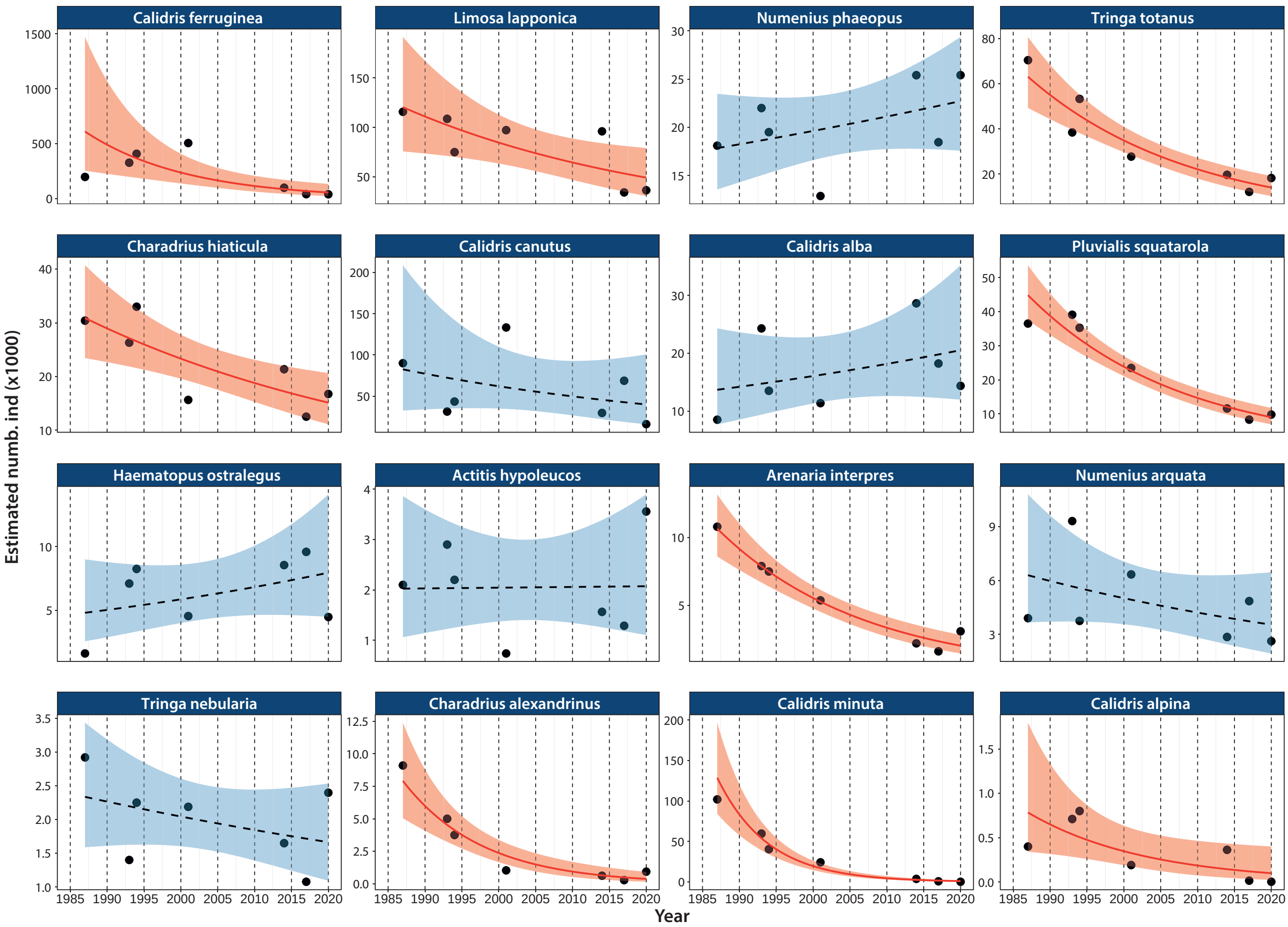

Figure 9.6. Estimates (represented by black circles) of the number of individuals for 16 migratory shorebird species spending the non-breeding period at the Bijagós Archipelago in 1987, 1993, 1994, 2001, 2014, 2017 and 2020 (estimated using different methods, see Table 9.3). Data retrieved from Zwarts *et al.* (1988), Salvig *et al.* (1994, 1997), Frikke *et al.* (2002) and GPC/IBAP/WSFI unpublished data (2014, 2017, 2020, see Van Roomen *et al.* 2021). Graphs are organized in decreasing order from the most abundant species in 2020 (left to right in each row). Trend lines were fitted using generalized linear models with negative binomial distribution and log link. Shaded areas around the line represent the 95% confidence interval. Solid lines and red shading represent species declining significantly; dashed lines and grey shading represent species with non-significant declines or increases ($P \geq 0.05$).

Figure 9.7. Shellfish collecting in the intertidal flats of the island of Bubaque, the most populated of the Bijagós Archipelago, Guinea-Bissau. (photo:).

Current population estimates and trends

During the 2020 IWC for Guinea-Bissau, more than 31,000 shorebirds were counted in the sampling area of the Bijagós Archipelago (Sá *et al.* 2020). Estimates of the total number of wintering shorebirds were produced, indicating that about 193,000 migratory shorebirds were using the Bijagós Archipelago in 2020 (van Roomen *et al.* 2021). Previous IWC counts for this area in 2014 and 2017 yielded total estimates of 352,000 and 231,000 respectively. These numbers are strikingly low when compared with the estimates in the 1980s and 1990s for the same sampling area (800,000 – 900,000), highlighting the steep declines observed in this important area (Fig. 9.5). These trends partly agree with those established for the EAF populations, revealing decreases in some Arctic breeding shorebird species (van Roomen *et al.* 2018), and with the declines reported for Banc d'Arguin in Mauritania (Oudman *et al.* 2020). However, some trends appear to be more specific to the Bijagós Archipelago.

At the species level most of the 16 species assessed here presented notable declines, and half of them presented statistically significant negative trends (Fig. 9.6). There was a striking decrease in the number of Curlew Sandpipers *Calidris ferruginea* from 2001 through to 2020, by about 75%. A similar pattern was observed for Little Stint *Calidris minuta*, which decreased by more than half from the 2001 count, and by more than 85% from the first estimate of 1986-87. Other previously abundant species like Grey Plover *Pluvialis squatarola*, Bar-tailed Godwit *Limosa lapponica*, Common Redshank *Tringa totanus* and Ruddy Turnstone *Arenaria interpres* also presented very steep declines. Red Knot *Calidris canutus*, Common Greenshank *Tringa nebularia* and Eurasian Curlew *Numenius arquata* have also decreased, although not statistically significantly. By contrast, there was an apparent increase in Eurasian Whimbrel *Numenius phaeopus*, Sanderling *Calidris alba* and Eurasian Oystercatcher *Haematopus ostralegus* (Fig. 9.6). These data are to be interpreted with caution due however to the difficulties inherent to the survey methods, particularly related to potential errors in estimating the proportion of the area counted by each observer among years and uneven distribution of shorebirds across the mudflat areas of the archipelago. The analysis presented here should therefore be regarded as preliminary. More sophisticated analyses are needed to establish whether the trends are as worrying as we now think they are, and to describe and explore ecological correlates at local and flyway levels.

9.5. Anthropogenic pressures on waterbirds

There are currently very few studies that address the anthropogenic pressures to waterbirds in the Bijagós

Archipelago, and more information is urgently needed. Based upon the on-ground experience, it is fair to consider that anthropogenic pressures within the archipelago appear to be of lower magnitude when compared, for instance, to threats faced by Palearctic migratory waterbirds further north in their distribution range in Europe, due to relatively low levels of human disturbance in the Bijagós Archipelago. However, we highlight here some of the potential threats that must be considered.

Recently, the governments of Guinea-Bissau and Senegal signed a protocol aiming to start oil exploitation within the shared marine areas of both countries (Brownfield & Charpentier 2003). Oil exploitation impacts go beyond the area of effective extraction and may affect ecosystems and biodiversity around it (UNEP-WCMC *et al.* 2007). In this case, oil spills may affect marine and intertidal ecosystems within the Bijagós Archipelago, resulting in the accumulation of hydrocarbons in the sediment and in the marine and intertidal food web. As high-level consumers, waterbirds will be the final recipient of a chain of bioaccumulation, which ultimately may affect their survival and breeding success.

The ancient practices and culture of the Bijagós communities have been responsible for the regulation of access to natural resources, promoting the sustainable use of marine resources (Biai *et al.* 2003, Campredon *et al.* 2010, Rachid *et al.* 2011). However, increasing global interactions are promoting the growth of international trade and exchange of cultural ideas, and Guinea-Bissau and the Bijagós islands are no exception. People are prone to adjust their ways of living, particularly younger generations eager to experience the westernised culture globalised through the media and the internet, which can lead to the substitution of traditional and sustainable use of natural resources for more unstainable practices. For instance, the overexploitation of a shellfish, the Bloody Cockle *Senilia senilis*, by local communities in the intertidal flats of the Island of Bubaque has recently been reported (Fig. 9.7). The main driver behind this is the high demand of Senegalese markets for this type of resource (P. Campredon pers. comm).

Despite its slow growth rate and despite having the potential to be the most beneficial activity in promoting both the development of local communities and the conservation of their natural environment, poorly managed and unregulated tourism may also present a serious potential threat to waterbirds and their habitats in the Bijagós Archipelago. When inadequately planned, tourism may alter the land use among the islands, and ultimately result in habitat loss and degradation, in addition to increased pollution and disturbance levels (especially when considering that sport fishing with fast and noisy boats is among the most explored touristic interests), which may also negatively affect waterbird populations (Davenport & Davenport 2006, Polet 2011). Moreover, because the conservation and protection of the unique ecological traits of waterbird habitats in this archipelago has been promoted by the ancient rules of the local culture (Maretti 2015), unregulated tourism also has the potential to disturb the fragile balance of the cultural structure of the Bijagós communities, jeopardising many centuries of community-based conservation (Ozorio & Lima 2019).

Global warming and human induced climate change may constitute the major threats within the Bijagós. Global warming is accelerating the rate of sea level rise, which negatively affects the availability of foraging habitat for shorebirds (Lourenço *et al.* 2013, Piersma & Lindström 2004, van de Kam *et al.* 2004, Zwarts *et al.* 2009). The mudflats and sandbanks of the Bijagós Archipelago require particular attention as these areas have low elevation and almost no coastal slope (Granadeiro *et al.* 2021). The sea level is predicted to rise by up to 20 cm at the coastline of Guinea-Bissau by 2050 (Republic of Guinea-Bissau 2018), which may have significant impacts on the intertidal area extent and on the distribution of benthic macroinvertebrate prey (Beninger 2018).

The impact of fisheries on waterbirds and on marine and intertidal food webs is difficult to measure and little knowledge is currently available on this topic in the Bijagós Archipelago. Nevertheless, fishing practices are shifting towards more intensive activity, especially for export pur-

Left: **Afonso Rocha**
centre: **Pedro Lourenço**
right: **Mohamed Henriques**

Figure 9.8. Participatory research in the Bijagós Archipelago, Guinea-Bissau.


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Caspian Terns | **Sterne caspienne** *(Hydroprogne caspia),* **Black-headed Gulls** | **Mouette rieuse** *(Chroicocephalus ridibundus)* & **Common Terns** | **Sterne pierregarin** *(Sterna hirundo)*

poses by migrant fishermen from neighbouring countries or through Asian and European large industrial fishing boats (Campredon & Catry 2017, Campredon & Cuq 2001, Diop & Dossa 2011). Such activities place increasing pressure on the Bijagós Archipelago marine and intertidal ecosystems (Leurs *et al.* 2021), having led to a clear reduction in the abundance of top predators like sharks and rays including the W African Sawfish *Pristis pristis*, so important to the Bijagós culture as an emblem animal, which had not been observed for a long time until recently (Leeney & Poncelet 2015). These changes can have top-down effects over entire food webs, affecting waterbirds and their prey. Moreover, the establishment of several temporary fishing camps by foreign fishermen has resulted in the cutting down of parts of mangrove forests to smoke fish, weakening coastal protection against erosion. More studies are required to assess the extent to which these apparently less relevant threats may affect waterbirds in the future.

9.6. Research, conservation and management in the Bijagós Archipelago

Conservation actions aimed at waterbirds in the Bijagós Archipelago have been going on since the 1980s. Several national and international organisations have worked together with local communities to create the MPA network in the Bijagós, comprising the Marine National Parks of João Vieira and Poilão, Orango National Park and the Community MPA of Urok. These have been the strongest conservation points in the archipelago through a long-term implementation of a set of conservation measures and regulation of access and use of marine resources, together with local communities. The success of these MPAs in conserving both natural resources, including areas used by waterbirds, and the local culture and identity, which is an important part of the conservation of the Bijagós Archipelago's ecological traits, is deserving of international recognition (Ramsar Convention 2012, UNDP 2019). The management of these protected areas and the implementation of conservation and monitoring activities have been maintained through the combined efforts of public institutions, like the Institute of Biodiversity and Protected Areas of Guinea-Bissau (IBAP), the National Institute for Research (INEP), and the Applied Fishing Research Centre (CIPA), with national and international NGOs, like Tiniguena - Esta Terra É Nossa!, Palmeirinha, ODZH, Noé Conservation and CBD Habitat Foundation, and several international universities.

More recently, IBAP, with the support of the MAVA Foundation, developed several projects in collaboration with European universities and research institutes, under a wide framework termed *Waders of the Bijagós: Securing* *the ecological integrity of the Bijagós Archipelago as a key site for waders along the EAF*. Shorebirds have been the focus of one of these large research projects, in which intertidal ecosystems of the Bijagós are being studied. This important international project has already produced multiple results such as the filling of knowledge gaps on shorebird ecology in the archipelago and on the way that shorebirds actively 'connect' the Bijagós with other parts of the world (Alves *et al.* 2021, Belo 2019, Bom *et al.* 2020, 2021, Carneiro *et al.* 2021, Catry *et al.* 2021, Henriques *et al.* 2021, Pedro Miguel Lourenço *et al.* 2018, Mathijssen 2020, Meijer *et al.* 2021, Parente 2020, Paulino *et al.* 2021) and on key factors regarding the hydrology and intertidal sediment (e.g. Granadeiro *et al.* 2021), as well as raising awareness and training of local community members.

Before this large project, other research initiatives, led by researchers from the University of Lisbon, had already started to address some of the key research questions, with important findings being published (Catry *et al.* 2017, 2016, Coelho *et al.* 2016, Lourenço *et al.* 2017, Lourenço *et al.* 2017, Lourenço *et al.* 2018). Another MAVA Foundation funded project entitled *La recherche participative au service de la conservation de la biodiversité du Parc National Marin de João Vieira-Poilão (Archipel des Bijagós)*, led by IBAP and ISPA from Portugal, had also achieved high success, with many key publications concerning terns, coastal fish and predator prey interactions (Carneiro *et al.* 2017, Correia *et al.* 2021, 2019, 2018, 2017, Correia 2018). It is of utmost importance that the ecological research results are used together with the monitoring efforts deployed during the IWC to strengthen and inform conservation, while it is also vital that efforts be made to secure the collection of relevant data on the long-term. The world is changing fast and the only way to try to cope is to know what is ecologically changing and why. Monitoring programmes for mangroves, intertidal flats, benthos, fish and birds need to be combined with focussed research that includes local participation (Fig. 9.7), so that knowledge, work, training and outreach go hand in hand. Research, monitoring and conservation are the three pillars on which simultaneous investments must be made to support the protection of sites of unique ecological value, like the Bijagós Archipelago.

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Ruddy Turnstones | **Tournepierre à collier** *(Arenaria interpres)* & **Grey Plovers** | **Pluvier argenté** *(Pluvialis squatarola)*