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## GTA Ecological Vulnerability Analysis.

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Front cover: Scopoli's shearwaters *Calonectris diomedea* (Kees Camphuysen)

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## Major data collections underlying the present analysis

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# Seabirds and other charismatic megafauna in offshore habitats off NW Africa

## 1. Introduction

The unique biodiversity and the significance as a stop-over, foraging and wintering area of NW Africa's offshore waters for seabirds originating from both hemispheres in a constantly changing, almost fluid species composition is beyond dispute. This is a compilation of data collected during dedicated, systematic seabirds at sea surveys: research cruises conducted between 1988 and 2022, mostly off Mauritania. The resulting database was used to list the species recorded, describe their spatio-temporal distribution patterns and relative abundance, characterise their foraging habitats and species interactions, assess their sensitivity to developments associated with the Greater Tortue Ahmeyim (GTA) project and to contribute to the development of mitigation plans. During these ship-based surveys, several species were recorded that had not been listed for the region previously, and numerous species were found to be considerably more numerous than assumed, using only coastal observations (e.g. Isenman *et al.* 2000, Browne 2000).

Mauritanian waters are part of the Canary Current Eastern Boundary Upwelling Ecosystem; one of only four such ecosystems in the World (California, Humboldt, Benguela and Canary currents; Chavez & Messié 2009). In Mauritania, most pelagic fish is captured along the shelf break - a narrow stretch of sea measuring 50 to 250 km wide, with demersal fisheries concentrated within the Neritic zone. The shelf break is formed by a steep drop off with a slope of 2.5 to 6° which starts at 70 km from the coast, except in the Northern part were the continental shelf is at is widest (150 km; Ramos *et al.* 2017). When the trade winds blow the surface waters away from the coast, cold and nutrient rich waters from deep in the ocean are drawn to the surface along this drop off. Intense tropical sunlight together with the influx of nutriments from the deep, provides perfect conditions for localized blooms of plankton – the foundation of highly productive food webs.

Seabirds and cetaceans are important indicator species to map (productive) pelagic hotspots. The productive shelf seas are targeted since the 1960, with increased intensity, by commercial fisheries. The local artisanal fleet uses relatively small but numerous vessels (pirogues and small vessels) and occupy mostly the nearshore coastal waters of the continental shelf. Many seabirds are seen in association with fishing vessels, but the ecological importance of these fishing activities for seabirds is not always obvious and requires careful observations in situ. During the research cruises used for the present analysis, natural foraging assemblages (and natural foraging habitats) were strictly separated from fishery induced foraging opportunities. The avifauna off Western Africa in the Northern Hemisphere winter is usually dominated by surface feeding and shallow plunge diving, plankton feeding and piscivorous seabirds, many of which are wintering birds originating from West Palaearctic breeding in the arctic, subarctic and temperate zone. In the Southern Hemisphere winter, seabirds from sub Antarctic and Antarctic waters gain importance, while regional seabirds (Macaronesian, African, or Mediterranean in origin) occur in variable numbers throughout the annual cycle.

Results from published tracking studies and some unpublished seabird-tracking data were used to put the results from ship-based surveys into a wider context and perspective. Satellite remote-sensing and wildlife tracking allow researchers to record rapidly increasing volumes of information on the spatial ecology of marine megafauna in the context of global change (Grémillet *et al.* 2022). In part this is a promise for the near future, and we suffer still from a bias towards larger species within the species spectrum as a whole. Note also that some trackings studies (using GPS loggers, satellite tags) provide highly detailed positional data, whereas others (geolocators) provide information with wide margins of error (Rakhimberdiev *et al.* 2016). In addition, the analysis of at-sea activity patterns in terms of actual foraging and feeding opportunities is still a hard nut to crack and all sorts of proxies may be used to interpret the data in ecological terms, usually without ground-truthing. Tracking studies typically show tracks of (sometimes few) individuals and rarely species interactions other than 'coincidental co-occurrences' that may, or may not, point at ecologically important bird areas. Ship-based surveys, essential to study wildlife in situ and with all their inter- and intraspecific interactions in a natural environment, require observers and are conducted only during hours of daylight. By bringing tracking data under the same umbrella with community studies conducted in the area itself, the chances we would miss areas that are genuinely important for seabirds as feeding grounds will become smaller. Co-occurrences with other charismatic megafauna (notably with cetaceans) are an important part of that mission.

## 2. Temporal distribution of survey data

The data from systematic ship-based surveys used here span the years 1986 to 2022, although the bulk were recorded during 2004 to 2022 (**Table 1**). Four quarters of the year were surveyed, but with a seasonal bias towards the Northern Hemisphere mid-summer (Jun-Jul). In the following species accounts, numbers of sightings and cumulative counts of individual animals have been scaled by effort to generate encounter rates such as sightings per unit distance ($n$ km$^{-1}$), or densities ($n$ km$^{-2}$), in order to evaluate spatial and temporal patterns in the relative abundance of species observed. Densities are based on sightings within the 300m strip transect that was continuously operated during virtually all surveys, using 10- or 5minute counting bins. Numbers of sightings or animals per unit distance are based on the 180° scan forward of the survey vessels, irrespective of distance (Tasker *et al.* 1984, Camphuysen *et al.* 2004). However, it should always be borne in mind that such statistics are less reliable when calculated for periods or areas of low effort. In 2000, a coding system was adopted that allowed specific coding of associations of birds and marine mammals with habitat aspects, multi-species (feeding) associations and a variety of behaviour types, with emphasis on feeding behaviour and foraging interactions (Camphuysen & Garthe 2004).

## 3. Spatial distribution of data

The location of all effort held in the project database, as 5- or 10-min observation bins, is plotted in **Figure 1.** Effort has been concentrated in Mauritanian shelf-waters and recent cruises were all systematic and repeated crossings of the shelf-break, travelling perpendicular from the Neritic zone and into the Oceanic zone or vice versa. Little survey effort has been applied in shallower, shelf waters as seabird surveys were confined to deeper habitats. Spatial coverage of the GTA project area is excellent for as far of Mauritanian waters are concerned.

# 4. Observer effort and analysis of the distribution data

All animals recorded 'in transect' (i.e. on or in contact with water within the 300m wide strip aside and ahead of the vessel, or in flight within the snap-shot; see Tasker *et al.* 1985) were used to assess densities ($n$ km$^{-2}$). By default, own-ship-attracted birds were excluded from transect counts, but large accumulations of seabirds assembled around nearby fishing vessels could sometimes, locally, lead to spectacularly high densities, enhancing spatial variability. The observer effort (km$^2$) has been summarised for 10'x10' rectangles, each with a surface area of *c.* 343 km$^2$ (18.5x18.5 km; **Fig. 2**), to provide a spatial pattern in observed densities. For most species, the combined dataset is too small to enough to warrant a more refined spatial analysis using for example kriging techniques and a single method was preferred over different approaches between species.

**Table 1**. Observer effort (latitudinal and longitudinal range, area (km$^2$), distance (km), and hours surveyed) using internationally standardised methods[1] for ship-based surveys off NW Africa, 1986-2022.

| **Observer effort per year** | | | | | | | | | | | | | **Count** | **Obs** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Latitudinal range** | | | | **Longitudinal range** | | | | **Area** | | **Distance** | | **Units** | **hours** |
| 1986 | 24.1288 | - | 24.6879 | °N | -18.5056 | - | -18.0105 | °W | 21.9 | km$^2$ | 73.1 | km | 10 | 3.7 |
| 1988 | 19.3337 | - | 24.1747 | °N | -17.8889 | - | -16.6067 | °W | 338.2 | km$^2$ | 1127.4 | km | 10 | 62.7 |
| 2000 | 14.6014 | - | 24.8110 | °N | -18.2145 | - | -16.2731 | °W | 229.0 | km$^2$ | 763.1 | km | 10 | 44.7 |
| 2003 | 17.5020 | - | 17.9844 | °N | -16.8374 | - | -16.0383 | °W | 296.8 | km$^2$ | 989.2 | km | 5 | 90.0 |
| 2004 | 16.1670 | - | 24.9875 | °N | -17.8489 | - | -16.0598 | °W | 462.7 | km$^2$ | 2658.5 | km | 10 | 138.8 |
| 2012 | 17.8744 | - | 20.8914 | °N | -18.2885 | - | -16.3286 | °W | 340.6 | km$^2$ | 1135.3 | km | 5 | 76.8 |
| 2015 | 16.1673 | - | 20.5021 | °N | -18.2460 | - | -16.3287 | °W | 540.6 | km$^2$ | 1802.1 | km | 5 | 123.2 |
| 2016 | 16.4550 | - | 20.6025 | °N | -18.1147 | - | -16.2555 | °W | 484.7 | km$^2$ | 1615.7 | km | 5 | 111.7 |
| 2018 | 16.4162 | - | 20.5015 | °N | -18.1602 | - | -16.1276 | °W | 414.5 | km$^2$ | 1381.6 | km | 5 | 85.7 |
| 2022 | 16.1990 | - | 25.2010 | °N | -18.1670 | - | -16.1740 | °W | 704.8 | km$^2$ | 2351.5 | km | 5 | 138.9 |
| | 14.6014 | | 25.2010 | °N | -18.5056 | | -16.0383 | °W | 3833.8 | km$^2$ | 13897.5 | km | | 876.0 |

| **Observer effort per month** | | | | | | | | | | | | | | **Count** | **Obs** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Q** | **month** | **Latitudinal range** | | | | **Longitudinal range** | | | | **Area** | | **Distance** | | **Units** | **hours** |
| 1 | JAN | 14.6014 | - | 24.8110 | °N | -18.5056 | - | -16.2731 | °W | 251.0 | km$^2$ | 836.2 | km | 10 | 48.3 |
| 1 | FEB | 16.1990 | - | 25.2010 | °N | -18.1670 | - | -16.1740 | °W | 661.8 | km$^2$ | 2208.0 | km | 5 | 130.3 |
| 1 | MAR | 17.5020 | - | 20.2630 | °N | -17.8530 | - | -16.0383 | °W | 339.8 | km$^2$ | 1132.7 | km | 5 | 98.7 |
| 2 | APR | 16.1670 | - | 24.9833 | °N | -17.8489 | - | -16.0598 | °W | 462.7 | km$^2$ | 2268.9 | km | 10 | 119.0 |
| 2 | MAY | 19.3337 | - | 24.9875 | °N | -17.8889 | - | -16.6067 | °W | 338.2 | km$^2$ | 1517.0 | km | 10 | 82.5 |
| 3 | AUG | 16.4162 | - | 20.5015 | °N | -18.1602 | - | -16.1276 | °W | 414.5 | km$^2$ | 1381.6 | km | 5 | 85.7 |
| 3 | SEP | 16.1673 | - | 20.5021 | °N | -18.2460 | - | -16.3287 | °W | 540.6 | km$^2$ | 1802.1 | km | 5 | 123.2 |
| 4 | NOV | 16.4550 | - | 20.8886 | °N | -18.2885 | - | -16.2555 | °W | 569.3 | km$^2$ | 1897.8 | km | 5 | 130.8 |
| 4 | DEC | 17.8744 | - | 20.8914 | °N | -17.7487 | - | -16.3286 | °W | 256.0 | km$^2$ | 853.2 | km | 5 | 57.7 |
| | | 14.6014 | | 25.2010 | °N | -18.5056 | | -16.0383 | °W | 3833.8 | km$^2$ | 13897.5 | km | | 876.0 |

[1] International standardisation was achieved in the early 1980s for oil- and gas-exploration/exploitation related studies of seabird distribution at sea (Tasker *et al.* 1984), and was subsequently adopted and refined for the UK Crown Estate in the early 21st century, to include impact assessments related to infrastructure developed to exploit renewable energy at sea (Camphuysen *et al.* 2004).

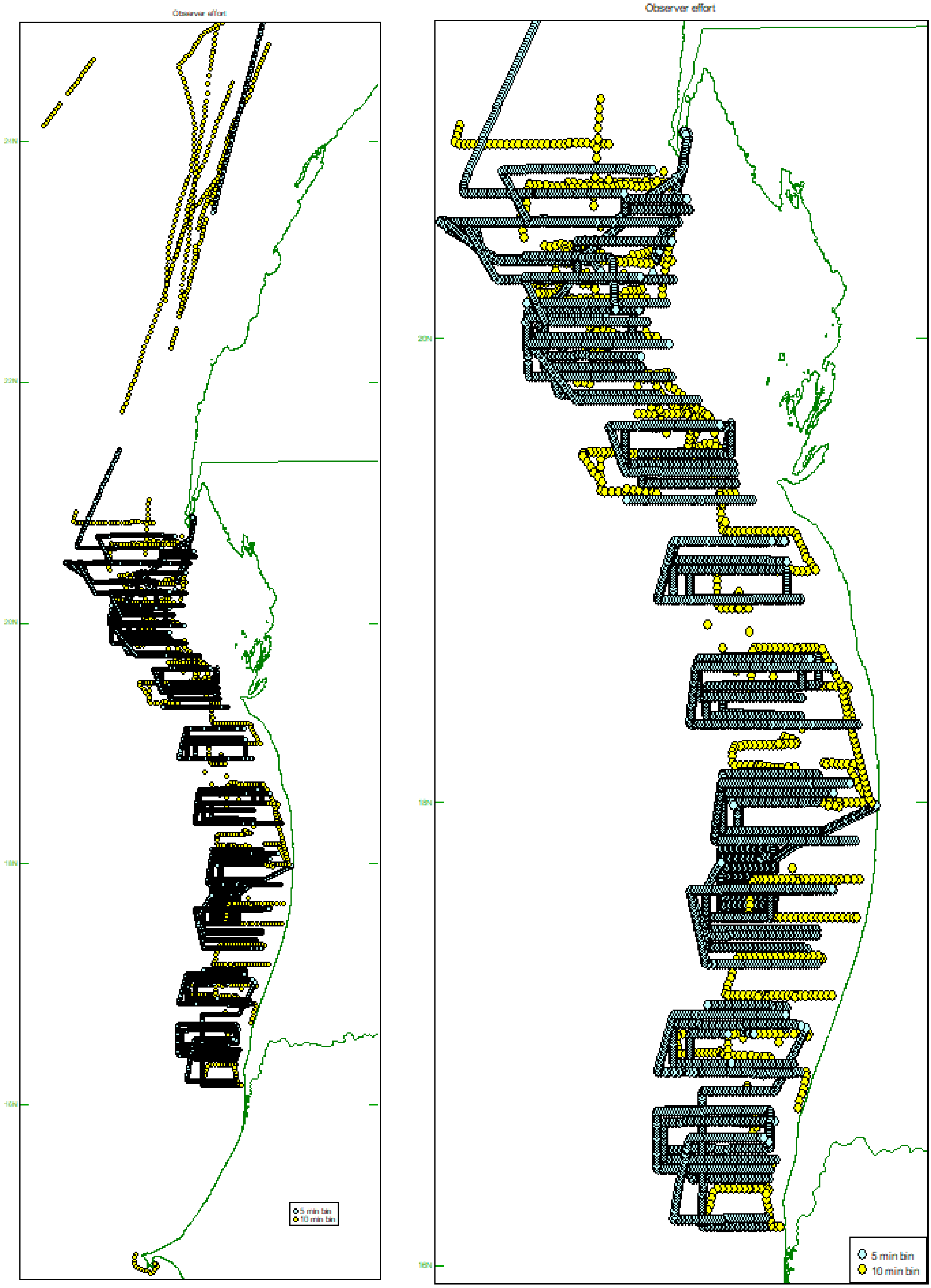


**Figure 1.** Systematic ship-based surveys used for this overview (left overview, right Mauritanian waters) plotted as individual bins of observation of either 5, or 10-min in length.

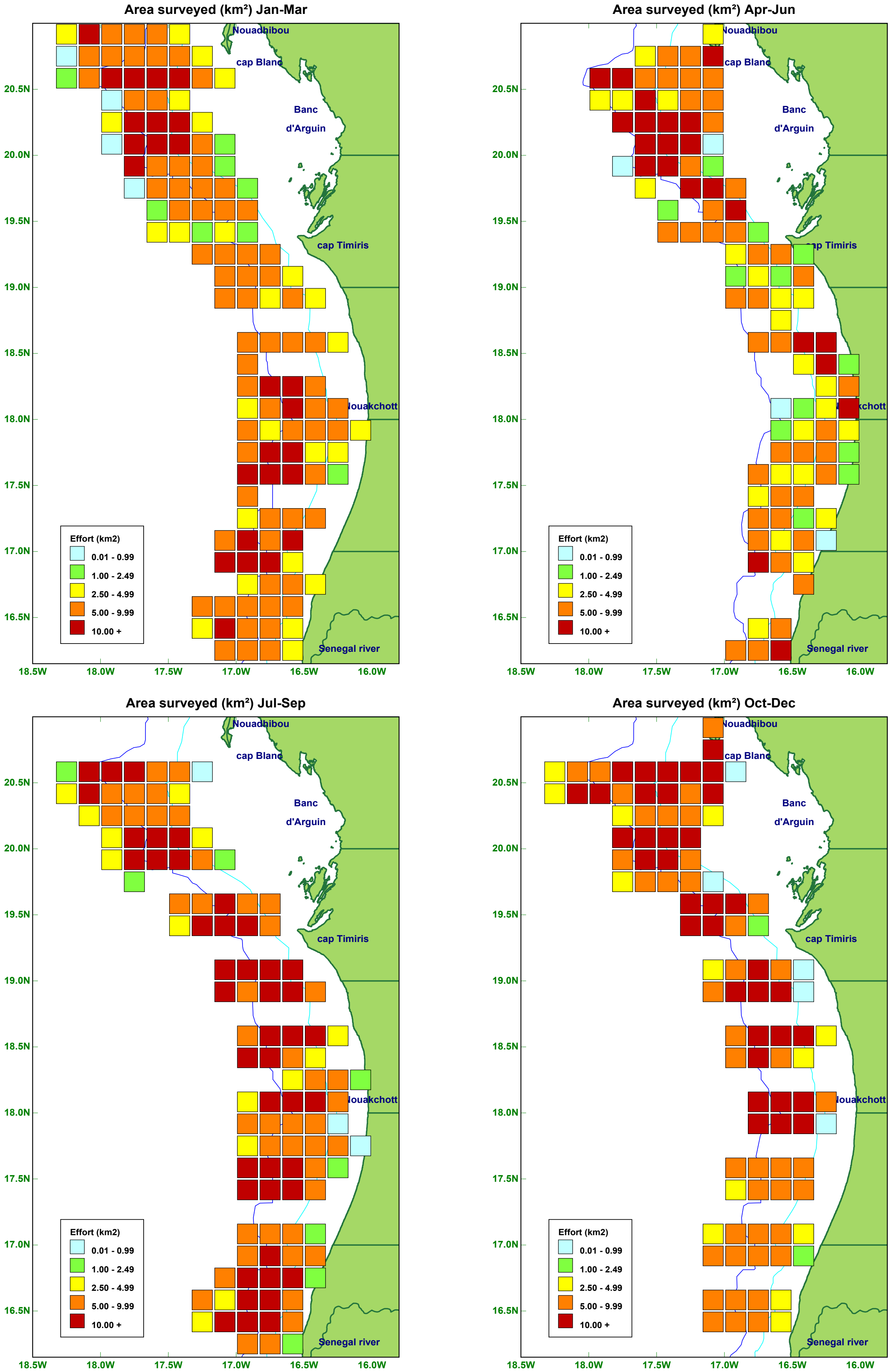


**Figure 2.** Observer effort per quarter, expressed as area surveyed (km²) per 10’x10’ rectangle, in Mauritanian waters, based on 300m strip-transects during ship-based surveys, 1986-2022 (*cf.* **Table 1**).

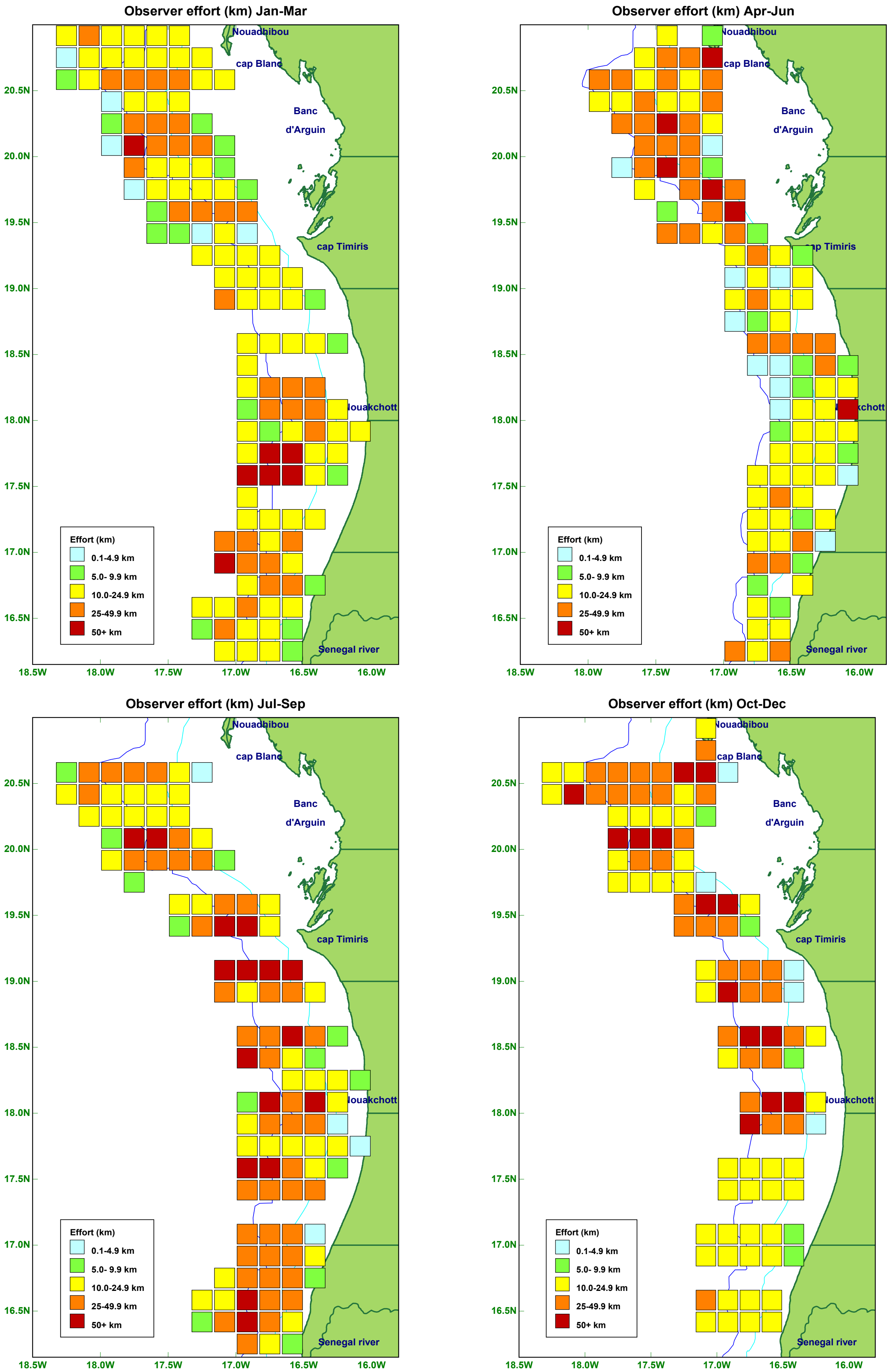


**Figure 3.** Observer effort per quarter, expressed as distance steamed (km) per 10’x10’ rectangle, in Mauritanian waters, based on 180° ahead scans during ship-based surveys, 1986-2022 (*cf.* **Table 1**).

## 5. Underlying data and mechanisms explaining spatial distribution patterns at sea

All data was collected during systematic ship-based surveys using internationally standardised protocols. A total of 48 seabird species, 25 cetaceans, one pinniped, 5 sea turtles, 3 sharks, one ray and several (large) fish species are represented in the database. In the field, some seabirds are difficult to identify to species level and the distinction between several *Calonectris* sheawaters and *Hydrobates* storm petrels or some of the smaller terns *Sterna* is particularly challenging in the field. On top of that, taxonomic conventions have changed such that what were formerly considered as single species is, in some cases, currently regarded as groups of 3-4 sister species (as in what were formerly considered Cory's Shearwater *Calonectris diomedea* with subspecies and even in the monotypic Madeiran Storm-Petrel *Oceanodroma castro*; Cramp & Simmons 1977). Where it was not always possible to identify animals to species level, a generic grouping has been assigned.

The sightings in the project database, based on cumulative counts of individual members of each species, are listed in Table 2, expressed as count rates per 100km of observer effort (180° scan forward of the research vessel). Note that as approximate indices of relative abundance, these sightings rates are biased by the response of certain species to the vessels used as observation platforms. Ship-attracted as well as ship-avoiding species were included in the analysis to generate Table 2. With most observer effort targeting the shelf-break and bordering pelagic and neritic waters, a narrow strip along the coast (termed 'nearshore waters' in this overview) plus the entire Banc d'Arguin National Park were not or only partially covered. For several resident colonial seabirds that means that at least part of their nearshore foraging range must have been missed during these surveys.

The importance of intertidal areas such as National Parc Banc d'Arguin, obviously of international importance for large numbers and many species of waders and other waterbirds, is both well-known and published elsewhere (Von Westernhagen 1970ab, Zwarts & Piersma 1990, Gowthorpe & Lamarche 1995, Campredon 2000, Shine *et al.* 2001, Isenmann 2007, Araujo & Campredon 2016). A large number of the breeding and wintering species are indeed strictly coastal, intertidal, or freshwater orientated in their foraging and roosting behaviour and these fall outside the scope of the current analysis that is based on ship-based cruises in offshore waters. Some novel information on coastal roost sites situated elsewhere along the Mauritanian coast, utilized by large numbers of gulls and terns, is included in this overview, however, because these roosts are less well known while they often hold species that travel regularly and en masse towards marine foraging grounds, nearshore, in the Neritic zone, around the shelf break or beyond.

The GTA gas development project is a technological challenge and involves producing vast volumes of gas in very deep water (~2700m depth), and moving that gas or condensate along >100 kilometres of flowlines to a modular floating LNG production system, or an offshore FPSO. The species accounts below focus entirely on offshore areas, which are generally much less well known in terms of biodiversity, but which are particularly at risk for accidental spills of hydrocarbons in the marine environment. Emphasis is on areas where several species occur together in high densities, where the biodiversity is above average, and especially where species not only co-occur but also interact while (apparently) foraging and feeding. An oil-sensitivity atlas is currently in preparation, in which species-specific Oil Vulnerability Indices (OVIs) are used to separate areas of lower and higher (oil-)sensitivity based on observed megafauna (*cf.* Camphuysen 2021). Data collected during ship-based surveys form the basis of this work, while the fairly recent, but rapidly growing body of publications reporting tracking studies are used to either confirm, or add on to, at-sea collected observer data that has accumulated over the years. Some key differences between these two rather different sets of data are: ship-based surveys are community studies, limited to daylight (visual observations), and depending on the presence of observers. Tracking studies are species-specific, sometimes suffering from small sample size (individual variability disrupting spatial patterns and time trends), but deliver 24/7 and are observer independent.

Distribution of seabirds at sea is not a random process. Seabird responses to environmental heterogeneity give for example strong circumstantial evidence for energy transfer beyond primary producers at fronts or at features of episodic upwelling (Haney 1986). Oceanographic fronts and upwelling areas are sites of enhanced physical and biological activity, leading to locally concentrated feeding by marine birds and other megafauna (Ashmole 1971, Boje & Tomczak 1978, Brown 1979, Ainley 1980, Haney & McGillivray 1985, Schneider 1990, Camphuysen & Van der Meer 2005). The Atlantic off NW Africa is characterised by trade winds induced upwelling of cold, nutrient rich waters (Helmke 2004). As one of the strongest Eastern Boundary Upwelling areas, it is characterised by low sea surface temperatures and high bio-production, both subject to strong seasonal and interannual variations. Satellite measurements of sea surface temperature (SST) can be used to recognise the upwelling of deep water and its mixing at the surface. Upwelling, defined as where the SST was 3.5K below an offshore reference temperature at the same latitude (1988-1999, 18°-25°N) showed maxima in January and May/June (Helmke 2004). Coastal upwelling is observed during the whole year around Cap Blanc (23-21°N). The meridional migration of the main upwelling centre follows the annual course of the belt of northeast trade winds, reaching its northernmost position in summer and its southernmost position in winter (Hagen 2001). Cold water upwellings support abundant and diverse faunas and as a result, the sea off Western Africa has been highlighted as an important area for seabirds (Cushing 1971, Brown 1979, Duffy 1989, Camphuysen & Van der Meer 2005).

Seabird prey patches also develop at fronts either through behavioural responses of prey to thermal or salinity gradients, or through interaction between prey behaviour and circulatory patterns (Le Fèvre 1986, Schneider 1990). Surface accumulations of foam, flotsam and seagrass at oceanographic fronts around the Mauritanian shelf-break characterised fronts utilised by seabirds better than salinity, temperature, density, or turbidity gradients measured during ship-based surveys (*cf.* Franks 1992, Witherington 2002). A commonly used alternative hypothesis, that enhanced primary production at fronts increases prey supply through increased animal growth, reproduction, or immigration, is much less supported (Schneider 1990).

The distribution of pelagic seabirds off the west coast of NW Africa (notably off Mauritania and Western Sahara; **Fig. 1**) is analysed according to trophic guilds. Piscivores and squid-eaters account for a large part of avian abundance and biomass, the remainder being planktivorous (phalaropes and storm-petrels, some smaller terns and jaegers) and omnivores (mostly large gulls, skuas). Intraguild competition for food is probably reduced by interspecific differences in foraging behaviour and habitat choice. Subsets of parameters for water masses correlate with seabird distribution, but local seabird distribution is primarily a function of the availability of food and the species' attributes for locating and capturing prey, whether or not facilitated by drivers such as predatory fish and marine mammals or not (Abrams & Griffiths 1981, Camphuysen & Webb 1999). Multi-species foraging assemblages (MSFAs) are prominent phenomena at the sea surface, providing seabirds with visual cues for food finding, but even more importantly, the differentiation of feeding methods deployed in MSFAs facilitate seabirds to reach prey that would otherwise be unavailable for them (Camphuysen & Webb 1999). The encircling of prey initiated by dolphins results in the formation of a compact 'ball' of prey fish close to the surface that attracts seabirds followed by a collective food hunt (Clua & Grosvalet 2001). Similarly, flocks of seabirds accompanying surface-schooling tunas are characteristic of tropical seas (Au & Pitman 1988). During our surveys, the relationships between seabirds, tuna, and cetaceans were studied to assess how the organisation of, and interactions within, the apex pelagic community might depend upon forage and foraging tactics of the underwater fauna.

In the species accounts below, all marine species and waterbirds observed during the systematic surveys are listed and discussed; as species groups or as individual species and by systematic order. Seabirds and waterbirds with a strongly marine orientation that were not encountered during surveys, but that are known to occur at least occasionally within the NW African coastal and offshore region, are included in the accounts and evaluated based on accessible, published sources. Common species and species groups are mapped to illustrate spatial and temporal patterns in occurrence within and around the GTA region. Throughout, emphasis is not on individual birds or single species but on ecological guilds, foraging habitats, and species interactions, thereby including interactions or associations with other megafauna and interactions with commercial or artisanal fisheries that might help explain the importance of some areas over others. So, important marine bird areas are not specifically areas where high numbers of birds occur of a certain IUCN conservation status (for example only amber or red-listed species), but areas where seabird communities at large rely on for their foraging activities, for resting, where they interact with marine mammals, or for any other relevant aspect of their life history while at sea.

Seabirds and cetaceans are useful indicator species to map (productive) pelagic hotspots. Cetaceans, pinnipeds, sea turtles and other non-avian species within the spectrum of charismatic megafauna are not reviewed here in any detail, but are considered within the context of multi-species foraging assemblages, driving, or at least potentially influencing seabird distribution at sea. Similarly, associations of marine fauna around visible fronts, with commercial or artisanal fisheries are included as a further explanatory factors driving or influencing the presence of absence of marine birds at sea. Records were assigned to dept contours when that info was collected, or to the three key depth zones: Neritic zone (from land up to 200m depth), Shelf-break zone (200-1000m depth) and Oceanic zone (>800m depth) based on locations if depth soundings were unavailable. Patterns in species diversity are assessed using the Shannon-Weiner Species Diversity Index (H'), or the proportion of each species of the total number of individuals $100\text{km}^{-1}$. The formula is as follows:

$$H' = -\sum_{i=1}^{s} p_i \ln p_i$$

where $s$ is the number of species, and $p_i$ is the proportion of individuals of each species belonging to the $i^{th}$ species of the total number of individuals.

**Table 2.** Species of seabirds and other charismatic megafauna represented in the project database, with sighting rates per 100km of observer effort in the 180° forward scan as indices of relative abundance, based on ship-based transects 1986-2022, 14-25°N, 16-19°W (**Table 1**).

| | | **Relative abundance** (*n*/100km) | | | | |
|---|---|---|---|---|---|---|
| **Marine birds** | | **Jan-Mar** | **Apr-Jun** | **Jul-Sep** | **Oct-Dec** | |
| Northern Fulmar | *Fulmarus glacialis* | 0.0 | 0.0 | 0.0 | 0.0 | Subarctic |
| Fea's Petrel | *Pterodroma feae* | 0.0 | 0.0 | 0.0 | 0.0 | Macaronesian |
| Bulwer's Petrel | *Bulweria bulwerii* | 0.0 | 0.0 | 0.6 | 0.0 | Macaronesian |
| Scopoli's Shearwater | *Calonectris diomedea* | 4.8 | 8.9 | 0.1 | 1.8 | Mediterranean |
| Scopoli's/Corys shearwater | *Calonectris spp.* | 2.3 | 13.6 | 11.6 | 54.8 | Macaron. /Mediterr. |
| Cory's Shearwater | *Calonectris borealis* | 26.0 | 0.4 | 0.9 | 257.7 | Macaronesian |
| Cape Verde Shearwater | *Calonectris edwardsii* | 0.0 | 0.0 | 33.5 | 21.4 | Macaronesian |
| Great Shearwater | *Ardenna gravis* | 0.0 | 0.0 | 2.2 | 3.4 | Subantarctic |
| Sooty Shearwater | *Ardenna grisea* | 0.1 | 0.7 | 0.8 | 4.4 | Subantarctic |
| Manx Shearwater | *Puffinus puffinus* | 0.2 | 0.1 | 1.2 | 0.3 | N Temperate |
| Balearic Shearwater | *Puffinus mauretanicus* | 0.0 | 0.1 | 0.0 | 0.1 | Mediterranean |
| Macaronesian Shearwater | *Puffinus baroli* | 0.0 | 0.0 | 0.1 | 0.0 | Macaronesian |
| Wilson's Storm-petrel | *Oceanites oceanicus* | 8.8 | 407.8 | 334.2 | 17.3 | Antarctic |
| White-faced Storm-petrel | *Pelagodroma marina* | 0.0 | 0.0 | 0.1 | 0.1 | Macaronesian |
| European Storm Petrel | *Hydrobates pelagicus* | 127.6 | 66.2 | 0.3 | 259.5 | N Temperate/Medit. |
| Leach's Storm Petrel | *Hydrobates leucorhoa* | 10.0 | 0.0 | 1.5 | 50.0 | N Temperate |
| unidentified storm-petrel | *Hydrobates/Oceanitus* | 6.0 | 8.4 | 0.0 | 0.5 | |
| Swinhoe's Storm Petrel | *Hydrobates monorhis* | 0.0 | 0.0 | 0.1 | 0.0 | |
| Band-rumped Storm Petrel | *Hydrobates castro* | 2.4 | 0.5 | 0.3 | 19.6 | Macaronesian |
| Red-billed Tropicbird | *Phaethon aethereus* | 0.0 | 0.0 | 0.0 | 0.0 | Tropical |
| Northern Gannet | *Morus bassanus* | 695.6 | 47.8 | 0.0 | 1165.3 | N Temperate |
| White-breasted Cormorant | *Phalacrocorax lucidus* | 2.9 | 0.1 | 0.0 | 0.0 | NW African |
| Great White Pelican | *Pelecanus onocrotalus* | 0.0 | 2.1 | 0.7 | 0.2 | NW African |
| Red Phalarope | *Phalaropus fulicarius* | 118.0 | 18.4 | 14.5 | 115.1 | Arctic |
| Pomarine Skua | *Stercorarius pomarinus* | 208.8 | 101.1 | 25.7 | 205.6 | Arctic |
| Parasitic Jaeger | *Stercorarius parasiticus* | 5.8 | 20.0 | 9.4 | 1.9 | N Temperate |
| Long-tailed Jaeger | *Stercorarius longicaudus* | 13.0 | 15.0 | 8.8 | 14.5 | Arctic |
| Great Skua | *Stercorarius skua* | 14.8 | 1.1 | 0.0 | 7.9 | N Temperate |
| unidentified skua | *Stercorarius spec.* | 1.9 | 0.1 | 0.0 | 0.0 | |
| South Polar Skua | *Stercorarius maccormicki* | 0.0 | 0.0 | 0.0 | 0.0 | Antarctic |
| Mediterranean Gull | *Ichthyaetus melanocephalus* | 0.0 | 0.0 | 0.0 | 0.1 | Mediterranean |
| Little Gull | *Hydrocoloeus minutus* | 0.0 | 0.0 | 0.0 | 0.1 | N Temperate |
| Sabine's Gull | *Xema sabini* | 0.5 | 235.0 | 4.8 | 8.2 | Arctic |
| Black-headed Gull | *Chroicocephalus ridibundus* | 5.4 | 0.0 | 0.0 | 0.4 | N Temperate |
| Slender-billed Gull | *Chroicocephalus genei* | 0.0 | 0.6 | 0.0 | 0.0 | Mediterranean |
| Audouin's Gull | *Ichthyaetus audouinii* | 0.2 | 0.1 | 0.0 | 0.5 | Mediterranean |
| Lesser Black-backed Gull | *Larus fuscus* | 208.9 | 49.8 | 0.7 | 55.9 | N Temperate |
| Yellow-legged Gull | *Larus michahellis* | 1.7 | 1.2 | 0.0 | 0.2 | Mediterranean |
| Black-legged Kittiwake | *Rissa tridactyla* | 8.2 | 0.0 | 0.0 | 0.4 | N Temperate |
| Gull-billed Tern | *Gelochelidon nilotica* | 0.0 | 0.1 | 0.0 | 0.0 | N Temperate |
| Caspian Tern | *Hydroprogne caspia* | 0.1 | 1.2 | 0.3 | 0.8 | NW African |
| Royal Tern | *Thalasseus maximus albidorsalis* | 7.2 | 49.1 | 17.8 | 5.9 | NW African |
| Lesser Crested Tern | *Thalasseus bengalensis* | 0.0 | 1.6 | 0.0 | 0.0 | Mediterranean |
| Sandwich Tern | *Thalasseus sandvicensis* | 37.3 | 28.4 | 9.5 | 20.5 | N Temperate |
| Roseate Tern | *Sterna dougallii* | 0.0 | 0.6 | 0.1 | 0.1 | N Temperate |
| Common Tern | *Sterna hirundo* | 46.2 | 95.4 | 198.8 | 125.8 | N Temperate |
| Arctic Tern | *Sterna paradisaea* | 6.0 | 15.1 | 0.0 | 0.1 | Subarctic/Arctic |
| Common / Arctic tern | *S. hirundo / S. paradisaea* | 3.9 | 583.7 | 0.1 | 1.2 | |
| Bridled Tern | *Onychoprion anaethetus* | 0.0 | 0.2 | 0.8 | 0.1 | NW African |
| Little Tern | *Sternula albifrons* | 0.0 | 0.1 | 0.0 | 0.0 | N Temperate |
| Whiskered Tern | *Chlidonias hybrida* | 0.0 | 0.0 | 0.0 | 0.1 | N Temperate |
| Black Tern | *Chlidonias niger* | 0.5 | 423.4 | 164.0 | 115.8 | N Temperate |
| unidentified tern | *Sterna spec.* | 11.4 | 3.9 | 0.0 | 0.0 | |

| Marine mammals and other megafauna species | | Relative abundance (*n*/100km) | | | | |
|---|---|---|---|---|---|---|
| | | Jan-Mar | Apr-Jun | Jul-Sep | Oct-Dec | |
| unidentified cetacean | | 0.0 | 0.1 | 0.0 | 0.0 | |
| unidentified whale | | 0.0 | 0.0 | 0.0 | 0.2 | |
| unidentified large whale | | 0.1 | 0.0 | 0.1 | 0.1 | |
| unidentified small whale | | 0.0 | 0.0 | 0.0 | 0.1 | |
| Blue / Fin Whale | Large *Balaenoptera sp.* | 0.3 | 0.1 | 0.0 | 0.1 | Long-distance migrant |
| Blue Whale | *Balaenoptera musculus* | 0.5 | 0.0 | 0.0 | 0.1 | Long-distance migrant |
| Fin Whale | *Balaenoptera physalus* | 0.7 | 0.0 | 0.0 | 0.4 | Long-distance migrant |
| Sei Whale | *Balaenoptera borealis* | 0.2 | 0.0 | 0.0 | 0.0 | Long-distance migrant |
| Bryde's Whale | *Balaenoptera edeni* | 0.0 | 0.0 | 0.0 | 0.1 | Tropical |
| Sei / Brydes Whale | Small *Balaenoptera sp.* | 0.0 | 0.0 | 0.0 | 0.1 | |
| Minke Whale | *Balaenoptera acutorostrata* | 0.0 | 0.0 | 0.0 | 0.0 | N Temperate |
| Humpback Whale | *Megaptera novaeangliae* | 0.1 | 0.0 | 0.2 | 0.1 | Long-distance migrant |
| Sperm Whale | *Physeter macrocephalus* | 0.5 | 0.0 | 0.7 | 1.9 | Long-distance migrant |
| Dwarf Sperm Whale | *Kogia simus* | 0.0 | 0.0 | 0.0 | 0.0 | Tropical |
| Cuvier's Beaked Whale | *Ziphius cavirostris* | 0.1 | 0.0 | 0.1 | 0.0 | Migrant / Regional |
| unidentified beaked whale | *Mesoplodon spec.* | 0.1 | 0.0 | 0.0 | 0.1 | Regional |
| Gervais' Beaked Whale | *Mesoplodon europaeus* | 0.0 | 0.0 | 0.1 | 0.0 | Regional |
| medium whale large fin | | 0.1 | 0.0 | 0.0 | 0.0 | |
| Killer Whale | *Orcinus orca* | 0.0 | 0.1 | 0.3 | 0.2 | Migrant / Regional |
| False Killer Whale | *Pseudorca crassidens* | 0.0 | 0.0 | 0.3 | 0.0 | Tropical |
| Short-finned Pilot Whale | *Globicephala macrorhynchus* | 3.5 | 0.6 | 31.9 | 1.9 | Tropical |
| unidentified dolphin | | 1.6 | 6.9 | 25.4 | 6.5 | |
| Atlantic Hump-backed Dolphin | *Souza teuszii* | 0.0 | 0.0 | 0.0 | 0.0 | Tropical |
| Rough-toothed Dolphin | *Steno bredanensis* | 0.0 | 0.0 | 0.2 | 0.0 | Tropical |
| Bottlenose Dolphin | *Tursiops truncatus* | 1.6 | 0.4 | 14.5 | 1.7 | Migrant / Regional |
| Striped Dolphin | *Stenella coeruleoalba* | 0.4 | 0.0 | 0.0 | 0.0 | Mediterranean |
| Pantropical Spotted Dolphin | *Stenella attenuata* | 0.0 | 0.0 | 0.4 | 0.0 | Tropical |
| Long-snouted Spinner Dolphin | *Stenella longirostris* | 1.0 | 0.0 | 0.0 | 0.0 | Tropical |
| Clymene Dolphin | *Stenella clymene* | 1.0 | 0.0 | 17.6 | 1.6 | Tropical |
| Atlantic Spotted Dolphin | *Stenella frontalis* | 7.6 | 0.0 | 21.1 | 17.2 | Tropical |
| unidentified Stenella dolphin | *Stenella sp* | 0.0 | 0.0 | 1.5 | 5.5 | |
| Common Dolphin | *Delphinus delphis* | 113.1 | 4.5 | 211.5 | 100.5 | Migrant / Regional |
| Fraser's Dolphin | *Lagenodelphis hosei* | 1.0 | 0.0 | 0.0 | 0.0 | Tropical |
| Risso's Dolphin | *Grampus griseus* | 1.3 | 0.0 | 5.4 | 3.6 | Regional |
| Harbour Porpoise | *Phocoena phocoena* | 0.2 | 0.0 | 0.0 | 0.1 | Regional |
| Mediterranean Monk Seal | *Monachus monachus* | 0.0 | 0.0 | 0.0 | 0.0 | Regional |
| unidentified sea turtle | | 0.1 | 0.0 | 0.3 | 0.6 | |
| Leathery Turtle | *Dermochelys coriacea* | 0.0 | 0.0 | 0.0 | 0.0 | Migratory |
| Loggerhead Turtle | *Caretta caretta* | 0.1 | 0.0 | 0.5 | 1.2 | Migratory |
| Hawksbill Turtle | *Eretmochelys imbricata* | 0.0 | 0.0 | 0.1 | 0.0 | Migratory |
| Green Turtle | *Chelonia mydas* | 0.0 | 0.0 | 0.1 | 0.3 | Migratory |
| Olive Ridley Turtle | *Lepidochelys olivacea* | 0.0 | 0.0 | 0.0 | 0.0 | Migratory |
| unidentified shark | | 0.0 | 0.1 | 0.2 | 0.3 | |
| Thresher | *Alopias vulpinus* | 0.0 | 0.0 | 0.0 | 0.0 | |
| Smooth Hammerhead | *Sphyrna zygaena* | 0.8 | 0.0 | 0.6 | 0.3 | |
| Nurse Shark | *Ginglymostoma cirratum* | 0.0 | 0.0 | 0.0 | 0.0 | |
| unidentified flying fish | | 1.7 | 0.7 | 80.3 | 26.1 | |
| unidentified ray | | 0.0 | 0.0 | 0.0 | 0.0 | |
| Lesser Guinean Mobula | *Mobula rochebrunei* | 0.0 | 0.0 | 0.3 | 0.5 | |
| Unidentified tuna | *Thunnus sp* | 0.0 | 0.0 | 0.0 | 2.4 | |
| unidentified tuna | | 0.6 | 0.0 | 12.1 | 4.0 | |
| Skipjack Tuna (Bonito) | *Katsuwonus pelamis* | 0.0 | 0.0 | 60.7 | 0.0 | |
| Sailfish | *Istiophorus platypterus* | 0.0 | 0.0 | 0.0 | 0.0 | |
| Swordfish | *Xiphias gladius* | 0.0 | 0.0 | 0.3 | 0.1 | |
| Sun-fish | *Mola mola* | 0.2 | 0.1 | 0.0 | 0.1 | |

# 6. Marine birds of Northwest Africa

## Seabirds and waterbirds concerned, by taxonomic order

**Anseriformes** - Waterfowl, including three families, but only the largest family is represented within this region, the Anatidae (ducks, geese, swans), comprising 178 species worldwide, of which 24 species known to occur in Mauritania, at least *c.* 30 in the larger region.

Only one species of duck was recorded during ship-based surveys (1986-2022): **Northern Shoveler** *Spatula clypeata*, which is an inland (freshwater) species, now recorded while on northward migration (Feb 2022).

The **Black Scoter** *Melanitta nigra*, arguably the only truly marine orientated species to be expected to occur in this region in numbers, is a fairly common Palearctic migrant wintering nearshore in Moroccan waters, with smaller flocks sometimes reaching northern Mauritania (Nov-Mar, occasionally Apr-May; Brown *et al.* 1982, Browne 2000, Isenmann *et al.* 2000). Black Scoters are not considered in the East Atlantic Flyway assessment in which the status of coastal waterbird populations is investigated (Van Roomen *et al.* 2018), which is probably because wintering birds rarely enter truly shallow estuaries and coastal wetlands. Further maritime species, none of which reviewed by Van Roomen *et al.* (2018), all rare Palearctic visitors in NW Africa, include **Greater Scaup** *Aythya marila*, **Velvet Scoter** *Melanitta fusca*, **Common Goldeneye** *Bucephala clangula*, **Smew** *Mergus albellus*, **Red-breasted Merganser** *Mergus serrator*, and **Goosander** *Mergus merganser* (Brown *et al.* 1982), none of which have thus far been recorded in Mauritania (Isenmann *et al.* 2000). **Common Shelduck** *Tadorna tadorna*, and **Ruddy Shelduck** *Tadorna ferruginea* have increased recently and utilize with increasing frequency intertidal areas of Mauritania, esp. around Nouadhibou (Isenmann *et al.* 2000, Van Roomen *et al.* 2018).

Moroccan waters have Black Scoters as winter visitors in rather large numbers (at least hundreds, likely in the low thousands). For Mauritanian waters such numbers are unknown, but small flocks reach the northern most area, perhaps including some deeper parts of the Banc d'Arguin National Park. Areas with sandy bottoms and abundant small molluscs such as *Donax vittatus* or *Venerupis corrugata* in coastal waters with a water depth below 20m may be attractive as foraging grounds for this species. Data deficient species in this region, but with a known high sensitivity for hydrocarbon pollution (slicks) and disturbance (shipping).

**Podicipediformes** - Containing one single, cosmopolitan family, the grebes (Podicipedidae), with 23 species worldwide, of which 3 species within the region.

No grebes were seen during systematic offshore ship-based surveys (1986-2022).

**Little Grebes** *Tachybaptus ruficollis* are resident breeders in Sahelian Mauritania (Senegal delta and valley associated wetlands, north to 18-20°N) and around Dakar (Senegal; Coulthard 2001), passage migrants and wintering in the Senegal Delta and further inland (Isenmann *et al.* 2000). **Black-necked Grebes** *Podiceps nigricollis* are Palearctic winter visitors, regularly recorded in the Djoudj National Bird Park, in the southwest of Mauritania and in adjacent areas in Senegal (Isenmann *et al.* 2000). For both species, nearshore marine occurrences cannot be excluded, but are probably rare under most conditions. A third species, the **Great Crested Grebe** *Podiceps cristatus*, is another Palaearctic winter visitor in Morocco, with stragglers reaching Senegal Delta (Brown *et al.* 1982).

**Phoenicopteriformes** - Flamingos (Phoenicopteridae), with 6 species worldwide, 2 of which within the region. Large, highly characteristic wading birds, cosmopolitan in tropical freshwater and marine shallow lakes and lagoons.

No flamingos were seen during systematic ship-based surveys (1986-2022) but considerable flocks were seen on beaches, notably near Noudhibou and in Morocco (roost counts 2012-2019, pers. obs.).

**Greater Flamingo** *Phoenicopterus roseus* is a resident breeder in coastal Mauritania (Banc d'Arguin, Aftout Es Sâheli) as well as in Senegal (Delta du Sine-Saloum). After breeding, especially young birds, but also adults disperse along the coast, mostly towards Senegal and Morocco, but also around Cap Blanc and Nouadibou, and in the Diawling and Aftout Es Saheli National Parks, and may utilize shallow nearshore waters in considerable numbers to forage and roost [photo]. **Lesser Flamingo** *Phoenicopterus minor*, an Afrotropical species occurring mostly in East Africa, is an incidental breeding species in the lagoons of Aftout Es Saheli/Trarza and in Senegal Delta. A common wintering species in Mauritanian Senegal Delta (Diawling, Djoudj wetlands, Lac de Guiers) and further to the south in Senegal and Gambia, with regular northern records in Banc d'Arguin (Van Roomen *et al.* 2018).

Resting flock of Greater Flamingos, Lesser Black-backed and Audouin's Gulls on the Atlantic tideline, Morocco 2019 (C.J. Camphuysen)

**Charadriiformes** - A complex order containing numerous families including shorebirds and relatives (sandpipers, plovers, phalaropes, stilts, jacanas, painted snipes, pratincoles), but also gulls and terns, seedsnipes, sheathbills, skimmers, skuas, and auks (390 species worldwide, approx. 98 species recorded in the region). Shorebirds and diving birds in the order Charadriiformes are an ancient and diverse adaptive radiation of waterbirds (Gill *et al.* 2022). Relevant for the offshore waters of NW Africa is only one species of wader (**Red**

**Phalarope** *Phalaropus fulicarius*), a circumpolar, high arctic species breeding on the tundra, but wintering offshore, in oceanic habitats), but all gulls and terns (Laridae), skuas (Stercorariidae), and auks (Alcidae).

Many species were seen during systematic ship-based surveys, even if just in flight passing by, including 11 species of waders (**Golden Plover** *Pluvialis apricaria*, **Grey Plover** *Pluvialis squatarola*, **Red Knot** *Calidris canutus*, **Sanderling** *Calidris alba*, **Dunlin** *Calidris alpina*, **Bar-tailed Godwit** *Limosa lapponica*, **Whimbrel** *Numenius phaeopus*, **Curlew** *Numenius arquata*, **Redshank** *Tringa totanus*, **Ruddy Turnstone** *Arenaria interpres*, **Red Phalarope**), 9 gulls (**Mediterranean Gull** *Ichthyaetus melanocephalus*, **Little Gull** *Hydrocoloeus minutus*, **Sabine's Gull** *Xema sabini*, **Black-headed Gull** *Chroicocephalus ridibundus*, **Slender-billed Gull** *Chroicocephalus genei*, **Audouin's Gull** *Ichthyaetus audouinii*, **Lesser Black-backed Gull** *Larus fuscus*, **Yellow-legged Gull** *Larus michahellis*, **Black-legged Kittiwake** *Rissa tridactyla*), 12 species of terns (**Gull-billed Tern** *Gelochelidon nilotica*, **Caspian Tern** *Hydroprogne caspia*, **Royal Tern** *Thalasseus maximus albidorsalis*, **Lesser Crested Tern** *Thalasseus bengalensis*, **Sandwich Tern** *Thalasseus sandvicensis*, **Roseate Tern** *Sterna dougallii*, **Common Tern** *Sterna hirundo*, **Arctic Tern** *Sterna paradisaea*, **Bridled Tern** *Onychoprion anaethetus*, **Little Tern** *Sternula albifrons*, **Whiskered Tern** *Chlidonias hybrida*, and **Black Tern** *Chlidonias niger*), and five skuas (**Pomarine Skua** *Stercorarius pomarinus*, **Parasitic Jaeger** *Stercorarius parasiticus*, **Long-tailed Jaeger** *Stercorarius longicaudus*, **Great Skua** *Stercorarius skua*, and **South Polar Skua** *Stercorarius maccormicki*).

Several additional marine species (gulls, terns, auks), known to occur at least occasionally in Mauritanian waters, some even as resident breeding species (listed in **Table 3**), were not encountered during systematic surveys at sea. Many of these are either very rare or are predominantly 'inshore' or at best nearshore species throughout the annual cycle, including **Red-necked Phalarope** *Phalaropus lobatus*, **Grey-headed Gulls** *Chroicocephalus cirrocephalus,* **Laughing Gull** *Leucophaeus atricilla*, **Franklin's Gull** *Leucophaeus pipixcan*, **Common Gull** *Larus canus*, **Kelp Gulls** *Larus dominicanus,* **Caspian Gull** *Larus cachinnans*, **Great Black-backed Gull** *Larus marinus*, **Sooty Tern** *Onychoprion fuscatus*, **White-winged Tern** *Chlidonias leucopterus*, **Common Guillemot** *Uria aalge* and **Razorbill** *Alca torda*.

The most important breeding stations for gulls and terns include: Parc National de Banc d'Arguin, Mauritania (20°07'N, 16°16'W), Aftout es Sâheli, Mauritania (17°22'N, 16°08'W), Parc National de la Langue de Barbarie, Senegal (15°55'N, 16°30'W), and Delta du Sine-Saloum, Senegal (13°52'N, 16°36'W). **Kelp Gulls** *Larus dominicanus* have recently 'colonised' NW Africa, given several documented, but still isolated (solitary pairs) breeding cases in Senegal, Mauritania, and Morocco (Keijl *et al.* 2001, Pineau *et al.* 2001, Bergier *et al.* 2011). Recent counts at roosts in Mauritania (2012-2018) suggest that at least several dozens of birds reside within the region, either as breeding birds, or as non-breeding visitors (C.J. Camphuysen, H. Verdaat & T. van Spanje *unpubl. data*). The absence of any sightings at sea is probably the result of (1) resident numbers being still extremely low, and again (2) that foraging usually occurs within 10 km from the coastline, or in inland and in estuarine areas (Van Roomen *et al.* 2018, Reusch *et al.* 2020). **Grey-headed Gulls** *Chroicocephalus cirrocephalus* can be quite numerous at coastal roosts, perhaps not so much in Mauritania (up to hundreds at the time, Cap Blanc & Nouadhibou; pers. obs.), but certainly in Senegal, where it breeds on rocky offshore islands, coastal dunes, in estuaries and in harbours (Van Roomen *et al.* 2018). The absence of any sightings at sea is therefore quite odd, and similar surveys off Senegal would most likely have produced reports within the Neritic zone. None of these species listed here are expected to form concentrations of individuals at sea that should be seen as highly sensitive to oil pollution, even though some taxa (notably the auks) rank high on species-specific Oil Vulnerability Indices (King & Sanger 1979, Camphuysen 1989).

**Phaethontiformes** - Single family, the tropicbirds (Phaethontidae), with 3 species (13 subsepcies) worldwide, of which one recorded in the region: **Red-billed Tropicbird** *Phaethon aethereus mesonauta* breeds Iles de la Madeleine (Senegal), 14°39'N, 17°28'W as well as on the Cape Verde Islands (Hazevoet 1995).

One species recorded during ship-based surveys: **Red-billed Tropicbird** *Phaethon aethereus*

**Gaviiformes** - Single family, divers or loons (Gaviidae) containing 5 species worldwide, three species of which may occur, but as Palaearctic winter visitors, three species are uncommon to rare along Atlantic coasts in Gibraltar Straits and off Morocco (Brown *et al.* 1982). Medium to large diving birds wintering in coastal areas of NW and W Europe. Highly sensitive species to marine oil pollution (King & Sanger 1979, Camphuysen 1989).

None seen during ship-based surveys. No currently known occurrences in Mauritanian waters (Isenmann *et al.* 2000, Brown *et al.* 1982).

**Procellariiformes** - Tube-nosed seabirds including four families, the Austral storm-petrels (Oceanitidae) albatrosses (Diomedeidae), northern storm petrels (Hydrobatidae), and the petrels, shearwaters and diving petrels (Procellariidae), containing ~147 species worldwide, of which at least 17 occur within this region. Most species are highly specialized for soaring flight close to the sea surface, chemoreception is a key aspect of their foraging behaviour (tracing and following olfactory cues), and several shearwaters are known as pursuit diving seabirds reaching considerable depths (25-80m).

Numerous species, representing three families, were seen during systematic ship-based surveys, including two Austral storm petrels (**Wilson's Storm-petrel** *Oceanites oceanicus*, **White-faced Storm-petrel** *Pelagodroma marina*), at least four Northern storm petrels (**European Storm Petrel** *Hydrobates pelagicus*, **Leach's Storm Petrel** *Hydrobates leucorhoa*, **Swinhoe's Storm Petrel** *Hydrobates monorhis*, and **Band-rumped Storm Petrel** *Hydrobates castro*[1]), three petrels (**Northern Fulmar** *Fulmarus glacialis*, **Fea's Petrel** *Pterodroma feae*[2], **Bulwer's Petrel** *Bulweria bulwerii*) and 8 shearwaters (**Scopoli's Shearwater** *Calonectris diomedea*, **Cory's Shearwater** *Calonectris borealis*, **Cape Verde Shearwater** *Calonectris edwardsii*, **Great Shearwater** *Ardenna gravis*, **Sooty Shearwater** *Ardenna grisea*, **Manx Shearwater** *Puffinus puffinus*, **Balearic Shearwater** *Puffinus mauretanicus*, **Macaronesian Shearwater** *Puffinus baroli*[3]). This list includes all tube-nosed seabirds currently known to have occurred in Mauritanian waters (Browne 2000), but note that several 'species' are in fact representing species complexes posing a major challenge on correct identifications at sea.

Many tube-nosed seabirds are wide-ranging, aerial seabirds covering enormous distances even during foraging and feeding and several species have migratory flyways spanning most of the globe (connecting Southern and Northern Hemispheres). For several of the recorded species, NW African offshore waters are an attractive stop-over during migration (short-term presence, low incidence of foraging behaviour), for other species they are important foraging grounds during breeding (regional breeding species) or during the non-breeding season. Albatrosses, in the Atlantic largely restricted to the Southern Hemisphere, were thus far not recorded or as incidental stragglers only.

[1]) In fact, a species complex, potentially including **Band-rumped Storm Petrel** *Hydrobates castro*, **Monteiro's Storm Petrel** *Hydrobates monteiroi*, **Cape Verde Storm Petrel** *Hydrobates jabejabe* the not yet described **Grant's Storm Petrel** that are almost impossible to separate with certainty under normal field conditions (Flood & Fisher 2011).

[2]) In fact, a species complex, potentially including **Zino's Petrel** *Pterodroma madeira*, **Desertas Petrel** *Pterodroma deserta* and **Fea's Petrel** *Pterodroma feae* (Flood & Fisher 2013).

[3]) Formerly listed as **Little Shearwater** or **Macaronesian Shearwater** *Puffinus assimilis*, but now regarded a regional species complex, including **Barolo Shearwater** *Puffinus baroli* and **Boyd's Shearwater** *Puffinus boydi.*

**Suliformes** - Totipalmate water and diving birds including four families, the frigatebirds (Fregatidae), gannets and boobies (Sulidae), anhingas and darters (Anhinigdae), and cormorants and shags (Phalacrocoracidae). There exist around 61 species worldwide, of which around six species occur in the region as breeding species, passage migrant, wintering species or straggler.

Only two species were recorded during systematic ship-based surveys: **Northern Gannet** *Morus bassanus* and **White-breasted Cormorant** *Phalacrocorax lucidus*. A third species, **Red-footed Booby** *Sula sula,* was recorded for the first time in Mauritanian waters as part of MMO observations.

Six species are formally listed for Mauritanian waters and inland areas, including **Northern Gannet** *Morus bassanus*, **Brown Booby** *Sula leucogaster*, **Great Cormorant** *Phalacrocorax carbo*, **White-breasted Cormorant** *Phalacrocorax lucidus*, **Reed Cormorant** *Microcarbo africanus* and **African Darter** *Anhinga melanogaster*. Further species include **Masked Booby** *Sula dactylatra* (Morocco 2006, Bergier *et al.* 2011) and well-documented sightings of **Red-footed Booby** *Sula sula* in Mauritanian waters (R. Irvine *in litt.*) and onboard a container vessel bound for Gambia and Senegal (T. Schreurs *pers. comm.*); both also known as stragglers from Senegalese waters. The occasional occurrence in Mauritanian waters of the now almost extinct Cape Verdian **Magnificient Frigatebird** *Fregata magnificens rothschildi*, listed for Senegal, or indeed any of the other (Atlantic) frigatebirds is a distinct possibility, albeit it will always be incidental records and solitary individuals (López-Suárez & Hazevoet 2014, Lawicki & De Vries 2018). That low numbers of White-breasted Cormorants were seen at sea, and not a single Reed Cormorant or African Darter, has to do with their ecology, which is strictly coastal, and brackish or freshwater orientated in case of the cormorants, and entirely freshwater oriented in case of the Darter (Brown *et al.* 1982, Van Roomen *et al.* 2018).

**Pelecaniformes** - This order contains five families: Ibises and spoonbills (Threskiornithidae), herons (Ardeidae), Hammerkop (Scopidae), Shoebill (Balaenicipitidae), and the pelicans (Pelecanidae). Approximately 118 species worldwide, of which at least 23 species occurring at least incidentally in the region.

Only two species were observed during ship-based surveys which included the **Great White Pelican** *Pelecanus onocrotalus* as could be expected, but also the **Little Egret** *Egretta garzetta.*

With intertidal areas falling beyond the scope of the present analysis, most of these large wading birds and pelicans are very partially included. The 17 herons, hammerkop, 4 ibises, and two spoonbills are all unlikely to use the marine environment other than shallow nearshore, intertidal waters, lagoons or marshlands. Exposure to marine pollutants, disturbance, or other any other potential threats will exclusively be in such habitats. The same is likely true for the **Pink-backed Pelican** *Pelecanus rufescens*, an uncommon visitor and occasional breeder almost entirely restricted to southern Mauritania and Senegal Delta (Isenmann *et al.* 2000). The **Great White Pelican** *Pelecanus onocrotalus*, breeding in large numbers on Arel Island in the National Parc Banc d'Arguin and in Aftout es Sâhel (Mauritania), is common in coastal areas including exposed beaches, occasionally venturing out to sea for considerable distances

## Breeding seabird species in NW Africa

At least 177 species of waterfowl (Anseriformes), grebes (Podicipediformes), flamingos (Phoenicop-teriformes), shorebirds, gulls, terns, skuas, auks (Charadriiformes), tropicbirds (Phaethoniformes), divers (Gaviiformes), tube-nosed seabirds (Procellariiformes), totipalmate (*i.e.* four-toes webbed) water and diving birds (Suliformes), ibises, spoonbills, herons, and pelicans (Pelecaniformes) occur in Mauritania, nearly 200 in the larger region (Senegal-Morocco), of which several are known from only a single sighting (vagrants; Brown *et al.* 1982, Urban *et al.* 1986, Browne 2000, Isenmann *et al.* 2000). With around 70 species of seabirds known to occur at least occasionally, only 17 species actually breed in Mauritania (Isenmann *et al.* 2010): **Little Grebe** *Tachybaptus ruficollis,* **White-breasted Cormorant** *Phalacrocorax lucidus,* **Reed Cormorant** *Microcarbo africanus,* **African Darter** *Anhinga melanogaster,* **Great White Pelican** *Pelecanus onocrotalus,* **Pink-backed Pelican** *Pelecanus rufescens,* **Greater Flamingo** *Phoenicopterus roseus,* **Grey-headed Gull** *Chroicocephalus cirrocephalus,* **Slender-billed Gull** *Chroicocephalus genei,* **Cape Kelp Gull** *Larus dominicanus vetula,* **Gull-billed Tern** *Gelochelidon nilotica,* **Caspian Tern** *Hydroprogne caspia,* **Royal Tern** *Thalasseus maximus albidorsalis,* **Common Tern** *Sterna hirundo,* **Bridled Tern** *Onychoprion anaethetus,* **Little Tern** *Sternula albifrons,* and **African Skimmer** *Rynchops flavirostris*.

A further species breeds localised in Senegal (Coulthard 2001, Keijl *et al.* 2001) and on the Cape Verde Islands: **Red-billed Tropicbird** *Phaethon aethereus*, and nine additional pelagic seabird species breed at the nearby Cape Verde Islands (Hazevoet 1995): **Fea's Petrel** *Pterodroma feae,* **Bulwer's Petrel** *Bulweria bulwerii,* **Cape Verde Shearwater** *Calonectris edwardii,* **Boyd's Shearwater** *Puffinus boydi,* **White faced Storm-Petrel** *Pelagodroma marina,* **Band-rumped Storm-Petrel** *Hydrobates castro,* **Cape Verde Storm-petrel** *Hydrobates jabejabe*, **Brown Booby** *Sula leucogaster*, and **Magnificent Frigatebird** *Fregata magnificens*.

Of these 27 species, only 17 were ever recorded during systematic offshore surveys, another three were encountered during onshore, coastal roost counts (**Table 3**). Why some regional breeding species were not seen at sea, or only rarely, is explained in the species accounts below. It is clear, however, that some species, like Little Grebe, African Skimmer, African Darter, Reed Cormorant, and Pink-backed Pelican, and are freshwater orientated rather than marine throughout the annual cycle (Brown *et al.* 1982, Urban *et al.* 1986). Some other species are simply too rare iver the NW African coastal shelf waters to be expected given the observer effort spent in the area.

**Table 3**. Seabird species breeding (BB) in Mauritania (MAU), Senegal (SEN) and on the Cape Verde Islands (CV) and sightings in Mauritanian offshore waters using the 180° forward scan during ship-based transects, 1988-2022, as well as on counts of coastal roosts near Nouadhibou and Nouakchott in 2012-2018. Indications of relative abundance at sea or on roosts: ? uncertain, + few, ++ dozens, +++ hundreds, ++++ thousands. Colours represent expected ecological orientation: green= freshwater, yellow = shallow coastal, blue = pelagic, rest expected wide-ranging shelf occurrences.

| | Breeding | | | Offshore sightings | | | | |
|---|---|---|---|---|---|---|---|---|
| | MAU | SEN | CV | Oceanic | Shelf-break | Neritic | Roosts | |
| **Little Grebe** *Tachybaptus ruficollis* | BB | BB | | | | | | |
| **Greater Flamingo** *Phoenicopterus roseus* | BB | BB | | | | | +++ | |
| **African Skimmer** Rynchops flavirostris | BB | BB | | | | | | |
| **Slender-billed Gull** *Chroicocephalus genei* | BB | BB | | | | ++ | ++ | |
| **Grey-headed Gull** *Chroicocephalus cirrocephalus* | BB | BB | | | | | +++ | |
| **Cape Kelp Gull** *Larus dominicanus vetula* | (BB) | (BB) | | | | | ++ | |
| **Gull-billed Tern** *Gelochelidon nilotica* | BB | BB | | | | + | + | |
| **Caspian Tern** *Hydroprogne caspia* | BB | BB | | | + | ++ | ++++ | |
| **Royal Tern** *Thalasseus albidorsalis* | BB | BB | | ++ | ++++ | ++++ | ++++ | |
| **Little Tern** *Sternula albifrons* | BB | BB | | | | + | ++ | 1) |
| **Bridled Tern** *Onychoprion anaethetus* | BB | | | + | + | + | + | |
| **Common Tern** *Sterna hirundo* | BB | BB | | ++++ | ++++ | ++++ | ++++ | 1) |
| **Red-billed Tropicbird** *Phaethon aethereus* | | BB | BB | + | + | | | |
| **White faced Storm-Petrel** *Pelagodroma marina* | | | BB | + | + | | | |
| **Band-rumped Storm-Petrel** *Hydrobates castro* | | | BB | +++ | +++ | ++ | | |
| **Cape Verde Storm-petrel** *Hydrobates jabejabe* | | | BB | ? | ? | ? | | *2)* |
| **Fea's Petrel** *Pterodroma feae* | | | BB | | + | | | |
| **Cape Verde Shearwater** *Calonectris edwardii* | | | BB | +++ | +++ | ++++ | | |
| **Boyd's Shearwater** *Puffinus boydi* | | | BB | +? | +? | | | 3) |
| **Bulwer's Petrel** *Bulweria bulwerii* | | | BB | ++ | + | | | |
| **Magnificent Frigatebird** *Fregata magnificens* | | | BB | | | | | |
| **Brown Booby** *Sula leucogaster* | | | BB | | | | | |
| **African Darter** *Anhinga melanogaster* | BB | BB | | | | | | |
| **Reed Cormorant** *Microcarbo africanus* | BB | BB | | | | | | |
| **White-breasted Cormorant** *Phalacrocorax lucidus* | BB | BB | | | | +++ | ++ | |
| **Great White Pelican** *Pelecanus onocrotalus* | BB | BB | | | ++ | ++ | +++ | |
| **Pink-backed Pelican** *Pelecanus rufescens* | BB | BB | | | | | | |

1)Majority mostly wintering or migratory birds, possibly including local resident breeding birds but this could not be separated with certainty. 2)Cape Verde Storm-petrels are in the Band-rumped Storm-petrel complex, only very recently recognised as separate species and not positively identified at sea. 3)Two smaller shearwaters breeding on Macaronesian islands (*Puffinus baroli* and *Puffinus boydi*) were not separated when encountered at sea.

## 7. Seasonality, depth zones, attractions by fisheries and species diversity

Early in the year, **Janurary-March**, in fact the second half of the Northern Hemisphere winter, the seabird community in Mauritanian offshore waters is numerically dominated by gannets (46.4%), skuas (16.3%), gulls (14.8%), and storm-petrels (10.1%) (**Table 4**). *Calonectris*-shearwates formed the bulk of the group of shearwaters (Σ 7 species), mostly Cory's Shearwaters, with no signs recorded of the Cape Verde Shearwater (**Table 2**). The group of storm-petrels (4 species) was completely dominated by Northern Hemisphere species, with the European Storm Petrel by far the most abundant species and the Antarctic Wilson's Storm-Petrels occurring in lower numbers than in any other season. Pomarine Skuas outnumbered all other skua species (Σ 4 species) by far and Lesser Black-backed Gulls, the most abundant of all gull species (Σ species), peaked in abundance in this season. In the group of terns (8 species), Sandwich and Common Terns were the most numerous species. Common and Atlantic Spotted Dolphins were the more numerous representatives in the dolphin group, Blue and Fin Whales were by far the most abundant representatives of the group of fin whales.

| **1st Quarter (Jan-Mar)** | | | |
|---|---|---|---|
| | **Oceanic** | **Shelf-break** | **Neritic** |
| Effort (km) | **1325** | **1142** | **1101** |
| petrels | 0.1 | 0 | 0 |
| shearwaters | 29.2 | 38.7 | 39.3 |
| | 0 | 2.0 | 4.2 |
| storm-petrels | 78.8 | 115.7 | 15.5 |
| | 0 | 318.7 | 14.6 |
| tropicbirds | 0 | 0.1 | 0 |
| pelicans | 0 | 0 | 0.1 |
| gannets | 45.6 | 224.8 | 1223.4 |
| | 0 | 320.2 | 687.7 |
| cormorants | 0 | 0 | 8.3 |
| phalaropes | 96.9 | 43.9 | 12.3 |
| skuas | 67.0 | 237.7 | 256.0 |
| | 0 | 117.9 | 199.7 |
| gulls | 10.5 | 41.3 | 143.3 |
| | 0 | 126.6 | 477.1 |
| terns | 35.8 | 77.8 | 171.4 |
| | 0 | 46.2 | 65.5 |
| **Totals** | **364.0** | **1711.6** | **3318.4** |
| | **Oceanic** | **Shelf-break** | **Neritic** |
| unident whales | 0.5 | 0.1 | 0.2 |
| fin whales | 2.3 | 1.5 | 1.7 |
| sperm whales | 1.3 | 0.1 | 0.1 |
| blackfish | 5.1 | 1.9 | 0 |
| beaked whales | 0.7 | 0 | 0 |
| dolphins | 66.7 | 319.0 | 40.3 |
| porpoises | 0 | 0 | 0.8 |
| turtles | 0.7 | 0.1 | 0.1 |
| sharks and rays | 1.8 | 0.2 | 0.5 |

**Table 4.** Major taxonomic groups of seabirds and other charismatic mega-fauna in each of the major oceanographic areas in Mauritanian waters (16-21°N): Oceanic (>800m water depth), Shelf-break (800-200m depth), and Neritic zone (200-0m water depth), with sighting rates per 100km of observer effort in the 180° forward scan as indices of relative abundance, based on ship-based transects, Jan-Mar (1st quarter), 2000-2022. In red, fractions observed in apparent association with fishing vessels.

In the **April-June** period, *i.e.* the Northern Hemisphere spring and early summer, but late autumn and early winter in the Southern Hemisphere, the seabird community in Mauritanian offshore waters has changed markedly and is numerically dominated by terns (56.8%), storm-petrels (21.5%), and gulls (11.5%), and (**Table 5**). Note that most of the collected data is fairly old, and that the Oceanic zone is relatively poorly investigated. In the earliest surveys, taxonomic conventions were such that observers didn't (and couldn't) discriminate between the various *Calonectris*-shearwaters. By contrast with the previous period, Wilson's Storm-petrels now outnumbered all other taxa within that group, although considerable numbers of European Storm-Petrels were still lingering around. The relative scarcity of Leach's and Band-rumped Storm-Petrels (truly pelagic species) will have been influenced by relatively poor coverage of Oceanic waters. Pomarine Skuas still outnumbered the other species, but the difference is much less extreme (**Table 2**). Sabine's Gulls suddenly outnumbered all other gull species at sea, while comic and Black Terns were by far the most abundant terns at sea. It is in this season that locally breeding Royal Terns peaked in their offshore abundance.

| **2nd Quarter (Apr-Jun)** | **Oceanic** | **Shelf-break** | **Neritic** |
|---|---|---|---|
| Effort (km) | **113** | **1448** | **1005** |
| petrels | 0 | 0.1 | 0.1 |
| shearwaters | 7.1 | 35.2 | 18.5 |
| | 0 | 4.4 | 0.3 |
| storm-petrels | 319.9 | 728.9 | 171.4 |
| | 0 | 359.2 | 21.0 |
| pelicans | 0 | 1.3 | 6.1 |
| | 0 | 0.1 | 0 |
| gannets | 0.9 | 47.8 | 83.5 |
| | 0 | 6.8 | 16.6 |
| cormorants | 0 | 0 | 0.2 |
| phalaropes | 0 | 0 | 0.1 |
| skuas | 151.1 | 150.6 | 108.7 |
| | 0.9 | 110.4 | 11.9 |
| gulls | 13.3 | 341.8 | 250.0 |
| | 2.7 | 163.6 | 80.7 |
| terns | 129.0 | 458.6 | 3007.9 |
| | 0 | 435.5 | 191.9 |
| **Totals** | **624.7** | **2844.4** | **3968.8** |
| | **Oceanic** | **Shelf-break** | **Neritic** |
| unident whales | 0 | 0 | 0.1 |
| fin whales | 0 | 0.1 | 0.2 |
| blackfish | 0 | 1.9 | 0 |
| beaked whales | 0 | 0.1 | 0 |
| dolphins | 0.9 | 23.9 | 0 |
| pinnipeds | 0 | 0 | 0.1 |
| turtles | 0 | 0 | 0.1 |
| sharks and rays | 1.8 | 0.1 | 0.1 |

**Table 5.** Major taxonomic groups of seabirds and other charismatic megafauna in each of the major oceanographic areas in Mauritanian waters (16-21°N): Oceanic (>800m water depth), Shelf-break (800-200m depth), and Neritic zone (200-0m water depth), with sighting rates per 100km of observer effort in the 180° forward scan as indices of relative abundance, based on ship-based transects, Apr-Jun (2nd quarter), 1988-2004. In red, fractions observed in apparent association with fishing vessels.

In **July-September**, the Northern Hemisphere late summer and early spring, but late winter and early spring in the Southern Hemisphere, the seabird community in Mauritanian offshore waters is numerically almost completely dominated by storm-petrels (46.1%) terns (41.5%) (**Table 6**). It is the virtual complete absence of Northern Gannets that was the most remarkable finding during offshore surveys in early autumn. Cape Verde Shearwaters outnumbered all other shearwaters (Σ 6 species). The group of storm-petrels was now completely dominated by Wilson's Storm-Petrels, skuas were at their low in these months with Pomarine Skuas only 3x more abundant than either Long-tailed Jaegers of Parasitic Jaegers (**Table 2**). Gulls were near-absent at sea, with only the very first (high Arctic) Sabine's Gulls moving through these waters. Common and Black Terns were again the most abundant species of tis group of nine species. The abundance and diversity, especially in the dolphins observed was a remarkable step up in comparison with the previous period, but it is quite possible that, again, the relatively poorly surveyed Oceanic waters in this period could explain this difference in sightings frequencies.

| **3rd Quarter (Jul-Sep)** | **Oceanic** | **Shelf-break** | **Neritic** |
|---|---|---|---|
| Effort (km) | **1182** | **769** | **1233** |
| petrels | 1.6 | 0.1 | 0 |
| shearwaters | 26.4 | 51.2 | 40.6 |
| | 0 | 0.3 | 32.1 |
| storm-petrels | 86.8 | 1052.6 | 110.2 |
| | 0 | 10.1 | 12.2 |
| tropicbirds | 0.1 | 0 | 0 |
| pelicans | 0 | 0 | 1.9 |
| gannets | 0 | 0 | 0.1 |
| phalaropes | 4.4 | 27.8 | 15.8 |
| skuas | 17.3 | 28.6 | 39.3 |
| | 0 | 6.4 | 35.5 |
| gulls | 2.4 | 3.8 | 5.3 |
| | 0 | 2.1 | 3.2 |
| terns | 398.2 | 289.1 | 273.7 |
| | 0 | 21.6 | 160.9 |
| **Totals** | **537.2** | **1493.7** | **730.9** |
| | **Oceanic** | **Shelf-break** | **Neritic** |
| unident whales | 0 | 0 | 0.2 |
| fin whales | 0.1 | 0 | 0.5 |
| sperm whales | 1.1 | 1.2 | 0.2 |
| blackfish | 77.6 | 14.0 | 0.9 |
| beaked whales | 0.2 | 0.3 | 0 |
| dolphins | 292.1 | 737.7 | 23.8 |
| | 0 | 7.8 | 0 |
| turtles | 1.9 | 0.8 | 0.3 |
| sharks and rays | 1.9 | 1.4 | 0.5 |

**Table 6.** Major taxonomic groups of seabirds and other charismatic megafauna in each of the major oceanographic areas in Mauritanian waters (16-21°N): Oceanic (>800m water depth), Shelf-break (800-200m depth), and Neritic zone (200-0m water depth), with sighting rates per 100km of observer effort in the 180° forward scan as indices of relative abundance, based on ship-based transects, Jul-Sep (3rd quarter), 2015-2018. In red, fractions observed in apparent association with fishing vessels.

Late in the year, **October-December**, or the first half of the Northern Hemisphere winter and the onset of the Southern Hemisphere summer, the seabird community in Mauritanian offshore waters is again numerically dominated by gannets (43.9%), now followed by storm-petrels (14.9%), shearwaters (13.4%) and terns (11.2%) (**Table 7**). Cory's Shearwaters were again found to dominate the shearwater group (7 species), with Cape Verde Shearwaters still present, but much reduced in numbers. Wilson's Storm-petrels were present, but in much reduced numbers and in fact a trio (European, Leach's and Band-rumped Storm-petrels) were now found to dominate the storm-petrel scene. Norther Gannets reached higher frequencies of sightings than in any other season, which was quite a change in comparison with the preceding period. Lesser Black-backed Gulls had returned, but not in numbers comparable to the second half of the Northern Hemisphere winter. Common and Black Terns continued to outnumber all other tern species at sea. Sperm Whales were more frequently seen than in any other season, while numbers of large Balaenopterid whales (fin whale group) were building up in these months.

| **4th Quarter (Oct-Dec)** | | | |
|---|---|---|---|
| | **Oceanic** | **Shelf-break** | **Neritic** |
| Effort (km) | **811** | **695** | **1245** |
| shearwaters | 158.1 | 250.2 | 388.4 |
| | 0 | 86.0 | 80.2 |
| storm-petrels | 244.9 | 490.3 | 317.0 |
| | 0 | 0.3 | 16.2 |
| pelicans | 0 | 0 | 0.5 |
| gannets | 69.4 | 1239.1 | 1682.3 |
| | 0 | 0 | 154.4 |
| cormorants | 0 | 0 | 0.1 |
| phalaropes | 95.0 | 267.9 | 42.8 |
| skuas | 90.8 | 151.2 | 163.7 |
| | 0 | 15.1 | 192.3 |
| gulls | 15.2 | 39.0 | 81.2 |
| | 0 | 2.2 | 31.5 |
| terns | 332.1 | 200.7 | 252.3 |
| | 0 | 5.9 | 13.1 |
| **Totals** | **1005.6** | **2748.0** | **3416.0** |
| | **Oceanic** | **Shelf-break** | **Neritic** |
| unident whales | 0.1 | 0.6 | 0.6 |
| fin whales | 1.7 | 0.7 | 0.7 |
| sperm whales | 0.7 | 6.0 | 0.3 |
| blackfish | 6.5 | 0.7 | 0 |
| beaked whales | 0.1 | 0.4 | 0 |
| dolphins | 239.8 | 197.0 | 35.7 |
| porpoises | 0 | 0 | 0.2 |
| pinnipeds | 0 | 0 | 0.1 |
| turtles | 6.0 | 1.3 | 0.1 |
| sharks and rays | 1.9 | 1.6 | 0.6 |

**Table 7.** Major taxonomic groups of seabirds and other charismatic megafauna in each of the major oceanographic areas in Mauritanian waters (16-21°N): Oceanic (>800m water depth), Shelf-break (800-200m depth), and Neritic zone (200-0m water depth), with sighting rates per 100km of observer effort in the 180° forward scan as indices of relative abundance, based on ship-based transects, Oct-Dec (3rd quarter), 2012-2016. In red, fractions observed in apparent association with fishing vessels.

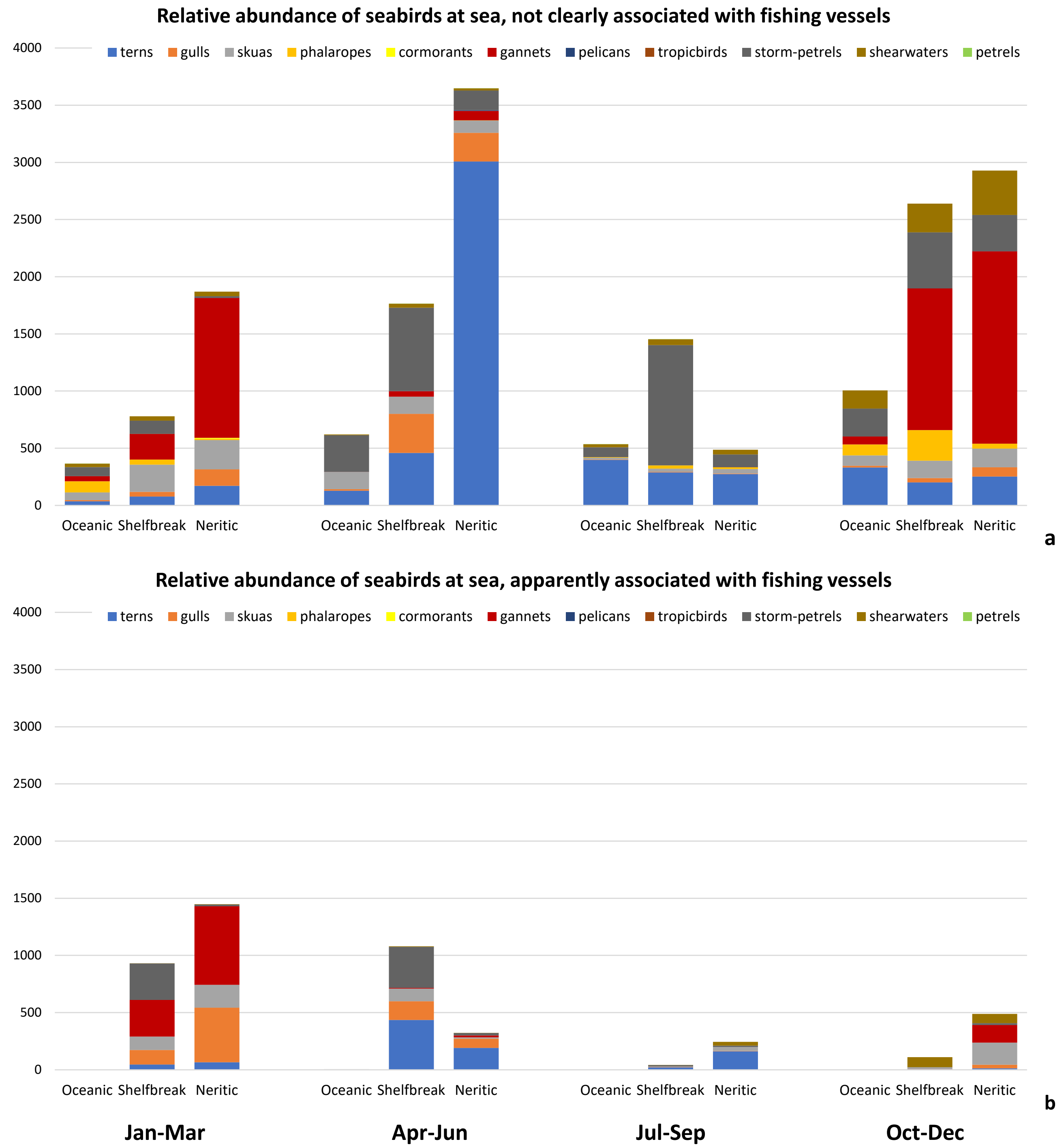


**Figure 4.** Major taxonomic groups of seabirds in each of the three oceanographic areas in Mauritanian waters (16-21°N): Oceanic (>800m water depth), Shelf-break (800-200m depth), and Neritic zone (200-0m water depth), as sighting rates (*n* $100km^{-1}$) in the 180° forward scan, based on ship-based transects for each quarter of the year, 1988-2016. Top panel (**a**): birds seen that were apparently not associated with a nearby fishing vessel. Bottom panel (**b**): birds seen in association with fishing vessels.

Using assessments of relative abundance based on the 180° forward scan (*n* $100km^{-1}$) for the Mauritanian offshore waters through the year, with a split for seabirds that were apparently, or were apparently not associated with fishing vessels, it is clear that seabirds were usually most numerous within the Neritic zone, followed by the shelf-break with lower numbers in Oceanic waters. Fisheries influences were almost entirely

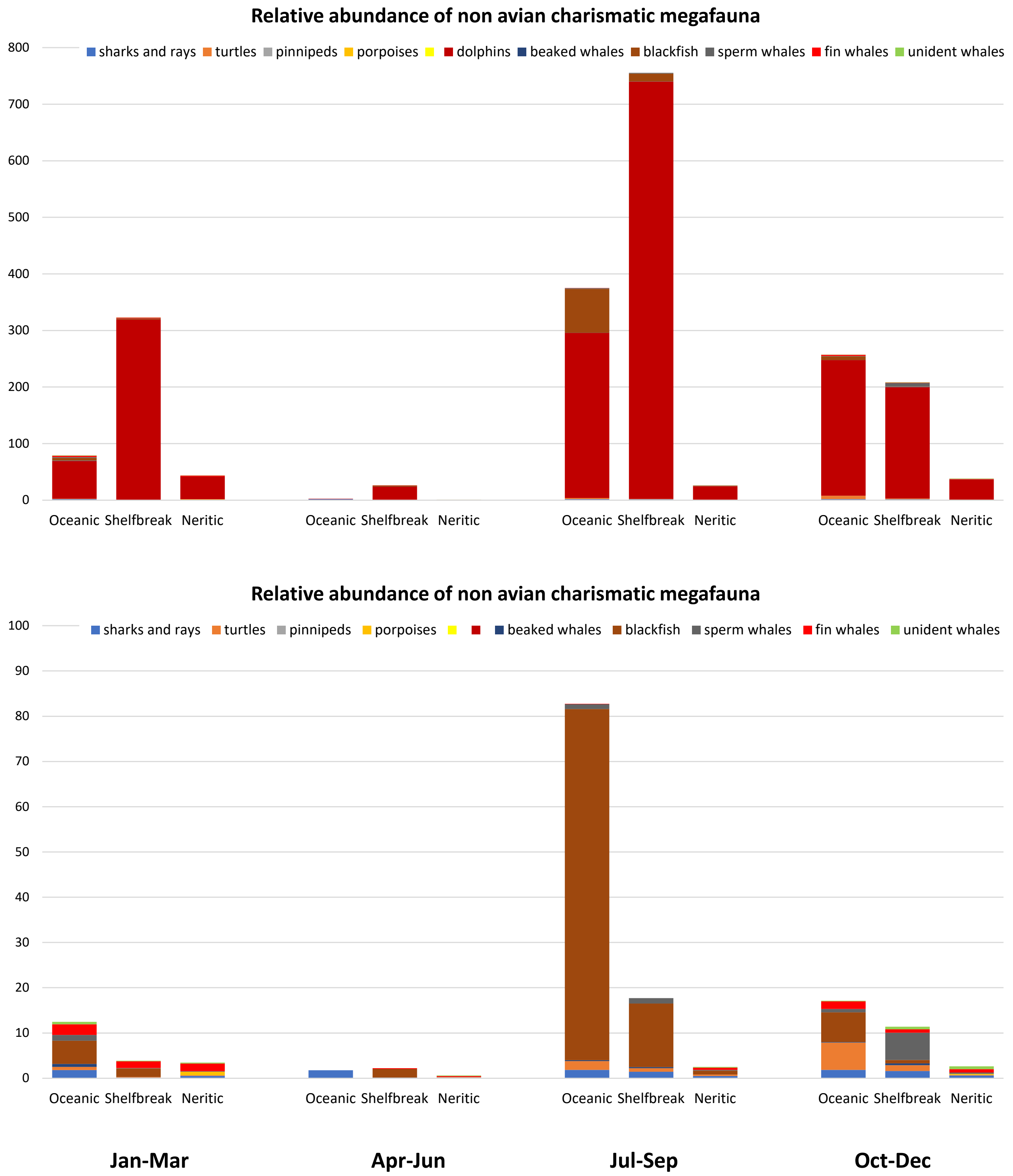


**Figure 5.** Major taxonomic groups of non-avian charismatic megafauna in each of the three oceanographic areas in Mauritanian waters (16-21°N): Oceanic (>800m water depth), Shelf-break (800-200m depth), and Neritic zone (200-0m water depth), as sighting rates ($n$ 100km$^{-1}$) in the 180° forward scan, based on ship-based transects for each quarter of the year, 1988-2016. Top panel (**a**): dolphins included. Bottom panel (**b**): dolphins excluded, adjusted scale.

restricted to the first two areas, and were stronger in the first half of the year than in the Jul-Dec period (**Tables 4-7, Fig. 4**). The Northern Hemisphere winter resulted in gannet- and skua-dominated seabird communities, whereas surveys in the summer period were rather tern and storm-petrel dominated. Seabird species diversity was relatively low in Jul-Sep (H' 0.94), but varied between 1.80 and 2.10 in the rest of the year (**Table 7**). In cetaceans, with rather lower variability (H' 1.04-1.75), the Shannon-Wiener diversity index was lowest in late (Northern Hemisphere) spring, Apr-Jun (**Table 8**). Species diversity in seabirds varied marginally over the different dept ranges (range H' 1.97-2.40), but peaked in Oceanic waters where the overall seabird abundance was typically rather lower. Species diversity in cetaceans was markedly higher in Oceanic regions (H' 2.05) than in shallower waters (range H' 1.28-1.50), with an effective number of species in the Oceanic zone that was double that of the Shelf-break, where the overall abundance of whales and dolphins was higher (**Table 8**).

**Table 8.** Seasonal (quarters of the year) and spatial (oceanographic zones) in relative abundance (*n* 100km$^{-1}$), number of species observed, Shannon-Wiener Species Diversity Index (H'), and effective number of species (ENS) of seabirds and cetaceans recorded in Mauritanian offshore waters, based on sighting rates in the 180° forward scan, during ship-based transects, 1988-2022.

| **Marine birds** | | | | | **Oceanographic** | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Season** | **100km$^{-1}$** | **Species** | **H'** | **ENS** | **Zone** | **100km$^{-1}$** | **Species** | **H'** | **ENS** |
| Jan-Mar | 1677.7 | 38 | 1.80 | 6.1 | | | | | |
| Apr-Jun | 3151.5 | 39 | 2.10 | 8.2 | Neritic | 2782.3 | 42 | 1.97 | 7.2 |
| Jul-Sep | 843.2 | 36 | 0.94 | 2.5 | Shelf-break | 2221.5 | 42 | 2.28 | 9.7 |
| Oct-Dec | 2536.2 | 39 | 1.98 | 7.2 | Oceanic | 575.6 | 33 | 2.40 | 11.0 |

| **Cetaceans** | | | | | **Oceanographic** | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Season** | **100km$^{-1}$** | **Species** | **H'** | **ENS** | **Zone** | **100km$^{-1}$** | **Species** | **H'** | **ENS** |
| Jan-Mar | 145.0 | 26 | 1.15 | 3.2 | | | | | |
| Apr-Jun | 14.8 | 10 | 1.04 | 2.8 | Neritic | 27.4 | 18 | 1.50 | 4.5 |
| Jul-Sep | 331.4 | 21 | 1.75 | 5.7 | Shelf-break | 279.7 | 23 | 1.28 | 3.6 |
| Oct-Dec | 142.1 | 22 | 1.58 | 4.8 | Oceanic | 216.2 | 26 | 2.05 | 7.8 |

## 8. Ecological guilds

Pelagic aspects of seabird ecology fall between the disciplines of ornithology (or marine ecology) and oceanography and in interpreting seabird distributions it is important to understand how a marine habitat is defined, how it is explored (food finding) and exploited (feeding) by seabirds, marine mammals, or other megafauna, alone or in multi-species assemblages (Brown 1980, Camphuysen & Webb 1988). The spatial and temporal distribution of food is a fundamental factor affecting the evolution of species (Safina & Burger 1988). It is one of the most important determinants of where an animal fits in the continuum between solitary territoriality and group living, throughout their annual cycle, so not just while breeding, but also while foraging and feeding.

In general, ecological segregation of foraging areas has been demonstrated for seabirds, in terms of prey types or size taken, foraging ranges or foraging depths (Furness & Monaghan 1987, Bertrand *et al.* 2021). The nature of available resources is best discussed initially in terms of availability, regarding the foraging/feeding methods (how is the food obtained) of the foraging animals, thereby bearing in mind that particular feeding methods require sophisticated and /or physiological adaptations, permitting species to exploit only a certain taxonomic variety of prey (Ashmole 1971). Seabird feeding techniques range from strictly aerial (e.g. frigatebirds) to deep diving taxa reaching hundreds of meter water depth (e.g. penguins, auks). The latter cover the entire epipelagic and, in some cases, reach the mesopelagic. In cetaceans, most species forage at some depth, but still within the epipelagic and into the mesopelagic, but the so called 'deep-water' species may reach thousands of meters deep reaching the bathypelagic. Important species-specific characteristics concern the prey choice (e.g. planktivorous, piscivorous, omnivorous), prey size (often, but not always, related to the body size of the predators), and food finding techniques (e.g. chemoreception (Wenzel 1980), visual detection, auditory detection).

Even in their preferred habitats, seabirds can exploit only a fraction of the potential prey which can be anywhere in the water column, while most seabirds forage only at or near the surface. Foraging seabirds therefore first and foremost rely heavily on conditions where, for a variety of physical or biological reasons, their prey is concentrated and accessible near the surface (Brown 1980, Hunt *et al.* 1998, Irons 1998, DiGiacomoa *et al.* 2002, Camphuysen *et al.* 2006, Scott *et al.* 2010, Scales *et al.* 2014, Cox *et al.* 2020). High densities of prey are important not only for their accessibility, but will also reduce the energetic costs of foraging. To understand why certain areas were more important than others for charismatic megafauna, and how consistent and predictable these areas actually are, at least the more recent surveyors (since ≥2000) were instructed to carefully document foraging behaviour, and any visible explanatory phenomena so that hotspot foraging areas could be earmarked as particularly important (Scott *et al.* 2010).

Until recently, the co-occurrence of various species on foraging grounds were usually discussed in terms of interspecific competition. Large-scale, multi-disciplinary at-sea studies of apex predator distribution patterns and their foraging behaviour provided new insights, however, into the ways in which marine predators utilise a shared prey resource. Many surface-feeding and plunge-diving seabirds were found to rely heavily on facilitation by pursuit-diving predators, such as from co-operatively feeding (prey driving) penguins and auks, cetaceans and large predatory fish such as various species of tuna and other species. But even between seabirds, the combination of various feeding techniques in a feeding frenzy meant that facilitation (more success while feeding) often prevailed over competition (reduced access to the resource), making multi-species foraging assemblages important, biological mechanisms to enhance foraging opportunities (Hoffman *et al.* 1981, Grover & Olla 1983, Hunt *et al.* 1988, Harrison *et al.* 1991, Haney *et al.* 1992, Mills 1998, Camphuysen & Webb 1999, Day & Nigro 2000, Clua & Grosvalet 2001, Camphuysen *et al.* 2006, Thoebault *et al.* 2014, 2016, Gomez-Laich *et al.* 2018, Cansse *et al.* 2020). Seabirds actively look-out for feeding frenzies and often eagerly join in (given that certainly smaller frenzies are often fairly short-lived), making individual, widespread searching a much more profitable process (Camphuysen 2011). As with behaviour, the more recent surveyors in NW African waters (since ≥2000) concentrated heavily on multi-species foraging assemblages and on the role that participants in these flocks were having, all to understand why certain areas were more ecologically important than others, and how consistent and predictable these areas actually are.

A final, but highly important factor enhancing prey availability are human fishing activities. Especially large scale, commercial fisheries are an excellent example leading to "conditions where their prey is concentrated and accessible near the surface", and in case of demersal fisheries a resource is opened up that would otherwise be entirely out of reach for virtually all seabirds. The presence and absence of fishing activities was therefore constantly monitored during the NW African surveys, and birds apparently associated with fishing vessels were specifically computer coded as such. Studies elsewhere in the Atlantic have shown that the role of fisheries as an explanatory factor explaining distribution patterns should not be overestimated. While some seabirds venture out into the ocean only because there are fishing fleets operating, most species profit from these anthropogenic opportunities (or food-subsidies) only within their natural habitats (Camphuysen & Garthe 1997). On occasions, it could even be established that piscivorous seabirds at sea ignored excessive amount of discarded suitable prey in preference of self-captured prey of the exact same kind (e.g. Camphuysen *et al.* 1995; pers. obs. Mauritanian waters). Hence, the simple co-occurrence of fishing fleets and (often attracted) seabirds is not enough to establish a link between the two.

### Foraging and feeding

Observed seabird foraging and feeding behaviour during the systematic surveys between 1988 and 2022 off the NW African coast included:

- Actively searching
- Aerial pursuit
- Skimming, Hydroplaning, Pattering, Dipping, Surface pecking, Surface seizing, Scavenging,
- Scooping prey from surface,
- Shallow plunging,
- Deep plunging,
- Pursuit plunging,
- Pursuit diving
- Feeding at fishing vessel,

**Active searching** behaviour was seen as the first indication that an area was of interest as a potential feeding area, and most birds classified as searching were in flight (e.g. area restricted circling, meandering flight, peering down). Searching behaviour is nothing more than an interpretation when viewing the movements of individual birds, but the actual intention to search for prey can easily be overlooked. All other recorded behaviours in the present overview are actual feeding activities (**Table 9**).

Some prey was obtained by **aerial pursuit** (robbing other seabirds), even though that prey could have originated from somewhere in the water column, picked up by the victim of the kleptoparasite. Prey obtained by aerial pursuit include birds (deliberate kills, e.g. Mullié *et al.* 2015), wind driven insects, and flying fish Of particular significance for numerous species of seabirds were various surface feeding techniques in which prey was captured at or really close to the sea surface: **skimming**, **hydroplaning**, **pattering**, **dipping**, **surface pecking**, **surface seizing**, and **scavenging**. The first four techniques involve airborne predators that briefly tough the water when capturing prey but remain more or less 'in flight', whereas the next three techniques involve swimming birds targeting prey at the surface (tiny prey by 'pecking', larger prey by settling and ingesting with difficulty, or larger corpses by tearing off flesh and scavenging). Still at the sea surface (less than 50cm depth) are **scooping prey** and **shallow plunging**. The first technique is best known for pelicans, but also deployed by gannets and this involves swimming birds that lower their head into the water to scoop-up food (often dense shoaling fish fry). Shallow plunging is an aerial technique commonly deployed by terns in which prey is detected by eye while flying and captured with a quick plunge dive, but since the bird does not disappear under the surface, that prey must have been very close to the surface.

To capture prey deeper into the water column, more powerful techniques are deployed, including **deep plunge diving**, **pursuit plunging** (typically wing-propelled), or **pursuit diving** (wing-propelled in penguins and auks, foot-propelled in cormorants and seaduck). The first technique is highly characteristic for Northern

**Table 9.** Recorded (*n*) and expected (+) foraging techniques of seabirds at sea during systematic surveys, 1986-2022, off NW Africa. Shown are total numbers of birds observed and various types of behaviour recorded (small numbers on line two are computer codes referring to these behaviour types). In light blue: surface foraging behaviour, reaching ~0.5m depth max, in dark blue deep diving foraging behaviour, reaching between 0.5m and around 80m of depth.

| | Totals | Aerial pursuit | Skimming | Hydroplaning | Pattering | Dipping | Surface pecking | Surface seizing | Scavenging | Scooping prey from surface | Shallow plunging | Deep plunging | Pursuit plunging | Pursuit diving (seafloor) | Actively searching | Feeding at fishing vessel |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 36 | 37 | 38 | 39 | 42 | 44 | 43 | 40 | 35 | 46 | 45 | 47 | 48 | 49 | 41 |
| Northern Fulmar | 1 | | | | | | + | + | + | | | | | | | |
| Fea's Petrel | 1 | | | | | | | | | | | | | | | |
| Bulwer's Petrel | 22 | | | | | | | | | | | | | | 10 | |
| Scopoli's Shearwater | 590 | | 1 | | | 10 | | 26 | | | | | 14 | | 22 | 7 |
| Scopoli's/Corys shearwater | 2485 | | | | | 115 | 2 | 6 | | | 21 | | 549 | | 455 | 7 |
| Cory's Shearwater | 8210 | | | 2 | 3 | 4 | | 8 | | | 88 | | 129 | | 1057 | 8 |
| Cape Verde Shearwater | 1653 | | | | | 1 | | 5 | | | 18 | | 11 | | 184 | |
| Great Shearwater | 166 | | | | | | | | | | 1 | | 2 | | 10 | |
| Sooty Shearwater | 177 | | | | | | | | | | | | 5 | | 9 | |
| Manx Shearwater | 60 | | | 2 | | | | | | | | | + | | 1 | |
| Balearic Shearwater | 9 | | | | | | | | | | | | + | | | |
| Macaronesian Shearwater | 6 | | | | | | | | | | | | + | | | |
| Wilson's Storm-petrel | 26917 | 2 | | | 11493 | 11 | 250 | | 10 | | | | | | 1761 | 34 |
| White-faced Storm-petrel | 8 | | | | 6 | | | | | | | | | | 2 | |
| European Storm Petrel | 14949 | | | | 7153 | 146 | 2 | 3 | | | | | | | 1003 | 405 |
| Leach's Storm Petrel | 1838 | | | | 527 | 6 | 1 | 1 | | | | | | | 300 | |
| unidentified storm-petrel | 582 | | | | 99 | 14 | | | | | | | | | 19 | |
| Swinhoe's Storm Petrel | 3 | | | | + | + | | | | | | | | | 1 | |
| Band-rumped Storm Petrel | 665 | | | | 97 | 38 | | | | | | | | | 103 | |
| Red-billed Tropicbird | 2 | | | | | | | | | | | + | | | | |
| Northern Gannet | 62749 | | | | 2 | 1 | 1 | 1 | | 2 | 296 | 16173 | 7 | | 9434 | 4941 |
| White-breasted Cormorant | 122 | | | | | | | | | | | | | 18 | | |
| Great White Pelican | 111 | | | | | | | | | + | | | | | 6 | |
| Red Phalarope | 9223 | | | | 1 | 1 | 5153 | 4 | | | | | | | 128 | |
| Pomarine Skua | 18972 | 431 | | | | 34 | 7 | 60 | 36 | | 56 | | | | 1789 | 920 |
| Parasitic Jaeger | 1350 | 192 | | | | | 2 | 6 | | | | | | | 93 | 38 |
| Long-tailed Jaeger | 1784 | 70 | | | | 50 | 189 | 9 | 1 | | | | | | 132 | 20 |
| Great Skua | 873 | 46 | | | | | | 15 | 4 | | | | | | 107 | 68 |
| South Polar Skua | 2 | + | | | | | | + | | | | | | | 1 | |
| Mediterranean Gull | 4 | | | | | + | | | | | | | | | 1 | |
| Little Gull | 4 | | | | | + | | | | | | | | | | |
| Sabine's Gull | 9298 | 1 | | | | 99 | 2 | 15 | 7 | | 6 | | | | 198 | 1389 |
| Black-headed Gull | 236 | | | | | + | | | | | 10 | | | | 85 | |
| Slender-billed Gull | 26 | | | | | 7 | | | | | | | | | | |
| Audouin's Gull | 30 | | | | | + | | | | | | | | | 5 | 3 |
| Lesser Black-backed Gull | 12121 | 15 | | | 1 | 93 | | 9 | 5 | | 4 | | | | 1199 | 3224 |
| Yellow-legged Gull | 124 | | | | | + | | + | | | | | | | 10 | 4 |
| Black-legged Kittiwake | 349 | | | | | 16 | 2 | | | | | | | | 40 | 56 |
| Gull-billed Tern | 2 | | | | | + | | | | | | | | | | |
| Caspian Tern | 80 | 1 | | | | | | | | | 1 | 7 | | | 14 | 5 |
| Royal Tern | 2889 | 2 | | | | 13 | | | | | 31 | 37 | | | 543 | 265 |
| Lesser Crested Tern | 62 | | | | | | | | | | | + | | | | |
| Sandwich Tern | 3491 | 2 | | | | 14 | | | | | 52 | 240 | | | 504 | 240 |
| Roseate Tern | 29 | | | | | | | | | | + | | | | 4 | |
| Common Tern | 15314 | 16 | 5 | | | 909 | 89 | | | | 2641 | 11 | | | 2261 | 277 |
| Arctic Tern | 822 | 2 | 1 | | | 6 | | | | | 30 | | | | 136 | |
| Common / Arctic tern | 22293 | 4 | | | | 9134 | | | | | 890 | 9 | | | 897 | 4775 |
| Bridled Tern | 38 | | | | | 5 | | | | | | | | | 3 | |
| Little Tern | 6 | | | | | 1 | | | | | | | | | 1 | |
| Whiskered Tern | 2 | | | | | 2 | | | | | | | | | | |
| Black Tern | 24452 | 83 | | | | 9146 | | 16 | | | 403 | | | | 1210 | 227 |

Gannets (thereby reaching depths of up to 25-30m), but also by the larger terns (probably usually less than 1m depth). Pursuit plunging is characteristic for shearwaters, now known to reach considerable depths (2-70m; Weimerskirch & Sagar 1996, Burger 2001). Pursuit diving has only been observed in some nearshore cormorants, but it would be the foraging technique by any seaduck or auks that could occur in these waters. Auks would have the physiological potential to dive several hundreds of metres deep, there potentially using the entire water column over the entire continental shelf (Neritic zone).

**Feeding at fishing vessels** is listed as a discrete foraging method, while it is in fact a feeding attraction formed by human fishing activities, whereby seabirds tend to use their preferred feeding technique (in the air, at the surface, or in the water column) to reach out for discarded fish or fishery waste, often in dense and sometimes very large assemblages of seabirds. Numbers observed in apparent association with fishing vessels (**Tables 4-7**) were much larger than the number of individuals scored as 'feeding at fishing vessel' (**Table 9**). The reasons is, that birds only heading for fishing vessels but simply in flight, flocks of resting in the wake, resting and preening or digesting, and awaiting further more interesting activities on these vessels, or otherwise were at least loosely associated with fishing boats were earmarked as 'fishing vessel associated' even if they were not actively feeding when seen.

## Associations with cetaceans

Seabirds were seen in association with cetaceans during nearly one fifth of all encounters, irrespective of the behaviour of the marine mammals (**Table 10**). This is an underestimate, for cetaceans could be seen at a considerable range at times, when any interaction with seabirds was very difficult to detect with certainty. Cetaceans involved, in declining order, were Common Dolphin 27x, Bottlenose Dolphin 9x, Atlantic Spotted Dolphin 8x, Short-finned Pilot Whale 8x, unidentified dolphin 6x, Fin Whale 5x, Risso's Dolphin 5x, Sperm Whale 4x, Blue Whale 3x, Sei Whale 2x, Atlantic Hump-backed Dolphin 1x, Clymene Dolphin 1x, Harbour Porpoise 1x, Humpback Whale 1x, Long-snouted Spinner Dolphin 1x, Rough-toothed Dolphin 1x, Sei / Brydes Whale 1x, Striped Dolphin 1x, and unidentified beaked whale 1x.

| | Sightings | Seabirds associated | | |
|---|---|---|---|---|
| fin whales | 71 | 10 | 14.1 | % |
| sperm whales | 49 | 4 | 8.2 | % |
| beaked whales | 7 | 1 | 14.3 | % |
| blackfish | 36 | 8 | 22.2 | % |
| dolphins | 236 | 52 | 22.0 | % |
| porpoises | 7 | 1 | 14.3 | % |
| | 406 | 76 | 18.7 | % |

**Table 10.** Recorded cetacean sightings (*n*) and occasions where seabirds occurred in apparent association (*n*, %) from sightings in the 180° forward scan, during ship-based surveys off NW Africa, 1986-2022.

Of all observed associations between seabirds and cetaceans, 8 (7%) occurred to the north of Cap Blanc in waters not assigned to depth zones. Of the other 105 encounters, 46.7% were in Oceanic waters, 31.4% over the Shelf-break and 21.9% within the Neritic zone. Frequencies of occurrence were similar in Jan-Mar, Jul-Sep, and Oct-Dec, while no associations were recorded in Apr-Jun. The absence of any associations in that period is probably because most surveys in that season were conducted earlier (1988, 2004) than most other surveys in Mauritanian waters, when the behavioural module on the observation protocol was not yet well enough established. The following species were attracted, in declining order of importance: Bulwer's Petrel (1 ass, 4 birds, 18.2% of all individuals seen), Scopoli's/Corys shearwater (4 ass, 138 birds, 5.6% of all), Red Phalarope (1 ass, 400 birds, 4.3% of all), Northern Gannet (37 ass, 2661 birds, 4.2% of all), Sooty Shearwater (3 ass, 6 birds, 3.4% of all), Great Skua (2 ass, 10 birds, 1.2% of all), Great White Pelican (1 ass, 1 birds, 0.9% of all), Band-rumped Storm Petrel (3 ass, 5 birds, 0.8% of all), Leach's Storm Petrel (6 ass, 12 birds, 0.7% of all), Wilson's Storm-petrel (13 ass, 139 birds, 0.5% of all), unidentified storm-petrel (1 ass, 3 birds, 0.5% of all), Long-tailed Jaeger (1 ass, 9 birds, 0.5% of all), Sandwich Tern (2 ass, 17 birds, 0.5% of all), Common Tern (12 ass, 67 birds, 0.4% of all), Cory's Shearwater (5 ass, 30 birds, 0.4% of all), Pomarine Skua (8 ass, 63 birds, 0.3% of all), Parasitic Jaeger (2 ass, 3 birds, 0.2% of all), Black Tern (4 ass, 44 birds, 0.2% of all), Lesser Black-backed Gull (1 ass, 15 birds, 0.1% of all), European Storm Petrel (2 ass, 12 birds, 0.1% of all), Cape Verde Shearwater (1 ass, 1 birds, 0.1% of all), and Sabine's Gull (3 ass, 4 birds, 0.0% of all).

### Associations with hunting tuna

Seabirds were seen in association with hunting tuna on 83 occasions, most of which (76, 91.6%) in the third quarter (Jul-Sep). In contrast to the associations of seabirds with cetaceans, were tuna rarely seen if there was no response in the avian community. Seabird-tuna associations were most often seen in Oceanic waters (78.3%), or over the Shelf-break (14.5%), and least frequent in the Neritic zone (7.2%). Tuna-driven foraging opportunities attracted 15 species of seabirds in total: Cory's Shearwater (0.6%), Cape Verde Shearwater (0.6%), Great Shearwater (0.0%), Wilson's Storm-petrel (4.1%), Leach's Storm Petrel (2.0%), White-faced Storm-petrel (0.1%), Northern Gannet (11.8%), Red Phalarope (0.2%), Long-tailed Jaeger (0.0%), Parasitic Jaeger (0.2%), Pomarine Skua (1.2%), Sabine's Gull (0.2%), Black Tern (53.6%), Common Tern (25.3%), and Sandwich Tern (0.0%). For Black Terns and Common Terns, tuna-driven foraging opportunities were the key attraction to venture that far out into the ocean, and Black Terns are known to continue feeding in association with tuna while wintering in the Gulf of Guinea (Wallace 1973, Lambert 1988).

### Species-specific prey

AS a non-breeding area for numerous species of seabirds are poorly known (Cramp & Simmons 1977, 1983, Cramp 1985; summarised in **Table 11**). The traditional handbooks provide guesses or expectations, often based on little published information. Extrapolations from one area to another can be dangerous, for species often adjust their foraging ‘preferences’ to readily available resources. Using these expectations, however, it is clear that all species known to gather substantial amounts of food reach peak densities within the Neritic zone, and in fact all species in these waters are almost entirely piscivorous, whether foraging at depth (Cory’s and Cape Verde Shearwaters, Northern Gannet and White-breasted Cormorant, or closer to the surface (all

**Table 11.** Principal prey (following Cramp & Simmons 1977, 1983, Cramp 1985), foraging depth (following **Table 9**), and oceanographic zone where highest numbers were recorded, deduced from sightings in the 180° forward scan, during ship-based surveys off NW Africa, 1986-2022.

| Species | Zoobenthos | Fish oil | Zooplankton | Fish larvae | Small fish | Small mesopelagic fish | Small pelagics | Medium fish | Flying fish | Fish unspecified | Discards | Cephalopods | Carrion | Birds | Depth | Zone |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Northern Fulmar | | | X | | | | | | | X | X | X | X | | Surface | (vagrant) |
| Fea's Petrel | | | | | X | | | | | X | | X | | | Surface | (vagrant) |
| Bulwer's Petrel | | | ? | ? | | ? | | | | | | | | | Surface | Oceanic |
| Scopoli's Shearwater | | | X | | | | | | | X | | | X | | Depth | Shelfbreak |
| Cory's Shearwater | | | X | | | | | | | X | | X | X | | Depth | Neritic |
| Cape Verde Shearwater | | | X | | | | | | | X | | X | X | | Depth | Neritic |
| Great Shearwater | | | | | | | X | | | | | X | | | Depth | Shelfbreak |
| Sooty Shearwater | | | X | | | | X | | | | | X | | | Depth | Shelf-Ner |
| Manx Shearwater | | | X | | | | X | | | | | X | | | Depth | Oceanic |
| Balearic Shearwater | | | X | | | | X | | | | | X | | | Depth | Shelf-Ner |
| Macaronesian Shearwater | | | | | | | X | | | | | X | | | Depth | Oceanic |
| Wilson's Storm-petrel | | X | X | X | | | | | | | | | | | Surface | Shelfbreak |
| White-faced Storm-petrel | | X | X | X | | | | | | | | | | | Surface | Oceanic |
| European Storm Petrel | | X | X | X | | | | | | | | | | | Surface | Shelfbreak |
| Leach's Storm Petrel | | X | X | X | | | | | | | | | | | Surface | Oceanic |
| Swinhoe's Storm Petrel | | X | X | X | | | | | | | | | | | Surface | Oceanic |
| Band-rumped Storm Petrel | | X | X | X | | | | | | | | | | | Surface | Oceanic |
| Red-billed Tropicbird | | | | | | | X | X | | | | X | | | Depth | (vagrant) |
| Northern Gannet | | | | | | | X | X | | | X | | | | Depth | Neritic |
| White-breasted Cormorant | | | | | | | | | X | | | | | | Depth | Neritic |
| Great White Pelican | | | | | X | | | | X | | | | | | Shallow | Neritic |
| Red Phalarope | | | X | X | | | | | | | | | | | Surface | Ocean-Shelf |
| Pomarine Skua | | | | | | | X | X | | X | X | | X | | Surface | Neritic |
| Parasitic Jaeger | | | | | X | | | | | X | X | | | | Surface | Shelf-Ner |
| Long-tailed Jaeger | | | X | X | X | | | | | X | | | | | Surface | Shelf-Ner |
| Great Skua | | | | | | | | X | | X | X | | X | | Surface | Neritic |
| South Polar Skua | | | | | | | | X | | X | X | | X | | Surface | (vagrant) |
| Mediterranean Gull | | | | | | | | | | X | | | | | Surface | Neritic |
| Little Gull | | | X | X | X | | | | | | | | | | Surface | Neritic |
| Sabine's Gull | | | X | | X | | X | | | X | | | | | Surface | Shelfbreak |
| Black-headed Gull | | | X | X | X | | | | | X | | | | | Surface | Neritic |
| Slender-billed Gull | | | | | | | | | | | | | | | Surface | Neritic |
| Audouin's Gull | | | | | X | ? | X | | | | X | X | | | Surface | Neritic |
| Lesser Black-backed Gull | | | X | | X | X | X | X | | | X | | X | | Surface | Neritic |
| Yellow-legged Gull | | | | | X | | X | X | | | X | | X | | Surface | Neritic |
| Black-legged Kittiwake | | | X | | X | | X | | | | X | | | | Surface | Neritic |
| Gull-billed Tern | | | | | | | | | | | | | | | Surface | Neritic |
| Caspian Tern | | | | | X | | | X | | | | | | | Shallow | Neritic |
| Royal Tern | | | | | X | | | X | | | X | | | | Shallow | Neritic |
| Lesser Crested Tern | | | | | X | | X | | | | | | | | Shallow | Neritic |
| Sandwich Tern | | | | | X | | X | | | | X | | | | Shallow | Neritic |
| Roseate Tern | | | X | | X | | X | | | | | | | | Shallow | Shelf-Ner |
| Common Tern | | | X | X | X | X | | | | | X | | | | Shallow | Neritic |
| Arctic Tern | | | X | | X | | | | | | | | | | Shallow | Shelfbreak |
| Bridled Tern | | | X | X | X | ? | X | | | | | | | | Shallow | Neritic |
| Little Tern | | | X | X | X | | | | | | | | | | Shallow | Neritic |
| Whiskered Tern | | | X | X | X | | | | | | | | | | Surface | (vagrant) |
| Black Tern | | | X | X | X | ? | | | | | | | | | Surface | Neritic |

Neritic zone. Seabirds that reach peak abundances in Oceanic waters or on the Shelf-break are generally concentrated on much smaller prey (zooplankton, fish larvae, small fish), likely supplemented with small mesopelagic fish at night (pers. obs.), do not are barely rely on food subsidies resulting from the activities of fishing vessels at sea, and are commonly attracted to cetaceans and hunting tuna that act as ‘beaters’ driving food towards the surface.

## 9. Species accounts

Following the considerations above, regarding foraging techniques, prey choice, preferred sea areas, associations with fisheries or other factors, the observed species were grouped in what could be considered ‘ecological guilds’ or at least functional groupings of closely related species in terms of foraging activities and general whereabouts at sea. Note that the seasonality of species within these groupings can be very different, but this will be discussed in the Species Accounts. Quarterly density maps (based on numbers of birds recorded within the 300m strip transect, as $n$ km$^{-2}$) have been produced only for sufficiently abundant species groups within the following taxonomic orders:

### Charadriiformes

- **Phalaropes** (Red Phalarope)
- **Skuas** (Pomarine Skua, Parasitic Jaeger, Long-tailed Jaeger, Great Skua, South Polar Skua, unidentified skuas)
- **Neritic gulls** (Audouin's Gull, Lesser Black-backed Gull, Yellow-legged Gull, Mediterranean Gull, Black-headed Gull, Slender-billed Gull, and Little Gull)
- **Pelagic gulls** (Black-legged Kittiwake and Sabine's Gull)
- **Regional large terns** (Gull-billed Tern, Caspian Tern, Lesser Crested Tern, and Royal Tern)
- **Sandwich tern** (1 species)
- **‘Commic terns’** (Arctic Tern, unidentified Common or Arctic tern, Common Tern, Roseate Tern)
- **Marsh terns** (Black Tern, Whiskered Tern)

### Procellariiformes

- ***Calonectris* shearwaters** (Cape Verde Shearwater, Cory's Shearwater, Scopoli's Shearwater, unidentified *Calonectris* shearwaters)
- **Other shearwaters** (Balearic Shearwater, Great Shearwater, Macaronesian Shearwater, Manx Shearwater, Sooty Shearwater)
- **Shelf-break storm-petrels (**European Storm Petrel, Wilson's Storm-petrel, unidentified storm-petrel)
- **Oceanic storm-petrels** (White-faced Storm-petrel, Leach's Storm Petrel, Band-rumped Storm Petrel, Swinhoe's Storm Petrel,)

### Suliformes

- **Northern Gannet** (1 species)

In the following overview, species are discussed that do occur, or likely may occur occasionally, at sea off NW Africa. Distribution patterns are discussed using the ship-based surveys conducted mostly off Mauritania, published sightings data wherever, or published tracking data in the peer reviewed literature.

**Anseriformes** No offshore sightings of seaducks

**Black Scoter** *Melanitta nigra* only to be considered. Expected region of significant numbers: off Morocco (hundreds to thousands wintering), small numbers (max. dozens?) in coastal areas of northern Mauritania (Cap Blanc, Nouadhibou, off Banc d'Arguin).

**Podicipediformes** No offshore sightings of grebes

Only species to be considered for occurrences at sea: **Little Grebes** *Tachybaptus ruficollis* and **Black-necked Grebes** *Podiceps nigricollis*. Will be strictly coastal, may utilise shallow waters, lagoons and estuaries.

**Phoenicopteriformes** No offshore sightings of flamingos

Only species to be considered for occurrences at sea: **Greater Flamingo** *Phoenicopterus ruber*. Strictly coastal, as a non-breeder widespread, utilising shallow waters, lagoons and estuaries, with roosts on beaches. Highly variable numbers along the entire coast, but in larger numbers where disturbance is low and conditions are favourable (Morocco to Senegal).

**Charadriiformes (1)** **Phalaropes**

The only wader of particular concern is the **Red Phalarope** *Phalaropus fulicarius*, a monotypic high Arctic species, breeding in tundras from western Alaska east across northern Canada to Baffin and Ellesmere Island, in Greenland, in Arctic Siberia from Novaya Zemlya to the Bering Strait, on the New Siberian Islands (Novosibirsk) and on Wrangel Island (Scott 2009). Very low numbers breed in Iceland and Svalbard. The migration routes are entirely oceanic, towards the major at-sea wintering grounds off Chile and West Africa. The world population is very coarsely estimated at ~1 million birds (Scott 2009). Historical, more or less incidental sightings, mostly within 8°N-24°N, 13°-18°W, have indicated the importance of the NW African region as a wintering ground, but the incidental reports failed to pinpoint consistency in the main concentrations (Holmes 1939, Stanford 1953, Bourne 1964, Bourne & Dixon 1975, Lambert 1988, Qninba *et al.* 1998). A recent sketch map by Scott (2009) is in fact quite inaccurate and concentrations of birds are proposed to occur largely beyond the most important wintering areas.

Red Phalaropes were seen year-round, but in very low numbers in the late Northern Hemisphere spring and early summer (**Fig. 6**). In fact, larger numbers (~600 individuals) were seen foraging at some fronts off Morocco in April 2004 during surveys between 23-24°N (~17°W), indicating that the wintering grounds had not been completely abandoned at that time, but extensive survey work off Mauritania produced few sightings

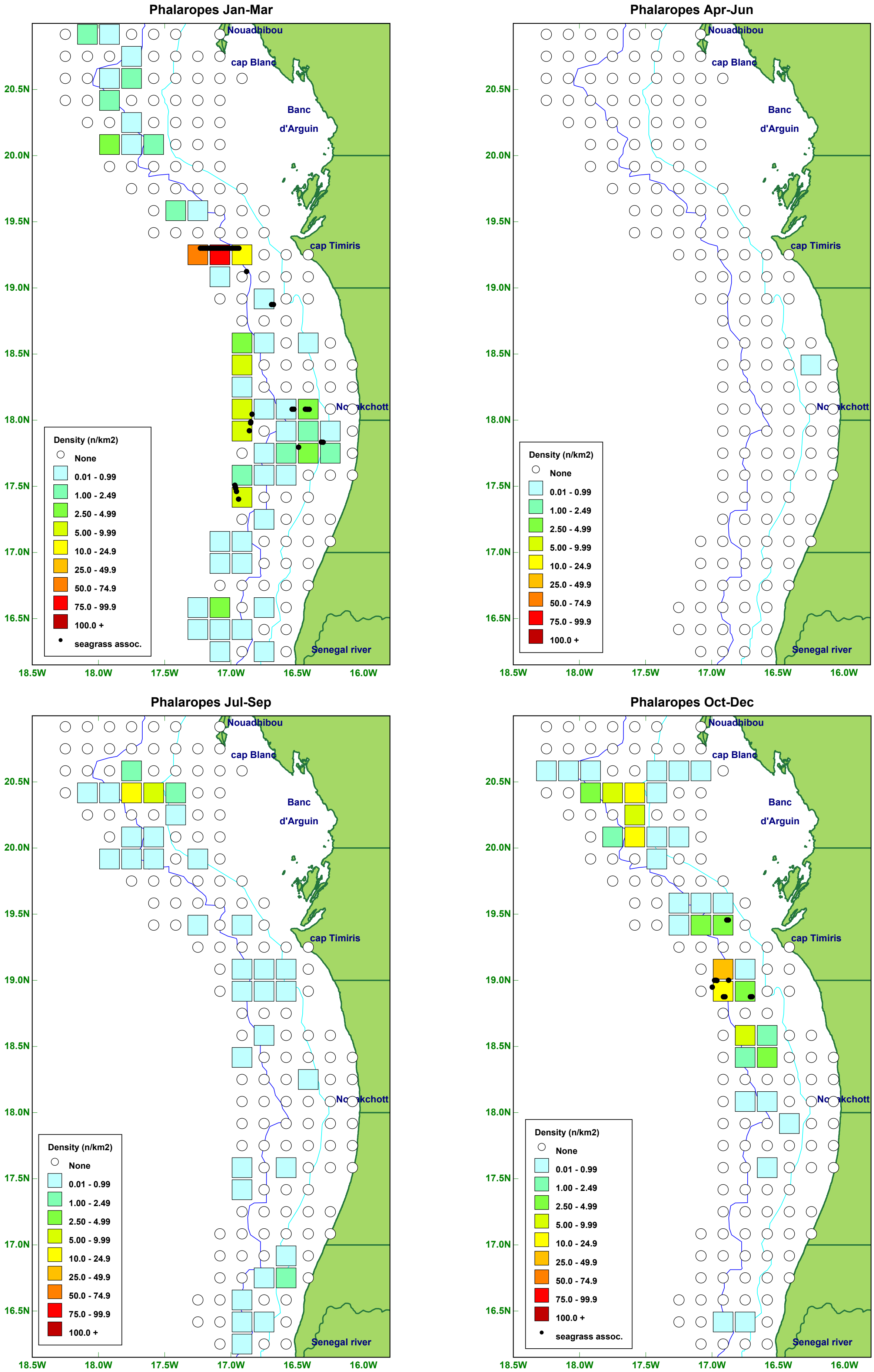


**Fig. 6** Charadriiformes (1) seasonal patterns in densities of phalaropes at sea, Mauritanian Shelf. Individual plots (●) are flocks of phalaropes seen in association with seagrass.

in that period.

Phalarope concentrations occurred typically far offshore (Shelf-break – Oceanic waters), with much lower densities within the Neritic zone. A single association of ~400 phalaropes with five foraging Fin Whales *Balaenoptera physalus* was recorded, again off Morocco, while in Mauritanian waters phalaropes typically operated 'on their own', not influenced by nearby fisheries, but highly attracted to frontal lines, especially those with accumulated flotsam or floating seaweeds (mostly seagrass). Small-scale coastal ocean fronts, eddies and internal waves capable of generating convergences at the surface are common, albeit ephemeral, in Senegalese, Mauritanian and West Saharan waters (Brown 1979, Camphuysen 2003). Apparently, these features are particularly important for phalaropes and their general location is probable quite predictable for the birds. The association with floating seagrass in winter (**Fig. 9**) was more important for phalaropes than for any other species, other planktivorous species such as storm-petrels included. Sampling floating seagrass over deep oceanic waters in November 2012 yielded numerous fish larvae, small juvenile fish and several crustaceans including copepods and Idoteidae (Camphuysen *et al.* 2013). The absence of petrels in otherwise suitable habitat is therefore difficult to understand. As in Mauritania, Grey Phalaropes seemed to be the only seabirds which commonly made use of the front off Senegal (Brown 1979).

Wintering numbers of Red Phalaropes in only the Mauritanian waters were estimated at ~140,000 individuals based on surveys in February 2022 (Camphuysen *et al.* 2022). Concentrations seen off the Moroccan coast suggest that similar numbers may occur in these waters, and Brown (1979) found Red Phalaropes in association with an oceanic 'front' far offshore off Senegal suggesting that these boundary zones are important feeding areas during the pelagic phase of this species annual cycle. To the south of Senegal the birds apparently concentrate at the northern boundary of the Guinea Current, another zone in which zooplankton is likely to be concentrated (Brown 1979). A conservative estimate of anything between 15% to perhaps as much as 25-30% of the world population (following Scott 2009) of Red Phalaropes wintering off the coast of NW Africa would make the presence of this species, certainly during the Northern Hemisphere winter (Oct-Mar), an immediate conservation concern. Since the wintering area as a whole, nor its function as a stop-over site for phalaropes wintering further to the south (Van Bemmelen *et al.* 2019a), has never been surveyed completely, it could be that areas of importance change from year to year, and should not be added up with confirmation of a simultaneous existence.

## Charadriiformes (2) Skuas

Five species of skuas are known to occur within the area, including four Arctic or Subartic/northern Temperate zone species: **Pomarine Skua** *Stercorarius pomarinus*, **Parasitic Jaeger** *S. parasiticus*, **Long-tailed Jaeger** *S. longicaudus*, **Great Skua** *S. skua*, and one representative from the Antarctic **South Polar Skua** *S. maccormicki.* That last species is either often overlooked, but otherwise a rare migrant travelling towards Greenland and Newfoundland or back to Antarctica via NW Africa (Salomonsen 1976, Lyngs 2003, Kopp *et al.* 2011). With

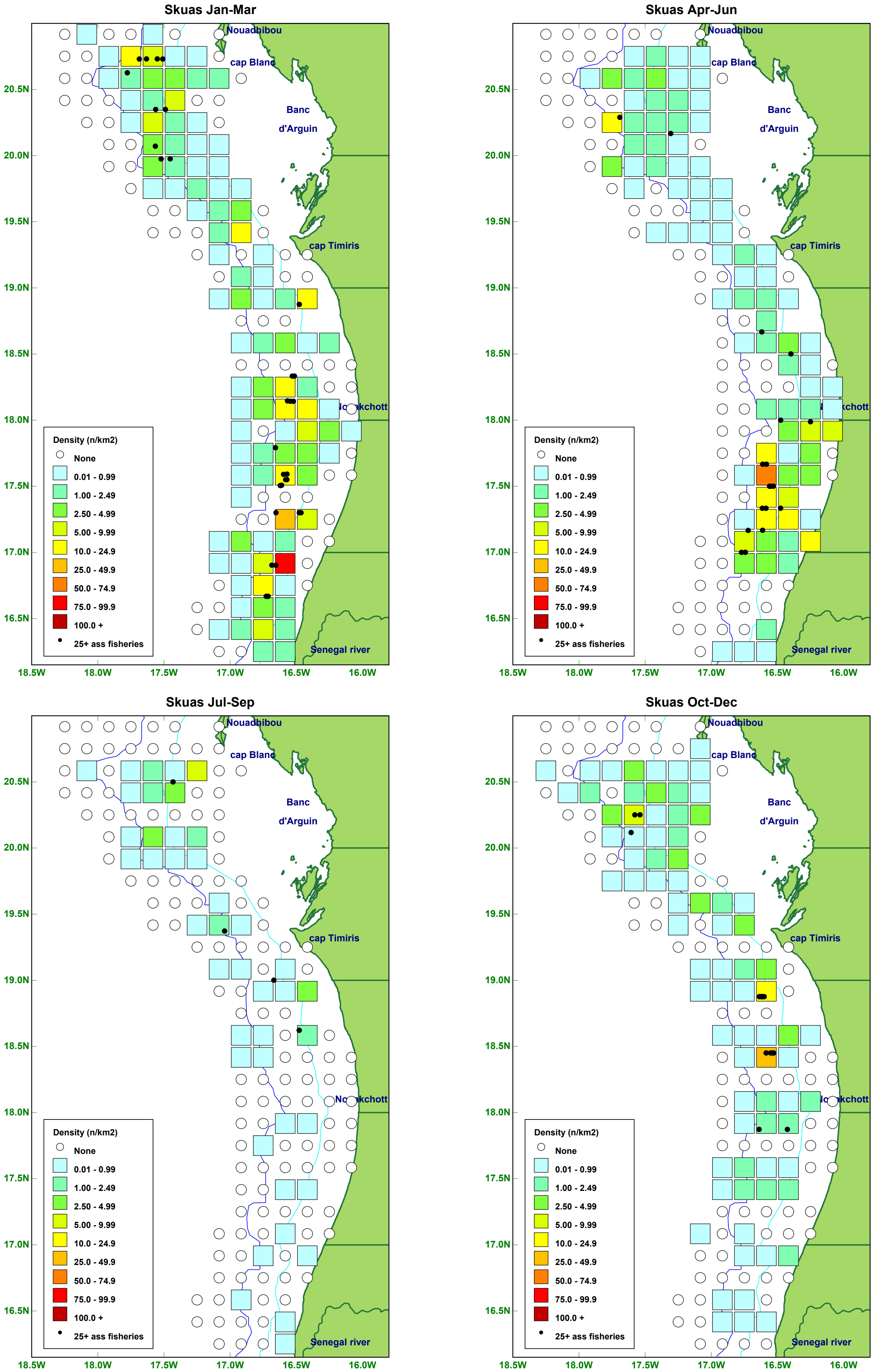


**Fig. 7** Charadriiformes (2) seasonal patterns in densities of skuas at sea, Mauritanian Shelf. Individual plots (●) are flocks of >25 skuas seen in association around fishing vessels.

only two sightings during systematic ship-based surveys, both off Cap Blanc, (9 May 2004, 4 Sep 2015), this species is not further considered in this account.

The skua family is a 'dominant feature' over the Continental shelf of NW Africa, with the Pomarine Skuas usually being by far the most numerous species. All four Northern Hemisphere skuas occur year-round in the area (lowest abundance in Jul-Sep), with comparatively higher sightings rates within the Neritic zone and over the shelfbreak than in Oceanic waters. All four taxa are somehow attracted to human fishing activities. A simple plot of fishing vessel associated flocks of skua number anything starting from 25 individuals (maximum count 930 skuas at the time) shows that the offshore densities are strongly influenced by fishing fleets. The Pomarine Skua is the more coastal species of them all, while the Long-tailed Jaeger is perhaps the more marine species, with relatively high numbers over the Shelf-break and in Oceanic waters. All species have been seen to kleptoparasitise other seabirds, but the Long-tailed Jaeger was also recorded frequently around visible fronts and foam lines, pecking for small, unidentified surface particles in small groups (up to 80 individuals together).

From **tracking studies**, it could be concluded that NW African waters off Mauritania are merely a stop-over site for the smallest two long-distance migrants, the Long-tailed Jaeger (Van Bemmelen *et al.* 2017, 2019b) and the Parasitic Jaeger, and as a wintering ground just south of where most Great Skuas tend to overwinter (Morocco, and off Portugal and Spain; Magnusdottir *et al.* 2012). For Pomarine Skuas, it is probably one of the most important wintering sites in the world (Furness 1987), which might explain why observed numbers are usually larger than those of any of the other skuas.

## Charadriiformes (3) **Neritic gulls**

Seven species are combined within this group, including the **Slender-billed Gull** *Chroicocephalus genei*, **Black-headed Gull** *C. ridibundus*, **Little Gull** *Hydrocoloeus minutus*, **Audouin's Gull** Ichthyaetus audouinii, **Mediterranean Gull** *I. melanocephalus*, **Yellow-legged Gull** *Larus michahellis*, and **Lesser Black-backed Gull** *Larus fuscus*. All species that roost on land and forage relatively close to the coast as central-place foragers. Slender-billed are at least potentially local breeding species. As stressed under the taxonomic overview above, several more gull species are known to occur in NW Africa, albeit often only as stragglers, and most would fit under this particular functional group of species. Especially the lack of records of **Grey-headed Gulls** *Chroicocephalus cirrocephalus* is quite striking, given their abundance in Mauritania and Senegal. The Little Gull is a bit of an odd inclusion in this group, which would ecologically perhaps fit better in any of the groups of terns. With only 4 individuals ever recorded at sea so far, including or excluding this bird anywhere would not make much difference.

Just as with the skuas, the presence of fishing vessels is an important factor driving distribution patterns (**Fig. 8**). Two-thirds of all Neritic gulls observed were logged as 'apparently associated with a fishing vessel' (*n*= 12,545 individuals). Neritic gulls were rarely seen in association with cetaceans (15 Lesser Black-backed Gulls were seen searching for prey in association with feeding Blue Whales *Balaenoptera musculus*, Feb 2022), and never with prey-driving tuna, and only a small fraction (1.2%) of all gulls within this group was recorded in Oceanic waters. By far the most abundant species is the Lesser Black-backed Gull, of which colour-rings indicate that Norwegian and Icelandic populations are comparatively well represented (Hallgrimsson *et al.* 2012). GPS tracking data showed a highly similar distribution over depth zones as from ship-based surveys

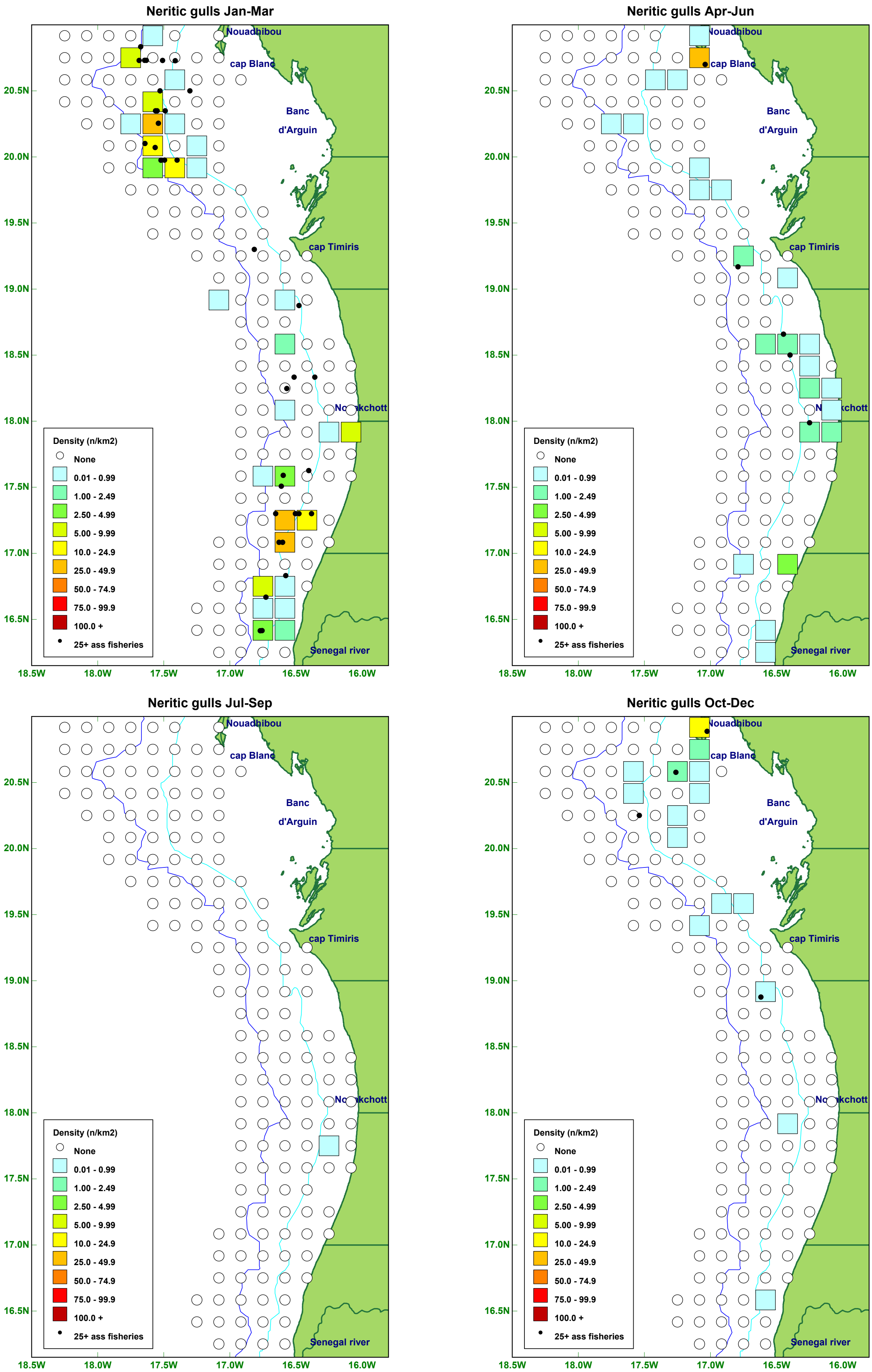


**Fig. 8** Charadriiformes (3) seasonal patterns in densities of Neritic gulls at sea, Mauritanian Shelf. Individual plots (●) are flocks of >25 gulls seen in association around fishing vessels.

(1.3% within the Oceanic zone from ship-based surveys, 2.2% from GPS tracking data; 20.4% over the Shelf-break from surveys, versus 39.2% from GPS tracking data; 78.3% in the Neritic zone from surveys, versus 58.6% from tracking data; **Fig. 9**$_{AB}$). The confirmation of strong link with commercial fisheries was another finding from the tracking study, but an unexpected revalation was the extensive use of offshore habitats at night (**Fig, 9**$_{B}$). The link with fisheries was perhaps even stronger than at daytime, but field studies revealed that Neritic gulls like Lesser Black-backed Gulls, but also Common Terns and Common Dolphins were actively hunting for prey (apparently mostly mesopelagic fish at the surface; **Fig. 11**). Nocturnal foraging activities are an issue that has barely been studied, even though there is considerable evidence that it is very important for marine mammals, and probably also for seabirds (Arcos *et al.* 2001Thomas *et al.* 2006, Dias *et al.* 2016).

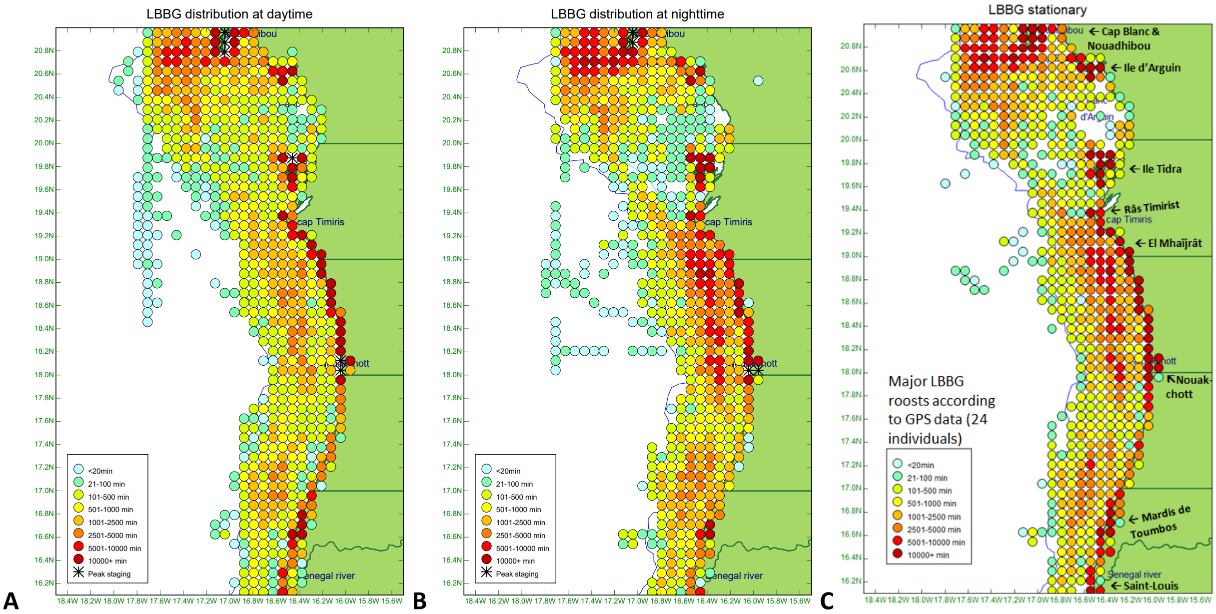


**Fig. 9** Charadriiformes (3) Neritic gulls: GPS tracking data of 21 individual **Lesser Black-backed Gulls** *Larus fuscus* wintering in Mauritanian waters (Oct-Apr, 2010/11-2021/21), expressed as time spent between subsequent GPS uploads (min). (**A**) distribution in daylight (07:00-17:59h), (**B**) distribution in darkness (18:00-06:59h), (**C**) time spent stationary at sea and on land, showing key roosts between Nouadhibou (Mauritania) and St Louis (Senegal). **Source:** J. Shamoun-Baranes & C.J. Camphuysen *unpubl. data*, UvA BiTS & NIOZ.

**Fig. 10**. Lesser Black-backed Gull with GPS tracker (C.J. Camphuysen).

**Fig. 11.** Nocturnal foraging on small mesopelagic fish by Lesser Black-backed Gulls and Common Terns, Mauritania, 7 Dec 2012 (C.J. Camphuysen)

Another species deserves special attention, the **Audouin's Gull** *Ichthyaetus audouinii*, perhaps for the exact same reason. This species breeds almost exclusively in the western Mediterranean (mostly in Spain), but is wintering mostly along the North and West African coast, south until at least Senegal and Gambia (Van Roomen *et al.* 2018). Counts at coastal roosts in Mauritania in the non-breeding season would easily result in hundreds and occasionally even in the low thousands of individuals (2012-2018, pers. obs, see also Van Roomen *et al.* 2018). With a known diet that consists mainly of epipelagic fish (small pelagic and shoaling fish species), often supplemented with fishery waste and discards dumped from fishing vessels (Oro *et al.* 1996, Gonzalez-Solis *et al.* 1997ab, Oro & Muntaner 2000), it is quite odd that only very few individuals were encountered during the ship-based surveys between 1986 and 2022 (30 individuals in total, 15 of which as ship-followers attracted to the research vessel, 9 in association with fishing vessels). Foraging (plunge diving) Audouin's Gulls were quite common in Mauritanian fish harbours such as in Nouadhibou and even near Nouakchott (Mauritania). On the breeding grounds, they are considered being rather specialized, nocturnal predators, primarily targeting shoaling clupeids (Pedrocchi et al. 1996, Gonzalez-Solis *et al.* 1997a, Moniz 2015). In Mediterranean waters, purse-seiners rather than demersal trawlers attract this species, if not to avoid inter-specific competition with the more powerful Yellow-legged Gulls closer to the coast an associated with demersal trawlers (Gonzalez-Solis *et al.* 1997a, Oro & Ruiz 1997). All ecological factors currently known of this species should lead to the expectation of a fairly common presence in offshore waters over the entire Mauritanian shelf, and perhaps even beyond, either around fishing vessels or self-targeting small pelagics by plunge diving. This could not be established during our surveys, for reasons we can only speculate about. If indeed Audouin's Gulls are predominantly nocturnal feeders, their commuting flights to and from roosts are in pitch darkness (contrary to commuting flights of Lesser Black-backed Gulls), for they have never been seen during any of these cruises.

Audouin's Gulls on the beach near Nouadhibou, Mauritania 26 Sep 2014 (C.J. Camphuysen)

## Charadriiformes (4) Pelagic gulls

Two species within this group, including the **Black-legged Kittiwake** *Rissa tridcatyla* and **Sabine's Gull** *Xema sabini*. Pelagic gulls typically roost at sea, not on land, and are comparatively rarely seen from the coast. The Black-legged Kittiwake is a widespread, cliff breeder within the temperate, subarctic and arctic climate zones on both sides of the North Atlantic (in fact disconnected circumpolar Holarctic), that is essentially oceanic in the non-breeding season, wintering primarily in the NW Atlantic, for which NW Africa is at the southern boundary of its distribution range (Bogdanova *et al.* 2017). Sabine's gulls have a patchy, circumpolar breeding distribution and overwinter in two ecologically similar areas in different ocean basins: the Humboldt Current off the coast of Peru in the Pacific, and the Benguela Current off the coasts of South Africa and Namibia in the

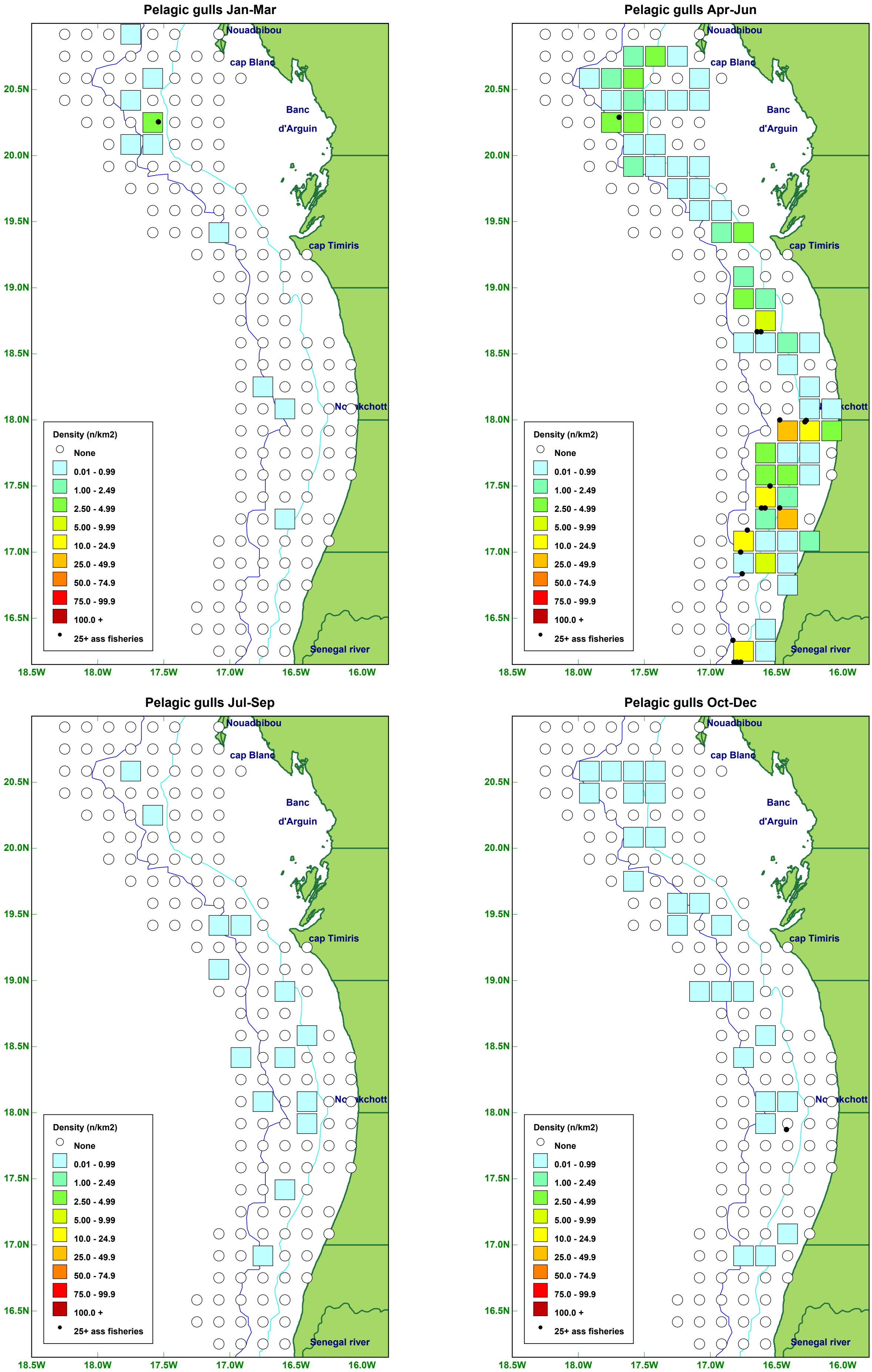


**Fig. 12** Charadriiformes (4) seasonal patterns in densities of Pelagic gulls at sea, Mauritanian Shelf. Individual plots (●) are flocks of >25 gulls seen in association around fishing vessels.

Atlantic (Davis *et al.* 2016). Using geolocators, it could be demonstrated that Atlantic migrants breeding in the Canadian high arctic leave their breeding grounds in late August, to arrive in their wintering areas around mid-November, using the NW African shelf as a stop-over site (~Sep-Oct). Failed breeders may depart breeding colonies as early as July, however (Davis 2015). Sabine's gulls wintering in the South Atlantic begin their spring migration between March and early May, spend 2-3 weeks off the coast of NW Africa between mid-March and June (Stenhouse *et al.* 2012). As so many migratory pelagic seabirds, Sabine's gulls, exploit highly localised areas of elevated marine productivity along a 28,000 km long migration route (Davis 2015). Birds breeding in Greenland spent an average of 45 days in the Bay of Biscay and Iberian Sea on their southern migration, while on their return north, Sabine's Gulls staged off the west African coast (Stenhouse *et al.* 2012).

The results of ship-based surveys fully support the tracking data, with Sabine's Gulls in spring (Apr-Jun) in Mauritanian waters being at least 30x more abundant than in any other season (**Table 2**). As expected, both species had a more marine orientation than the Neritic gulls, but in Oceanic waters even Sabine's Gulls were comparatively scarce (overall abundance year-round, 42.4 birds 100km$^{-1}$ in the Neritic zone, 170.2 over the Shelf-break, 2.7 in Oceanic waters). Shelfbreak fisheries formed a major attraction (72% of all Sabine's Gulls observed were in association with fishing vessels), where up to several hundreds of birds would gather and feed in spring, smaller flocks in other seasons (**Fig. 12**). Few birds were seen to join natural multi-species foraging associations, associations with cetaceans were equally scarce, including on case of foraging on Sperm Whale *Physeter macrocephalus* excrements, and two associations with oceanic dolphins.

## Charadriiformes (5) Regional large terns

Four species within this group, including **Gull-billed Tern** *Gelochelidon nilotica*, **Caspian Tern** *Hydroprogne caspia*, **Royal Tern** *Thalasseus maximus albidorsalis*, and **Lesser Crested Tern** *Thalasseus bengalensis*. By far the most numerous and widespread species observed in offshore waters was the Royal Tern, which occurred in all seasons, but with peak abundances in spring (Apr-Jun). Whether all terns recorded as 'Lesser Crested Terns' were correctly identified is perhaps questionable; confusion with Royal Terns is easy.

**Caspian Terns** *Hydroprogne caspia* were strictly coastal, and almost exclusively seen within the Neritic zone. Low numbers, year-round, would indicate that local birds rather than long distance migrants from Scandinavia were involved. The observed numbers during offshore surveys were very small in comparison with the flocks of Caspian Terns accumulating at some favourite roosts onshore, suggesting that few foraging and feeding individuals would venture out into the ocean for more than ~10km. Apart from 7 sightings in spring (Apr-Jun) off the Senegal River (nearby some major breeding colonies in Senegal), all observed Caspian Terns were seen off Banc d'Arguin (another major breeding area) and around Cap Blanc (large numbers roost at Cap Blanc and near Nouadhibou). The offshore surveys have evidently missed the most important foraging groungs along the coast for this species.

**Royal Terns** *Thalasseus maximus albidorsalis* breed in large numbers on the Pelican and Flamingo Islands, on Zira, and Cheddid in the Banc d'Arguin National Park, which is clearly reflected in frequent occurrences to the northwest of Cap Timiris and to the south of Cap Blanc (**Fig. 13**). With egg-laying starting around mid-April (laying peak May-mid-June), it is clear that their abundance offshore in the second quarter (Apr-Jun) is in the egg phase, rather than during chick care. In early autumn (August surveys), adults accom-

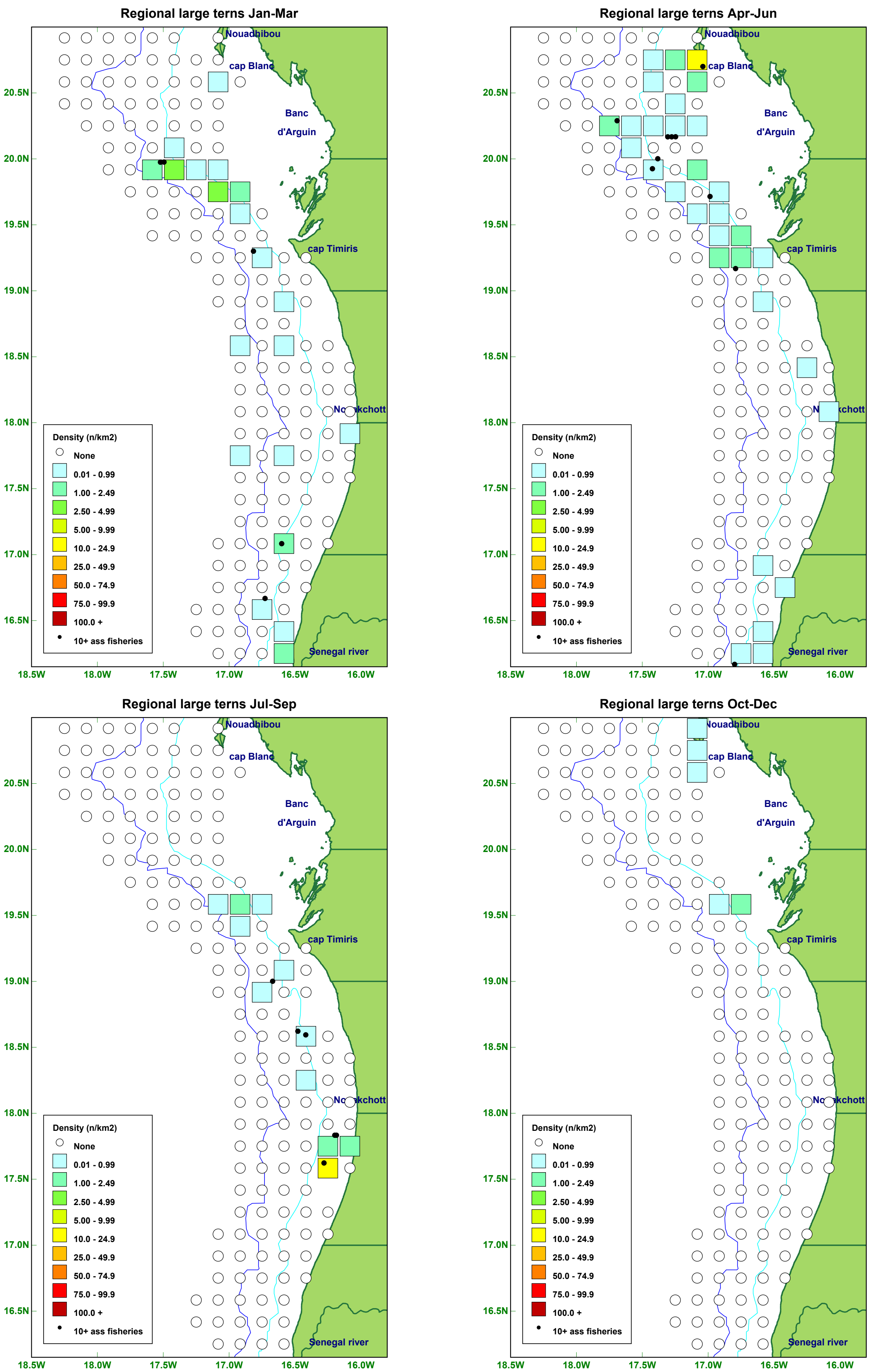


**Fig. 13** Charadriiformes (5) seasonal patterns in densities of Regional large terns at sea, Mauritanian Shelf. Individual plots (●) are flocks of >10 terns seen in association around fishing vessels.

panying noisy begging fledglings are a common sight at sea, but the chick rearing phase (July) was essentially missed during the offshore surveys reported here.

Royal Terns were heavily attracted to fishing vessels or to the research vessel and large flocks could be seen resting on the superstructure of otherwise inactive (or towing) trawlers (74.3% of all observed Royal Terns at sea, *n*= 2889). The research vessel itself formed an attraction, either as a resting platform, or as something to at least briefly change course for. The result of this is, that overall recorded densities are probably somewhat inflated, as a result of birds seen in transect that were there because they had altered course to check out just another vessel. None of these species were ever seen in feeding frenzies in association with marine mammals, tuna, or other predatory fish driving small fish prey to the surface. The inshore part of commuting flights, to and from the colony, as well as any nearshore foraging, were largely missed during the offshore surveys reported here. Sightings within the first quarter (Feb-Mar) involved numerous adult summer plumage Royal Terns operating in pairs and frequently engaged in (noisy) courtship display while in flight, even while far out to sea.

### Charadriiformes (6) **Sandwich Tern**

One species within this group, **Sandwich Tern** *Sterna sandvicensis*, a wintering bird and passage migrant breeding in W Europe, travelling towards South Africa and into the Indian Ocean (Cramp 1985). Sandwich Terns are entirely 'marine' in their orientation, throughout the annual cycle. The majority of the Sandwich Terns to be seen in Mauritania probably originate from W European colonies. Birds breeding in the Black Sea winter primarily in the eastern Black Sea, the central and sout-eastern Mediterranean, with a small number of birds reaching West Africa (Cramp 1985).

In NW African waters, peak abundances were observed within the Neritic zone, connecting to nearshore (coastal) foraging opportunities (**Fig. 14**). Large numbers can occur at onshore roosts on beaches, with Caspian, 'commic', and Black Terns, to rest and preen between foraging bouts at sea. Commuting flights between roosts and offshore foraging opportunities are therefore expected to have influenced the coastal distribution patterns. Flocks around fishing vessels were observed year-round, with up to 140 individuals at the time. Around one-fifth of all Sandwich Terns observed were somehow associated with fishing vessels, and just as with Royal Terns, large flocks could accumulate and rest on the superstructure of these vessels. Associations with cetaceans were rare: with fin whales on one occasion (32 individuals), once with dolphins (solitary tern). Tuna driven foraging frenzies were only once seen to include some Sandwich Terns.

### Charadriiformes (7) **'Commic' terns**

Three species within this group, including **Roseate Tern** *Sterna dougallii*, **Common Tern** *Sterna hirundo*, and **Arctic Tern** *Sterna paradisaea*.

Only **Common Terns** breed along the West African coast, but in modest numbers, around 100-200 pairs only (Isenmann 2000, Keijl *et al.* 2001). Hence, most if not all 'commic' terns observed during at-sea surveys were passage migrants and winter visitors. The three species in this group are difficult to tell apart

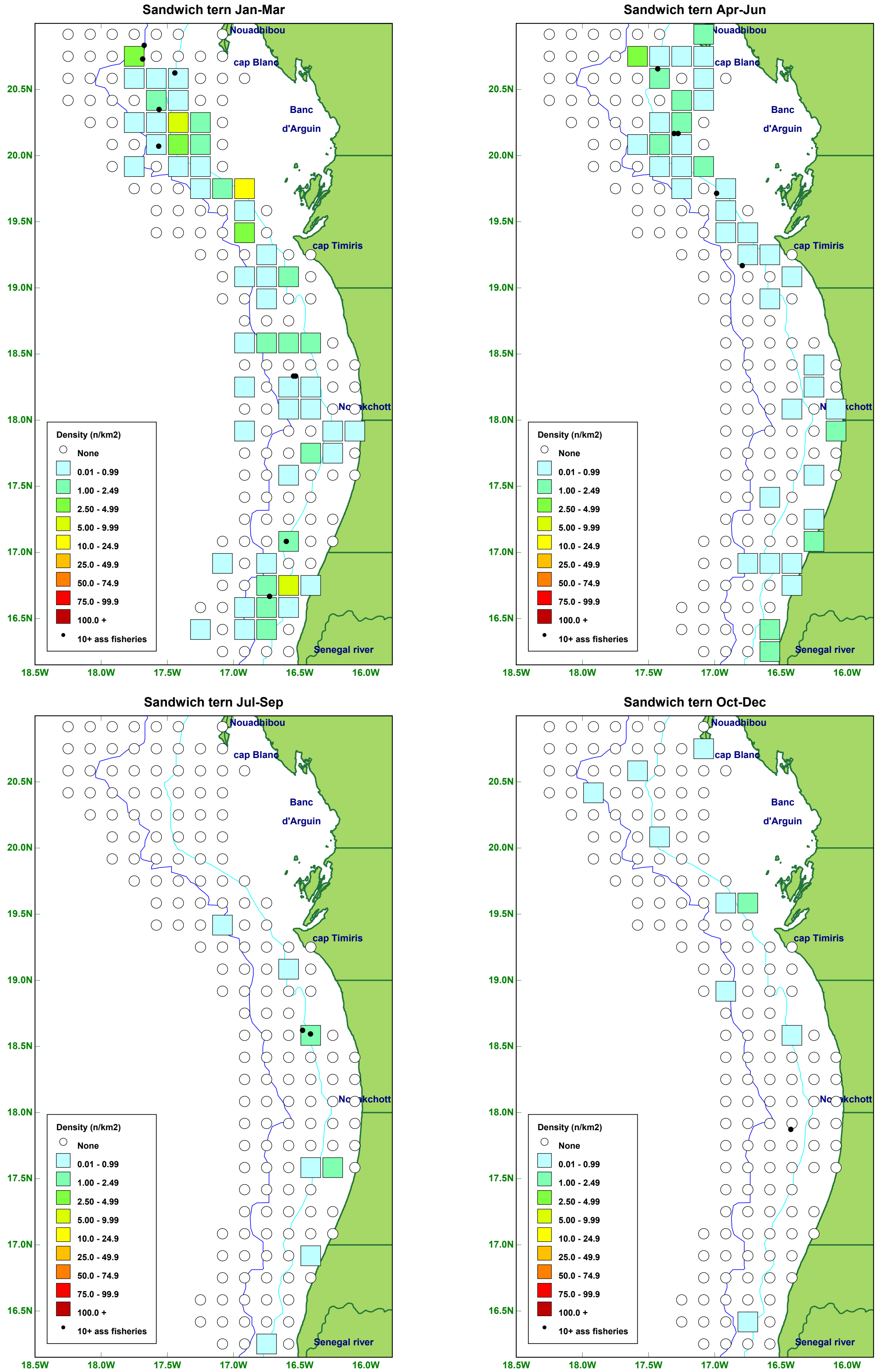


**Fig. 14** Charadriiformes (6) seasonal patterns in densities of Sandwich Terns at sea, Mauritanian Shelf. Individual plots (●) are flocks of >10 terns seen in association around fishing vessels.

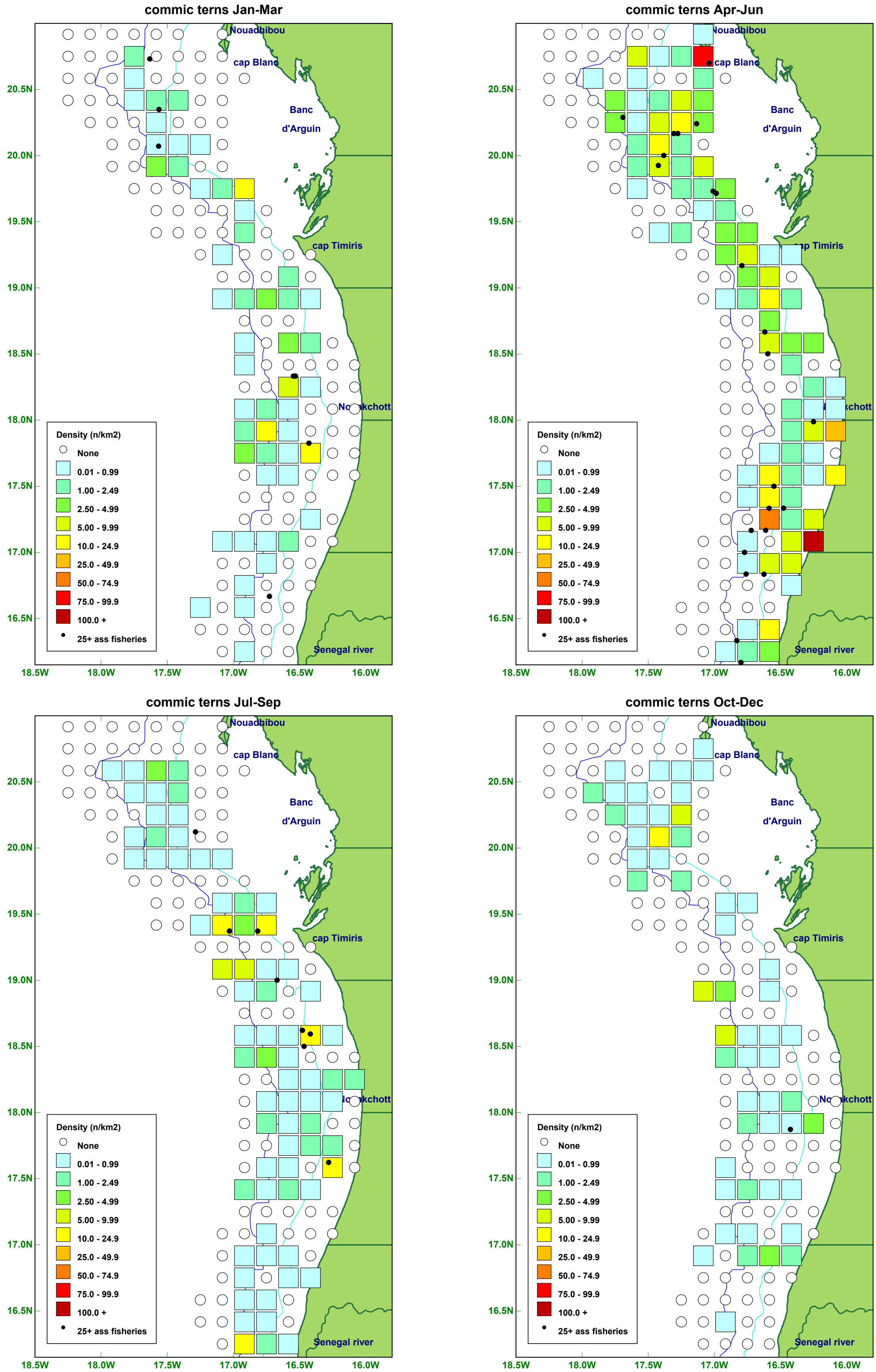


**Fig. 15** Charadriiformes (7) seasonal patterns in densities of 'commic terns' at sea, Mauritanian Shelf. Individual plots (●) are flocks of >25 terns seen in association around fishing vessels.

under normal field conditions and as many as 58% of all 'commic' terns seen remained unidentified (*n*= 38,303). All three species are migratory. European **Roseate Terns** winter exclusively in West Africa, with at least some reaching the southern tip of the African continent. Roseate Terns are considered the 'most thoroughly marine'of all European terns (Cramp 1985). Roseate Terns breeding in North America and the West Indies winter along the coast of South America, south to Brazil. The migratory movements of **Arctic Terns** are legendary, and they were legendary because they were 'known' to travel from the Arctic to the Antarctic on their annual quest between breeding and wintering grounds. Little did we know, until trackers were deployed, that their annual journeys were roundtrips that in fact covered three oceans (Atlantic, Indian and Southern Ocean) on trips over ~90,000 km annually for some individuals (Egevang *et al.* 2009, Fijn *et al.* 2013, Wong *et al.* 2021). **Common Terns**, finally, stopped over 'around the Canary Islands' in spring and autumn, but their main wintering distribution was the upwelling seas alongside the West African coast (Becker *et al.* 2016). Spring migration was longer (56 ± 8 days) than autumn migration (37 ± 17 days), and during both migration and wintering, the terns spent more time on salt water than during breeding and post-breeding. Common Terns are known winter in Neritic waters around the African Continent (Cramp 1985), so many birds from European breeding grounds travel further than these German tagged individuals. With the European population of Roseate Terns being comparatively small, and Arctic Terns travelling on, on their epic journeys, the majority of the 'commic' terns off NW Africa, for the greater part of the annual cycle should be Common Terns, which is in line with successful identifications at sea (0.1% Roseate Tern, 5.1% Arctic Tern 94.8% Common Tern). Fanatic 'birders', however, given time, would probably find more of these rarer terns amongst the masses of birds that have to be counted and identified on these ship-based surveys.

The bulk of the 'commic' terns were seen in Neritic waters and over the Shelf-break, with a slightly higher abundance nearer the coast (overall, 462.8 $100km^{-1}$ in the Neritic zone, 315.2 $100km^{-1}$ over the Shelbreak). Arctic Terns were distinctly more numerous over the Shelf-break (12.5 $100km^{-1}$) than in the Neritic zone (4.7 $100km^{-1}$). Numerous flocks of 'commic' terns were seen attending fishing vessels year-round, up to over 1000 individuals at the time (**Fig. 15**). In total, 37% of all 'commic' terns observed were somehow associated with fishing vessels. Other foraging opportunities were more important, however, and these included associations with large fin whales (2x), Sperm Whales (2x) and pods of dolphins (8x). Tuna schools in deep water attracted thousands of Common Terns in autumn (Aug-Dec), even though these birds were massively outnumbered by Black Terns *Chlidonias niger* in these feeding frenzies. Self-feeding was common in all terns, but certainly also in Common Terns (flying against the wind in loose formations, frequently dipping or shallow plunge diving). The ship-based data demonstrate that the NW African shelf is of great importance as a stop-over and non-breeding staging area throughout the year, offering a multitude of foraging opportunities, during daytime, but also, more 'secretively', at night (**Fig.11** ). At the beach roosts many thousands of terns can be seen resting and preening between foraging excursions.

## Charadriiformes (8) **Marsh terns**

Two species within this group, including **Whiskered Tern** *Chlidonias hybrida*, **Black Tern** *Chlidonias niger*, but in fact only one 'marine' species is involved and that is the Black Tern Whiskered Terns have a more freshwater orientation in tropical Africa.

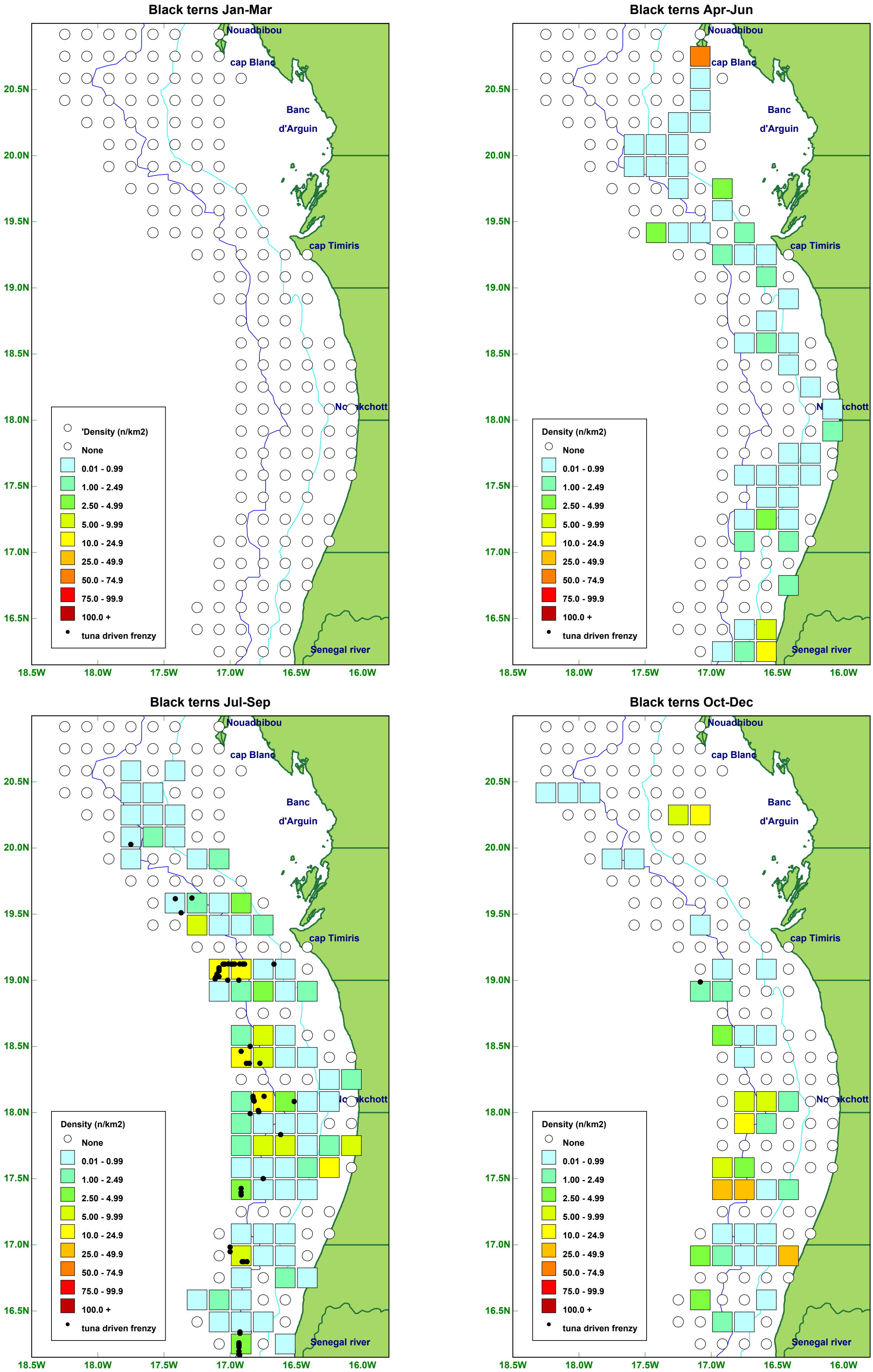


**Fig. 16** Charadriiformes (8) seasonal patterns in densities of marsh terns at sea, Mauritanian Shelf. Individual plots (●) are feeding frenzies of marsh terns seen over hunting tuna schools.

Black Terns breed throughout the West Palearctic in scattered inland colonies in Most of Europe and Russia. The main wintering area for Eurasian birds is tropical West Africa, where they are supposed toe be 'largely coastal' (Cramp 1985). Southbound movements in Central Europe start in late July and departures continue until mid-September (Bezzel & Reichholf 1965). Movements are directed towards the African west coast, and the furthest individuals will reach wintering areas as far south as Namibia, or occasionally South Africa. By far the majority is thought to spend the winter in tropical African 'coastal' waters, where the can be seen far away from the coast, day and night, especially in the Gulf of Guinea (Lambert 1988). These marsh terns are in fact some of the more marine species in winter. The significance of Moroccan and Mauritanian waters is a long-established fact, even though details on their ecology at sea were poorly understood (Hammond 1958, Lambert 1971, Bourne & Dixon 1973, Hales & Hallett 1995, Bourne 1997, Brenninkmeier *et al.* 1998, Wynn 2003, Van der Winden *et al.* 2004). From a recent tracking study, various details were confirmed. Black Terns carrying geolocators from four Dutch colonies migrated to West Africa, but whereas some individuals flew nonstop, the others made stops of varying length en route. Post-breeding stopovers were detected at the Alborán Sea, seas near the Canary Islands and Banc d'Arguin, Mauritania. Staging durations varied between 2-35 days, and the longer the staging took, the longer the subsequent flights were. Black Terns staged at the Banc d'Arguin, the marine shelf-break seas between Senegal and Liberia, and in the Gulf of Guinea, or went as far south as the Benguela Current off Namibia (Van der Winden *et al.* 2014). During the non-breeding season, Black Terns depend mainly on relatively large prey (shrimps and fish). Food availability explained their migration patterns to a major extent (Van der Winden 2002).

The enormous significance of Mauritanian waters for Black Terns is uncontested and could be further demonstrated through ship-based surveys during most of the year (**Fig. 16**). Black Terns formed enormous flocks on roosts, in nearshore feeding frenzies, and in feeding frenzies offshore, including in Oceanic waters and more often than any other seabird in association with small tuna, such as Skipjack Tuna *Katsuwonus pelamis* (photos below). Commuting flights, with Common Terns, were a common phenomenon off Mauritania

Offshore feeding frenzy with Black Terns and Common Terns targeting forage fish driven towards the surface by Skipjack Tuna *Katsuwonus pelamis*, 5 Sep 2015. Water depth >1400m (H Verdaat)

Part of an offshore feeding frenzy with mostly Black Terns and some Common Terns targeting forage fish driven towards the surface by Skipjack Tuna Katsuwonus pelamis, 5 Sep 2015. Water depth 1047m (CJ Camphuysen)

Mass flights of restless Black Terns over the Nouadhibou airport roosts at dusk, 15 Sep 2015. Lesser Black-backed Gulls on the foreground (CJ Camphuysen).


Mass feeding frenzy of Black Terns just near the Nouadhibou roosts, 28 Sep 2014, showing that mass feeding activities occur also in nearshore waters. Frenzies like these were often near anchored vessels, were stable (long duration) with birds frequently commuting between the onshore roost and the nearshore foraging opportunity (CJ Camphuysen).

at their peak abundances in autumn. Thousands of birds were recorded in association with hunting tuna, rather fewer with cetaceans (associated with Sperm Whale 1x, with dolphins 3x), although ‘beaters’ driving prey towards the surface were an important foraging ‘aspect’. Comparatively few Black Terns were seen in association with fishing vessels. Ship-following behaviour was usually fairly short and a means of transport rather than a foraging option. Associated birds were constantly on the look-out, however, dipping for small prey ahead of the ship or in its wake. During the surveys, high numbers of Black Terns could be seen in Oceanic waters (virtually all foraging) over the Shelf-break (also often foraging, but considerable commuting flights from roosts to Oceanic feeding grounds), and within the Neritic zone. Tens of thousands of Black Terns were seen during the survey, while the onshore beach roosts could number over a hundred thousand of individuals. Black Terns were easily among the most abundant seabirds in the area in spring (Apr-Jun), but very high numbers could be seen in summer (Wynn 2005) and autumn (**Table 2**), making this area of particular significance for this species.

### Phaethontiformes - **Red-billed Tropicbird** *Phaethon aethereus*

Breeding species in small numbers in Senegal and on Cape Verde Islands. Straggler, few sightings in deeper waters (Oceanic, Shelfbreak). No associations of any kind observed.

### Gaviiformes divers or loons Gaviidae

No offshore sightings of divers Species to be considered for rare occurrences at sea given their wintering occurrence in Moroccan waters: Will be strictly coastal, may utilise shallow waters and estuaries, if anywhere, most likely in the northern part of Mauritania and off Morocco.

### Procellariiformes (1) *Calonectris* shearwaters

Three species within this group, including **Scopoli's Shearwater** *Calonectris diomedea*, **Cory's Shearwater** *C. borealis*, and **Cape Verde Shearwater** *C. edwardsii*. Scopoli's Shearwater os breeding almost exclusively in the Mediterranean, Cory's Shearwater is breeding in the subtropical Atlantic in Portugal and Spain, on Madeira, the Canaries and the Azores. The Cape Verde Shearwater is an endemic species for these islands. Until quite recently considered as a polytypic species with three subspecies (Cramp & Simmons 1977). Identification at sea can be a challenge (Porter *et al.* 1997, Gutiérrez 1998, Flood & Gutiérrez 2021). Surveys prior to 2000 did not separate the (then) subspecies.

*Calonectris*-shearwaters as a group, occurred year-round in large numbers, but sightings rates peaked in Oct-Dec (**Table 2**, **Fig. 17**). Field identifications since 2000 would suggest that Cory's Shearwaters outnumbered Scopoli's Shearwaters with a ratio 5:1 (*n* = 1278) in late winter (Jan-Mar). In spring (Apr-Jun) the reverse was found, but with a much smaller number of identified individuals (*n*= 352). Cape Verde Shearwaters dominated the scene almost completely in early autumn (Jul-Sep), with around 90% of all *Calonectris*-shearwaters identified in these months (*n*= 1100). Cory's Shearwaters were ten times more abundant than the still common Cape Verde Shearwaters, which in turn outnumbered Scopoli's Shearwaters at a ratio 10:1 (*n*= 7725) in early winter (Oct-Dec). Only tracking data can reveal if these conclusions could be true, and fortunately, there are many studies conducted in recent years (Ristow *et al.* 2000, Louzao *et al.* 2009, Ramos *et al.* 2013, Perez *et al.* 2014, Grémillet *et al.* 2015, Paiva *et al.* 2015, Peron & Grémillet 2016, Ramos *et al.* 2020, **Table 12**).

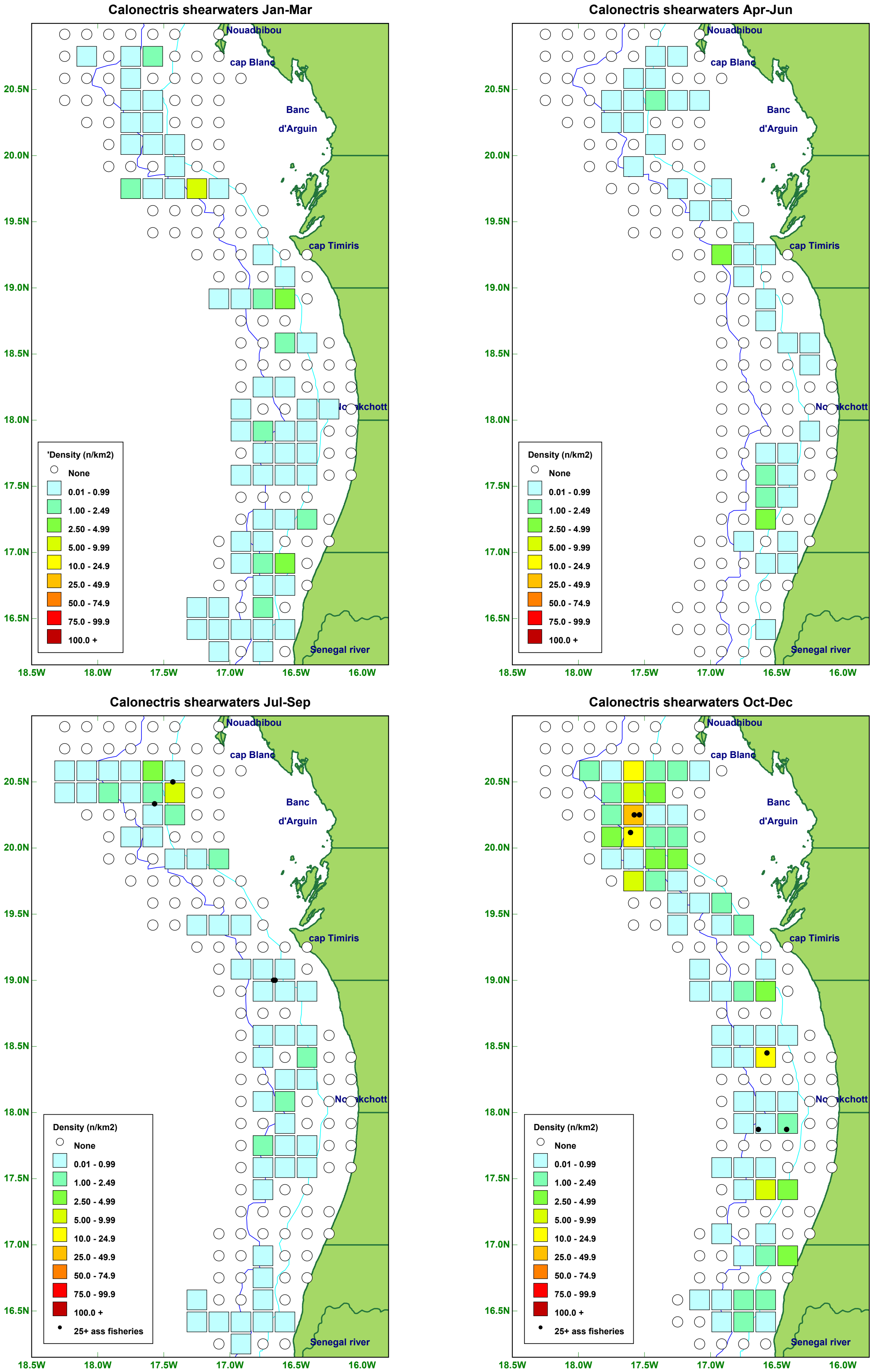


**Fig. 17** Procellariiformes (1) seasonal patterns in densities of *Calonectris* shearwaters at sea, Mauritanian Shelf. Individual plots (●) are flocks of >25 shearwaters seen in association around fishing vessels.

**Table 12.** *Calonectris*-shearwaters in NW African waters, based on various tracking studies.

| Species | Season | Occurrence | Source |
|---|---|---|---|
| *C. diomedea* | Nov-Dec | Passage migrant from Greece, passage Nov-Dec, shelf seas Morocco – Senegal, towards Gulf of Guinea and central tropical Atlantic. Tracked birds left Mediterranean late and wintered farther north than expected by authors [satellite tracking] | (1) |
| *C. diomedea* | Oct-Mar? | Passage migrant from Chafarinas, Mediterranean, 57% of all tracked birds wintering off the coasts of Western Sahara-Senegal [light loggers geolocation] | (2) |
| *C. diomedea* | Nov-Mar | Birds from Riou and Frioul Islands off Marseille and Lavezzi Island in Corsica, wintering off NW Africa, Ghana-Morocco, with high concentrations Continental Shelf waters Western Sahara, Mauritania, Senegal; primarily Neritic zone off Mauritania/Senegal between Dakar and Nouakchott [light loggers geolocation and Argos PTTs] | (4) |
| *C. diomedea* | Nov-Feb | Birds from Riou and Frioul Islands off Marseille and Lavezzi Island in Corsica, wintering Western Sahara – Senegal, few moved on to Ghana. Peak numbers SW Mauritania/NW Senegal [light loggers geolocation, Argos PTTs, GPS-loggers] | (6) |
| *C. borealis* | (Oct-Mar), rare | Breeding Azores and Canaries: passage migrant, only one bird (7%) wintering off West Africa, rest travelled towards Benguela-Agulhas Current and Brazilian Current [light loggers geolocation] | (2) |
| *C. borealis* | (Jul-Sep) | Breeding Canary Islands: kernel density distributions (50% contours) during chick rearing all off Morocco and Western Sahara, Cap Blanc – Cap Rhir, 20-35°N [Argos PTTs and GPS-loggers] | (3) |
| *C. borealis* | (Oct-Mar), rare | Breeding Selvagem Grande, wintering areas include Benguela/Agulhas current, Brazilian Current, NW Atlantic and few birds Canary Current [geolocators] | (7) |
| *C. borealis* | (Oct-Mar), rare | Breeding Selvagem Grande, Madeira, Portugal: most migrated to Southern Hemisphere, 8% remained close to breeding colonies, foraging in the Canary current [geolocators] | (8) |
| *C. borealis* | Jul-Sep | Breeding Gran Canaria: major feeding areas during chick-rearing off Western Sahara and Morocco, range 20°-30°N [GPS loggers] | (9) |
| *C. edwardsii* | (Jun) (Sep) | Breeding birds Raso Islet, Cape Verde Islands, studied during mid-June (incubation) and mid-September (chick-rearing). In June, foraging over shelf and shelf-break off Senegal. September: mostly foraging near colonies Cape Verde Islands, very few trips towards shelf break Mauritania [GPS-loggers] | (5) |

**Sources:** (1) Ristow *et al.* 2000, (2) González-Solís *et al.* 2007, (3) Ramos *et al.* 2013, (4) Gremillet *et al.* 2015, (5) Paiva *et al.* 2015, (6) Peron & Grémillet 2016, (7) Dias *et al.* 2011, (8) Perez *et al.* 2014, and (9) Ramos *et al.* 2020

Tracking studies indicate that Scopoli's Shearwaters are more inclined to winter off West Africa (~40% wintering Canary Current region, 10% Gulf of Guinea, 40% Benguela Current, 10% Brazilian Current) than Cory's Shearwaters, in which wintering destinations vary per breeding colony (overall ~7-10% Canary Current, 60-70% Benguela/Agulhas Current, 9-30% Central South Atlantic, <9% Brazilian Current, 4% North Atlantic). Given the very different, but also poorly known population size of either species, and given the large differences in migratory movements and wintering destinations between colonies, it is quite hard to provide an estimate of species composition off West Africa throughout the annual cycle. The migratory movements of Cape Verde Shearwaters are even less well known, but they are assumed to winter mostly in the South Atlantic (Hillcoat *et al.* 1977, Olmos 2002). The results of tracking studies would suggest that Scopoli's Shearwaters are somehow overlooked (misidentified). The ship-based surveys, however, have demonstrated that the West African shelf waters are much more significant for the endemic Cape Verde Shearwater than what could be anticipated from the limited tracking work.

The ship-based surveys yielded peak abundances immediately after the breeding season (Oct-Dec), when Cape Verde Shearwaters were still present but declining in numbers. Large numbers could be seen throughout the year, but the fact that all species had a strong tendency to approach and follow the research vessel (as any vessel), true densities must have been somewhat underestimated (protocols require that 'ship attracted birds' are not included for density assessments). Large numbers around trawlers were seen only in the 3rd and 4th quarter of the year, with flocks up to 600 individuals at the time. In all, 17% of the Scopoli's and

Cory's Shearwaters were seen in association of fishing vessels (*n*= 11,285), and 10% of all Cape Verde Shearwaters (*n*= 1653). All species were seen to be attracted by whales and dolphins at times, in all seasons except in late spring, aiming at large fin whales (2x), Sperm Whales (2x), or various dolphins (6x). Cape Verde Shearwaters were often seen in association with prey-driving tuna, in all depth zones (2x Neritic, 2x Shelf-break, 7x Oceanic), but only in late summer and early autumn (Jul-Sep) in the chick-rearing period (Paiva *et al.* 2015).

A wide variety of feeding techniques were deployed by all species within this group, including skimming, hydroplaning, pattering, and surface pecking (all <1%), dipping (13%), surface seizing (5%), shallow plunging (13%) and pursuit plunging (72%). Their reliance on dolphins and tuna was much less than expected from other studies in tropical waters (Morgan 1986, Clua & Grosvalet 2001).

## Procellariiformes (2) Other shearwaters

Five species within this group, including **Great Shearwater** *Ardenna gravis*, **Sooty Shearwater** A. grisea, **Manx Shearwater** Puffinus puffinus, **Balearic Shearwater** Puffinus mauretanicus, and **Macaronesian shearwaters** *Puffinus baroli/boydi*.

A mix of Southern Hemisphere shearwaters (*Ardeanna* sp.), regional breeders (Macaronesian shearwaters), and bird originating from the Mediterranean (*Puffinus mauretanicus*) and W Europe (*P. puffinus*). Low numbers of all species as passage migrants; Southern Hemisphere reached peak abundances in autumn and early winter (Jul-Dec, **Table 2, Fig. 18**), with over 70% of all shearwaters travelling in a southerly direction. Foraging shearwaters were rarely seen (7 individuals pursuit plunging, 2 hydroplaning), some Sooty Shearwaters *Ardenna grisea* were showing an interest in large fin whales (1x), a Sperm Whale (1x) and in a pod of dolphins (1x). One Great Shearwater (*Ardenna gravis*) was seen in a feeding frenzy over hunting bonito's. All data suggest that West African waters are a stop-over site for shearwaters travelling towards the Southern Hemisphere, with little indications of extensive use of these waters by any of these species. The higher number of sightings in the northern part of the Mauritanian region does indicate that the area of cool-water upwelling forms a major attraction (**Fig. 18**). Sightings were fairly evenly spread over all depth zones (3.6 $100km^{-1}$ in Oceanic waters, 4.1 $100km^{-1}$ over the Shelf-break and 2.5 $100km^{-1}$within the Neritic zone, or a ratio of 1.4 : 1.7 : 1).

## Procellariiformes (3) Shelf-break storm-petrels

Two species within this group, including **Wilson's Storm-petrel** *Oceanites oceanicus* and **European Storm Petrel** *Hydrobates pelagicus*

Two storm-petrels occupying similar habitats in West African waters, but at contrasting times of the year. Wilson's Storm-Petrel is a Southern Hemisphere species breeding on suitably exposed rocky coasts and inland sites in Antarctica, on the Falkland, South Georgia, Crozet, Heard, Kerguelen and Macquarie Islands. The European Storm-petrel, as its name implies, is a Northern Hemisphere species breeding in the East Atlantic in Iceland, Norway, Faeroe Islands, Britain and France *(H. p. pelagicus*), and on islands in the western Mediterranean (*H. p. melitensis*). From the systematic ship-based surveys, it was found that Wilson's Storm-petrels arrive in West African waters in Mar-Apr, reach peak abundances in the Northern Hemisphere summer

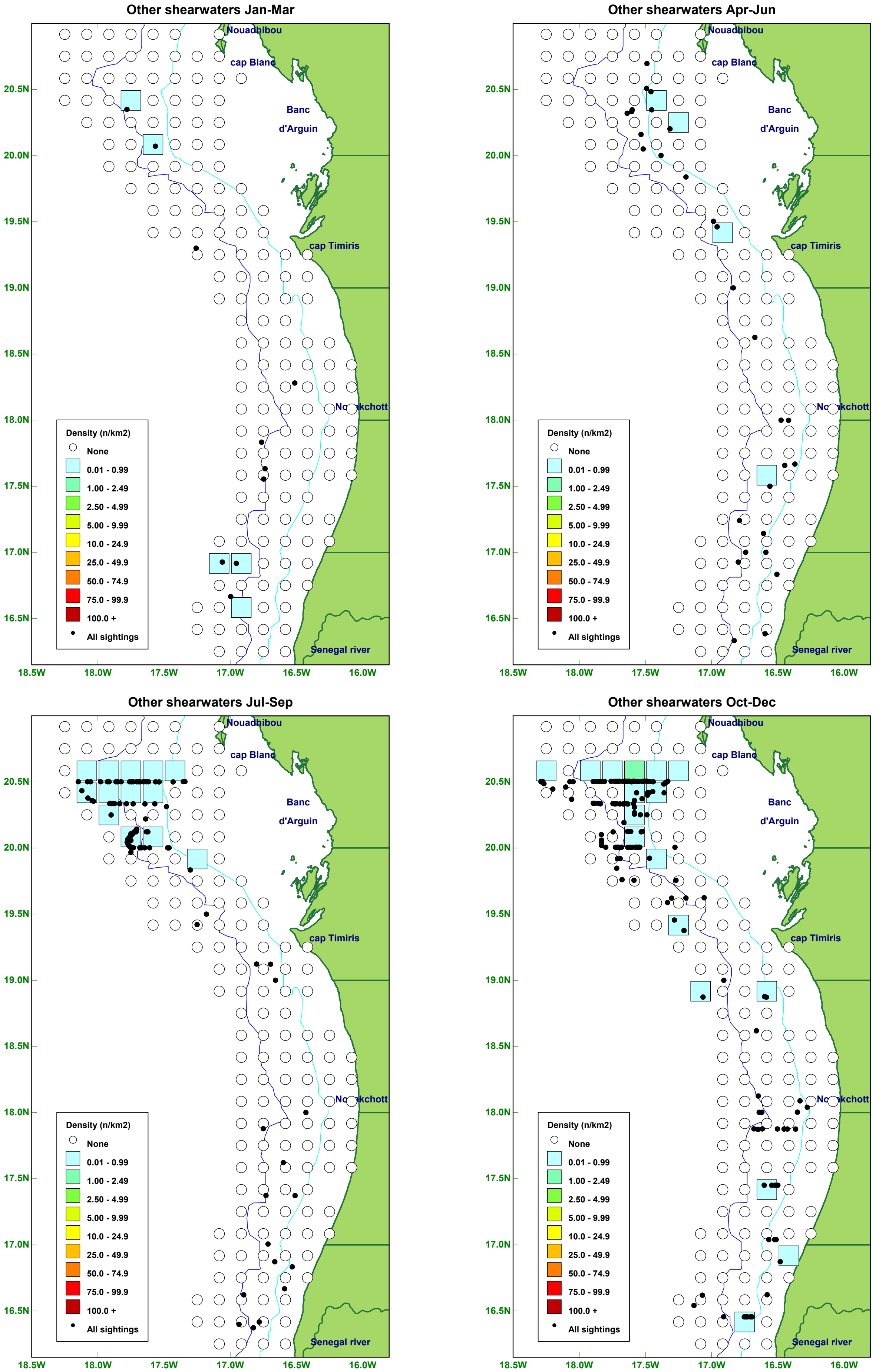


**Fig. 18** Procellariiformes (2) seasonal patterns in densities of other shearwaters at sea, Mauritanian Shelf. Black symbols represent individual sightings, whether in transect or not.

(*i.e.* May-Aug) and then travel back to their breeding grounds. Numbers are lowest Dec-Feb. European Storm-petrels have the opposite seasonal pattern: arrival in October, departure around March, peak abundance Nov-Feb, thereby 'replacing' its Southern Hemisphere counterpart. This timing of arrival and stay is completely in line with ringing-results from birds ringed in the United Kingdom (Fowler 2002). The first long-distance tracking results using geolocators on European Storm-petrels from a colony near Benidorm (West Mediterranean) did not reveal the utilisation of West African waters, but in fact suggested that these birds use central North Atlantic wintering grounds (Militão *et al.* 2022)

By far the largest numbers of Shelf-break storm-petrels in association with fishing vessels, as the group name implies, were seen over the Shelf-break (**Fig. 19**). At least 10 flocks of petrels numbering over 300 individuals at the time were recorded (range 350-1823 individuals; mean flock size 805 ± 509 individuals), all in the first (Jan-Mar) and second (Apr-Jun) quarters of the year. Large winter flocks comprised almost exclusively European Storm-petrels, in spring the larger groups were composed almost entirely of Wilson's Storm-petrels. Mid-summer surveys in West African waters have not been conducted thus far, but an opportunistic boat-based survey to the Mauritania upwelling zone in July 2005 encountered huge concentrations of Wilson's Storm-petrels. Flocks of up to 600 birds were concentrated along the boundary between warm surface waters and cooler upwelled waters. These flocks formed an aggregation of at least 5,000 birds (Wynn & Krastel 2012). From systematic surveys in May and August it could be suggested that Wilson's Storm-petrels in summer are nearly twice as numerous/abundant as European Storm-petrels in winter (**Table 1**). Both species can only be regarded as 'abundant' during their respective peak periods, and as gregarious seabirds, they commonly form large, dense flocks while foraging, or while resting at sea. There is no doubt that the Canary Current is a major wintering ground for both species, albeit at contrasting times of the year.

Both species occurred widespread, but in higher densities over the Shelf-break than elsewhere in Mauritanian waters. Large flocks around fishing vessels developed (for as far as specifically recorded) particularly around large freezer trawlers targeting small pelagics. The smaller petrels would not really join the feeding frenzies of larger seabirds fighting for scraps, but rather concentrate on fish oil slicks that rapidly developed at sea during hauling, when the catch was concentrated and lifted under pressure. The absence of such large oily slicks around demersal trawlers may have made these vessels less attractive. Wilson's Petrels, much more than European Storm-petrels, tended to follow also the research vessel, thereby constantly foraging in the wake of the steaming vessel. Assuming both species are largely planktivorous (including very small fish and fish larvae), it is remarkable to note that association with floating seagrass (as in Red Phalaropes) were only very rarely recorded and the two groups, phalaropes and storm-petrels, did generally not really co-occur, except perhaps at distinct convergence front lines. As participants in multi-species foraging associations, the smaller storm-petrels usually 'did their own thing', so rather than competing for the main prey targeted in such frenzies, fluttering in the periphery of these flocks, picking up small morsels by rapid action.

Associations with marine mammals (10x dolphins, 6x blackfish, 1x Sperm Whale in Wilson's Storm-petrel; 1x large fin whales and 1x dolphins in European Storm-petrels) were similar, foraging in the periphery or in the wake rather than upfront, and flocks that developed were usually fairly small (dozens rather than hundreds). Wilson's Petrels were seen to join tuna-driven foraging opportunities together with terns in substantial numbers (hundreds) in Oceanic waters, once in the Neritic zone.

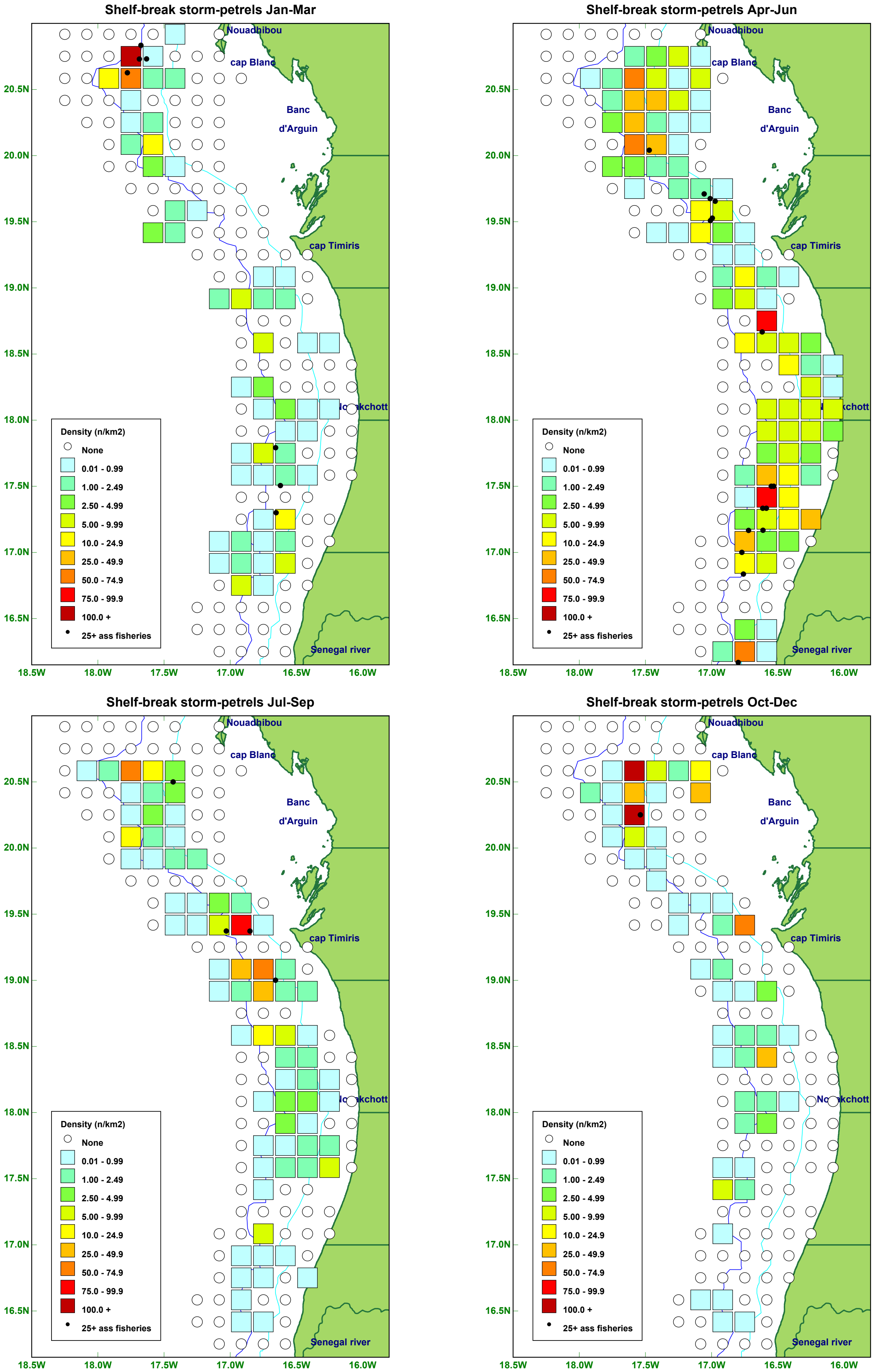


**Fig. 19** Procellariiformes (3) seasonal patterns in densities of Shelf-break storm-petrels at sea, Mauritanian Shelf. Individual plots (●) are flocks of >25 storm-petrels seen in association around fishing vessels.

Large flock of Wilson's Storm-petrels, 11 May 2004, foraging over fish oil slick formed during *Sardinella* fisheries, Mauritania (E. Winter).

## Procellariiformes (4) Oceanic storm-petrels

At least four species within this group, including **White-faced Storm-petrel** *Pelagodroma marina*, **Leach's Storm Petrel** *Hydrobates leucorhoa*, **Swinhoe's Storm Petrel** *Hydrobates monorhis*, and unassigned members of the Macaronesian species complex, formerly listed as **Madeiran Storm-petrel** *Oceanodroma castro*.

This group, largely confined to Oceanic waters during ship-based surveys in the area (**Fig. 20**), is composed of one North Atlantic long-distance migrant (**Leach's Storm Petrel** *Hydrobates leucorhoa*) and Macoronesian breeding species for which the West African shelf would potentially be within range for foraging, even when nesting. What is listed as 'Madeiran Storm-petrels' are in fact representatives of a species complex, including 'summer breeders' (warm season) and 'winter breeders' (cold season) and the Cape Verde Islands, Selvagens, Canaries, Madeira, Berlengas and on the Azores (Flood & Fisher 2011). During historical ship-based surveys off Senegal, the eastern limit of Leach's Storm-petrels was at about 20°W but, while most birds seen east of 23°W were 'Madeiran', which was seen as 'consistent with what is known of the biology of Madeiran Storm-Petrels that they should remain in these relatively barren waters instead of flying a little farther east to feed in the more productive shelf and slope waters' (Brown 1979). In Mauritanian waters, a similar distinction was not found, in fact at best an opposite trend was recorded, with 83% of all Leach's Storm-petrels in Oceanic waters (*n*= 1838), against 74% of birds identified as 'Madeiran' (*n*= 658).

Oceanic storm-petrels were most abundant in the Northern Hemisphere winter (Oct-Mar), which was apparently the case for all species involved, except the rare and elusive **Swinhoe's Storm-petrel** *Hydrobates monorhis* (Jul-Sep). None of these species readily joined fishing vessels, but even associations with oceanic convergence fronts were at best weak, or difficult to ascertain. Associations with cetaceans did occur, however, both in Leach's Storm-petrels (1x Sperm Whales, 5x dolphins) and in 'birds identified as 'Madeiran' (1x large fin whales, 1x blackfish, 2x dolphins). Tuna-driven foraging opportunities in Oceanic waters once attracted a remarkably large group of Leach's Storm-petrels (91 individuals), and interest in prey-driving tuna was shown twice by the otherwise rare and infrequent **White-faced Storm Petrel** *Pelagodroma marina* (3 individuals). Ship-based surveys have demonstrated the significance of West African waters for this species, but the relative 'contributions' of the various 'Madeiran' storm-petrels requires further investigations.

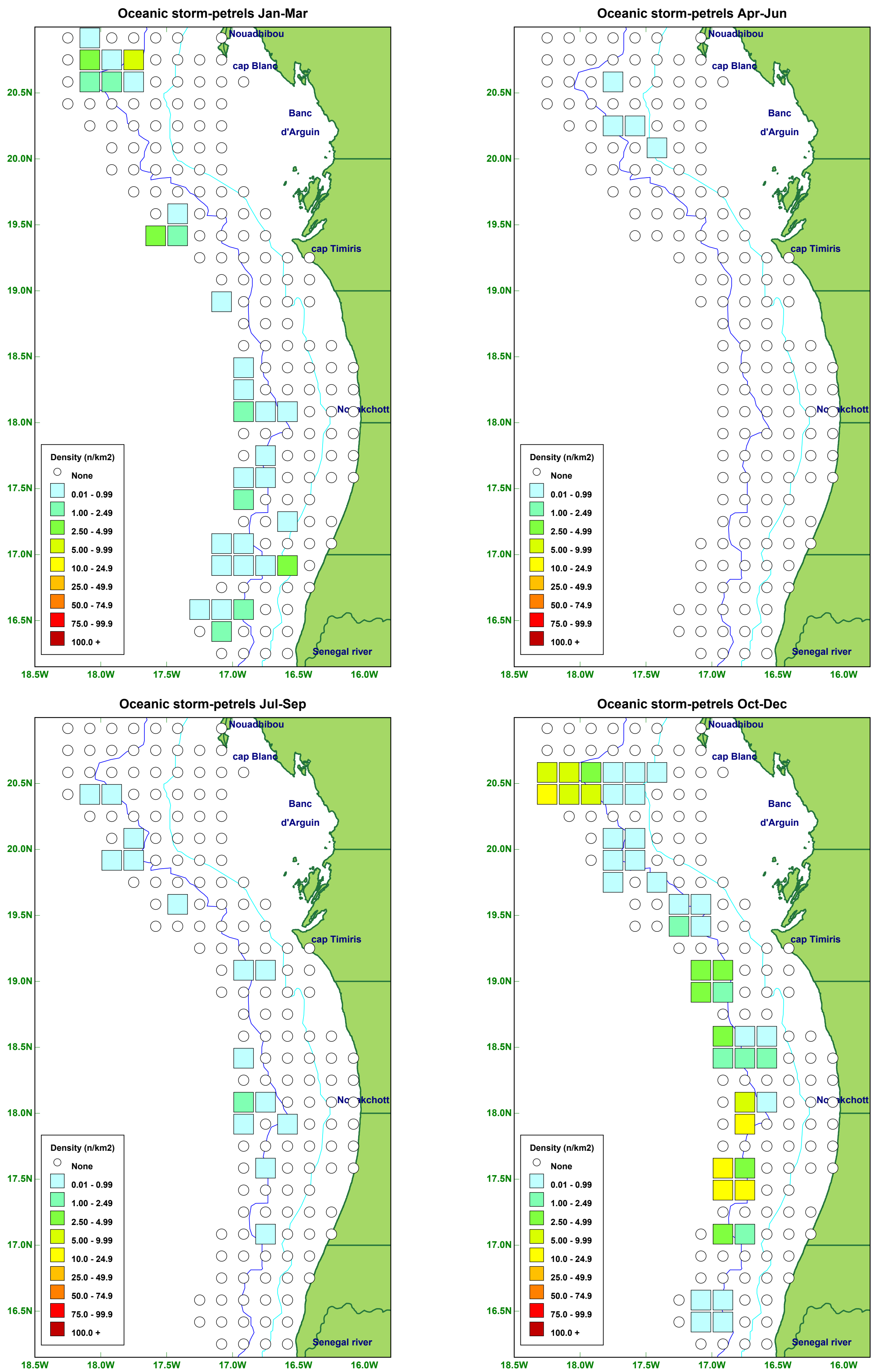


**Fig. 20** Procellariiformes (4) seasonal patterns in densities of Oceanic storm-petrels at sea, Mauritanian Shelf.

**Suliformes** **Northern Gannet**

One species is considered within this group, **Northern Gannet** *Morus bassanus*, despite occasional sightings of various boobies as vagrants off western Africa (see **Chapter 6**). The second species in this order that is often seen in the marine environment (**White-breasted Cormorant *Phalacrocorax lucidus***) is not used for the map and data analysis in this Species Account, but briefly discussed in the end of the text.

Northern Gannets breed on both sides of the North Atlantic in large colonies (Nelson 1978) and migrate or disperse south in the non-breeding season, thereby sometimes crossing the North Atlantic from west to east or vice versa. The migratory movements of Northern Gannets are well known, and the significance of the Canary Current region is without any doubt, from ringing (Wanless 2002) as well as from many tracking studies (Kubetzki *et al.* 2009, Fort *et al.* 2012, Fifield 2014, Fifield *et al.* 2014, Garthe *et al.* 2016, Lane *et al.* 2021), even though very few scientists have studied Northern Gannets on the southern boundary of their wintering grounds. Using geolocators for area use and stable isotopes as proxies for diet, Grecian *et al.* (2019) reported that gannets were highly repeatable in their non-breeding destination over consecutive years, and that isotopic signatures were also strongly repeatable, with individuals assigned to one of two dietary clusters. The only non-breeding destination in which the two dietary clusters co-occurred was off northwest Africa. The few individuals that switched dietary clusters between years were in better condition relative to the rest of the population, suggesting there may be benefits to flexibility during the non-breeding period.

Northern Gannets were without doubt one of the most prominent features of the avian community off NW Africa in winter (Oct-Mar). Based on surveys in early winter 2012, for Mauritanian waters alone, an estimate of c. 325,000 individuals or c. 30% of the world population seemed appropriate (Camphuysen *et al.* 2013). This estimate, while it must be seen as an order of magnitude only, was well in accordance with estimates based on the distribution of birds carrying geolocators (Kubetzki et al. 2009) and this would arguably make NW African waters one of the most important wintering areas for this species in the North Atlantic. Numbers in early winter were so large, and gannets were so widespread, that their almost complete absence in early autumn (Jul-Sep) was in fact difficult to believe (**Fig. 21**). Numbers dropped already in the second half of the winter, when numerous adults were leaving to return to their breeding grounds.

Northern Gannets are piscivorous birds that deep plunge dive for their prey (up to ~25-30m depth). They readily make use of foraging opportunities near trawlers, are often seen to follow cetaceans, and highest densities were encountered over the Neritic zone. Combining all survey work for Mauritanian waters, gannets were 3x more abundant in Neritic waters than over the Shelf-break, where they occurred in 10x higher numbers than in Oceanic waters (ratio 28 : 11: 1). Cetaceans were an important attraction in deeper waters, where they apparently provided access to resources that was otherwise out of reach (of all associations with cetaceans, 47% were in Neritic waters, 36% over the Shelf-break, 17% in Oceanic waters). Up to several hundreds of gannets could be seen following either large fin whales (8x), Sperm Whales (2x), beaked whales (1x), various dolphins (25x), or Harbour Porpoises *Phocoena phocoena* (1x) (Oct-Dec median flock size 15, IQR 2-42.5, max 122, *n*= 13; Jan-Mar 37, IQR 5.75-72.5, max 490, *n*= 30). Only a single feeding frenzy with (535) Northern Gannets and other seabirds using prey hunting tuna as beater was observed, which was in the Neritic zone, and which differed in various aspects of the 'common' tuna driven foraging opportunities in deeper waters (see under Marsh terns). Commercial fisheries formed another major attraction, and flocks of associated Northern Gannets could easily number many hundreds and up to 1250 individuals (Oct-Dec median

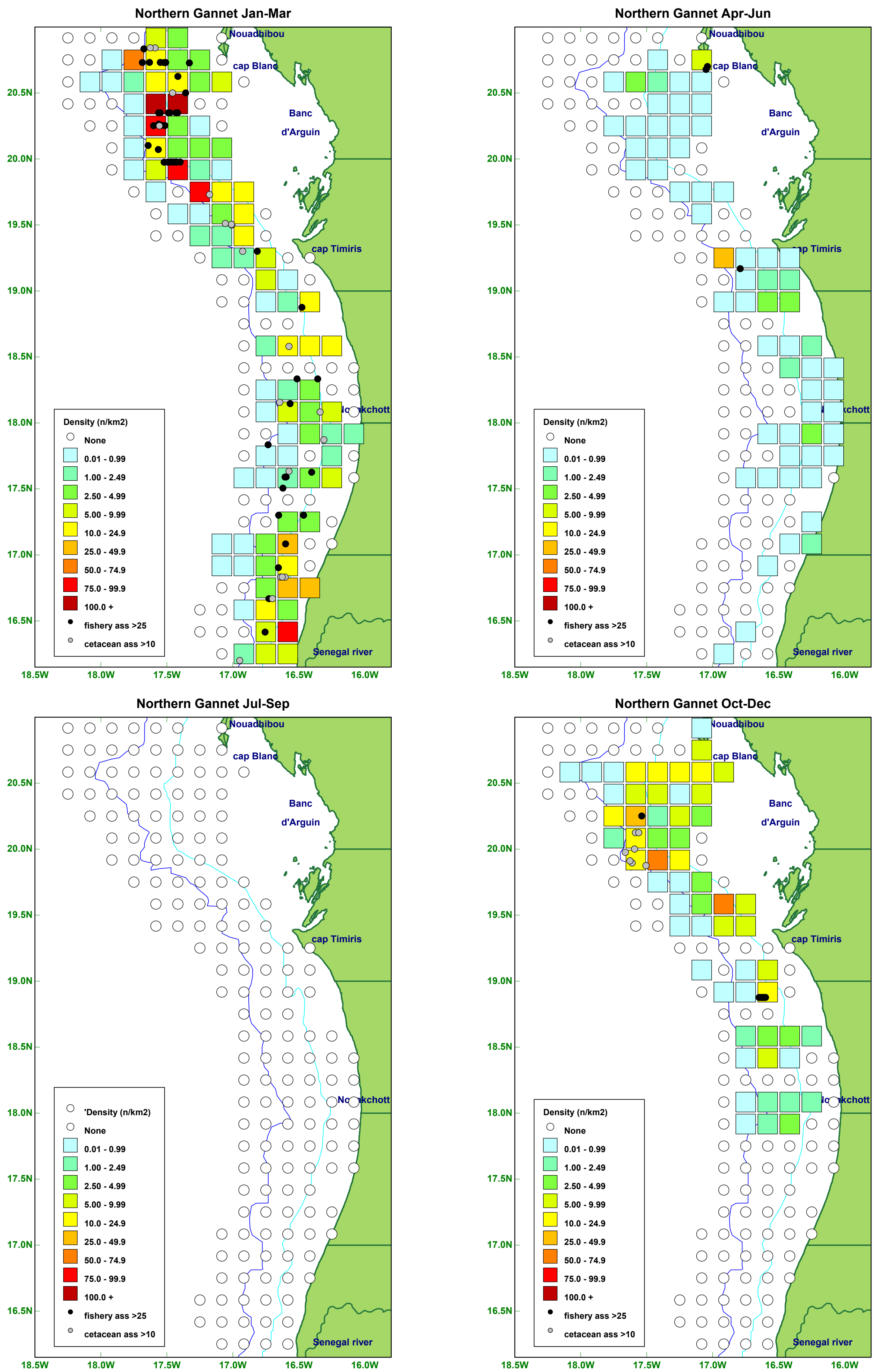


**Fig. 21** Suliformes, seasonal patterns in densities of Northern Gannets *Morus bassanus* at sea, Mauritanian Shelf. Individual plots (●) are >25 gannets in association with fishing vessels (black), and >10 around cetaceans (grey).

flock size 14, IQR 2-249, max 520, *n*= 17; Jan-Mar median flock size 36.5, IQR 4-155, max 1260, *n*= 86). 'Self-fishing' was equally common, however, and very large congregations of birds could be formed, typically mono-specific, over schools of small pelagics, often targeted from great heights (suggesting fish schools relatively deep in the water column. Whether larger flocks of associated Northern Gannets formed over pelagic freezer trawlers (targeting smallpelagics) than over demersal trawlers, could not be ascertained over all collected data, because earlier observers did not discriminate between types of vessels.

Flock of Northern Gannets, 19 Feb 2022, illustrating complex age structure off Mauritania in late winter (CJ Camphuysen).

The second species in this category, the White-breasted Cormorant, is a nearshore species that was only observed when the research vessel left or entered harbours. The systematic surveys do not contribute anything other than that to the distribution or relative abundance of this species at sea.

## Pelecaniformes

One species within this group, the **Great White Pelican** *Pelecanus onocrotalus*, a local breeding species. Year-round sightings at sea, but always in small numbers. Larger and more sensitive concentrations of pelicans may be expected nearshore around Cap Blanc, inshore (intertidal flats) Band d'Arguin, in the Senegal delta and occasionally elsewhere. Great White Pelicans were twice seen in association with Harbour Porpoises, but the exact reason of this perceived interest expressed by the birds has not been recorded. An association with a small fishing vessel has been observed only once (1 bird).

## 10. Discussion and conclusions

From the species accounts, it is clear that for at least twelve ecological clusters of seabirds, based on surveys in Mauritanian territorial waters, the offshore zone of western Africa is of particular significance, at least during part of the year, and these clusters are: phalaropes, skuas, Neritic gulls, pelagic gulls, regional large terns, Sandwich Tern, 'commic' terns, marsh terns, *Calonectris*-shearwaters, Shelf-break storm-petrels, Oceanic storm-petrels, and Northern Gannet. The combined densities are presented in **Fig. 22**, with plotted locations of particularly large numbers of actively foraging individuals, associated with fishing vessels, associated with cetaceans, or apparently 'self-feeding', independent of any obvious drivers.

It clearly shows that throughout the year, important concentrations of seabirds occur, with a more or less always higher density of animals within the prime region of upwelling, just to the south of Cap Blanc, and over the upper Shelf-break, immediately bordering the Neritic zone. Major fisheries related foraging associations occurred in distinct clusters, again south of Cap Blanc (esp Jan-Mar), but also further to the south along the aforementioned Shelf-break. A further analysis, and new data, would be required to assess the importance of the various fleets operating these waters, but that large to medium 'trawlers' (demersal as well as pelagic gears) attract more seabirds than for example artisanal fleets of pirogues is evident; hence the offshore distribution of major feeding frenzies. It is in deeper, Oceanic waters that the role of hunting cetaceans was most prominent. Resources may there be typically 'out of reach' for seabirds, at least during daytime.

Some species, notably some expected Neritic gulls, were either absent or uncommon during the ship-based surveys conducted thus far. As could be shown from GPS tracking data in Lesser Black-backed Gulls, there is considerable nocturnal activity at sea which is clearly missed during the (visual) observations on board these research vessels. In case of the Lesser Black-backed Gull, offshore distribution patterns at daytime were essentially similar as during the night, despite the extensive use of onshore roosts spread out over coastal Mauritania. In this species, it could be an individual choice to forage at night and roost during the day, or vice versa, but a preference for nocturnal in a species like the Audouin's Gull could perhaps explain the absence or scarcity of this species offshore, relative to observed numbers roosting on Morocco's and Mauritania's beaches. Nocturnal feeding is also quite prominent in various species of cetaceans (Pierpoint *et al.* 2000, Baird *et al.* 2001, 2002, Brophy *et al.* 2009, Henderson *et al.* 2011, Herzing & Elliser 2013), which could explain why so may oceanic dolphins (for example) were not foraging when observed, but rather engaged in bowriding. Anecdotal information (night-time observations onboard research vessels) pointed at radically different behaviour by dolphins under the cover of darkness, while being followed by night-feeding gulls and terns, possibly hunting on mesopelagic fish or other prey that rose to the surface layer at night. Ship-based visual observations are not the appropriate means of studying these patterns and shifts in behavior, so a coupling with for example acoustic techniques or tagging studies is strongly recommended to solve the 'nocturnal' issue.

Various tracking studies, insofar published, confirmed the significance of the study area for a large number of seabirds, but also that important regions (largely unsurveyed using recent observation protocols extend in a northerly direction (Western Sahara and West Morocco, up to at least 35°N) and in a southerly

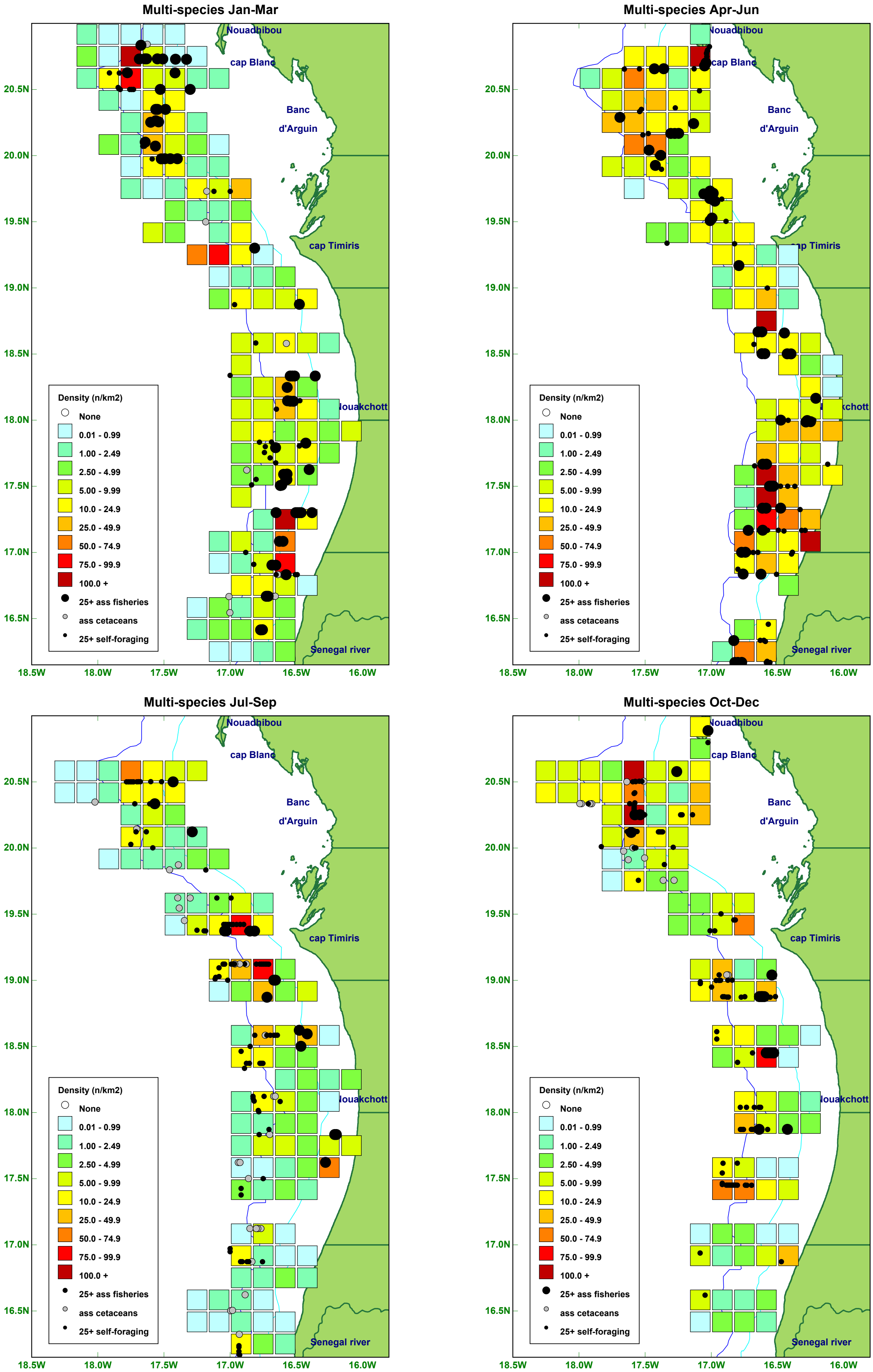


**Fig. 22** Seasonal patterns in densities of multi-species composite combining 12 ecological guilds at sea, Mauritanian Shelf (see text). Individual plots are >25 individuals with fishing vessels, any around cetaceans, and >25 self-feeding.

direction (Senegal towards Gulf of Guinea), for some species even beyond and into Ghanese waters. Tracking studies using geolocators are not exact enough to pin-point ecological relevant areas with any precision, and GPS tracking studies are still 'novel ', ongoing and thereby unpublished, or have been analyses such that exact information on whereabouts at sea are difficult to summarize in ecological terms. In most studies, attempts to discriminate between (major) foraging areas, based on concrete foraging behaviour, are clearly in their infancy, various proxies that require interpretation are used and are potentially misleading, and most data lack ground truthing in these wintering or stop-over areas. Nevertheless, the future potential for tracking studies is enormous, and that no on-site observers are required is one of the most important aspects on the plus side of that approach. One of the negative aspects is that tracking studies are essentially single-species studies, with a strong bias to individual behaviour and differentiation. Again, in the (near) future, high-quality tracking studies will become so widely used that major datasets can be combined to pinpoint offshore areas of particular importance, just as recently was conducted for an unknown major seabird hotspot in the North Atlantic (Davies *et al.* 2021).

**Sensitivity analysis**

The study area supports habitats of critical importance for numerous species of seabirds throughout the annual cycle and originating from both hemispheres. Seabird species are often selected for sensitivity analysis, based on their position on the IUCN Red List, and areas are often ranked according to the occurrence and abundance of somehow threatened or endangered species. While to political motivation for such an approach may be understandable, it does not make sense in ecological terms. Marine ecosystems are complex and do not rely on the conservation status of some individual species. By protecting food-webs and ecological communities rather than individual taxa, in practice by minimising damage inflicted on their key environments, it is anticipated that any mitigation measures implemented will benefit all community members. Of the spectrum of potential environmental risks arising from the GTA project, including toxic contaminants, hydrocarbon spills, habitat disruptions, construction noise, disturbance and risks arising from increased vessel traffic. Lights on vessels at night might attract certain species (notably Procellariiforms) and disturb their nocturnal foraging behaviour, an issue that can be was resolved or reduced by switching off unnecessary lights. Surface pollution and habitat disruption are likely to be of greatest immediate concern in the context of seabirds at sea.

**Mitigation measures**

Mitigation measures need to be appropriate, practical and adaptive to unforeseen circumstances. Monitoring the effectiveness of mitigation is important, with periodical reviews of performance to feed back into planning and implementation stages. The achievement of zero residual impacts following the implementation of mitigation measures is an unrealistic expectation that may, at worst, lead to a culture of denial. The marine biosphere is subject to multiple interactive influences resulting in an inevitable degree of unpredictability. While every effort should be made to mitigate for likely scenarios in which operations may interact with marine mammals, unforeseen circumstances may arise and accidents may happen. Mechanisms should be put in place to detect, report and analyse the circumstances of any apparent impacts, with the positive aim of adapting and improving mitigation measures. Procedures should also be put in place to respond to accidents involving marine fauna.

Evaluating the ecological importance of the GTA area based on existing data, as an environmental impact assessment, is one thing, but for more specific concerns, preparedness should be reaching further. With hydrocarbon spills as a most prominent and foreseeable risk for seabirds, an analysis of area sensitivity is particularly urgent. Existing data on seabird distribution should be used to perceive the risks from oil spills more precisely, to allow spill managers to plan their actions such that further ecological damage can be minimised (Oil Vulnerability Analysis based on seabird distribution data). For areas where such data are lacking, but where impact of GTA activities can be expected, there should be an immediate urge to upgrade existing data and to collect more where needed.

Awareness of the importance of the GTA region for seabirds and other charismatic megafauna, but in connection with the productivity and biological diversity of these waters leading to profitable human fisheries, should strongly be encouraged by appropriate presentations to all field personnel. These are sensitive areas. Ecological damage inflicted cannot easily be turned back. Maritime crew should receive additional training in the recognition of vulnerable species and areas and be encouraged to follow procedures for recording and reporting observations of marine fauna. Trained observers, experienced and with knowledge of *all* species occurring in the GTA area, should be deployed during risky construction operations. All information from the field regarding megafauna should be reported to a central coordinator in as near real-time as possible, with the aim of collating data, identifying spatio-temporal sensitivities and advising operators accordingly. Whenever possible, observations should follow strict international protocols and not be conducted hap-hazardly. Vessel traffic should be routed to avoid major foraging aggregations of seabirds and other megafauna, in all seasons. Unnecessary exterior lights on vessels should be switched off at night. Whenever operationally possible, vessel traffic at night should be minimised and operations such as re-supply and crew changes be scheduled for daylight hours.

**Monitoring, reporting and response measures**

The collection and collation of data on marine fauna observations at sea has the potential to alert operational managers of sensitive areas to be avoided, improve the effectiveness of mitigation plans and contribute to the body of scientific knowledge. Any incidents resulting in actual or suspected harm to marine animals should be reported by completion of an incident report form.

**Recommendations**

The data compiled for this project have the potential to make a valuable contribution to marine ecology science in this very important, yet poorly documented region. It is recommended that further analyses be carried out on the project data with the main objectives of identifying environmental drivers of species distribution and generating abundance estimates of species groups. Publication of this and further studies in peer-reviewed scientific journals would a requirement and provide a robust basis for on-going mitigation planning and monitoring, in addition to providing a valuable contribution to the science and conservation of flagship species of marine megafauna.

## 11. Summary

- This is a compilation of data collected during dedicated, systematic seabirds at sea surveys conducted between 1988 and 2022, mostly off Mauritania.
- The resulting database was used to describe spatio-temporal distribution patterns and relative abundance of functional groups of seabirds (ecological guilds), characterise foraging habitats, habits, and species interactions, to assess their sensitivity to developments associated with the Greater Tortue Ahmeyim (GTA) project.
- The unique biodiversity and the significance as a stop-over, foraging and wintering area of west Africa's offshore waters for seabirds originating from both hemispheres in a constantly changing, almost fluid species composition is described.
- Piscivores and squid-eaters account for a large part of avian abundance and biomass, the remainder being planktivores and omnivores.
- Considering foraging and feeding techniques, habitat choice, prey types, and overall abundance, 13 functional groups, or ecological guilds were defined for which distribution patterns were mapped
- Functional groups include phalaropes, skuas, Neritic gulls, pelagic gulls, regional large terns, Sandwich Tern, 'commic' terns, marsh terns, *Calonectris*-shearwaters, other shearwaters, Shelf-break storm-petrels, Oceanic storm-petrels, and Northern Gannet.
- Associations with cetaceans, commercial fishing operations, and tuna have been highlighted as mechanisms by which seabirds may enhance their foraging opportunities at sea.
- Particularly important concentrations of phalaropes, skuas, terns, Cape Verde Shearwaters, storm-petrels, and Northern Gannets were found, indicating that this area is of significant international importance for marine wildlife.
- Throughout the year, important concentrations of seabirds occur, with a higher density of animals within the prime region of upwelling, south of Cap Blanc and over the upper Shelf-break, immediately bordering the Neritic zone.
- Major fisheries related foraging associations occurred in distinct clusters, south of Cap Blanc, and further to the south along the Shelf-break.
- In deeper, Oceanic waters the role of hunting cetaceans was most prominent enhancing foraging opportunities of seabirds.
- Nocturnal foraging strategies require further research.
- With hydrocarbon spills as a most prominent and foreseeable risk for seabirds, an analysis of area sensitivity is particularly urgent.
- The results were corroborated by modern tracking studies, that were less precise in exact foraging whereabouts, feeding habitats and species interactions, but that showed that the area of importance is larger (Senegal-Morocco) than what was surveyed.

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**May 2022**

*This document gives a first comprehensive, science-based, impression of the megafauna community with emphasis on seabird distribution patterns, seasonal trends, habitats and species interactions in the GTA project area and beyond (West Africa) to help host governments, bp and its partners to improve mitigation management for net-zero impact on biodiversity.*

*The offshore zone harbours internationally important seabird populations, interacting with migrating marine mammals (cetaceans), sea turtles, sharks, other large predatory fish and fishery resources, aggregating in well-defined areas at predictable times.*

*The analysis is focused on ecological guilds, or 'functional groups' of species and on foraging opportunities, thereby to demonstrating the importance of the area within the annual life-cycle of taxa originating from both hemispheres, as a foraging ground during breeding, as a stop-over, or wintering (non-breeding) area.*

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## Contents

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