Ship-based seabird and marine mammal surveys off Mauritania, 4-14 September 2015

Cape Verde Shearwater *Calonectris edwardsii* (HV)

C.J. Camphuysen

(2015)

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Final version

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Glossary

Forage fish	Forage fish, also called prey fish or bait fish, are small pelagic fish which are preyed on by larger predators for food. Predators include other larger fish, seabirds and marine mammals. Typical ocean forage fish feed near the base of the food chain on plankton, often by filter feeding. They include particularly fishes of the family Clupeidae (herrings, sardines, sardinella, menhaden, anchovies and sprats), but also other small fish.
Neritic	Shallow zone, coastal shelf waters, for this study defined as all surveyed areas with a water depth of <200m
Oceanic	Deep water zone, for this study defined as all surveyed areas with a water depth of >800m
Shelf break	Transition between oceanic deep water and shallow shelf waters, for this study defined as all surveyed areas with a water depth of 200-800m
SST	Sea surface temperature (°C), measured on board

Contents

(1) Preface

The research presented in this cruise report on pelagic biodiversity of the shelf break was carried out in the framework of the Programme « Biodiversity Oil and Gas », an initiative of the Mauritanian Ministry of Environment and Sustainable Development, in partnership with the Ministry of Energy, Oil and Mines and the Ministry of Fisheries and Maritime Economy. It is sponsored by the United Nations Development Programme (UNDP), the German Agency for International Cooperation (GIZ), the World Conservation Union (IUCN) and WWF. Financial support for this survey was also provided by Kosmos Energy, Dallas, Texas (USA).

Ship-associated Royal Tern, 5 Sep 2015 (CJC)

(2) Rationale

The significance of Mauritanian waters as a breeding ground, stop-over, feeding and wintering area for charismatic megafauna is beyond dispute. Yet, this unique biodiversity is constantly under threat, as a result of land-based activities and also due to various maritime sectors: over-fishing, bycatch, maritime traffic and an emerging offshore oil and gas industry. The economic wealth for Mauritania generated by commercial (industrial) fisheries and the development of its offshore oil and gas reserves is incontestable. However, the risks involved for the unique marine fauna should be minimised as much as possible.

Emblematic, often "non-commercial" species play essential roles in the marine ecosystem. Their protection should therefore not only be a combat for conservationists but also for managers promoting long term economic wealth based on the fishery sector. The wildlife utilising Mauritanian waters has a breeding origin as wide apart as the Antarctic and the Arctic, and calving grounds of large marine mammals off Mauritania are currently just regaining their significance, now that severely depleted whale stocks are slowly recovering.

Since 2006, Mauritania is extracting oil from an exploitation site situated approximately 80 km offshore its capital Nouakchott. Other oil and gas discoveries have been made as well in these deep waters around the shelf break and abyssal plain. Most companies present in Mauritania obey by codes of conduct stipulating to avoid and mitigate impacts on biodiversity. It may therefore be expected that companies develop environmental management policies based on detailed knowledge about the host environment. When working in a developing country, such as Mauritania, where national authorities have tight budget constraints for ecological research, it may be expected that responsible industry players invest voluntarily in baseline data collection.

The Deepwater Horizon spill in the Gulf of Mexico became a text book example showing how a poor understanding of the regional ecological vulnerability resulted not only in severe reputational damage for the industry but also in long-term and largely avoidable impacts on the ecology and local economy. The BP guidelines for in-house contingency planning were partly based on "copy/paste" work from other regions and included recommendations which would only benefit marine wildlife off the Californian coast. Coastal swamp ecosystems and deep sea benthic communities, such as cold water corals, became badly affected as a result of poor pre-spill preparedness. The surface waters of the Gulf of Mexico are rather poor, and as a result, relatively few casualties were retrieved during this spill. This would be different in a Mauritanian context, where the rich surface waters have been compared to a marine "Serengeti Park". The shelf break in particular harbours huge concentrations of seabirds and cetaceans, that gather in rather small, well-defined but also predictable areas. Oil companies, in particular Kosmos Energy but also Tullow Oil, are therefore particularly interested in the specific vulnerability of these areas and to enhance oil spill preparedness and to reduce risks involved with seismic operations, drilling etc.

Today, Mauritania's national oil spill contingency plan recognises the most important sensitive coastal areas. However, detailed knowledge about the occurrence of the most sensitive pelagic sea areas is arguably more important, but is still lacking. Considering that new oil development zones are situated right within one of the richest pelagic ecosystem in the world, intensified efforts aimed at collecting baseline data are urgent. Such data would not only provide essential information to draft sound oil spill contingency planning, it would also strengthen national strategies for Marine Protected Areas as well as efforts to green fishery policies towards more sustainable exploitation.

The offshore surveys conducted within the Programme Biodiversité Gaz et Pétrole (2012), an initiative of the Mauritanian Ministry of Environment, provide baseline data that are essential for implementing policies aimed at safeguarding the unique biodiversity for future generations. Substantial uncertainties exist regarding both the abundance and diversity of wildlife around the rich shelf break area during the greater part of the year. Some areas within these rich upwelling waters are clearly more sensitive to impacts than others. However, with existing data, coarse sensitivity maps can still not be made available to the government and environmental managers working for the various maritime sectors. It is our aim to collate and share existing data collected by ourselves (within and prior to the present research programme), merge data into single databases, invite other scientists to join in and share data in order to try and complete the picture year-round. Further surveys are required to fill the most pressing data gaps that are currently still existing (**Fig. 1**).

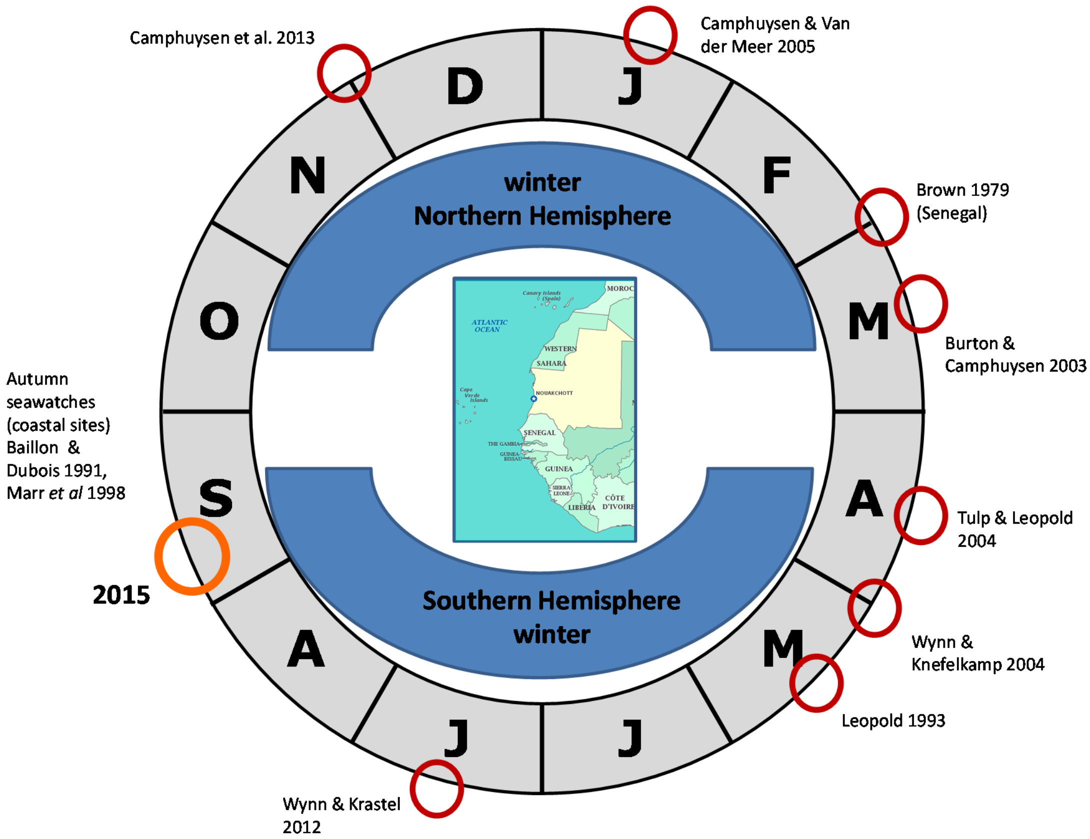


Fig. 2.1 Recent comprehensive surveys of seabirds and/or megafauna assemblages in Mauritanian waters, including some coastal seawatches and the contribution of the 2015 surveys in early September (**orange**) with regard to timing and seasonality.

Mapping marine wildlife is just the start of the project. Not all areas are equally important for wildlife and the presence or absence of animals is only of secondary importance. Large areas are transit zones rather than feeding or foraging areas. Within this project we emphasise on species interactions and foraging aggregations, not just from an ecological perspective, but in order to obtain solid information on habitat characteristics that are important for a whole suite of species at the same time, species that not only interact, but that depend on each other to find food. A species-by-species approach is just the beginning, an ecological guild and assembly approach will be followed once the base material has been collected and once the species interactions are better understood. It is to be foreseen that rather small, highly specific and super-important sea areas can be pin-pointed. These are the areas that deserve special protection and special attention during any future calamities or any type of exploration or exploitation activities planned in the near-future.

For the oil and gas industry, it is our aim to provide tailor-made sensitivity maps based on observed densities multiplied by species-specific and area-specific oil vulnerability indices (King & Sanger 1979, Begg *et al.* 1997, Camphuysen 1998, Camphuysen *et al.* 2007b). With these maps, for any season, high quality advice can be provided regarding the sensitivity of particular areas within and around the Mauritanian upwelling system (cf. Carter *et al.*1993, Webb *et al.* 1995). Species-specific information is now completely invisible, even though this information is underlying the sensitivity maps, because this is irrelevant during contingency planning. For nature conservation agencies, intimate knowledge of the prime foraging areas and foraging habitats is essential information to improve conservation strategies. For both, mitigation and conservation, knowledge of the areas of multiple species interactions, *i.e*. areas that 'really matter', is the type of information we currently require most urgently [CJC & SK].

Deep diving Sperm Whale, 13 September 2015, Timiris Canyon (HV)

(3) Introduction

Mauritanian waters are part of the Canary Current eastern Boundary Upwelling Ecosystem. There are four such ecosystems in the World (California, Humboldt, Benguela and Canary currents). Together they generate about 20% of the global fish catches (Chaves & Messié 2009). In Mauritania most of the fish is caught along the shelf break - a narrow stretch of sea measuring 50 to 250 km wide. This shelf break is formed by a steep drop off with a slope of 2.5-6° which starts at 70 km from the coast, except in the Northern part were the continental shelf is at is widest (150 km; Antobreh & Krastel 2006). 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 extremely productive food webs.

The productive shelf seas are targeted since the 1960, with increased intensity, by commercial fisheries. The local artisanal fleet uses relatively small vessels and occupy the coastal waters of the continental shelf. The industrial fleet targeting small pelagic fish species and benthic species concentrates along the shelf break. This fleet is composed of European and Asian trawlers able to localize with sonar every fish school and to catch them at depths going beyond 1000 meters (IMROP, atlas maritime des zones vulnerable en Mauritanie 2012). Numerous studies have focused on population dynamics of the target species with the aim to regulate the fishing sector via a quota system in order to prevent fishery resource collapse. Even though these target species are part of, and depend on, complicated food webs, study on non-commercial species were not included in previous research programs.

Dwindling fishery resources and the recent discovery of oil and gas in this area have triggered a societal debate about the need to put in place a sound policy to better protect the marine environment. As both hydrocarbon development and industrial fishing concentrate along the shelf break, more information about the ecological importance of this particular sea area is urgently required (Mauritanian Ministry of environment. Document du Programme Biodiversité Gaz et Pétrole 2012).

During these past years interesting discoveries have been made along the shelf break. Next to oil and gas, carbonate mud mounds were discovered measuring 100 meters high and 400 km long (Banda and Timiris mounds). These biogenic structures were constructed over a time span of 12.000 years by deep-sea corals during three distinct periods (Eisele *et al.* 2011). Today, corals entered in a growing phase and life coral has been documented on the summits of these mud mounds as well as in the deep trenches of canyon systems where they thrive alongside other fragile long living life forms such as sponges and giant oysters of 500 years old (Krastel *et al.* 2004, Westphal *et al.* 2007, Anon. 2010). These recent findings on fragile benthic ecosystems call for a more careful spatial planning for bottom trawling but also offshore oil and gas drilling, pipeline layout as well as use of dispersants during oil spills. During the last Deepwater Horizon blowout oil coagulated in combination with dispersants, sank to the seafloor and smothered deep sea coral habitat.

Distinct areas of rich biodiversity are also encountered in the water column. This calls for better spatial planning of economic uses and more careful management of environmental impacts caused by fishing on pelagic species, maritime traffic, seismic surveys and offshore oil and gas production.

While the entire shelf break area is very productive and rich in biodiversity, it is well established that the waters off the Cap Blanc form a distinct zone of biological productivity and diversity thanks to upwelling taking place here all year round (Pinela *et al.* 2010). Other and more temporary zones of enhanced productivity can also be detected further south. The location and drivers behind these zones of intense upwelling are not well understood. But it is has been reported from other countries such as New Zealand and Canada that canyons may play a role as they concentrate detrital organic matter and facilitate the upwelling process from deep ocean water to the surface. It is not unlikely that hotspots of pelagic biodiversity are also formed above several canyons transiting the Mauritanian shelf break such as the Timiris canyon.

Seabirds and cetaceans have proven to be good indicator species to map pelagic hotspots. The avifauna off Western Africa is normally dominated by surface feeding and shallow plunge diving, often plankton feeding seabirds, many of which are wintering birds originating from West Palaearctic breeding grounds (arctic, subarctic and temperate zones). In earlier studies, many seabirds were associated with the large trawlers around the Shelf-break, but the exact importance of these fishing activities for seabirds is still unclear.

This report presents the first results obtained during the ship-based seabird and marine mammal surveys conducted between 4 and 14 September 2015 and must be seen as a preliminary analysis of the data and a further step in data collection. This cruise was part of the longer-term research project financed via the Programme "Biodiversity Gas and Oil" (BGO) which is spearheaded by the Mauritanian Ministry of environment and implemented in conjunction with the Ministry of Fisheries and the Ministry of Mining and Oil. The activities are funded primarily by the GIZ, UNDP/GEF and IUCN and co-sponsored by the private sector.

The survey was carried out by the Mauritanian Institute for Sea Research IMROP in co-operation with Dutch researchers and sponsored by Kosmos Energy. The project contributes to the objective of the Programme BGP to gain better insights into the overall ecological vulnerability of the area to oil and gas development and commercial fisheries in general and in particular to understand the sensitivity of the Shelf-break area to surface pollution during late summer. The report is one of the building blocks that will form the future guideline for sound oil spill preparedness in the shelf break area and prime oil and gas development site.

In this cruise report species accounts and short ecological interpretations of the collected material are presented. This is preceded by a short introduction of the methods and protocols and a description of the methods chosen to analyse, map, present and illustrate the data. For this report, plankton data and information on fish abundance (echo sounder) were not yet available. Where relevant, these data will be included in the final publication of results. [SK]

4 Methods and study area

4.1 Observer effort

The ship *Al Awam* surveyed the Mauritanian Continental shelf (Neritic zone) and slope (Shelf break) towards and from deeper Oceanic waters between Nouadhibou (Mauritania) and St. Louis (Senegal), 4-14 September 2015 (**Fig. 1**). Mean (± SD) daily observer effort amounted to 134.4 ± 22 5-minute counts, or 11.2 ± 1.8 hours of observation. With an average speed of 7.9 ± 0.4 knots, on 163.7 ± 31.2 km could be surveyed, given the 300m wide strip-transect covering an area of 49.1 ± 9.3 km² on a daily basis (**Table 4.1**).

Transects were designed to cross the shelf break preferably at a 90° angle and followed a zigzag pattern with 2-3 shelf-slope crosses each day (surveying from dawn to dusk; **Fig. 4.1**). Data were collected in 5-minute periods and for each period, the geographical position was recorded as well as the ship's speed, sea state, sea surface temperature (SST), the presence of clearly visible fronts, lines of flotsam as well fisheries activities and the presence or absence of plastic floats (indicating set nets, drift nets or octopus pots). A total of 28 individual transects (east-west orientation only) were labelled A-Z and ZA, ZB respectively, labelling from north to south, to facilitate a grouped analysis of the data where needed (**Fig. 4.1**, **Table 4.2**).

Table 4.1 Observer effort per day: date, mean latitude (°N), number of 5-minute counts (*n*), area surveyed (km²), hours of observation, and distance travelled (km) for each of three pre-defined depth zones (m).

					Counts (n)			Area (km²)		
Dd	Mm	Yy	Latitude		Oceanic >800m	Shelf-break 200-800m	Neritic <200m	Oceanic >800m	Shelf-break 200-800m	Neritic <200m
4	Sep	2015	20.4	°N	63	36	47	23.6	14.4	18.3
5	Sep	2015	19.0	°N	39	31	76	14.9	11.7	28.7
6	Sep	2015	18.0	°N	39	52	55	14.8	20.0	21.4
7	Sep	2015	17.0	°N	44	17	59	16.9	6.4	21.9
8	Sep	2015	16.5	°N	49	38	59	18.1	14.3	22.2
9	Sep	2015	16.5	°N	39	32	73	14.9	12.0	26.1
10	Sep	2015	17.5	°N	67	51	28	23.6	17.9	9.7
11	Sep	2015	18.5	°N	41	46	59	14.4	16.0	20.6
12	Sep	2015	19.5	°N	42	36	68	15.1	12.9	24.3
13	Sep	2015	20.0	°N	43	21	50	15.1	7.4	17.2
14	Sep	2015	20.1	°N	28	20	30	8.6	6.8	9.9
Totals					494	380	604	180.1	139.8	220.4
					Hours			Distance (km)		
4	Sep	2015	20.4	°N	5.3	3.0	3.9	78.7	48.1	61.2
5	Sep	2015	19.0	°N	3.3	2.6	6.3	49.8	38.9	95.7
6	Sep	2015	18.0	°N	3.3	4.3	4.6	49.2	66.7	71.5
7	Sep	2015	17.0	°N	3.7	1.4	4.9	56.4	21.4	73.0
8	Sep	2015	16.5	°N	4.1	3.2	4.9	60.4	47.7	74.0
9	Sep	2015	16.5	°N	3.3	2.7	6.1	49.6	39.9	86.9
10	Sep	2015	17.5	°N	5.6	4.3	2.3	78.6	59.7	32.4
11	Sep	2015	18.5	°N	3.4	3.8	4.9	48.1	53.3	68.8
12	Sep	2015	19.5	°N	3.5	3.0	5.7	50.4	42.9	81.1
13	Sep	2015	20.0	°N	3.6	1.8	4.2	50.4	24.8	57.2
14	Sep	2015	20.1	°N	2.3	1.7	2.5	28.6	22.8	33.0
Totals					41.2	31.7	50.3	600.2	466.1	734.7
%%					33.4%	25.7%	40.9%	33.3%	25.9%	40.8%

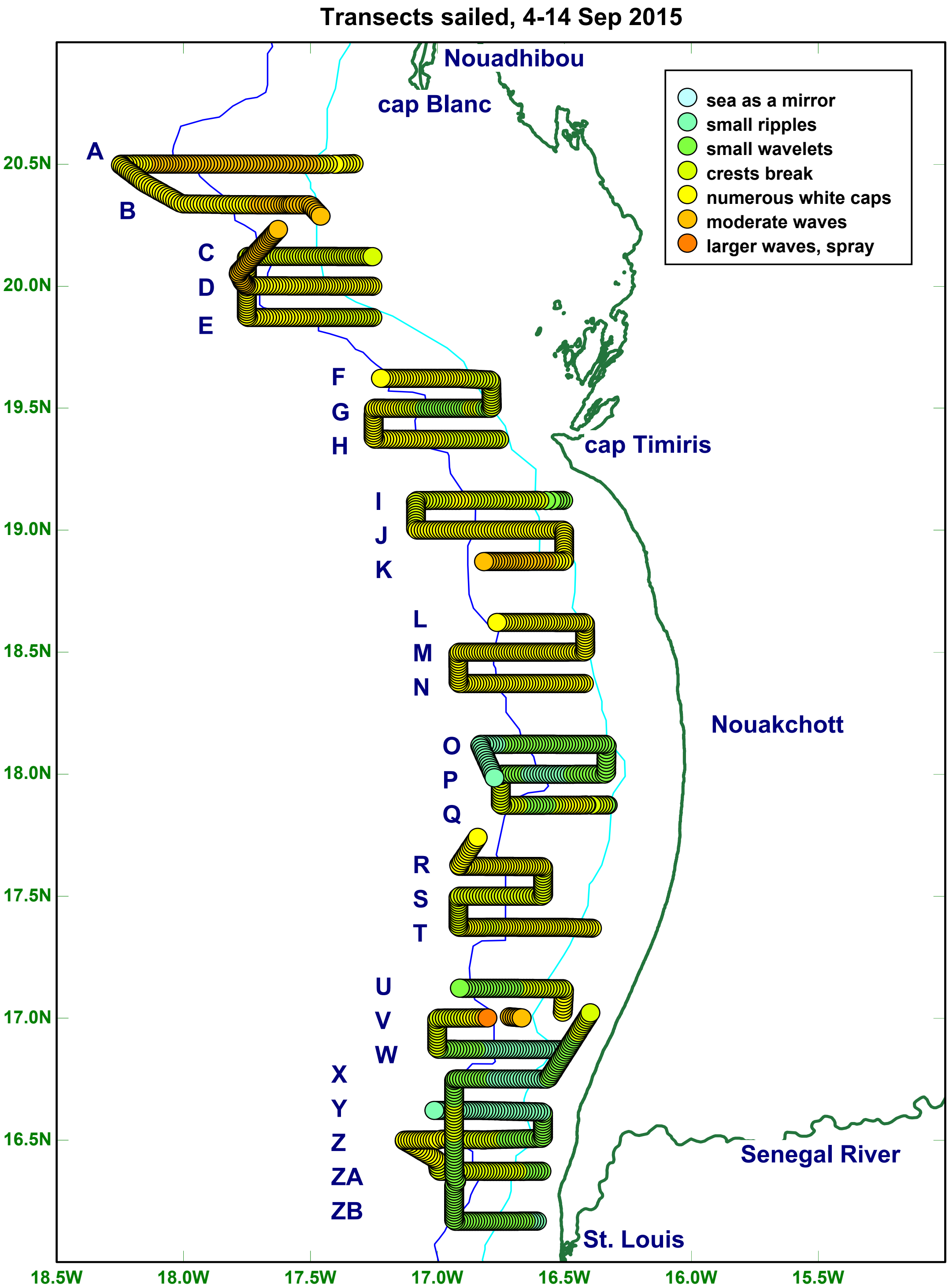


Figure 4.1 Observer effort (plots of 5-minute counts, with colours indicating sea state (legend) during the survey). The shelf slope (100-1000m depth contours) is indicated. Data can be summarised per horizontal leg (labelled A-ZB), by depth (Neritic, Shelf break, Oceanic) and latitude. See depth profiles in **Appendix 1**.

Table 4.2 Observer effort per leg (i.e. numbered east ←→ west transects): date, number of 5 minute counts, hours of observation, latitude (°N) maximum and minimum longitude (°W), minimum and maximum water depth (m), area surveyed (km²), distance travelled (km), and average speed (knots). The data can be summarised per leg (A-Z, ZA, ZB) as in **Figure 4.1.**

								Longitude				Depth								
Leg	Dd	Mm	Yy	Counts	Hrs	Latitude		Max	-	Min		Min	Max		Area		Distance		Speed	
A	4	Sep	2015	74	6.2	20.5	°N	18.2	-	17.3	°W	41	1197	m	29.4	km²	97.9	km	8.6	knots
B	4	Sep	2015	68	5.7	20.4	°N	18.2	-	17.5	°W	50	1374	m	25.6	km²	85.2	km	8.1	knots
C	13	Sep	2015	47	3.9	20.1	°N	17.8	-	17.3	°W	20	1140	m	16.0	km²	53.3	km	7.3	knots
D	14	Sep	2015	45	3.8	20.0	°N	17.8	-	17.3	°W	28	1011	m	15.7	km²	52.2	km	7.5	knots
E	13	Sep	2015	43	3.6	19.9	°N	17.7	-	17.3	°W	102	1361	m	15.7	km²	52.2	km	7.9	knots
F	12	Sep	2015	38	3.2	19.6	°N	17.2	-	16.8	°W	7	919	m	13.8	km²	46.0	km	7.8	knots
G	12	Sep	2015	44	3.7	19.5	°N	17.2	-	16.8	°W	16	1443	m	15.0	km²	49.9	km	7.4	knots
H	12	Sep	2015	42	3.5	19.4	°N	17.2	-	16.8	°W	19	1275	m	15.7	km²	52.5	km	8.1	knots
I	5	Sep	2015	48	4.0	19.1	°N	17.1	-	16.5	°W	37	1429	m	18.8	km²	62.7	km	8.5	knots
J	5	Sep	2015	49	4.1	19.0	°N	17.1	-	16.5	°W	43	1425	m	18.4	km²	61.3	km	8.1	knots
K	5	Sep	2015	27	2.3	18.9	°N	16.8	-	16.5	°W	91	335	m	10.1	km²	33.8	km	8.1	knots
L	11	Sep	2015	33	2.8	18.6	°N	16.8	-	16.4	°W	58	573	m	11.5	km²	38.3	km	7.5	knots
M	11	Sep	2015	47	3.9	18.5	°N	16.9	-	16.4	°W	54	1311	m	15.8	km²	52.8	km	7.3	knots
N	11	Sep	2015	44	3.7	18.4	°N	16.9	-	16.4	°W	78	1390	m	15.8	km²	52.8	km	7.8	knots
O	6	Sep	2015	43	3.6	18.1	°N	16.8	-	16.3	°W	53	1388	m	16.3	km²	54.4	km	8.2	knots
P	6	Sep	2015	34	2.8	18.0	°N	16.7	-	16.3	°W	74	960	m	13.2	km²	43.9	km	8.4	knots
Q	6	Sep	2015	37	3.1	17.9	°N	16.8	-	16.3	°W	74	813	m	14.1	km²	47.0	km	8.2	knots
R	10	Sep	2015	33	2.8	17.6	°N	16.9	-	16.6	°W	235	1419	m	11.0	km²	36.7	km	7.2	knots
S	10	Sep	2015	28	2.3	17.5	°N	16.9	-	16.6	°W	191	1317	m	10.9	km²	36.2	km	8.4	knots
T	10	Sep	2015	50	4.2	17.4	°N	16.9	-	16.4	°W	76	1162	m	16.9	km²	56.4	km	7.3	knots
U	7	Sep	2015	35	2.9	17.1	°N	16.9	-	16.5	°W	76	939	m	13.3	km²	44.4	km	8.2	knots
V	7	Sep	2015	23	1.9	17.0	°N	17.0	-	16.7	°W	99	1563	m	8.3	km²	27.7	km	7.8	knots
W	7	Sep	2015	44	3.7	16.9	°N	17.0	-	16.5	°W	25	1448	m	16.3	km²	54.4	km	8.0	knots
X	9	Sep	2015	33	2.8	16.8	°N	16.9	-	16.6	°W	30	838	m	12.4	km²	41.3	km	8.1	knots
Y	8	Sep	2015	37	3.1	16.6	°N	17.0	-	16.6	°W	33	1195	m	13.8	km²	46.1	km	8.1	knots
Z	8	Sep	2015	49	4.1	16.5	°N	17.1	-	16.6	°W	29	1547	m	18.2	km²	60.7	km	8.0	knots
ZA	8	Sep	2015	35	2.9	16.4	°N	17.0	-	16.6	°W	23	1164	m	13.2	km²	43.9	km	8.1	knots
ZB	9	Sep	2015	31	2.6	16.2	°N	16.9	-	16.6	°W	38	455	m	11.0	km²	36.6	km	7.7	knots

4.2. Survey methods

The surveys were conducted according to the strip-transect method in which a 300m wide transect on one side (with favourable light) and ahead of the ship was used, including a snap-shot for flying birds(Tasker *et al.* 1984, Camphuysen *et al.* 2004). Ship-attracted birds were labelled as such and could therefore be excluded from analysis if that was needed (Camphuysen *et al.* 2004). All observations were conducted by a team of two observers (CJC, HV), except during lunch breaks when a single observer was used for short periods of time (<30 min d^{-1}). Sightings by other observers on board were ignored to standardise the sampling and detection probabilities as much as possible. The surveys included full behavioural observations using international procedures (Camphuysen & Garthe 2004). This allowed us to pin-point main feeding areas and it permitted us to describe and quantify species interactions encountered during these surveys.

4.3 Population estimates derived from strip-transect counts

The observer effort has subsequently been summarised in 10'x10' rectangles, each with a surface area of *c.* 343 km² (18.5x18.5 km; **Fig. 4.2**) to provide a spatial pattern in observed densities (number of birds or marine mammals per km²). This single dataset is too small and most birds are simply not recorded frequently enough to warrant a more refined spatial analysis using for example kriging techniques[1], but future analyses with merged data will be highly suitable for a more advanced spatial statistical analysis.

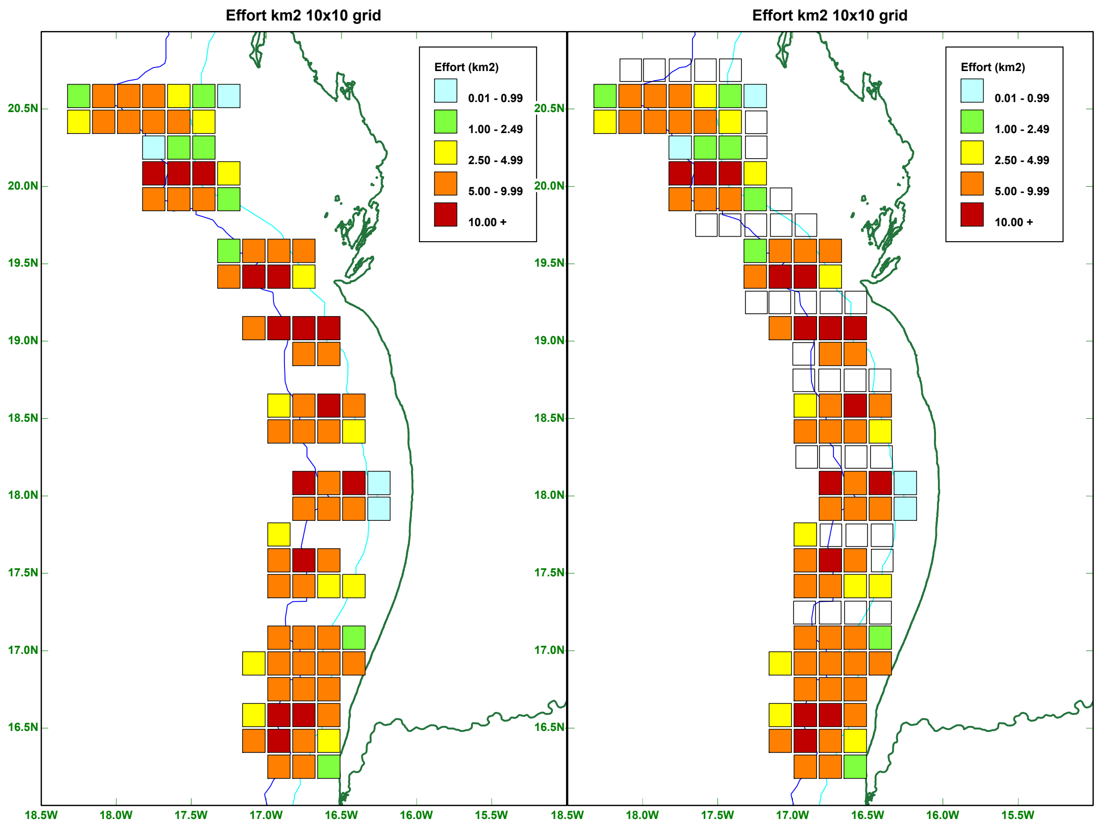


Fig. 4.2 Observer effort as km² per 10x10'grid square (left, 85 sub-sampled rectangles in total), and area used for extrapolation (right): 120 10x10' rectangles and the positioning of unsurveyed (*i.e.* blank) rectangles relative to the surveyed grid cells.

For each rectangle, abundance estimates were calculated based on birds recorded within the 300m strip-transect. Of the 85 sub-sampled rectangles, mean coverage amounted to 6.36 ± 3.41

[1] Geostatistical techniques to interpolate the value if a random field as a function of the geographical location at an unobserved location from observations of its value at nearby locations

km², range 0.37-16.52 km² (*i.e.* on average 1.8 ± 1.0%, with a maximum of 4.8% of the total surface area). Poor coverage was in four rectangles (light blue in **Fig. 4.2** (left), 0.64 ± 0.30 km², or <0.2% of the total surface area). In order to obtain estimates of total numbers within the studied area (that is within all sufficiently surveyed rectangles), a mean density ± SD was calculated over the numbers of birds per km² found in each of 81 rectangles. An extrapolated number was calculated by using the overall mean density found for all 120 10x10' rectangles covering similar areas around the shelf slope, as indicated in **Fig. 4.2** (right; unsurveyed blocks and poorly surveyed blocks included). As an example: an overall density of 2.07 ± 4.9 Common Terns per km² calculated over 81 properly surveyed 10x10' rectangles would lead to an estimate of *c.* 57,000 individuals for studied blocks (green to red in **Fig. 4.2**-left) and an estimate of 85,000 individuals for all 120 rectangles drawn in **Fig. 4.2**-right. Since these extrapolations are very crude, and seabird distribution patterns are usually very patchy, the estimates will therefore always be accompanied by the observed mean density ± SD. For small birds such as storm-petrels and phalaropes that are easily missed, a species-specific correction factor was calculated based on assessments of densities within 4 distance bands away from the ship (see Species Accounts, see also Camphuysen *et al.* 2013).

4.4 Oceanographic features, bathymetry, sea surface temperature

All 28 transects aimed at crossing the Shelf-break at a more or less right angle (perpendicular), travelling from west to east or vice versa. Records of depth (m) were kept every 15 minutes and missing values were imputed for each 5-minute period by assuming linear change between subsequent recordings (**Fig. 4.3**). The resulting depth profiles for each of the transects (A-Z, ZA, and ZB) are provided in **Fig. 4.4.** Note that Oceanic waters (>800m deep) were not reached on transects, K (5 Sep), L (11 Sep), and ZB (9 Sep), and only just on transects F (12 Sep), Q (6 Sep), and X (9 Sep) (**Table 4.2**).

All counts in waters less than 200m deep were classified as "**Neritic**", counts in waters between 200 and 800m deep were considered "**Shelf break**", whereas counts in deeper waters were listed as "**Oceanic**". Total survey time spent in each of these areas amounted to 33.4% (41.2 hours, 180.1 km° surveyed) in Oceanic waters, 25.7% (31.7 hours, 139.8km² surveyed) over the Shel break and 40.9% (50.3 hours, 220.4 km² surveyed) within the Neritic zone (**Table 4.1**).

Sea surface temperatures ranged from 20.5-30.2°C, with a clear spatial pattern from south (warm, homogeneous) to north (cooler, more variable) (**Fig. 4.6-7**). Notably cooler waters were encountered around 20°30'N, to the SW of Cap Blanc, notably within the neritic zone (24-25°C or lower), indicating upwelling of cooler waters from the deep. Slightly cooler waters occurred around 20°N, but further to the south (transects L-ZB), sea surface temperatures rarely ever dropped below 28°C (**Fig. 4.5**). Between St Louis (16°N) and just to the northwest of Nouakchott (18°30'N) there was hardly a temperature gradient between sea surface temperature in the Oceanic and Neritic zone and recorded values were always just over 28°C (**Fig. 4.5-6**).

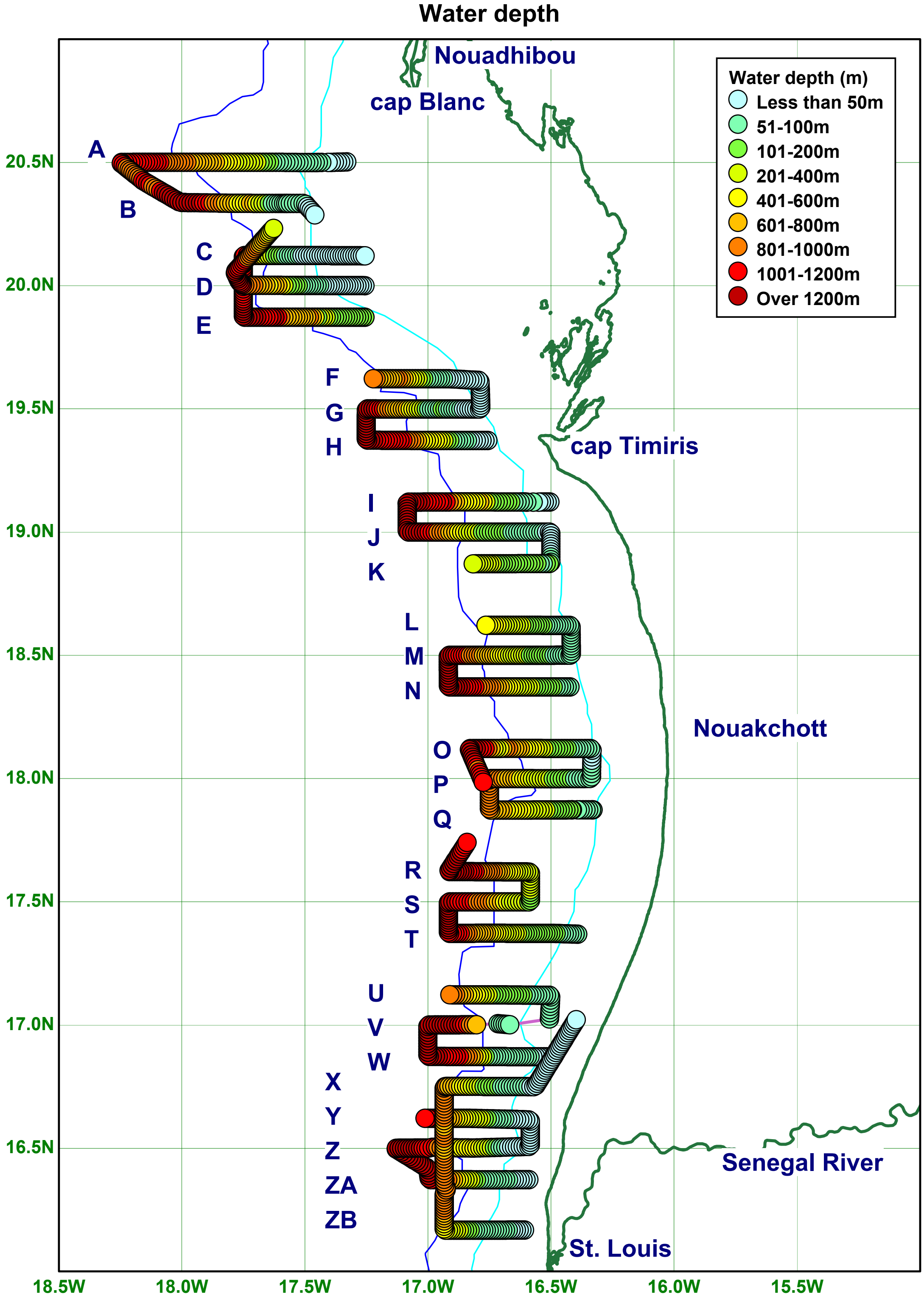


Figure 4.3 Observer effort (plots of 5-minute counts), with colours indicating water depth (m, see legend) during the survey. Based on these actual recordings, data were summarised by depth category (Neritic, Shelf break, Oceanic). See depth profiles for individual legs A-Z, ZA, and ZB in **Appendix 1**.

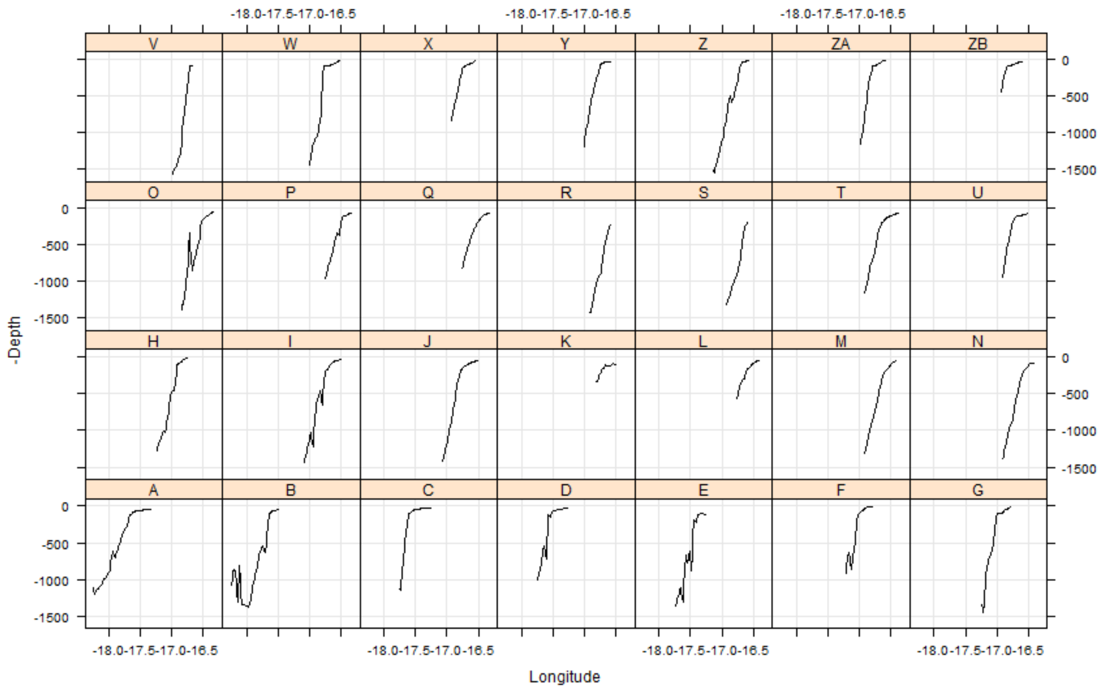


Fig. 4.4 Water depth (m) profiles for each of 28 transects A-Z, ZA, and ZB (see **Appendix 1** for more detailed depth profiles).

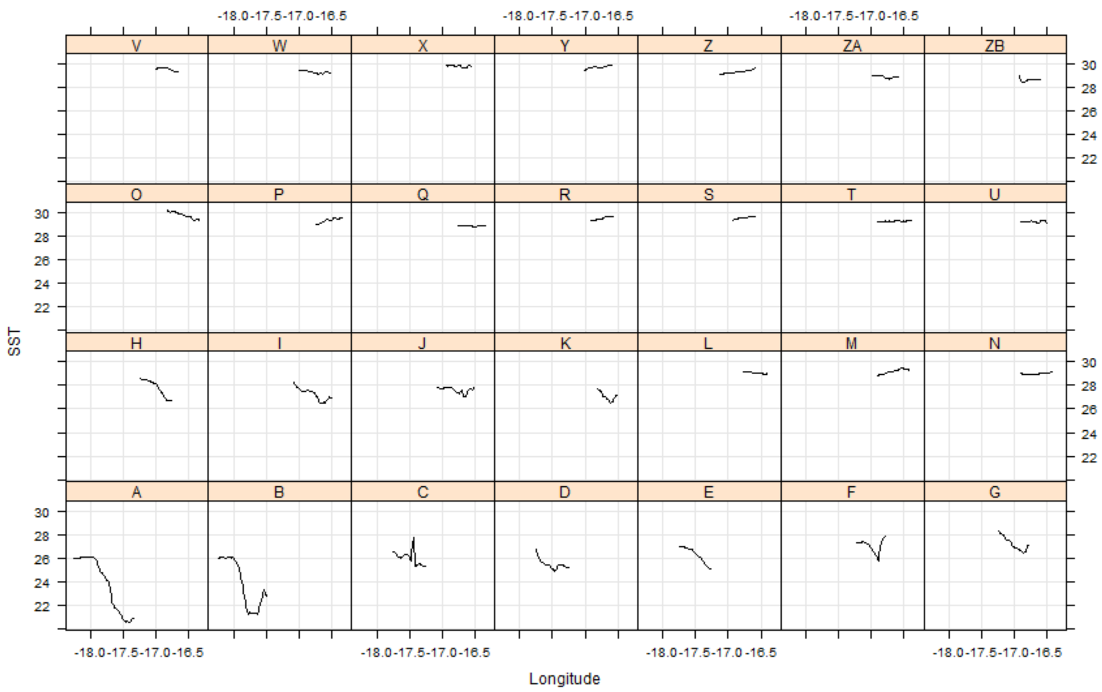


Fig. 4.5 Sea surface temperature (SST °C) profiles for each of 28 transects A-Z, ZA, and ZB.

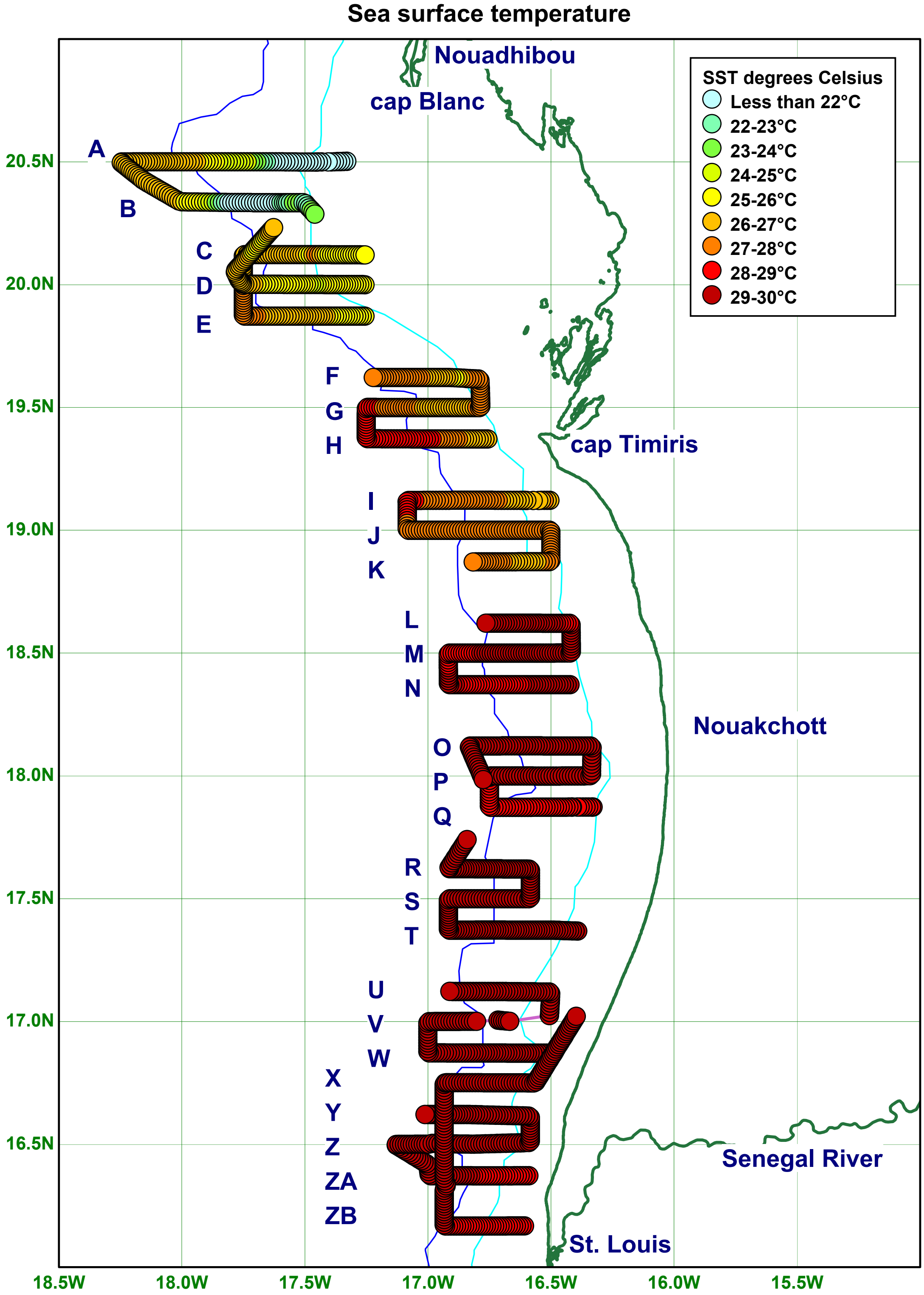
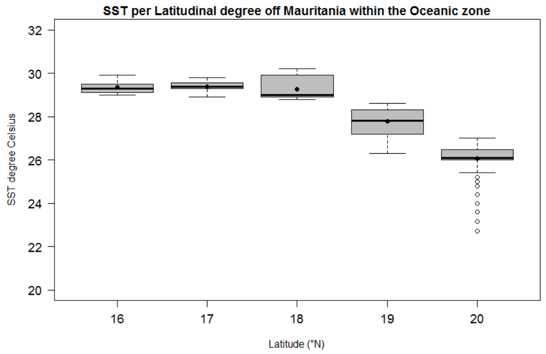
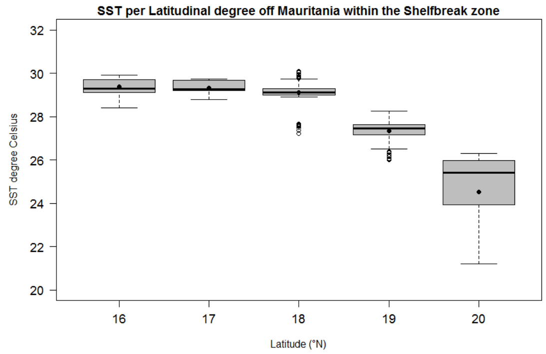


Figure 4.6 Observer effort (plots of 5-minute counts), with colours indicating sea surface temperature (°C SST, see legend) during the survey. Note rather homogeneous patterns in the south (L-ZB), with SST around 30° continuously. Note temperature gradients towards slightly cooler nearshore waters including some relatively cold water intrusions to the south of Cap Blanc.





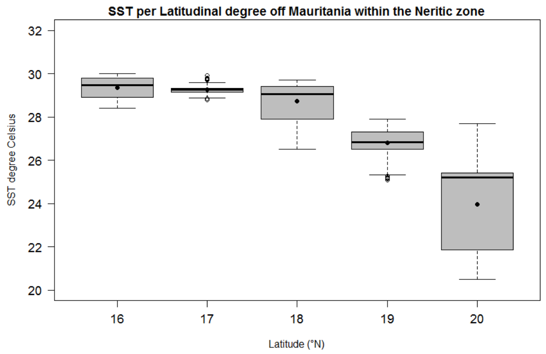


Figure 4.7. Mean sea surface temperature (SST °C) during all transects grouped by latitudinal degree (20-16°N) and water depth (Oceanic, Shelf break or Neritic). Note distinctly lower temperatures in the northerly areas (19-20°N) and a larger temperature range within the Neritic zone.

4.5 Meteorological data

Weather conditions were favourable to excellent during most of the survey, with light winds, clear skies and bright sunshine during most of the days. One rapidly developing tropical storm occurred on 7 Sep 2015, and the surveys had to be discontinued for some hours in violent winds (9-10B) and torrential rains.

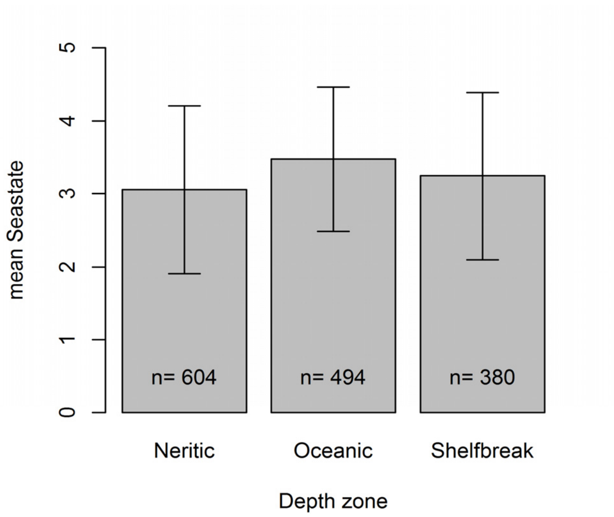


Fig. 4.8. Sea state conditions encountered during surveys (see **Fig. 1** for spatial patterns) in each of the main depth zones. The difference in sea state between these areas was highly significant (ANOVA $F_{2.1475}$= 19.81, P< 0.001).

The wind was northerly (350-020°) to north-westerly (290-320°), an on average between 6 and 15 knots (3-4B), except op 7 September, when the prevailing wind was easterly (80°) at only 6 knots (2B; Windyty 2015, historical data archives). The sea state ranged from 2 (small wavelets) to 4 (numerous white caps) on nearly all days, with significantly rougher conditions over Oceanic waters (**Fig. 4.8**). These relatively small wind waves, combined with a gentle (light to moderate) swell, gave excellent observation conditions during most of the programme.

Noon air temperatures (°C) in Nouakchott ranged from 34-36°C between 4-8 September, fell to 29°C on 9 September, peaked at 38-40° on 10-11 September, and stabilised between 35-38°C during the remainder of the survey (12-14 September). At-sea air temperatures were lower and ranged from 29-31°C during most of the surveys (Windyty 2015, historical data archives). Rain of any significance did not occur during the surveys, except during the short, rapidly developing tropical storm on 7 September.

4.6 Commercial and artisanal fisheries

Commercial trawler (industrial fisheries) (CJC)

Pirogue (artisanal fisheries) (HV)

The Islamic Republic of Mauritania has some of the world's most fish-abundant waters due to its strong upwelling coastal currents and a large continental shelf favouring the development of fisheries resources (COFREPECHE *et al.* 2014). Mauritanian legislation distinguishes three kinds of fishing: "**artisanal**", "**coastal**" and "**industrial**". The access of foreign fleets to Mauritanian coastal fishing zones is made possible through bilateral agreements, private arrangements with private companies or by the acquisition of private licences. Access conventions are currently in force between Mauritania and a Chinese company (access to small pelagics) and a Japanese company (tuna), while a bilateral agreement with Senegal allows for access by an artisanal fleet of canoes and a Senegalese fleet of bait boats based in Dakar (COFREPECHE *et al.* 2014). Nouadhibou is the primary fishing port for the industrial fleet, while 80% of its artisanal boats land at Nouakchott (US Aid/West Africa 2008).

During this project, with an offshore survey generally conducted at well over 5 nm from the nearest Mauritanian coast (Senegalese border and Cap Blanc), we only distinguished between industrial (pelagic and demersal trawlers) and artisanal fisheries (pirogues). Conform ESAS survey techniques, for each 5-minute period of observation, fishing vessels within visible range (by eye) were identified and counted. Codes included (1) no fishing vessels around, (4) vessels at >2km distance, (6) vessel(s) at <2km distance, (7) vessel(s) at 0.5-2km distance, and (9) fishing fleet around the observation vessel (at least 5 vessels). Pelagic and demersal trawlers were not separated, active and inactive boats were included, but notes were made for vessels that were clearly inactive and as a result might have lost the attractive value for seabirds. In total, industrial and artisanal fishing vessels were both recorded for 11% of the total survey time (**Table 4.3**). Most fisheries were confined to the Neritic zone (<200m deep waters), with a clear concentration in more northerly areas (18-20°N). In addition, some pirogues were seen over deeper waters (Oceanic, 18-19°N), and pirogues were rather widespread off NW Senegal (Neritic-Oceanic, 16°N). Artisanal fish floats were most abundant off Cap Timiris (**Fig. 4.9**).

Common Dolphins *Delphinus delphis* joining a shelf break pirogue in 556m deep waters, 8 Sep 2015 (CJC)

Table 4.3 Number (*n*) of 5-minute counts and percent of time (%) with visible industrial or artisanal fishing vessels (FV) per degree latitude (20°N-16°N) in water bodies characterised by depth (Oceanic >800m, Shelf break 200-800m, Neritic <200m depth).

	All 5-minute counts (*n*)			% of counts with **industrial** FV			% of counts with **artisanal** FV		
°N	Oceanic	Shelf break	Neritic	Oceanic	Shelf break	Neritic	Oceanic	Shelf break	Neritic
20	107	63	112	-	-	41	-	-	37
19	108	73	128	3	15	29	11	-	19
18	67	75	122	-	4	46	10	-	11
17	99	94	89	-	-	-	-	-	3
16	113	75	153	-	-	5	9	16	27
			1478			11			11

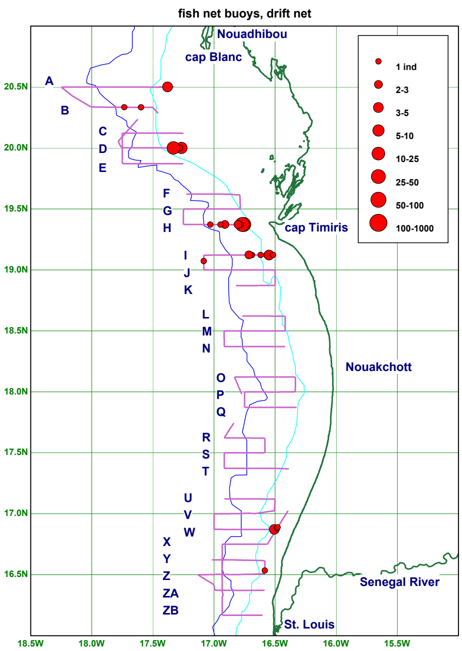


Fig. 4.9 Sightings of fish floats (artisanal fisheries) off the Mauritanian coast, 4-14 Sep 2015.

4.7 Hydroacoustic data

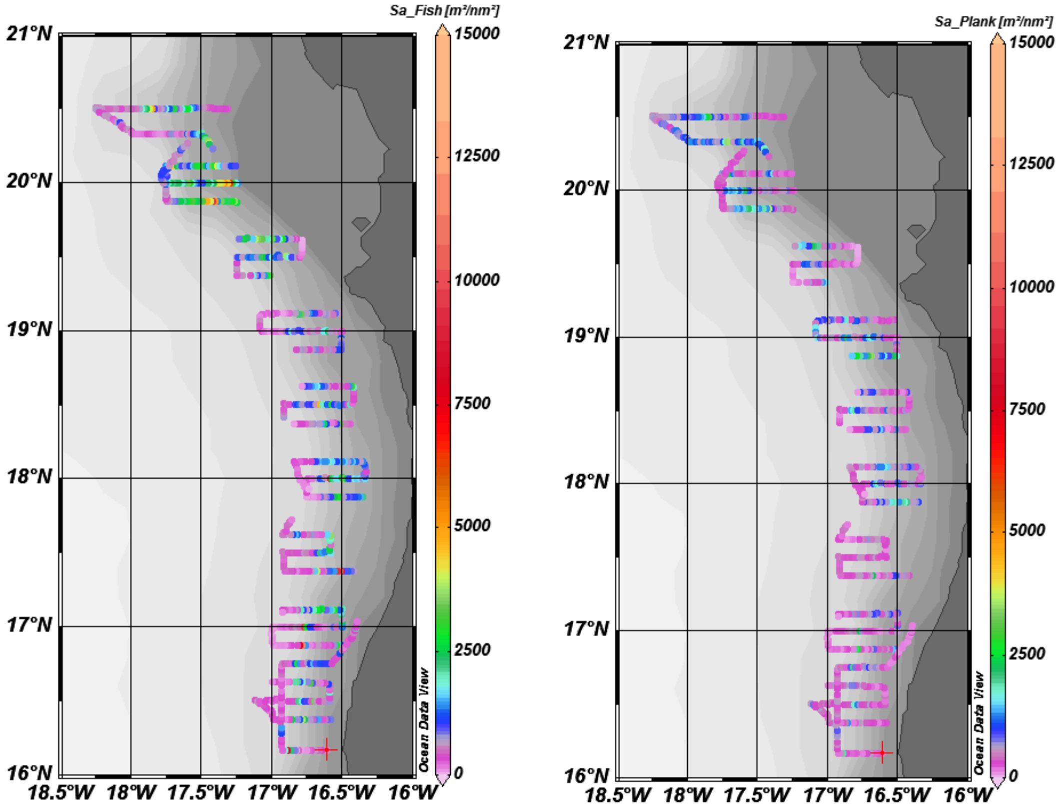


Fig. 4.10 Distribution of fish (left, total acoustic density) during the Al Awam surveys, 4 - 14 September 2015 (analysis MAJ/IMROP)

Mohamed Ahmed Jiyid ould Taleb at work on board Al Awam (FD)

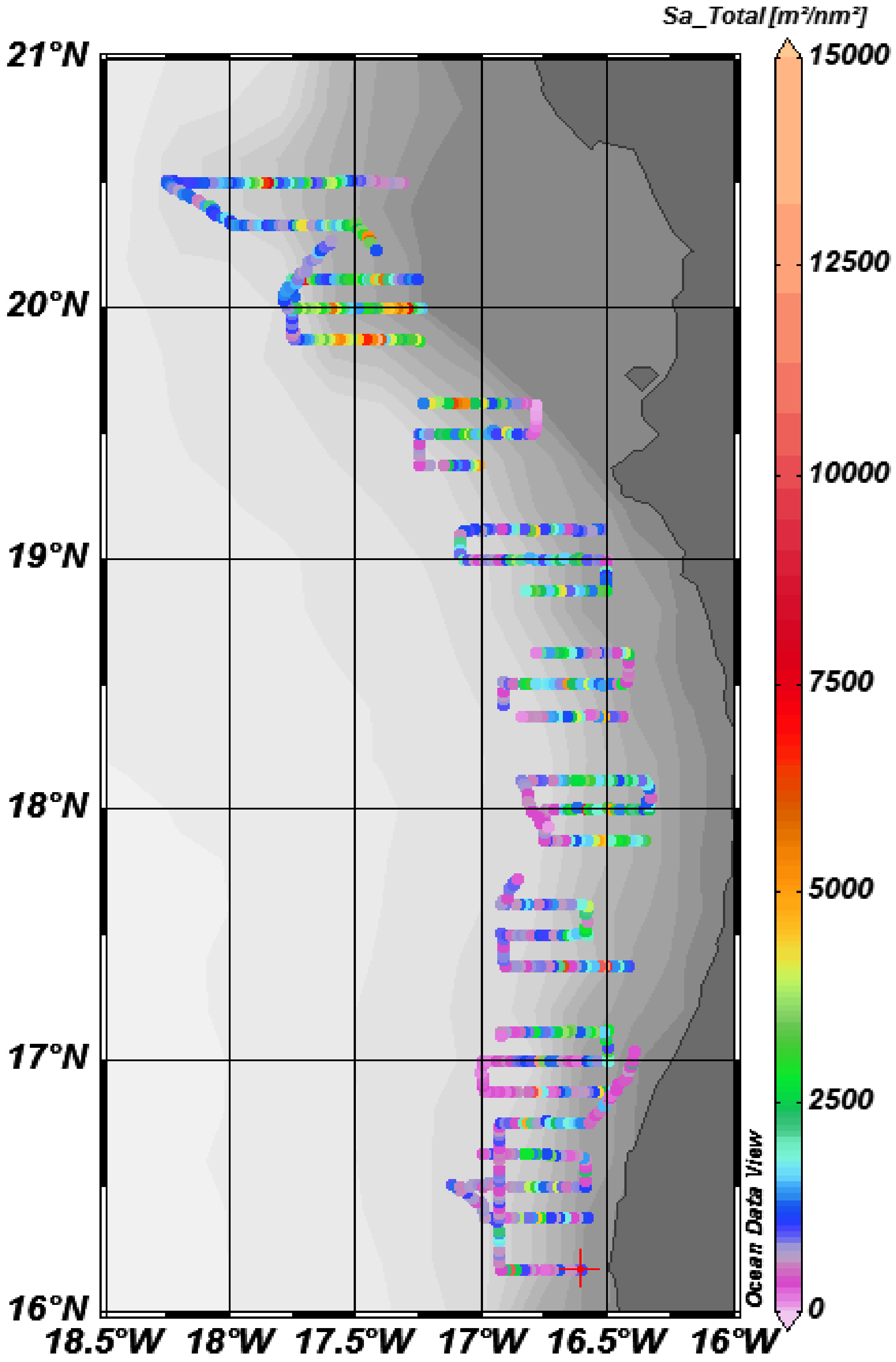


Fig. 4.11 Distribution of fish and plankton combined (total acoustic density) during the Al Awam surveys, 4 - 14 September 2015 (analysis courtesy Mohamed Ahmed Jiyid ould Taleb (MAJ), IMROP).

5. Results

5.1 General results and main findings

After covering the entire Shelf-break area off the Mauritanian coast between 4 and 14 September 2015, a total of at least 30 species of marine birds and 13 species of cetaceans were recorded. With 14 different species, the tubenoses were particularly well represented, followed by terns (7 species) and skuas (4 species; **Table 5.1**). Most numerous were Common Terns *Sterna hirundo* (5442 individuals) and Black Terns *Chlidonias niger* (3714, two boreal species), Wilson's Storm-petrels *Oceanites oceanicus* (1149, an Antarctic species), Pomarine Skuas *Stercorarius pomarinus* (808, an Arctic species), and Cape Verde Shearwaters *Calonectris edwardsii* (585, a regional seabird). Common Terns were particularly widespread: present in 79 (93%) of a total of 85 surveyed 10'x10'rectangles (**Fig. 4.2**). Black Terns (73%) and Wilson's Storm-petrels (72%) were seen in nearly three-quarters of the surveyed rectangles. In terms of foraging aggregations, tuna-driven feeding frenzies attracting Common and Black Terns in deep oceanic waters were the most prominent feature (**Fig. 5.1**). Two types of tuna driven multi-species foraging associations (MSFA's) were encountered, and both types will be discussed in depth in this cruise report. MSFAs dominated by smaller terns were typical for the warmer areas, with sea surface temperatures ranging from 27°C to more than 30°C, between the latitudes of the Senegal river in the south and Cap Timiris in the north. This same area was very rich in *Stenella* and *Delphinus*-dolphins, but despite obvious foraging behaviour of these small cetaceans, only trivial numbers of seabirds were attracted. Both the foraging aggregations, the species-specific foraging behaviour, and the interactions between species will be highlighted in the species accounts following below.

Fig. 5.1 Offshore feeding frenzy with Black Terns and Common Terns targeting forage fish driven towards the surface by Skipjack Tuna, 5 Sep 2015. Water depth >1400m (HV)

Table 5.1 All 30 species of seabirds observed, 4-14 September 2014, on board Al Awam off the Mauritanian coast, and their most likely breeding origin. Non-regional species are migrants that utilise these waters as stop-over or as wintering area (non-breeding season). Nomenclature and taxonomic order following Gill & Donsker (2015). Species that (also) breed in Mauritania are marked with an asterisk (*)

English name	French name	Scientific name	Breeding origin
Wilson's Storm-petrel	Océanite de Wilson	*Oceanites oceanicus*	Antarctic
European Storm Petrel	Océanite tempete	*Hydrobates pelagicus*	Boreal/Mediterranean
Band-rumped Storm Petrel	Océanite de Castro	*Oceanodroma castro*	Regional
Swinhoe's Storm Petrel	Océanite de swinhoe	*Oceanodroma monorhis*	Unknown
Leach's Storm Petrel	Océanite culblanc	*Oceanodroma leucorhoa*	Boreal
Scopoli's Shearwater	Puffin cendré (Mediterannée)	*Calonectris diomedea*	Mediterranean
Cory's Shearwater	Puffin cendré (Atlantique)	*Calonectris borealis*	Regional
Cape Verde Shearwater	Puffin du Cap-Vert	*Calonectris edwardsii*	Regional
Sooty Shearwater	Puffin fuligineux	*Ardenna grisea*	Sub-antarctic
Great Shearwater	Puffin majeur	*Ardenna gravis*	Sub-antarctic
Manx Shearwater	Puffin des Anglais	*Puffinus puffinus*	Boreal
Balearic Shearwater	Puffin des Baléares	*Puffinus mauretanicus*	Mediterranean
Barolo Shearwater	Puffin de Macaronésie	*Puffinus baroli*	Regional
Bulwer's Petrel	Pétrel de Bulwer	*Bulweria bulwerii*	Regional
Great White Pelican*	Pélican blanc	*Pelecanus onocrotalus*	Regional
Red Phalarope	Phalarope à bec large	*Phalaropus fulicarius*	Arctic
Sabine's Gull	Mouette de Sabine	*Xema sabini*	Arctic
Audouin's Gull	Goéland d'Audouin	*Ichthyaetus audouinii*	Mediterranean
Lesser Black-backed Gull	Goéland brun	*Larus fuscus*	Boreal
Caspian Tern*	Sterne caspienne	*Hydroprogne caspia*	Regional
Royal Tern*	Sterne royale	*Thalasseus maximus*	Regional
Sandwich Tern	Sterne caugek	*Thalasseus sandvicensis*	Boreal
Little Tern(*)	Sterne naine	*Sternula albifrons*	Boreal
Bridled Tern*	Sterne bridée	*Onychoprion anaethetus*	Regional
Common Tern*	Sterne pierregarin	*Sterna hirundo*	Boreal
Black Tern	Guifette noire	*Chlidonias niger*	Boreal
South Polar Skua	Labbe Antarctique	*Stercorarius maccormicki*	Antarctic
Pomarine Skua	Labbe pomarin	*Stercorarius pomarinus*	Arctic
Parasitic Jaeger	Labbe parasite	*Stercorarius parasiticus*	Arctic
Long-tailed Jaeger	Labbe à longue queue	*Stercorarius longicaudus*	Arctic

Table 5.2 All 13 species of cetaceans observed, 4-14 September 2014, on board Al Awam off the Mauritanian coast. Cetaceans utilise these waters as wintering area or as resident species, but their migratory pathways and local seasonality are largely unknown.

English name	French name	Scientific name	Group
Blue Whale	Baleine Bleue	*Balaenoptera musculus*	Mysticeti
Humpback Whale	Baleine a bosse	*Megaptera novaeangliae*	
Sperm Whale	Cachalot	*Physeter macrocephalus*	Odontoceti
Gervais' Beaked Whale	Mesoplodon de Gervais	*Mesoplodon europaeus*	
Killer Whale	Orque	*Orcinus orca*	
False Killer Whale	Faux-orque	*Pseudorca crassidens*	
Short-finned Pilot Whale	Globicéphale tropical	*Globicephala macrorhynchus*	
Risso's Dolphin	Dauphin de Risso	*Grampus griseus*	
Bottlenose Dolphin	Grand dauphin	*Tursiops truncatus*	
Pantropical Spotted Dolphin	Dauphin tacheté pantropical	*Stenella attenuata*	
Clymene Dolphin	Dauphin de Clymene	*Stenella clymene*	
Atlantic Spotted Dolphin	Dauphin tacheté Atlantique	*Stenella frontalis*	
Common Dolphin	Dauphin commun	*Delphinus delphis*	

In terms of habitat differentiation and shifts in sea surface temperatures (SST), the northerly part of the study area (18°-21°N latitude) was considerably more complex than that further to the south (**Fig. 5.2**, see also **Figs. 4.4-5**). Within this area, biodiversity was generally higher (seabirds as well as marine mammals), both industrial and artisanal fisheries were encountered with the highest frequencies (**Table 4.3, Fig. 4.9**), and the acoustic density recorded on board (both that reflecting fish and plankton) was highest, notably over the Shelf-break area (**Fig. 4.10**). The cooler waters (SST) south of Cap Blanc are indicative for the upwelling of nutrient-rich waters.

SST recorded (degrees Celsius)

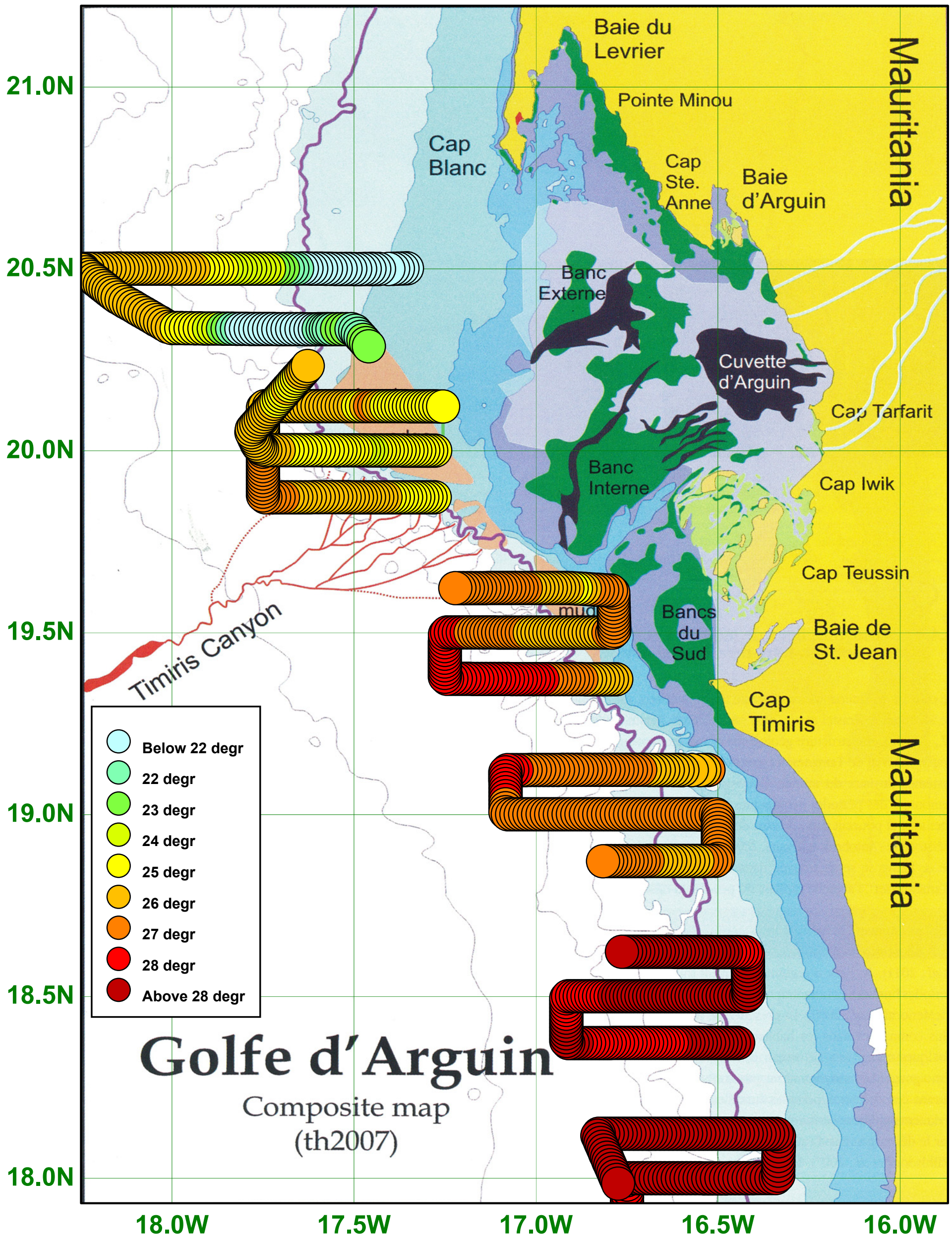


Fig. 5.2 Recorded sea surface temperatures (SST, °C) along survey tracks, superimposed over a chart with detailed bathymetry and bottom features, 18°-21°N latitude, Al Awam surveys, 4-14 Sep 2015.

5.2 'No detections' and diurnal patterns in megafauna behaviour

Observations were recorded in 5-minute bins (*n* = 1478), usually from sunrise (~06:50h) to just before sunset (~19:00h) in order to profit from all available daylight. Transects were sailed away from the coast in the morning, and back towards the coast around noon, in order to take optimal advantage of sunlight behind the vessel. The last, third leg, however, was often under more difficult conditions with sun glare ahead of the ship (with plenty of time available on the last two days, the third leg of the day was compromised).

In total, 17% of 1478 5-minute bins of observation were without any sightings (**Fig. 5.3, Table 5.3**). Consistent with the earlier remarks about a more complex bathymetry, a higher biodiversity and probably also a higher productivity in the more northerly waters, 'blanks' in the data turned out to be more common between 16°-17°N latitude (22-23%, *n* = 623 5-minute bins), but the exact locations were highly variable. Blanks were relatively rare over the Shelf-break (13%, *n* = 380 bins).

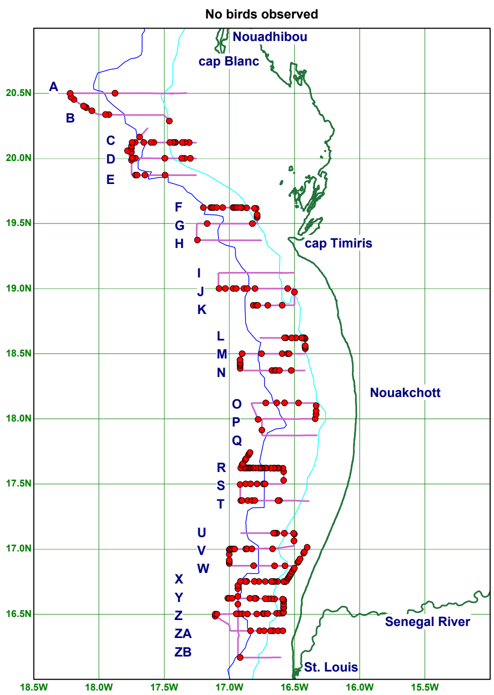


Table 5.3 Percentage (%) of five-minute bins without any sightings per latitudinal degree and within each of the water depth zones (except perhaps presistent ship-following seabirds).

Latitude	Oceanic	Shelf-break	Neritic	Overall
20°N	17%	3%	13%	12%
19°N	11%	11%	11%	11%
18°N	9%	16%	18%	15%
17°N	37%	13%	13%	22%
16°N	14%	20%	31%	23%
Overall	18%	13%	18%	17%

Fig. 5.3 Spatial pattern in five-minute observation periods without any sightings, except perhaps persistent ship-followers.

Few earlier studies have addressed the issue of diurnal patterns in seabird activity during ship-based surveys, even though most observers will admit that there are distinct periods of inactivity apparently resulting in prolonged periods with few sightings. Camphuysen (1999) was the first to evaluate diurnal activity patterns in wintering pelagic seabirds. Cox *et al.* (2013) studied the influence of both spatial oceanographic and temporal tidal variability on predator-prey interactions and were able to identify fine-scale relationships between seabird species and their prey fluctuating throughout the day. Camphuysen *et al.* (2013) described flock formations of Northern Gannets around sunset in Mauritanian waters in November 2012, suggesting that large aggregations were formed to spend the night at sea. Many temporal variations in environmental conditions are periodic and, for example, tidal, daily, lunar and annual periodicities provide challenges and opportunities for evolutionary adaptation (Gwinner 1975; Camphuysen 1999), and, as a result provide challenges for survey design. Camphuysen *et al.* (2004) raised the issue in survey protocols outlined for the UK Crown Estate, but failed to produce strict guidelines in the absence of evidence-based suggestions.

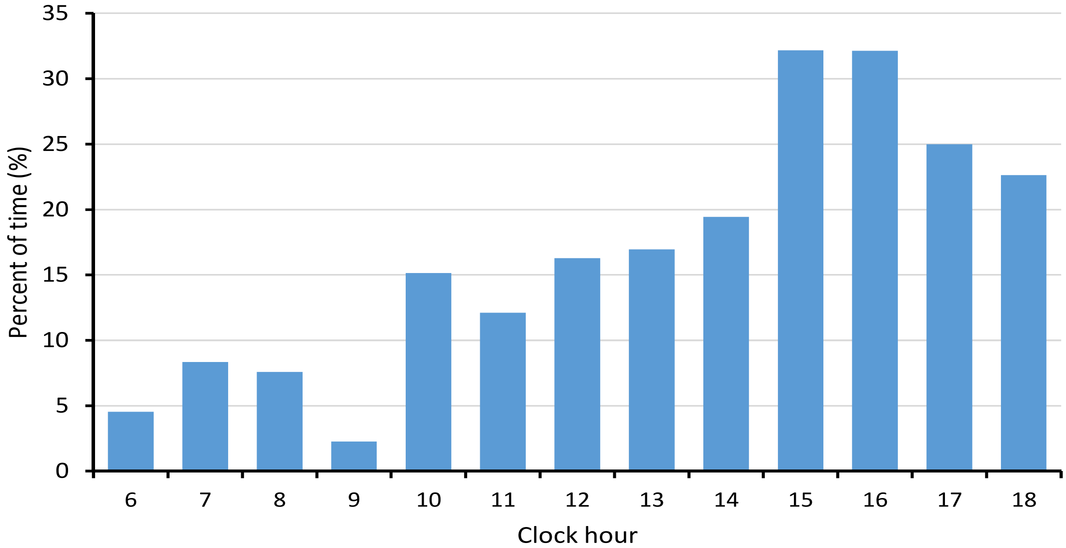


Fig. 5.4 Five-minute bins (%) without any sightings, except perhaps persistent ship-followers, relative to the time of the day in all areas combined, 4-14 Sep 2015.

Table 5.4 Observer effort (hrs) per clock hour in each of the depth zones throughout the surveys 4-14 Sep 2015 and the proportion if time (% of 5-munute observation periods) without any sightings.

	Observer effort (hrs)			**Percent of time without sightings**		
Hr	Oceanic	Shelf break	Neritic	Oceanic	Shelf break	Neritic
6	0	0	1.8	nd	nd	4%
7	0	0	11.0	nd	nd	8%
8	0.1	5.0	5.9	0%	10%	5%
9	4.8	5.8	0.5	1%	2%	0%
10	9.5	1.5	0	14%	16%	nd
11	9.9	1.1	0	13%	0%	nd
12	6.9	3.3	0.5	21%	7%	0%
13	2.1	4.6	3.2	20%	16%	15%
14	1.0	1.4	6.6	33%	23%	16%
15	1.0	1.3	7.3	16%	37%	33%
16	1.0	2.0	6.3	41%	20%	34%
17	1.8	2.2	5.1	38%	19%	22%
18	3.2	3.5	2.2	34%	14%	19%

Survey design is always a (cost-effective) compromise between numerous factors, and detection probability (light conditions) is one issue that is often taken into consideration. With three Shelf-break crossings day^{-1}, favourable light is guaranteed on at least two legs, but poor conditions are likely on the final leg. Changes in seabird activity (or presence) at sea were not taken into consideration, but are highlighted in this cruise report. 'Blank' 5-minute bins (observation periods without any detections) were clearly more frequent in the afternoon (**Fig. 5.4**) in all depth zones (**Table 5.4**). With a nearshore early morning starting point, biases arose in observer effort towards early morning and mid-afternoon observations in the Neritic zone, activities mostly just before noon and late afternoon in Oceanic waters, and a three-modal pattern in observation effort over the Shelf-break (**Fig. 5.5**). For the moment we can only speculate on the effects of these biases on the overall results.

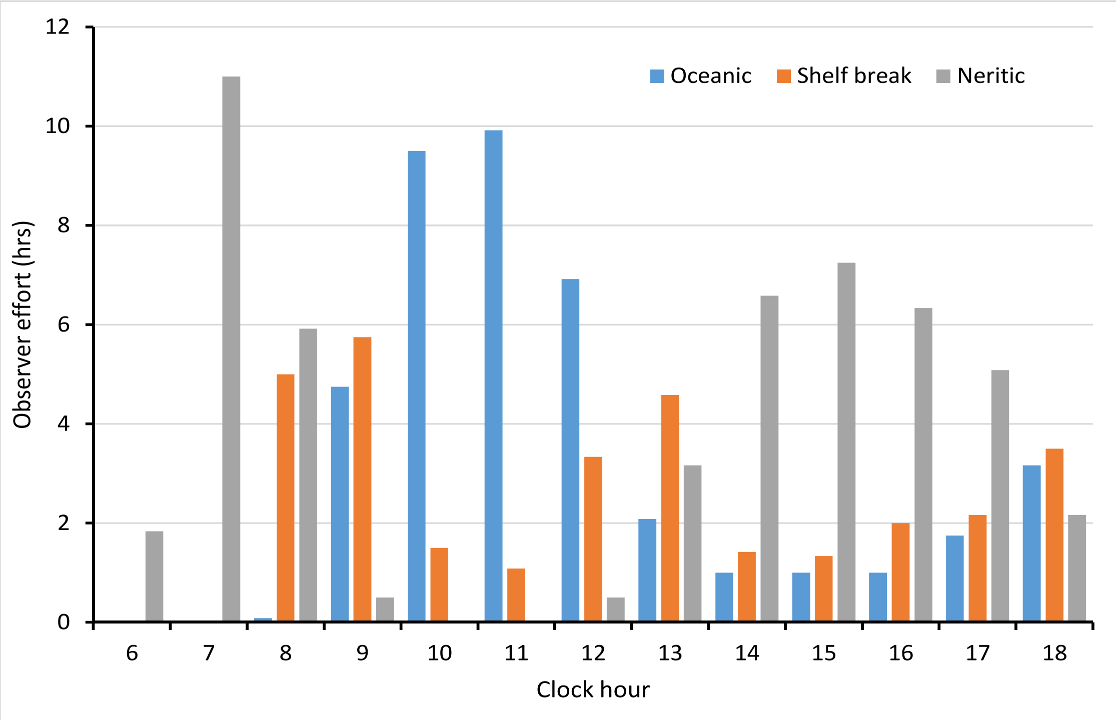
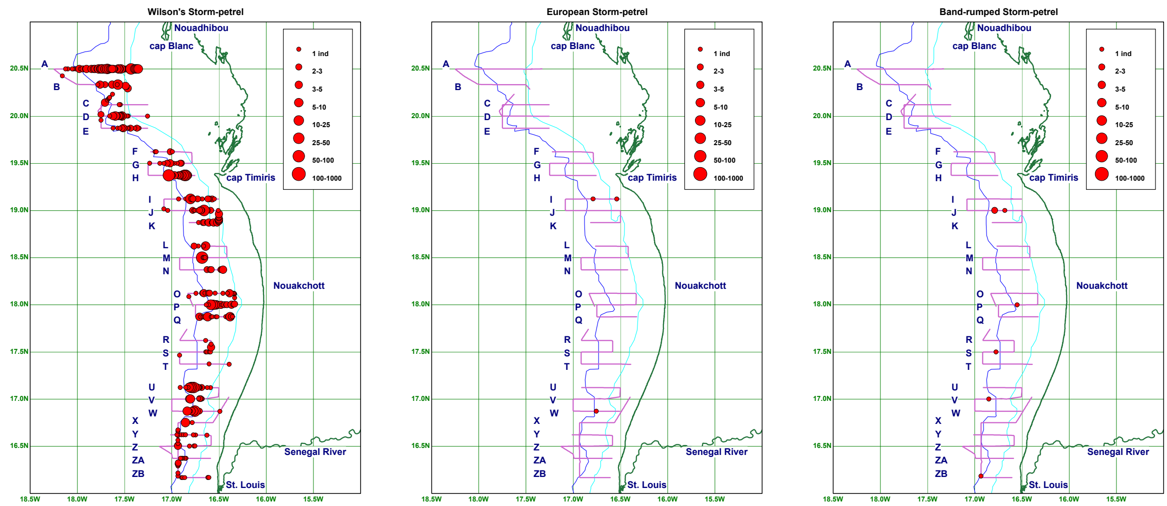


Fig. 5.5. Observer effort (hrs) per clock hour in each of the depth zones throughout the surveys 4-14 Sep 2015 (as in **Table 5.4**).

5.3 Species accounts

5.3.1 Tubenoses Procellariiformes

A total of 5 species of storm-petrels Hydrobatidae have been recorded in the September 2015 surveys, including one southern hemisphere species (Wilson's Storm-petrel *Oceanites oceanicus*), two migrants from the North Atlantic (European Storm-petrel *Hydrobates pelagicus* and Leach's Storm-petrel *Oceanodroma leucorhoa*), one 'regional' species breeding in Macaronesia (Band-rumped Storm-petrel *O. castro*) and a new species for Mauritanian waters (Swinhoe's Storm-petrel *O. monorhis*). Only one species was common and widespread (**Fig. 5.6**), and the identification challenges were therefore less severe than in other seasons (but see *O. castro*).



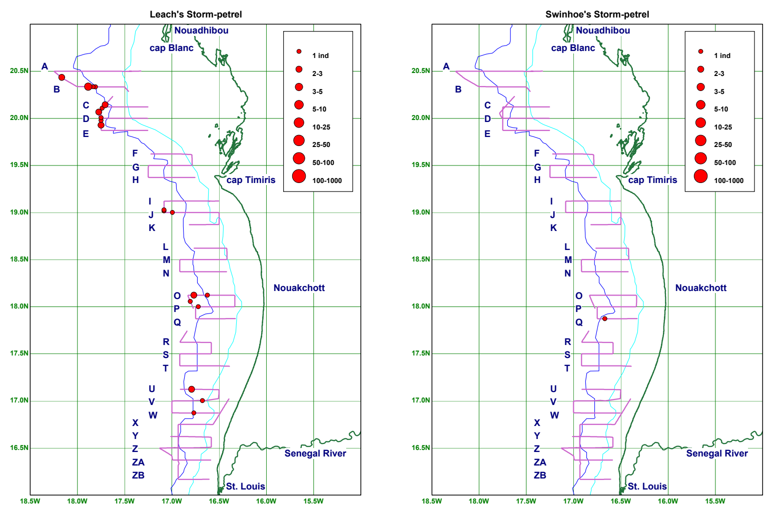
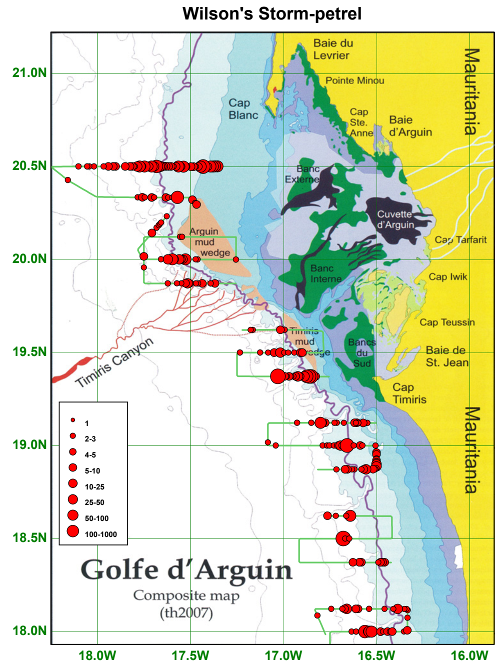


Fig. 5.6 Sightings of storm-petrels off the Mauritanian coast, 4-14 Sep 2015.

Wilson's Storm-petrel Océanite de Wilson *Oceanites oceanicus* (1149 sightings)

This is the abundant high-latitude sub-Antarctic and Antarctic storm-petrel that migrates north and into the northern Hemisphere around May and that returns in October-November in the southern Hemisphere (Onley & Scofield 2007). During northern Hemisphere winter surveys in Mauritanian waters (Nov-Apr), Wilson's Storm-petrels are very scarce, but the species is abundant in summer (Leopold 1993, Wynn & Krastel 2012). Wilson's Storm-petrels were by far the 'dominant' storm-petrels during the present survey, with 1149 records scattered over the entire study area. However widespread, sightings were significantly more frequent within the Neritic zone (49%) and over the Shelf-break (47%) than further offshore, with only 4% Oceanic sightings (n= 1149; G_{adj}= 383.9, df=2, P< 0.001; **Fig. 5.6**). Of all Wilson's Storm-petrels seen in which further details were recorded regarding direction of flight or particular associations (n= 704), 40.2% were in flight. 11.6% followed the observation vessel, and 29.8% were associated with a fishing vessel. Flight directions were random, or wind-influenced. There was no evidence for directed migration. Fish oil slicks near fishing vessels could attract large numbers of pattering Wilson's Storm-petrels. Behavioural notes were made with 787 Wilson's Storm-petrels and 92.3% were foraging (dipping, pattering, or actively searching for prey).



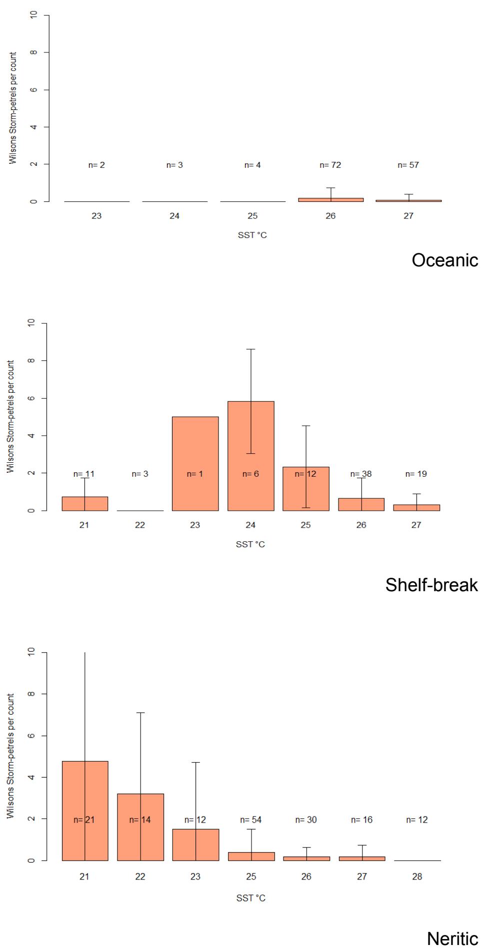


Fig. 5.7 Wilson's Storm-petrel observations in the northerly part of the study area, and concentrations (petrels 5-min count^{-1}) relative to the sea surface temperature (SST, 21-27°C) within the Oceanic zone (top), over the Shelf-break (central) and within the Neritic zone (bottom), to the north of 19°30'N Latitude. The sample size (number of counts) is given within each graph.

Wynn & Krastel (2012) reported unprecedented concentrations of Wilson's Storm-Petrels at the oceanic upwelling front offshore Mauritania in July 2005. Flocks of up to 600 birds were found concentrated along the boundary between warm Oceanic surface waters and cooler upwelled waters over the shelf and continental slope. These flocks formed an aggregation of at least 5,000 birds and was found at *c.* 20°N, 17°30'W (Wynn & Krastel 2012). In September 2015, the strongest SST gradients were found slightly further to the north (Transects A-B, **Fig. 4.5-6**) and prominent concentrations of Wilson's Storm-petrels were found in areas where cooler waters reached the surface (23-24°C at the Shelf-break, 21-23° within the Neritic zone; **Fig. 5.7**). These concentrations were much smaller than the flocks reported by Wynn & Krastel (2012), but our observations provide further evidence of the importance of a narrow mixing zone at the continental shelf edge to this species. Convergent processes at the upwelling front are likely to concentrate zooplankton and small prey fish in this zone (Wynn & Krastel 2012).

A total of 90 petrels (12.8%, *n*= 704) were seen in association with cetaceans (**Table 5.5**). Six occasions occurred, over the Shelf-break and/or within the Oceanic zone, and small numbers of petrels were involved usually. One megapod of oceanic dolphins was followed by nearly 80 Wilson's Storm-Petrels (MSFA#152; **Table 5.5**). Three herds of Short-finned Pilot Whales *Globicephala macrorhynchos* were attended by some Wilson's Storm-petrels. These rather large pods of deep-diving odontocetes tended to attract rather few seabirds otherwise (see Short-finned Pilot Whale). The most complex and diverse (9 seabird species attracted) MSFA formed over a defecating adult male Sperm Whale *Physeter macrocephalus* (MSFA#323).

Table 5.5 Wilson's Storm-petrels associated with cetaceans in multi-species foraging frenzies (MSFAs). Shown are the flock number (MSFA, database reference#), the depth zone and actual water depth (m), the geographical position (decimal degrees), and the sea surface temperature (SST, °C).

MSFA	**116**	**118**	**134**	**152**	**153**	**323**
Depth zone	Shelf-break	Oceanic	Oceanic	Shelf-break	Shelf-break	Oceanic
Latitude (°N)	18.12	18.12	16.87	17.12	17.12	20.14
Longitude (°W)	-16.66	-16.67	-16.84	-16.79	-16.85	-17.71
SST (°C)	29.9	30.0	29.3	29.2	29.2	25.9
Depth (m)	770	813	859	367	627	942
Cape Verde Shearwater						1
Sooty Shearwater						4
Wilson's Storm-petrel	2	2	4	79	1	3
Leach's Storm Petrel				2		2
Long-tailed Jaeger						9
Parasitic Jaeger						2
Pomarine Skua						36
Black Tern					1	22
Common Tern					1	2
Sperm Whale (*defecating*)						1
Short-finned Pilot Whale	28	30	50			
Bottlenose Dolphin			15			
unidentified dolphin				250		
Common Dolphin				220	54	
Atlantic Spotted Dolphin				360		

From our strip-transect surveys, an estimate of total numbers in 81 studied 10’x10’ rectangles arrived at 28,500 individuals (1.03 ± 2.35, max 11.2 km^{-2}; **Fig. 5.8**). For the entire Mauritanian slope area, 120 rectangles, an estimate of *c.* 42,300 individuals seems appropriate.

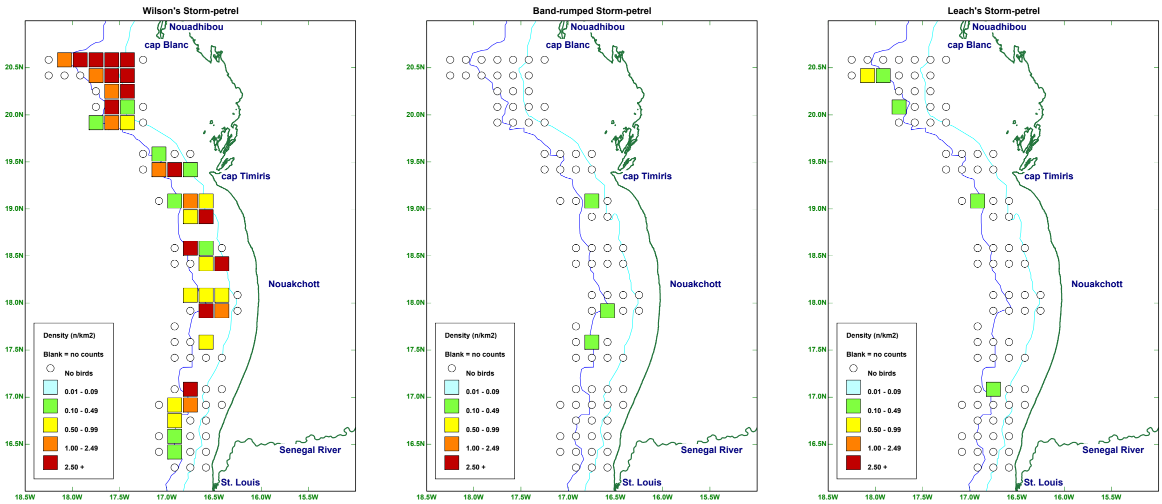


Fig. 5.8 Densities (n km^{-2}) of commoner storm-petrels off the Mauritanian coast, 4-14 Sep 2015.

European Storm-petrel Océanite tempete *Hydrobates pelagicus* (3)

A common breeding species in the temperate northeast Atlantic, in the Mediterranean and on the Canary Islands. European Storm-petrels are abundant winter visitors off the Mauritanian coast (Camphuysen & Van der Meer 2005, Camphuysen *et al.* 2013). Only three sightings during the present survey of solitary individuals, two on 5 Sep 2015 (19.12ºN, 16.54ºW, 43m deep water (Neritic), SST 26.9°C, poskey 180003015, and 19.12ºN, 16.79ºW, 662m deep (Shelf-break), 27.5°C, poskey 180003035), one 7 Sep 2015 (16.87ºN, 16.76ºW, poskey 180003326, 100m deep, SST 29.2°C (Neritic), **Fig. 5.6**).

Band-rumped Storm-petrel Océanite de Castro *Oceanodroma castro* (7)

Leach's Storm-petrel Océanite culblanc *Oceanodroma leucorhoa* (29)

Band-rumped Storm-petrels (formerly known as Madeiran Storm-petrel) are in fact a species complex breeding in the Pacific and Atlantic tropical and subtropical zones (Flood & Fisher 2011). Since confident identification of the various Atlantic taxa (such as Monteiro's Storm Petrel *Oceanodroma monteiroi* and Cape Verde Storm Petrel *Oceanodroma jabejabe*) at sea is generally impossible, all sightings are listed under “Band-rumped Storm-petrel *Oceanodroma castro*”. Leach's and Band-rumped species are not particularly closely related, but seemingly overlap in habitat requirements off the Mauritanian coast (Camphuysen & Van der Meer 2005, Camphuysen et al. 2013). Leach’s Storm-petrels breed in the northern Pacific and Atlantic Oceans and spend the non-breeding season in the tropical and South Atlantic Ocean (Camphuysen 2007a) and in the tropical Pacific Hemisphere (Onley & Scofield 2007). Both species are highly pelagic, but were relatively scarce during this September survey. Sightings of the two species combined were significantly more frequent within the Oceanic zone (67%, n= 36; G_{adj}= 12.0, df=2, P< 0.01). Only three individuals were seen within the shallow Neritic zone, including 2 Leach's Storm-petrels (7 Sep 2015) and a single Band-rumped Storm-petrel (5 Sep 2015; **Fig. 5.6**). Densities were too low and the distribution patterns were too fragmented for a meaningful estimate of total numbers (**Fig. 5.8**).

Swinhoe's Storm-petrel Océanite de swinhoe *Oceanodroma monorhis* (1 record)

Swinhoe's Storm-petrel is only known to breed on islands of Japan, Korea and Russian islands in the Sea of Japan (Onley & Scofield 2007) Since 1983 there have been records from the North Atlantic, including Norway, Britain, France, Spain, Italy and Macaronesia (Selvagens Isl.). The Swinhoe's Storm-petrel represents a new species of seabird for Mauritanian waters (Isenmann *et al.* 2010). A single individual was seen near a Wilson's Storm-petrel on 6 Sep 2015 (17.87ºN, 16.67ºW, 555m deep water (Shelf-break), SST 28.9°C, poskey 180003187; **Fig. 5.6**). Diagnostic features were the size, completely dark brown rump, forked tail that was usually held closed, and the clear white bases to the primary shafts. The pale crescent on the upperwing was actually quite distinct, but the overall impression was darker than an ordinary Leach’s Storm-petrel. The bird was actively moulting (P1 missing; **Fig. 5.9**).

Fig. 5.9 Snapshots of Swinhoe’s Storm-petrel off the Mauritanian coast, 6 Sep 2015 (HV).

A total of **8 species of shearwaters** have been recorded in the September 2015 surveys, including three taxa of the *Calonectris* complex, two passage migrants breeding on the southern hemisphere (*Puffinus griseus* and *gravis*), two migrants from the northern hemisphere (*P. puffinus and mauretanicus*) and a small ‘regional’ species breeding in Macaronesia (*P. baroli*). An interesting overall pattern was the higher diversity of species along the northernmost legs (20°N), notably in Oceanic waters (SST 24-27°C). Only Cape Verde Shearwaters *Calonectris edwardsii* occurred widespread in Mauritanian waters in September 2015 (**Fig. 5.9**), and the results suggest that most migratory shearwaters may have travelled even further offshore than our surveys ranged into the open ocean. The highest natural densities (away from vessels) occurred at the distinctly cooler waters over the Shelf-break (SST 22-24°C; **Table 5.6**).

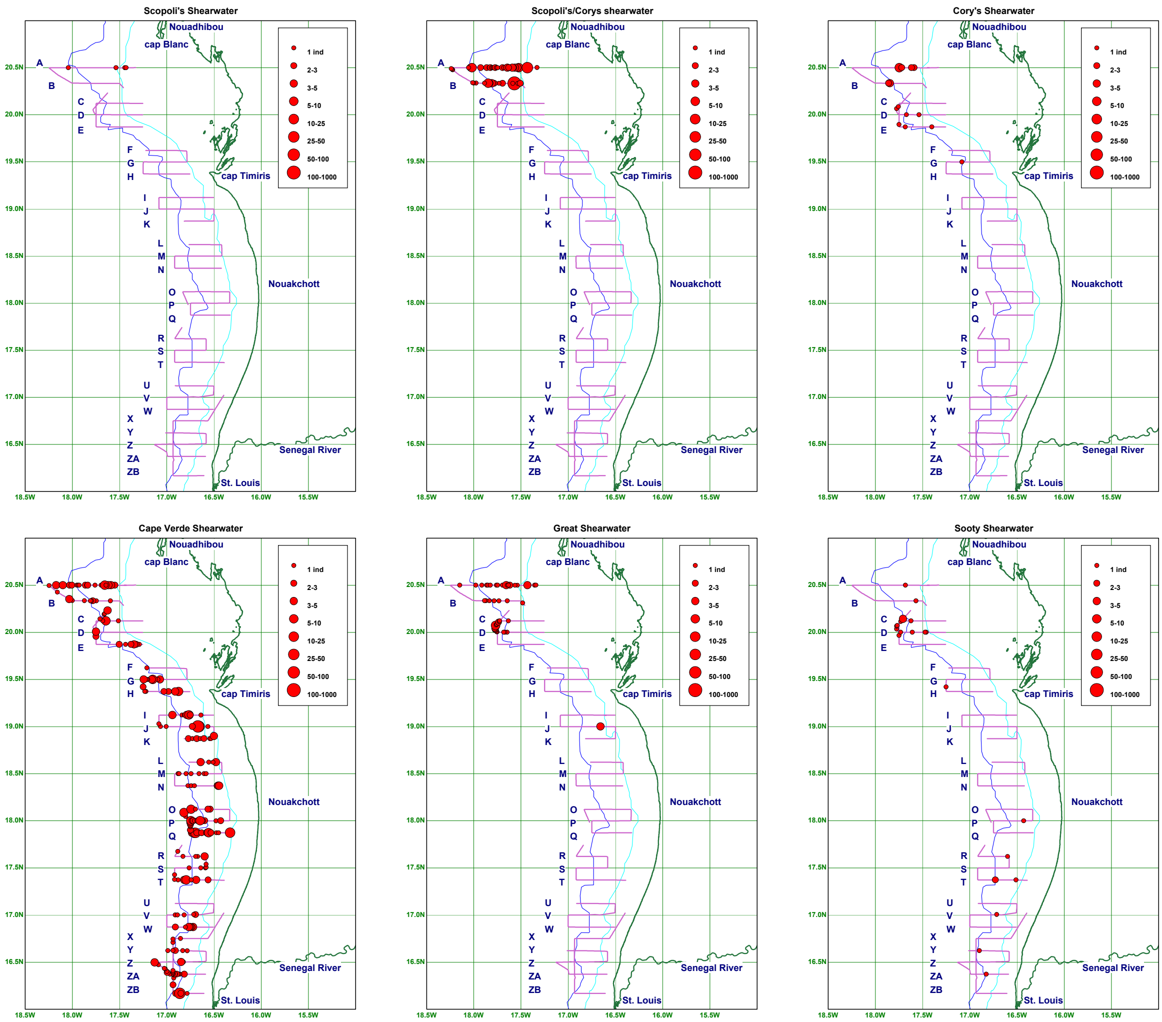


Fig. 5.10 Sightings of larger shearwaters off the Mauritanian coast, 4-14 Sep 2015.

Table 5.6 Number of species of shearwaters Puffinus and *Calonectris* spp. and overall densities (*n* km^{-2}) per latitudinal degree and sea surface temperature, 4-14 September 2014. Highest values in red.

Shearwater species diversity (*n*)

°N Latitude	<22°C	22-23°C	23-24°C	24-25°C	25-26°C	26-27°C	27-28°C	28-29°C	29-30°C
20	4	4	4	6	6	7	2		
19					2	2	6	2	
18						1	1	1	1
17								2	2
16								1	3

Shearwater relative abundance (*n* km^{-2})

°N Latitude	<22°C	22-23°C	23-24°C	24-25°C	25-26°C	26-27°C	27-28°C	28-29°C	29-30°C
20	1.7	0.4	1.6	0.8	0.1	0.5	0		
19					0	0.0	0.1	0.2	
18						0.2	0.1	0.1	0.2
17								0.1	0
16								0.3	0.0

Scopoli's Shearwater Puffin cendré (Mediterannée) *Calonectris diomedea*
Cory's Shearwater Puffin cendré (Atlantique) *Calonectris borealis*
Cape Verde Shearwater Puffin du Cap-Vert *Calonectris edwardsii*

What was formerly known as 'Cory's Shearwater *Calonectris diomedea*' is now a complex of three closely related taxa, one mostly confined to the Mediterranean (Scopoli's Shearwater *C. diomedea*), one to Macaronesian and Portuguese Atlantic waters (Cory's Shearwater *C. borealis*) and one endemic to the Cape Verde Islands (Cape Verde Shearwater *C. edwardsii*). Only Cape Verde Shearwaters were common and widespread during the September surveys, whereas the sightings of the larger species (nominate *diomedea* and the Atlantic race *borealis*) were restricted to the northernmost transects sailed in relatively cold surface waters (**Fig. 5.10-11**).

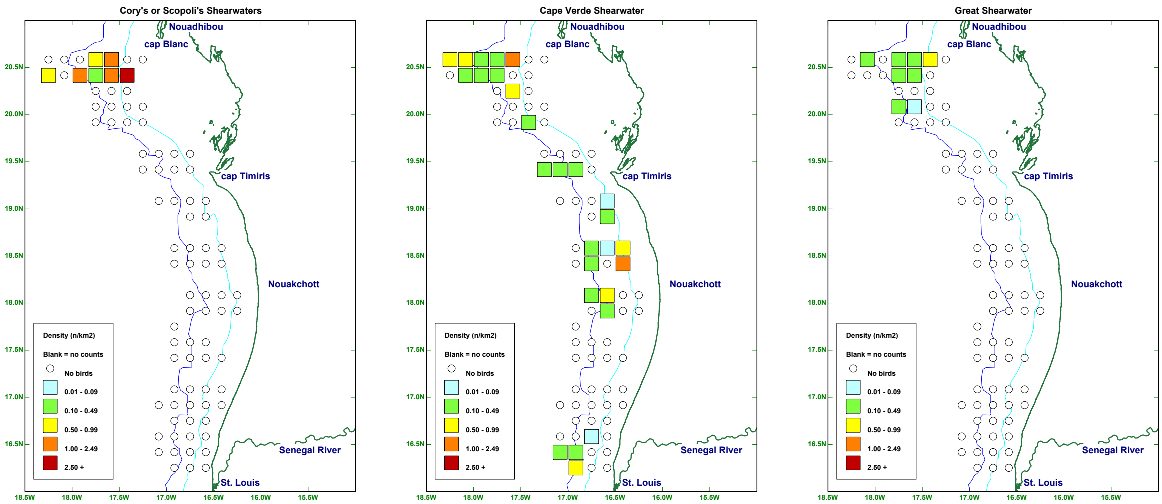


Fig. 5.11 Densities (n km^{-2}) of larger shearwaters off the Mauritanian coast, 4-14 Sep 2015.

Based on the observed densities (**Fig. 5.11**), for all "Cory's Shearwaters" combined, a crude estimate of total numbers present within 81 studied 10'x10' rectangles arrived at 7600 individuals (0.27 ± 0.73, max 4.9 km^{-2}). Ship-following was much less of an issue than in winter surveys of this region (Burton & Camphuysen 2003, Camphuysen & Van der Meer 2005, Camphuysen *et al.* 2013). For the entire Mauritanian slope area (*i.e.* 120 rectangles), an estimate of *c.* 11,000 individuals seems appropriate. With regard to confirmed Cape Verde Shearwaters, however, our strip-transect surveys arrived at 3600 individuals (0.13 ± 0.28, max 1.4 km^{-2}), or *c.* 5400 individuals for the entire Mauritanian slope area, which would equal about half of all shearwaters in the *Calonectris* complex present in these waters. Note that all genuine Cory's and Scopoli's Shearwaters, together with a fair number of unidentified individuals, were exclusively observed in the northernmost 13 rectangles (near Cap Blanc). Further to the south, only Cape Verde Shearwaters were seen.

The more widespread Cape Verde Shearwaters were usually seen while simply in flight (54%, n= 579 birds with annotations). Of these, putting aside 41 individuals in which a flying direction was not clear (potentially searching for prey!), 61% were seen heading in a W, NW, or N direction (n= 279 birds in flight with flight direction). Sightings were significantly more numerous in shallower waters, with 22% Oceanic, 33% over the Shelf-break and 45% within the Neritic zone (*n*= 585; G_{adj}= 18.9, df=2, *P*< 0.01). A fair number of birds was ship-associated (20% associated with the Al Awam, the observation platform, another 20% associated with fishing vessels, *n*= 579), pointing at the significance of fisheries for this species. Only two shearwaters were seen in association with large marine animals (0.3%, *n*= 579), one with an unidentified turtle, one in a large feeding frenzy developing near a defecating Sperm Whale *Physeter macrocephalus* (14 Sep 2015). Two individuals were loosely associated with a frontline (searching behaviour, 0.3%, *n*= 579), and some 6% (*n*= 579) participated in MSFAs (natural feeding frenzies, a total of six flocks with Cape Verde Shearwaters). Probably all feeding frenzies were triggered by the subsurface activities of bonitos, but the most northerly one (birdflock 314, **Table 5.7**) in relatively cool and shallower waters was a frenzy involving slightly larger reddish forage fish that did no attract Black Terns (**Table 5.7**), but numerous skuas that were seen to violently attack the shearwaters present (**Fig. 5.12**).

Table 5.7 Multi-species feeding associations (**MSFAs**) with **Cape Verde Shearwaters** involved. Shown are the flock number (database reference), the depth zone and actual water depth (m), the geographical position (decimal degrees), and the sea surface temperature (SST, °C). *Reddish forage fish.

Birdflock#	**80**	**101**	**120**	**196**	**242**	**314**
Depth zone	Oceanic	Shelf-break	Shelf-break	Oceanic	Oceanic	Shelf-break
Latitude (°N)	19.03	17.87	18.12	16.26	18.37	20.12
Longitude (°W)	17.08	16.71	16.74	16.93	16.77	17.63
SST (°C)	28.0	28.9	30.1	29.2	28.9	26.0
Depth (m)	1449	669	720	863	904	209
Cape Verde Shearwater	1	16	6	2	1	8
Great Shearwater						1
Wilson's Storm-petrel		3				
Parasitic Jaeger	1					1
Pomarine Skua						44
Black Tern	26	45	185	5	52	
Common Tern	24	41	16	14	19	22
forage fish ball at surface	1	1	1	1	1	1*
Skipjack Tuna (Bonito)	10	not seen	5	10	5	15

Fig. 5.12 Reddish forage fish, and Cape Verde Shearwater under attack of two Pomarine Skuas (detail of MSFA #314 in the disintegration phase, 13 Sep 2015, see **Table 5.6** for further details; CJC).

Great Shearwater Puffin majeur *Ardenna gravis* (68 records)

Sooty Shearwater Puffin fuligineux *Ardenna grisea* (25 records)

Passage migrants from the southern hemisphere, with breeding colonies on Tristan da Cunha and some other small islands in the South Atlantic (Great), on the Falkland islands, in Tierra del Fuego and in the South Pacific (Sooty; Cramp & Simmons (1977). With a breeding season commencing around October, the birds seen in Mauritanian waters in September must either be rushing 'home', or are mostly (immature?) non-breeding birds. Most birds were seen in the northerly part of the study area (**Fig. 5.10**). Sightings in all depth zones according to expectation, with 50% Oceanic, 19% over the Shelf-break, and 31% within the Neritic zone in Great Shearwaters (*n*= 68; G_{adj}= 3.8, df= 2, n.s.), and 44% Oceanic, 24% Shelf-break and 32% Neritic in Sooty Shearwaters (*n*= 25; G_{adj}= 0.6, df= 2, n.s.). Both Great and Sooty Shearwaters were typically seen in flight, with 71% (Great, *n*= 58) or even 100% (Sooty, *n*= 19) travelling in a southerly direction. A total of 7 Great Shearwaters (10%, *n*= 67) and a single Sooty (4%*, n*= 25) were seen in association with fishing vessels, one Great Shearwater was seen in a natural MSFA (**Table 5.6**). Four Sooty Shearwaters (16%) were recorded in a large feeding frenzy developing near a defecating Sperm Whale (14 Sep 2015).

Little [Barolo] Shearwater Puffin de Macaronésie *Puffinus baroli* (3 records)

Small round-winged, short-tailed, white-faced shearwaters, formerly regarded as one of the Little Shearwater (*P. assimilis*)-group (Austin *et al.* 2004, Onley & Scofield 2007), breeding in the Azores and on the Canaries. Three sightings, solitary individuals, all 4 Sep 2015 (20.34ºN, 17.91ºW, poskey 180002972, 20.38ºN, 18.08ºW, poskey 180002958, and 20.50ºN, 17.85ºW, poskey 180002906; 2x Oceanic, 1x Shelf-break; **Fig. 5.13**).

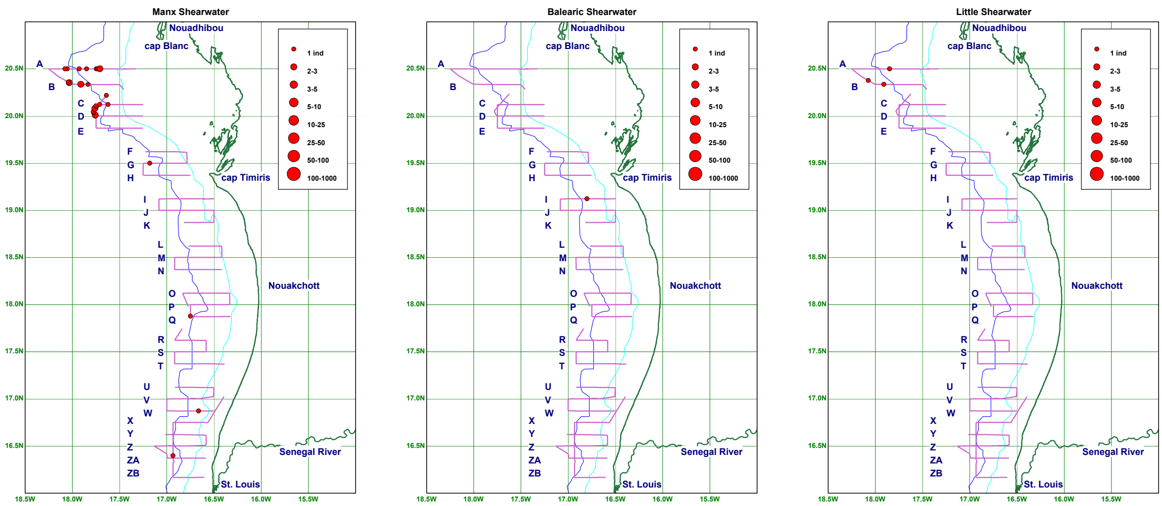


Fig. 5.13 Sightings of smaller shearwaters off the Mauritanian coast, 4-14 Sep 2015.

Manx Shearwater Puffin des Anglais *Puffinus puffinus* (31 records)

A boreal to subtropical species, with very large nesting colonies in the North Atlantic (United Kingdom, Ireland, Iceland, Faeroe islands, France, the Channel islands; with a total of more than 300,000 pairs on islands off Wales, Scotland and Ireland), smaller colonies in Macaronesia (Azores, Canary Islands and Madeira). The north east of North America has recently been colonised. Sightings were typically far offshore, with 71% Oceanic, 23% over the Shelf-break and only 6% within the Neritic zone (n= 31; G_{adj}= 12.4, df=2, P< 0.01). Frequent sightings were exclusively within the northern part of the study area (**Figs 5.13-14**).

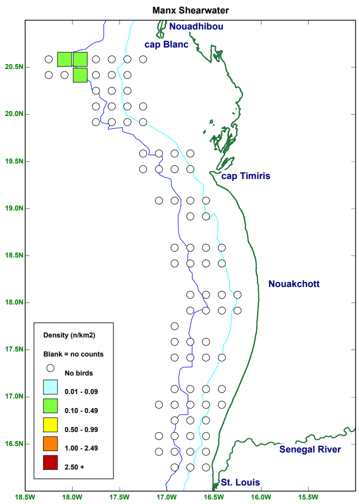


Fig. 5.14 Densities (n km^{-2}) of Manx Shearwaters off the Mauritanian coast, 4-14 Sep 2015.

Balearic Shearwater Puffin des Baléares *Puffinus mauretanicus* (1 record)

A red-listed species breeding on the Balearic Islands in the western Mediterranean. Numerous Balearic shearwaters enter the Atlantic in late summer. Rare, a single individual in flight, 5 Sep 2015 (Shelf-break; 19.13ºN, 16.80ºW, poskey 180003036; **Fig. 5.13**)

Bulwer's Petrel Pétrel de Bulwer *Bulweria bulwerii* (1)

Bulwer’s Petrel is a tropical species, breeding on islands in the eastern Atlantic (Macaronesia), Indian and Pacific Ocean between 10° and 40°N latitude (Onley & Scofield 2007). Isenmann *et al.* 2010 report occurrence in Mauritanian waters as ‘likely’ during the breeding season (Feb-Sep), with offshore records in May published in 1962. A single individual was encountered, 5 Sep 2015 (19.05ºN, 17.08ºW, 1463m deep (Oceanic), SST 28.1°C, poskey 180003065; **Figs. 5.15**).

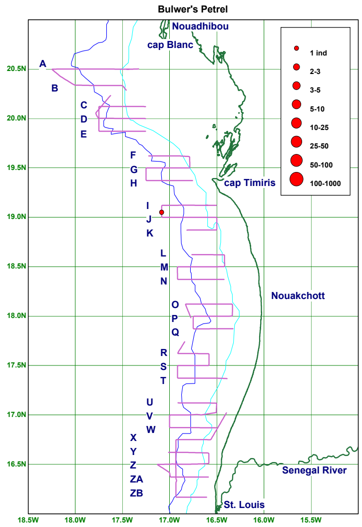


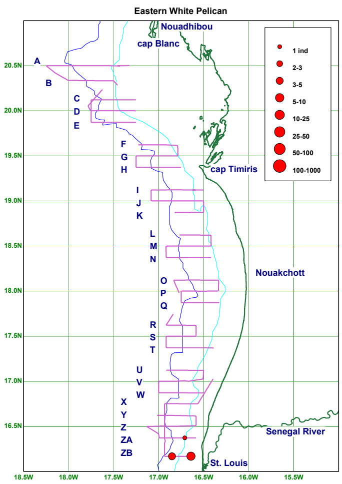
Fig. 5.15 Sightings of Bulwer's Petrel off the Mauritanian coast, 4-14 Sep 2015

Foto's Bulwer's Petrel, 5 Sep 2015 (HV)

5.3.2 Pelicans and gannets Pelicaniformes

Great White Pelican Pélican blanc *Pelecanus onocrotalus* (11)

Great White Pelicans at sea, 36km from the coast, water depth 152m, 9 Sep 2015 (CJC)



Great White Pelican, 22km from the coast, water depth 70m, 8 Sep 2015 (CJC)

Fig. 5.16 Sightings of pelicans off the Mauritanian coast, 4-14 Sep 2015.

Great White Pelicans are resident in many African countries on large alkaline or freshwater lakes, but they are sometimes marine, such as in Mauritania and South Africa (Brown *et al.* 1982). The offshore records at considerable distances from the nearest land, such as during these surveys (3 records, 11 animals in total) still came as a slight surprise (**Fig. 5.16**). One solitary Great White Pelican flew past in an easterly direction towards land at 22 km from the shoreline (70m depth, 8 Sep 2015). Six preening individuals were seen at 14 km from the coast (42m depth, 9 Sep 2015), and another four individuals were seen at 36km from the shore (152m depth, 9 Sep 2015).

Northern Gannet Fou de Bassan *Morus bassanus* (no records)

In a cruise report documenting observed species during a survey, one particular species is noteworthy given a complete absence: the Northern Gannet. In a similar survey conducted in the exact same area in November 2012, not only were gannets the most numerous seabirds encountered (an estimated 325,000 individuals based on an average density of 11.8 individuals km^{-2}), but gannets comprised 86% of the avian biomass at the time recorded over the Mauritanian outer shelf and shelf break zone (Camphuysen *et al.* 2013). In the present survey, 4-14 September 2015, not a single Northern Gannet was observed, not even the odd summering immature individual. The complete absence and the striking contrast with its omnipresence in November (and later in winter Burton & Camphuysen 2003, Camphuysen 2003, Camphuysen & Van der Meer 2005) raises questions about the month October, when the area must suddenly be invaded by migratory Northern Gannets from the north.

5.3.3 **Waders** Charadriiformes

Red [Grey] **Phalarope** Phalarope à bec large *Phalaropus fulicaria* (372)

Red Phalaropes are 'marine waders' breeding in the high arctic and wintering in high numbers off the NW African coast. Phalaropes were widespread, but occurred generally in low densities, with a clear concentration of birds in the cooler sea surface waters just to the southwest of Cap Blanc (**Fig. 5.17**). Sightings were typically over the Shelf-break and outer Neritic zone, with 4% of all records within the Oceanic zone, 49% over the Shelf-break and 47% within the Neritic zone (n= 372; G_{adj}= 130.5, df=2, P< 0.01). Numbers encountered over the Shelf-break were at least two times higher than expected from differences in observer effort. From our strip-transect surveys, an estimate of total numbers in 81 studied 10'x10' rectangles arrived at 11,200 individuals (0.40 ± 1.86, max 14.5 km^{-2}; **Fig. 5.17**). For the entire Mauritanian slope area, 120 rectangles, an estimate of *c.* 16,600 individuals seems appropriate. Virtually all birds were in winter plumage, only some faint orange traces of the original summer plumage could be seen in some birds. The presence of a high arctic breeding species in NW Africa in early September could be seen as 'early', or at least timely, and the presence of non-breeders (sub-adults?) or failed breeders should not be excluded. Of 195 observed phalaropes with annotations, 34.9% were in flight (of which 60% southward), and 63.6% were associated with foamy frontlines or concentrations of floating litter and seaweeds.

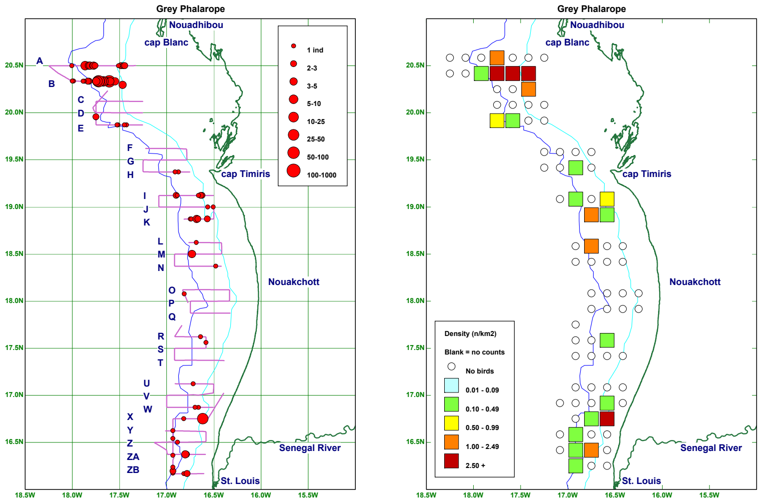


Fig. 5.17 Sightings (left) and densities (n km^{-2}, right) of Red Phalaropes, off the Mauritanian coast, 4-14 Sep 2015.

Of interest for phalaropes, as for planktivorous storm-petrels Hydrobatidae, are convergent processes at the upwelling front that may concentrate zooplankton and small prey fish (Wynn & Krastel 2012). In September 2015, the strongest SST gradients were found around 20°20'-20°30'N latitude (Transects A-B, **Fig. 4.5-6**). Prominent concentrations of Red Phalaropes occurred in areas where the sea surface temperature was lowest (21-22°C, **Fig. 5.18**). Observed numbers were highly variable within this area. The high arctic Red Phalaropes were probably only just arriving in the Mauritanian and overall numbers were still modest. The larger flocks were all seen in areas with water temperatures below 22°C (85 at 21.3°C (Shelf-break); 61 at 21.8°C, (Neritic), 20 at 21.5°C (Neritic), 18 at 21.3°C (Shelf-break), and 14 at 21.4°C (Shelf-break). These observations provide further evidence of the importance of a narrow mixing zone at the continental shelf edge to phalaropes (*cf.* Brown 1979, Briggs *et al.* 1984, Wynn & Knefelkamp 2004, Camphuysen et al. 2013).

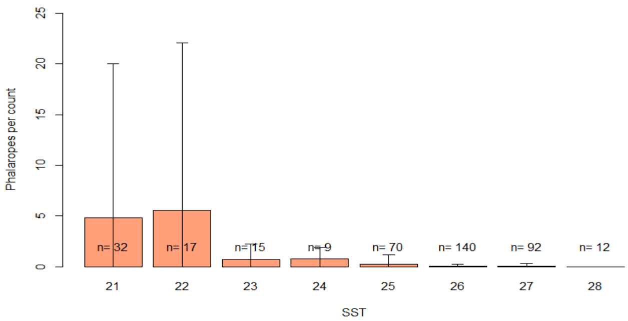


Fig. 5.18 Concentrations (n 5-min count^{-1}) of Red Phalaropes relative to the sea surface temperature (SST, 21-27°C) to the north of 19°30'N Latitude (see als **Fig. 5.7**). The sample size (number of counts) is given within the graph.

5.3.4 Gulls Laridae

Only three species of gulls were encountered during the September 2015 offshore surveys and inspections of coastal roosts revealed that none of the common wintering species had arrived "at strength" in Mauritania.

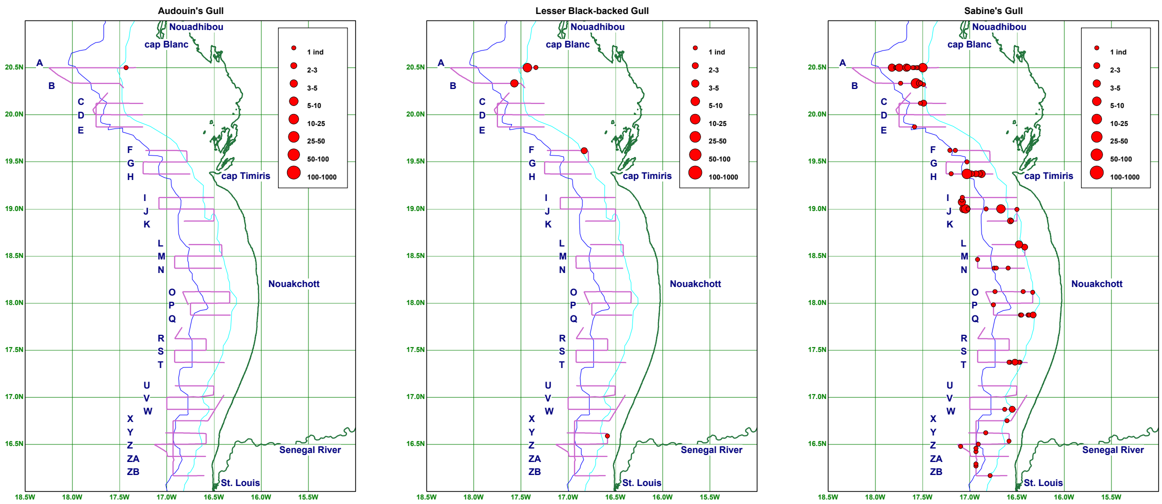
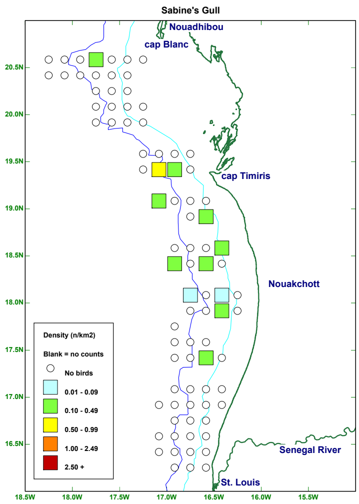


Fig. 5.17 Sightings of gulls off the Mauritanian coast, 4-14 Sep 2015.



Sabine's Gulls (HV)

Fig. 5.18 Densities (n km^{-2}) of Sabine's Gulls off the Mauritanian coast, 4-14 Sep 2015.

Sabine's Gull Mouette de Sabine *Xema sabini* (146)

Sabine's Gulls in the Atlantic are Holarctic migrants breeding in the high Arctic (Greenland, Canada, Svalbard, Russia) that spend their non-breeding season mostly off South Africa (Cramp & Simmons 1977, del Hoyo *et al.* 1996). Post-nuptial migration off the Mauritanian coast takes place from mid-August to November (Isenmann *et al.* 2010).

Sightings of Sabine's Gulls were fairly common in all depth zones, but with a slight inshore (Neritic) bias. In all, 18% of all records were within the Oceanic zone, 29% over the Shelf-break and 53% within the Neritic zone (n= 146; G_{adj}= 9.5, df=2, P< 0.05). Sightings were slightly more frequent to the southwest of Cap Blanc, in an area with relatively cool surface waters, and to the west of Cap Timiris (**Fig. 5.17**). Of 131 Sabine's Gulls with annotations, 57.3% were seen in flight, 10.7% were associated with the observation base, and 29.8% were associated with fishing vessels. Despite their migratory status (Isenmann *et al.* 2010), there was no clear flight direction prevailing and most birds seemingly utilised the Mauritanian shelf as a stop-over. Immatures or juveniles were not seen (12 individuals were not aged), and 56% of the nearby adults (*n*= 89) were still in full summer plumage.

From our strip-transect surveys, an estimate of total numbers in 81 studied 10’x10’ rectangles arrived at 900 individuals (0.03 ± 0.10, max 0.8 km^{-2}). For the entire Mauritanian slope area, 120 rectangles, an estimate of *c.* 1300 individuals seems appropriate (**Fig. 5.18**).

Audouin's Gull Goéland d'Audouin *Ichthyaetus audouinii* (1)

This Palearctic migrant, breeding in the Mediterranean is a common winter visitor and passage migrant in Mauritanian waters. The Audouin's gull is considered a rather specialised nocturnal forager on shoaling clupeids (Gonzalez-Solis *et al.* 1997), but little is known of their foraging activities in West Africa. Between 100 and 200 individuals were seen at roosts near Nouadhibou on 4 Sep 2015. During the September surveys, only a single individual was observed at sea, an adult bird attending trawler on 4 Sep 2015 (20.50ºN, 17.43ºW, 53m depth (Neritic), 20.6°C, poskey 180002874; **Fig. 5.17**)

Lesser Black-backed Gull Goéland brun *Larus fuscus* (17)

A Palearctic migrant, breeding in west Europe and an abundant winter visitor in Mauritania. Relatively small numbers (hundreds to low thousands) were found at the traditional roosts in Nouadhibou and Nouakchott prior to and immediately following our surveys (tens of thousands of roosting birds are seen in winter in these areas).

Only 17 individuals (including at least 4 adults and 1 2cy individual) were seen during the transect counts conducted between Cap Blanc and the Senegal river delta, 4-14 Sep 2015, all within the Neritic zone (9-68m water depth (**Fig. 17**). Of these birds, 13 individuals were seen attending fishing vessels, and 2 were associated with the observation platform.

5.3.5 Terns Sternidae

Arguably the best represented taxonomic group of seabirds in terms of overall numbers were terns (7 species, nearly 10,000 individuals recorded). Common Terns *Sterna hirundo* and Black Terns *Chlidonis niger*, two Palearctic migrants, were by far the most numerous species, followed at distance by the regional Royal Tern *Thalasseus maximus* and another Palearctic migrant, the Sandwich Tern *Thalasseus sandvicensis*. Terns were prominent around fishing vessels with up to

430 individuals per encounter and a maximum of 4 different species per boat. All fishing vessel-associated terns were seen within the Neritic zone (60.1 ± 23.7m water depth, range 9-108m), except two flocks over the Shelf-break (533-568m depth). Royal, Sandwich and Common Terns had a great tendency to alight on the vessels themselves, to roost and preen on the superstructures. Black Terns, however, one of the most numerous terns during these surveys, were rarely seen near fishing vessels (4x, 2-6 individuals per encounter, 3x Neritic zone, 1x Shelf-break), and rarely alighted onboard these vessels.

Caspian Tern Sterne caspienne *Hydroprogne caspia* (2)

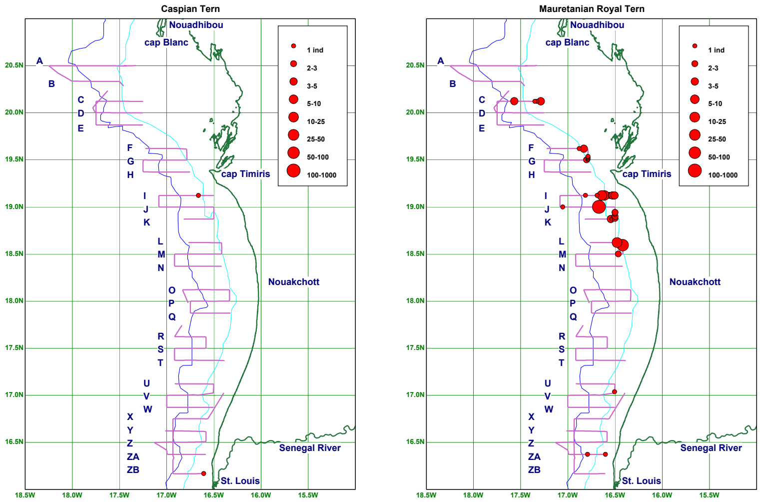
The Caspian Tern is a cosmopolitan species with a scattered distribution. Caspian Terns breed near large lakes and along ocean coasts (del Hoyo *et al.* 1996). Caspian terns are a resident species and year-round breeders in Mauritania and Senegal (with at least between 5,000-10,000 pairs in the Banc d'Arguin (Isenmann *et al.* 2010).

Caspian Terns were abundant at beach roosts near Nouadhibou on 4 and 15 September 2015, but were rare at sea during the September censuses suggesting strictly nearshore foraging activities. Only two sightings: one 5 Sep 2015 (19.12ºN, 16.63ºW, 104m depth (Neritic), SST 26.5°C, poskey 180003025), another 9 Sep 2015 (16.17ºN, 16.61ºW, 38m depth (Neritic), SST 28.6°C, poskey 180003570; **Fig. 5.19**).

Mauretanian Royal Tern Sterne royale *Thalasseus maximus albidorsalis* (355)

Royal Terns of the subspecies *albidorsalis* breed along the northwest coast of Africa and that includes the coast of Mauritania, where it is confined almost exclusively to the Banc d'Arguin, Senegal, and Gambia (Isenmann *et al.* 2010). Breeding numbers are seemingly variable, but 15,000-17,000 pairs were listed for 1998 and 2004, and exchanges are expected to occur with the 23,000-43,000 pairs breeding in Senegal and 15,000 pairs in Gambia (Isenmann *et al.* 2010). Mauritanian breeders disperse in the non-breeding season and winter mainly from Morocco to Ivory Coast and Ghana (del Hoyo *et al.* 1996, Isenmann *et al.* 2010).

Offshore sightings were not uncommon during the September 2015 surveys (**Fig. 5.19**), but nearly all sightings were within the Neritic zone (<1% of all records Oceanic, <1% Shelf-break and 99% Neritic zone; n= 355; G_{adj}= 358.4, df=2, P< 0.01). From our strip-transect surveys, an estimate of total numbers in 81 studied 10’x10’ rectangles arrived at 400 individuals (0.01 ± 0.10, max 0.8 km^{-2}; **Fig. 5.20**). For the entire Mauritanian slope area, 120 rectangles, an estimate of perhaps only *c.* 600 individuals seems more appropriate. It should be noted, however, that the ship-following tendencies of this species are such that population estimates based on strip-transect counts should be treated with caution. Royal Terns were commonly roosting onboard fishing vessels (75.6%) or the observation platform itself (17.3%, n= 353), sometimes targeting arising foraging opportunities when these came within visible range from these roosting platforms.



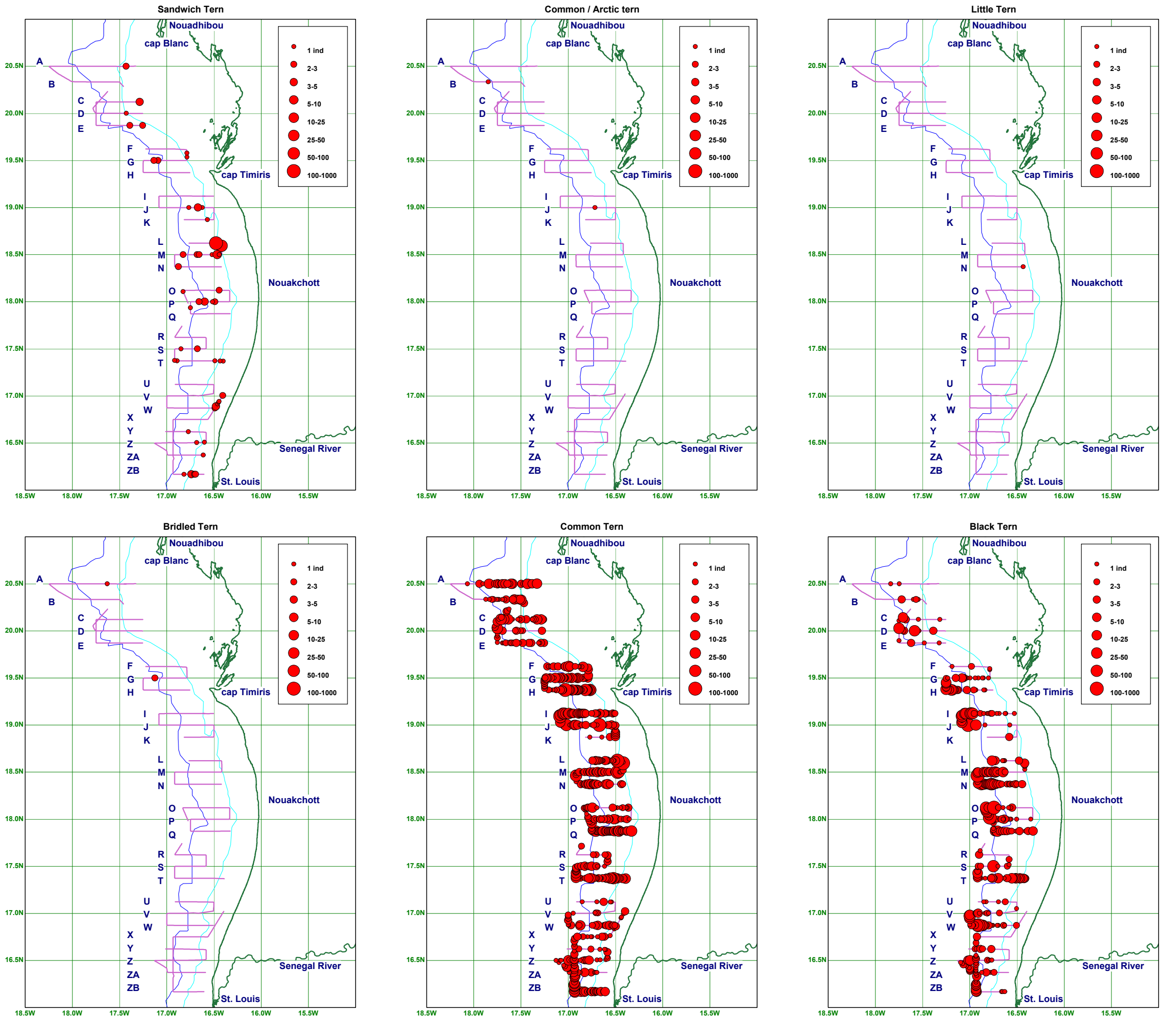


Fig. 5.19. Sightings of terns off the Mauritanian coast, 4-14 Sep 2015.

Sandwich Tern Sterne caugek *Thalasseus sandvicensis* (281)

Sandwich Tern can be found in coastal colonies in Europe, Africa, Asia, Southern America. It is a highly migratory species, undergoing post-breeding dispersive movements north and south to favoured feeding grounds before migrating southward (del Hoyo *et al.* 1996).

Sightings were common within the Neritic zone, but less frequent at greater distances from the coast (**Fig. 5.19**). In all, only 3% of all records were within the Oceanic zone, 6% over the Shelf-break and 91% within the Neritic zone (n= 281; G_{adj}= 174.3, df= 2, P< 0.01). Of all Sandwich Terns observed, 75.4% were associated with fishing vessels, and another 6% were seen roosting on board the observation platform. Only a single bird was seen to participate into a natural MSFA (0.4%).

From our strip-transect surveys, an estimate of total numbers in 81 studied 10'x10' rectangles arrived at 1400 individuals (0.05 ± 0.34, max 2.9 km^{-2}; **Fig. 5.20**). For the entire Mauritanian slope area, 120 rectangles, an estimate of *c.* 2100 individuals seems appropriate.

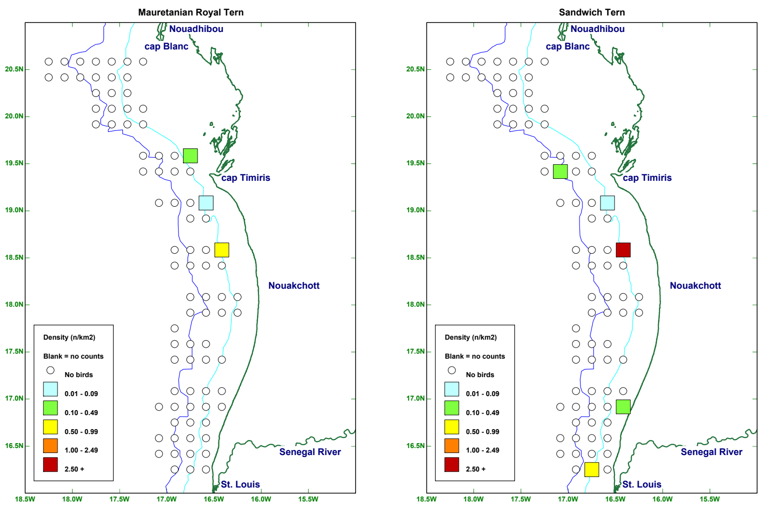


Fig. 5.20 Densities (n km^{-2}) of Royal Terns and Sandwich Terns off the Mauritanian coast, 4-14 Sep 2015.

Little Tern Sterne naine *Sternula albifrons* (1)

Little Terns breed on the coasts and inland waterways of temperate and tropical Europe and Asia (Cramp & Simmons 1983). The Afrotropical subspecies *Sternula albifrons guineae* are resident breeders in Mauritania (restricted to the Banc d'Arguin) and Senegal, but numbers are very small and the birds reach the northern edge of their breeding range in Mauritania (Isenmann *et al.* 2010). The nominate is a strongly migratory species, wintering as far south as in South Africa and Australia (Olsen & Larsson 1995, del Hoyo *et al.* 1996). A single individual was observed nearby our own ship, 11 Sep 2015 (18.37ºN, 16.43ºW, 78m depth (Neritic), SST 29.1°C, poskey 180003861; **Fig. 5.19**). It is unclear if this was a local bird (*S.a. guieae*) or an early Palearctic migrant (*S.a. albifrons*).

Bridled Tern Sterne bridée *Onochoprion anaethetus* (3)

The Bridled Tern is migratory and dispersive, wintering widely through tropical oceans. It has markedly marine habits compared to most terns (del Hoyo *et al.* 1996). The Atlantic subspecies *melanopterus* breeds in Mexico, the Caribbean and in west Africa (Cramp & Simmons 1983, Olsen & Larsson 1995). Rare, two sightings during the September surveys in highly contrasting habitats (**Fig. 5.19**): one individual on 4 Sep 2015 (20.50ºN, 17.63ºW, 94m depth (Neritic), SST 21.8°C, poskey 180002889), and two individuals 12 Sep 2015 (19.50ºN, 17.13ºW, 725m depth (Shelf-break), SST 27.5°C, poskey 180004071).

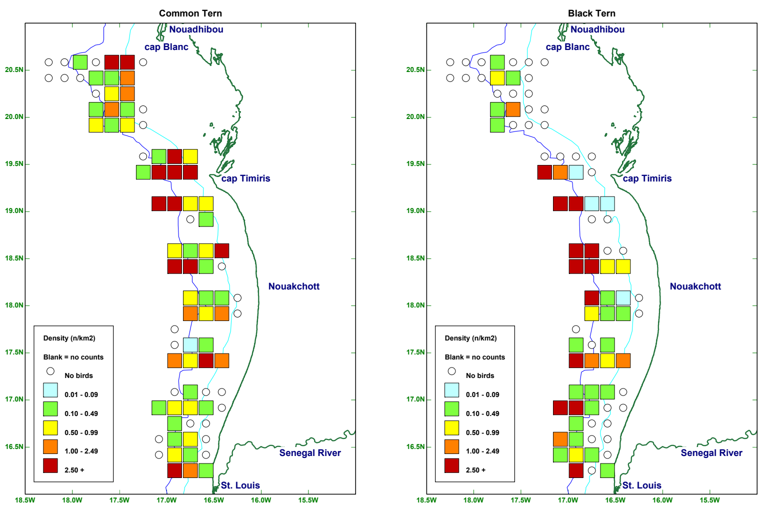


Fig. 5.21 Densities (n km^{-2}) of Black Terns and Common Terns off the Mauritanian coast, 4-14 Sep 2015.

Common Tern Sterne pierregarin *Sterna hirundo* (5442)

Common Terns have a circumpolar distribution and breed in temperate and subarctic regions of Europe, Asia and North America (Cramp & Simmons 1983, del Hoyo *et al.* 1996). Most populations of the Common Tern are strongly migratory. In Mauritania, Common Terns are abundant winter visitors (Isenmann *et al.* 2010). Only a few hundreds of pairs breed in NW Africa (Mauritania-Guinea Bissau).

Common Terns were widespread throughout the study area in September 2015 (**Fig. 5.19**). Sightings were common in all depth zones, but with a slight bias towards the Neritic zone. In all, 23% of all records were within the Oceanic zone, against 24% over the Shelf-break and 53% within the Neritic zone (n= 5442; G_{adj}= 180.9, df= 2, P< 0.001). This pattern changed when only actively foraging Common Terns were selected, because now 38% occurred within the Oceanic zone, 21% over the Shelf-break and 41% within the Neritic zone (n= 2328). Numbers of foraging Common Terns were slightly lower (Shelf-break) or identical (Neritic zone) to an expectation based on observer effort, but slightly higher within the Oceanic zone (G_{adj}= 20.6, df= 2, P< 0.01).

Of 5059 Common Terns in which notes of directions of flight or any associations were made, 43.4% were recorded as 'in flight', 9.4% were associated with the observation base, and 27.8% were associated with fishing vessels. A total of 857 terns were participating into MSFAs (41 flocks in total), and details of the flocks with the highest numbers of Common terns are listed in **Table 5.8**. All these MSFAs were in deeper waters and they were probably all driven by tuna activities (Skipjack Tuna *Katsuwonus pelamis* driving post-larval pelagic forage fish towards the surface). Further details are provided under Black Tern *Chlidonias niger*. A total of 42 Common terns (0.8%) were seen in associated with cetaceans, typically with oceanic dolphins, but once with an adult male Sperm Whale (**Table 5.9**).

From our strip-transect surveys, an estimate of total numbers in 81 studied 10'x10' rectangles arrived at 57,000 individuals (2.07 ± 4.94, max 33.4 km^{-2}; **Fig. 5.21**). For the entire Mauritanian slope area, 120 rectangles, an estimate of *c.* 85,000 individuals seems appropriate.

Table 5.8 Multi-species feeding associations (**MSFAs**) with >40 **Common Terns** involved. Shown are the flock number (database reference), the depth zone and actual water depth (m), the geographical position (decimal degrees), and the sea surface temperature (SST, °C).

Birdflock#	**70**	**73**	**74**	**77**	**101**	**184**
Depth zone	Oceanic	Oceanic	Oceanic	Oceanic	Shelf-break	Shelf-break
Latitude (°N)	19.12	19.12	19.12	19.09	17.87	16.17
Longitude (°W)	-16.99	-17.04	-17.05	-17.08	-16.71	-16.93
SST (°C)	27.7	27.9	28.0	28.2	28.9	29.0
Depth (m)	1074	1299	1359	1468	669	409
Cape Verde Shearwater					16	
Wilson's Storm-petrel					3	
Black Tern	70	35	30	64	45	10
Common Tern	42	70	50	118	41	58
forage fish ball	1	1	1	1	1	1
Skipjack Tuna (Bonito)	25	20	20	30	not seen	10

Table 5.9 Common Terns in association with cetaceans. Conventions as in **Table 5.8**

Birdflock#	**162**	**163**	**186**	**199**	**232**	**323**
Depth zone	Oceanic	Oceanic	Shelf-break	Oceanic	Oceanic	Oceanic
Latitude (°N)	16.50	16.50	16.17	16.32	17.50	20.14
Longitude (°W)	-17.00	-16.98	-16.93	-16.93	-16.86	-17.71
SST (°C)	29.2	29.2	29.0	29.2	29.5	25.9
Depth (m)	1102	1067	455	894	1158	942
Cape Verde Shearwater						1
Sooty Shearwater						4
Wilson's Storm-petrel						3
Leach's Storm Petrel						2
Long-tailed Jaeger						9
Parasitic Jaeger						2
Pomarine Skua						36
Black Tern	20			1		22
Common Tern	22	2	6	8	2	2
Sperm Whale						1
Common Dolphin			350	750		
Clymene Dolphin	560					
unidentified dolphin					1	

Black Tern Guifette noire *Chlidonias niger* (3714)

The Black Tern is a boreal species that breeds in freshwater marshes across most of Canada, the northern United States and much of Europe and western Asia (Cramp & Simmons 1983, Olsen & Larsson 1995, del Hoyo *et al.* 1996). In the African wintering areas Black Terns are truely marine birds that do not just feed in coastal waters, but also far offshore (Glutz von Blotzheim & Bauer 1982). According to these authors, lagoons and salt pans are used primarily as overnight roosts. Off the north coast of the Guinea Gulf, large mixed tern flocks, dominated by Black Terns, feed in August-October when a seasonal shift of the upwelling system reaches coastal waters with migratory surface shoaling sardines (*Sardinella aurita*). In winter and spring, this upwelling and the convergence runs 600 km away from the coast and the terns are by day well beyond the radar limits (>22 km offshore) of a previous study (Grimes 1977). What prey the Black Terns would be feeding on is unclear.

One of the key aspects of the early autumn surveys off the Mauritanian coast was to find out if the major onshore roosts of Black Terns, for example those near Nouadhibou (40-50,000 individuals roosting in September 2014; *personal observations*; **Fig. 5.22**) would communicate with any offshore foraging locations, and if so, what the attraction would be to forage so far from land and in an oceanic environment. Upon arrival in Nouadhibou, 3 Sep 2015, the known roosts south of the airport were checked and vast numbers of Black Terns were found to congregate at nightfall (at least tens of thousands of terns, probably again around 40,000 at least, *personal observations*). These flocks, or at least similar numbers were still present when the surveys were completed, on 15 Sep 2015. At nightfall, a continuous stream of terns was seen to arrive from the west (from the ocean) in flocks of 20-200 individuals at the time. With our surveys we hoped to pinpoint their daytime foraging destinations and feeding activities.

Fig. 5.22 Mass flights of restless Black Terns over the Nouadhibou airport roosts at dusk, 15 Sep 2015. Lesser Black-backed Gulls on the foreground (CJC).

Fig. 5.22a Roosting Black Terns at the Nouadhibou roosts, 27 Sep 2014, a small fragment of a very large concentration of birds (CJC).

Fig. 5.22b Roosting Black Terns with Caspian, Sandwich and Common Terns at Cap Blanc, 15 Sep 2015 (CJC).

With Common Terns, Black Terns were the commonest seabirds encountered during the 2015 cruises criss-crossing the Mauritanian shelf break. Sightings were common in all depth zones, but particularly at greater distances from the coast in deeper Oceanic waters. In all, 76% of all records were within the Oceanic zone, against only 19% over the Shelf-break and 5% within the Neritic zone (*n*= 3714; G_{adj}= 1815.6, df= 2, *P*< 0.0001). This preference for Oceanic conditions was even more obvious when only actively foraging terns were selected: 85% within the Oceanic zone, 14% over the Shelf-break and only 1% within the Neritic zone (*n*= 2974). From our strip-transect surveys, an estimate of total numbers in 81 studied 10'x10' rectangles arrived at 56,000 individuals (2.01 ± 5.23, max 25.9 km^{-2}). For the entire Mauritanian slope area, 120 rectangles, an estimate of *c.* 83,000 individuals seems appropriate.

Fig. 5.23 Part of an offshore feeding frenzy with mostly Black Terns and some Common Terns targeting forage fish driven towards the surface by Skipjack Tuna, 5 Sep 2015. Water depth 1047m (CJC)

Black Terns were primarily foraging in close association with hunting bonitos (mostly Skipjack Tuna *Katsuwonus pelamis*), especially in warm Oceanic waters to the south of 20°N. Smaller numbers were seen foraging over the shelf break, usually without evidence for hunting tuna, and foraging was rare within the Neritic zone (**Table 5.10**). Oceanic areas with warm surface waters (29°-30°C) were preferred over the cooler waters further to the north (cf. **Figs. 4.6, 5.19, 5.21**). The oceanic feeding frenzies were typically short-lived and terns would respond immediately when forage fish would hit the surface waters as a result of the attacks by bonitos (**Fig. 5.23** and **5.27-29**). Common Terns and Black Terns were often feeding together within these feeding frenzies, but relatively few other seabirds were seen to participate. Black Terns were recorded to participate in 59 MSFAs, of which 19 (32%) were just Black Terns and Skipjack Tuna together. Common Terns were observed in 68% of the flocks, Cape Verde Shearwaters (8%), Wilson's Storm-petrels (2%), Long-tailed Jaegers (2%), Parasitic Jaegers (8%), Sabine's Gulls (3%), and Sandwich Terns (2%) only occasionally. The flock size of Black Terns ranged from 1-225 individuals (37.0 ± 44.6), that of Common Terns in these mixed flocks with Black Terns ranged from 1-118 individuals (15.7 ± 21.6). Bonitos were involved (as drivers) in at least 97% of 59 the MSFAs with Black Terns involved. The mean water depth was 1113.8 ± 301.9m (range 409-1574m; 10x Shelf-break, 49x Oceanic), SST averaged 29.1 ± 0.8°C (range 26.8-30.2°C).

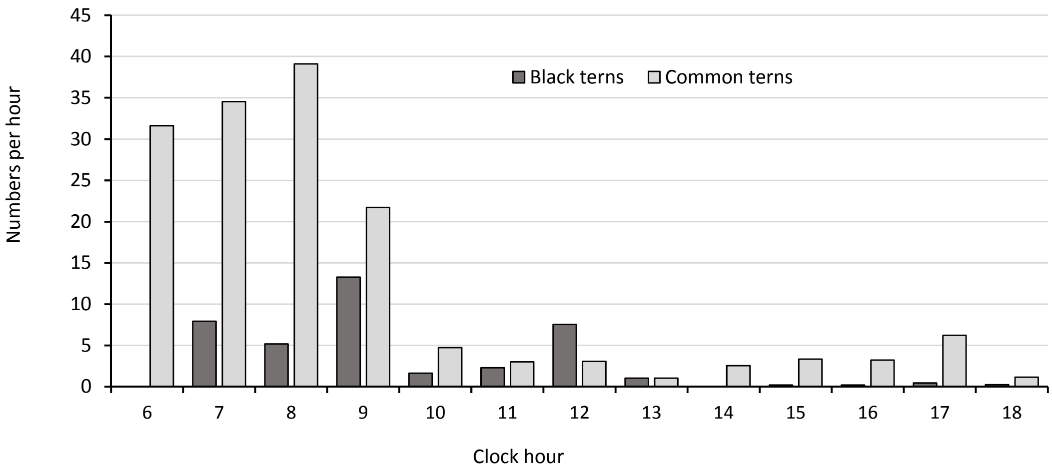


Fig. 5.24 Seaward flights of Black Terns and Common Terns (n h^{-1} to the SW, W and NW in flight) relative to the time of the day, 4-14 Sep 2015.

Fig. 5.25 Travelling mixed flock of Black Terns and Common Terns, Sep 2015 (HV)

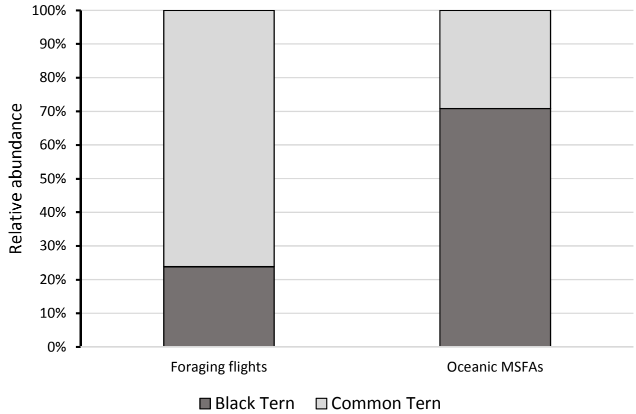


Fig. 5.26 Relative abundance of Black Terns and Common Terns engaged in seaward foraging flights (*as in* **Fig. 5.23)** and in the resulting tuna-driven MSFAs in Oceanic and Shel-break waters, 4-14 Sep 2015.

Seaward movements were recorded primarily in the morning (07:00-12:00, **Fig. 5.24-25**), whereas movements towards land (onshore roosts) were possibly at greater height, or were otherwise largely overlooked. There is a remarkable discrepancy between the relative abundance of Black Terns and Common Terns engaged in foraging flights towards Oceanic waters and the relative abundance of the two species within the MSFAs targeting tuna-driven forage fish (**Fig. 5.26**). Considering all data, only 24% of the terns engaged in westward movements were Black Terns (n = 1820), whereas 70% of the terns in offshore feeding frenzies targeting tuna were Black terns (n= 2789. Even when the data are restricted to latitudinal degrees (<19.25°N) in which tuna driven feeding frenzies that attracted almost exclusively terns occurred, Common Terns numerically predominated in the foraging flights (66.5%, n= 1219), and 71% of the terns in MSFAs were Black terns (n= 2704). There is a number of explanations for this discrepancy, which will be addressed in the **Discussion** of this report.

Table 5.10 Densities (n km^{-2}) of Black Terns and Common Terns per latitudinal degree in each of the three depth zones, densities of foraging terns without tuna detections and with tuna and the proportion (%) of all foraging terns with tuna.

		All terns observed		Foraging, no tuna		Terns targeting tuna			
°N	Depth	Black T	Common T	Black T	Common T	Black T	% tuna	Common T	% tuna
20	Neritic	0.0	1.2	0.0	0.1		0		0
	Shelf-break	1.3	1.2	1.1	0.1		0	0.6	87
	Oceanic	0	0.1	0	0		n.d.		n.d.
19	Neritic	0	2.9	0	0.2		n.d.		0
	Shelf-break	0.3	7.6	0.0	4.8		0		0
	Oceanic	10.1	5.5	2.0	0.8	7.7	79	4.0	84
18	Neritic	0.2	7.2	0.1	5.8		0		0
	Shelf-break	1.9	0.6	1.3	0.1		0		0
	Oceanic	24.8	3.0	3.8	1.7	20.3	84	1.0	36
17	Neritic	0.4	1.3	0.1	0.2		0		0
	Shelf-break	0.4	0.5	0.1	0.1		0		0
	Oceanic	1.0	0.7	0.2	0.1	0.7	81	0.4	76
16	Neritic	0.0	0.4	0.0	0.2		0		0
	Shelf-break	1.2	2.6	0.1	0.5	0.9	93	2.0	81
	Oceanic	2.6	1.0	0.3	0.4	2.1	86	0.5	57

Fig. 5.27 Part of an offshore feeding frenzy with mostly Black Terns and some Common Terns targeting forage fish driven towards the surface by Skipjack Tuna, 5 Sep 2015. Water depth 1468m (CJC)

Fig. 5.28 Part of an offshore feeding frenzy with mostly Black Terns and some Common Terns targeting forage fish driven towards the surface by Skipjack Tuna, 5 Sep 2015. Water depth 1047m (CJC)

Fig. 5.29 Black Tern with small fish from forage fish driven towards the surface by Skipjack Tuna, 5 Sep 2015. Water depth 1047m (HV)

Foraging Black Terns were typically dipping and it proved to be notoriously difficult to spot the prey they picked up during the fieldwork itself. After consulting numerous photos taken during these encounters, small fish were detected that were approximately one beak length of the terns in size (**Fig. 5.29**). Black-Terns were exclusively seen foraging on forage fish that produced a silvery rather than a reddish ‘boiling water’ when under attack by bonitos (see under **Forage fish balls** in this report).

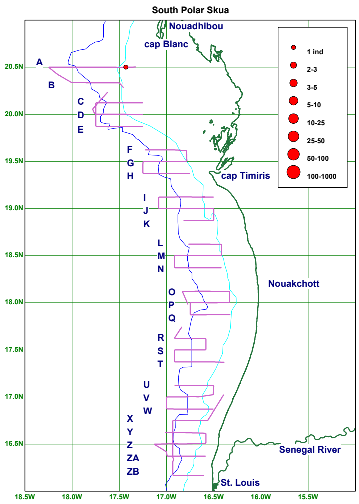
Not all foraging activities of Black Terns are in the deeper waters Mauritania. Nearshore feeding was commonly observed and feeding flocks were often extremely large. During fieldwork between 22 and 29 Sep 2014 (when a scheduled offshore campaign could not take place) and in early Sep 2015, visits were paid to beaches just to the southeast of Nouadhibou airport and at Cap Blanc where gulls and terns were known to roost in often impressive numbers (**Fig. 5.22-22a**). Dozens of nearshore foraging Black Terns were observed at tidal fronts around Cap Blanc on 15 Sep 2015 and roosting numbers were modest (an estimated 2500-4000 individuals; **Fig. 5.22b**). At beaches near Nouadhibou airport, tens of thousands of Black Terns were roosting and feeding frenzies near anchored vessels were often equally massive (**Fig. 5.30-31**). Apart from these mass feeding frenzies, small parties of terns were seen to forage along the coast (dipping). We have no material showing what prey items these terns have been feeding on and further campaigns to sample faeces from roosts could provide some answers on these questions.

Fig. 5.30 Black Terns approaching Nouadhibou roosts, 27 Sep 2014, commuting between the onshore roost and the nearshore foraging opportunities shown above (CJC).

Fig. 5.31 Mass feeding frenzy of Black Terns just near the Nouadhibou roosts, 28 Sep 2014, showing that considerable feeding activities occur also within the Neritic zone. 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 (CJC).

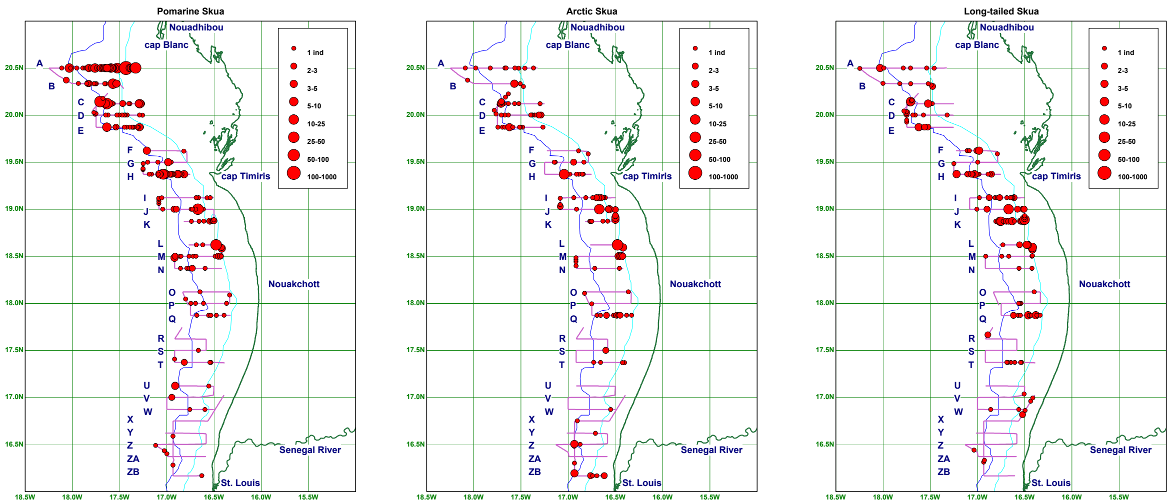
5.3.6 Skuas Stercorariidae

With four species, the third most diverse group of seabirds encountered. The Boreal Great Skua *Stercorarius skua*, a common wintering species in these waters, was not observed in September 2015.



Pomarine Skua (HV)

Fig. 5.32 Sightings of South Polar Skua (top left) and of the arctic and boreal smaller skuas and jaegers (below) off the Mauritanian coast, 4-14 Sep 2015.



South Polar Skua Labbe Antarctique *Stercorarius maccormicki* (1)

The South Polar Skua breeds in Antarctica north to the South Shetlands islands and ranges in Mar-Oct at sea to Alaska, Greenland, NW Africa, and into the Indian Ocean (Shirihai 2002). A single dark morph individual was seen attending a commercial trawler, 4 Sep 2015 (20.50ºN, 17.43ºW, poskey 180002874; **Fig. 5.32**). The blackish underwing coverts and 'cold', evenly sooty blackish-brown colour and relatively slender bill were considered diagnostic. The sighting could be confirmed by three observers, all of which with considerable field experience with this species.

Pomarine Skua Labbe pomarin *Stercorarius pomarinus* (821)

The Pomarine Skua breeds on tundras of northern Russia, Canada and Alaska but is a marine species outside the breeding season (del Hoyo *et al.* 1996). High numbers winter in upwelling regions of the tropics and subtropics, and that includes Mauritanian waters (Furness 1987, Camphuysen & Van der Meer 2005, Isenmann *et al.* 2010).

Pomarine Skuas were the most numerous skua encountered in September 2015, but numbers were concentrated in the northern part of the study area (**Fig. 5.32**), and often near fishing fleets. The observation platform itself was less an attraction to Pomarine Skuas in Sep 2015 (only 9.1%*, n*= 761) than in Nov-Dec 2012 (20%, *n*= 2134), but fisheries formed a major attraction. In total 46.6% of all Pomarine Skuas seen in September 2015 were seen in direct association of a fishing vessel. The association or the effect on relative abundance of Pomarine Skuas was even more obvious if the mere presence or absence of industrial fishing vessels within visible range [of the observers team] was considered. Pomarine Skuas per km steamed were 6.2x more numerous (1.07 versus 0.17 km^{-1}) within the Oceanic zone, 9.0x more numerous over the Shelf-break (2.20 versus 0.24 km^{-1}) and even 21.6x more numerous within the Neritic zone (2.93 versus 0.14 km^{-1}) when industrial trawlers were at least visible somewhere. Of the industrial fleets observed, numerous (Chinese) vessels were inactive at daytime, and the skuas were perhaps just hanging around awaiting nocturnal foraging opportunities.

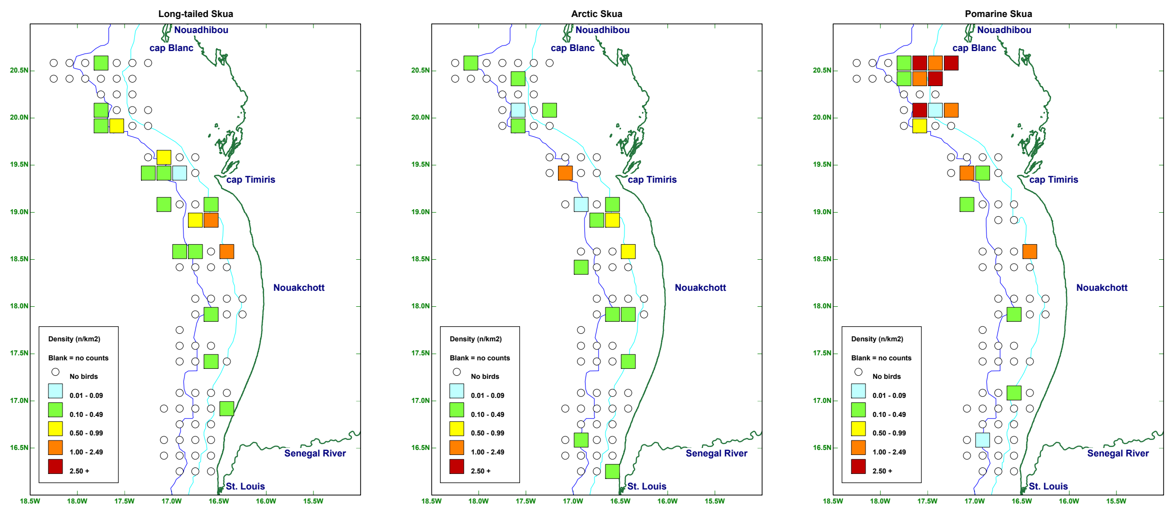


Fig. 5.33 Densities (n km^{-2}) of skuas off the Mauritanian coast, 4-14 Sep 2015.

Sightings were common in all depth zones, but with an inshore (Neritic) bias (even stronger than in Parasitic Jaegers, see below). In all, 13% of all records were within the Oceanic zone, 18% over the Shelf-break and 69% within the Neritic zone (*n*= 808; G_{adj}= 146.1, df=2, *P*< 0.001). From our strip-transect surveys, an estimate of total numbers in 81 studied 10'x10' rectangles arrived at 7000 individuals (0.25 ± 0.79, max 4.4 km^{-2}; **Fig. 5.33**). For the entire Mauritanian slope area, 120 rectangles, an estimate of *c.* 10,400 individuals seems appropriate for the moment. Juveniles were rare in the Pomarine Skua (1% in 240 aged individual birds, if these two individuals were not in fact 2nd calendar year skuas), that were mostly immatures (28%) or adults (71%) often in summer plumage. Of immatures, adults or unaged birds, 12% were dark phase birds, 88% were light phase individuals (n= 219). Pomarine Skuas not only readily attacked most species of shearwaters (**Table 5.11**), but their attacks on shearwaters were particularly violent. Some terns were attacked and a single aerial pursuit was aimed a flying fish.

Parasitic Jaeger/Arctic Skua Labbe parasite *Stercorarius parasiticus* (265)

The Parasitic Jaeger breeds circumpolar in coastal tundras, mainly within 57-80°N Latitude and it is a marine species outside the breeding season (del Hoyo *et al.* 1996). Parasitic Jaegers winter primarily ion coastal areas of the Southern Hemisphere (Furness 1987, del Hoyo *et al.* 1996). In Mauritania it is seen as an Holarctic migrant with a greater affinity for coastal waters than the three other smaller skuas/jaegers (Isenmann *et al.* 2010).

The distribution pattern of sightings of Parasitic Jaegers was remarkably similar as the pattern in sightings of Long-tailed Jaegers (**Figs. 5.32-33**). Identification problems were minor, because the majority of the birds were adults and in summer plumage. As in Pomarine Skuas, nearly half of all Parasitic Jaegers (40.9%, *n*= 237) were seen in direct association with fishing vessels, where they mostly kleptoparasitised smaller terns. Further associations included cetaceans (0.8%), foraging bird flocks (MSFAs; 2.1%), a hydrographic front (0.4%), and the observation platform itself (4.2%). Sightings of Parasitic Jaegers were common in all depth zones, but with a clear inshore (Neritic) bias, which is in accordance with the suggestions by Isenmann *et al.* (2010). In all, 13% of all records were within the Oceanic zone, 22% over the Shelf-break and 65% within the Neritic zone (*n*= 265; G_{adj}= 39.8, df=2, *P*< 0.001), but which was similar as that found in the Pomarine Skua (G_{adj}= 2.09, df= 2, n.s.). From our strip-transect surveys, an estimate of total numbers in 81 studied 10’x10’ rectangles arrived at 2400 individuals (0.08 ± 0.26, max 1.8 km^{-2}; **Fig. 5.33**). For the entire Mauritanian slope area, 120 rectangles, an estimate of *c.* 3500 individuals seems appropriate. Juveniles were rare in the Parasitic Jaeger (6% in 133 aged individual birds), that were mostly immatures (22%) or adults (72%) in full summer plumage, and the latter were always in the possession of the two longer central tail feathers. Of immatures, adults or unaged birds, 39% were dark phase birds, 61% were light phase individuals (n= 141), suggesting a boreal rather than a high artic breeding origin (Southern 1943, Furness 1987). Most aerial pursuits were aimed at terns (**Table 5.11**), three on shearwaters, and an attack aimed at a Wilson’s Storm-petrel was apparently an attempted kill.

Long-tailed Jaeger/Long-tailed Skua Labbe à longue queue *Stercorarius longicaudus* (248)

The Long-tailed Jaeger breeds circumpolar in coastal tundras mainly within 57-80°N. It is a marine species outside the breeding season (del Hoyo *et al.* 1996) wintering mainly in the Southern Oceans (Furness 1987, del Hoyo *et al.* 1996). In Mauritania it is seen as an Holarctic migrant wintering in small numbers with peak occurrences during passage (Sep-Nov and Feb-May; Isenmann *et al.* 2010). Long-tailed Skuas are rarely seen in coastal waters (Isenmann *et al.* 2010), suggesting a more pelagic life-style than the other smaller skuas off NW Africa.

In September 2015, Long-tailed Jaegers were common and widespread with a total of 248 positively identified individuals (**Fig. 5.32**). Sightings were common in all depth zones, but slightly lower than expected within the Oceanic zone. In all, 21% of all records were within the Oceanic zone, 23% over the Shelf-break and 56% within the Neritic zone (*n*= 248; G_{adj}= 13.8, df=2, *P*< 0.01). The slightly stronger presence within the Oceanic zone made the distribution differ from Parasitic Jaegers (G_{adj}= 6.61, df=2, *P*< 0.05). Fresh juveniles were seen (41 individuals, 19% of 213 well aged birds), as well as apparent second calendar year birds that had retained a near-juvenile plumage, but that were in active wing moult (3 birds, 1%). Of the remaining 169 mostly adult (91%), some subadult (9%) birds, 168 individuals were light phase, mostly of the Scandinavian (dark-bellied and -breasted) type, one adult bird could only be described as dark phase. Most mature jaegers were in summer plumage, with few if any winter plumage feathers, but most had lost the long central tail feathers. None of these looked distinctly fork-tailed, suggesting that the feathers were broken rather than shed. From our strip-transect surveys, an estimate of total numbers in 81 studied 10'x10' rectangles arrived at 2600 individuals (0.09 ± 0.25, max 1.5 km^{-2}; **Fig. 5.33**). For the entire Mauritanian slope area, 120 rectangles, an estimate of *c.* 3800 individuals seems appropriate. Aerial pursuits were uncommon and mostly aimed at Common or Black Terns (**Table 5.11**). One Long-tailed Skua did an attempt to rob a Cape Verde Shearwater with no success.

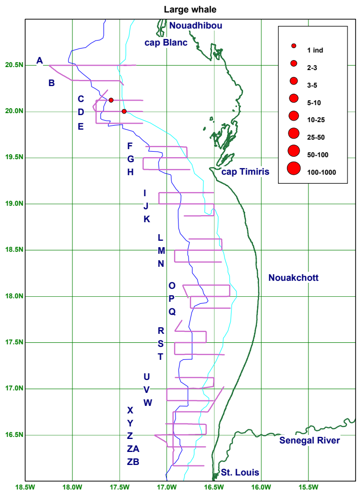
Adult summer plumage Long-tailed Jaegers, Scandinavian type, in these cases still with the long central tail feathers in place, 5 Sep 2015 (HV).

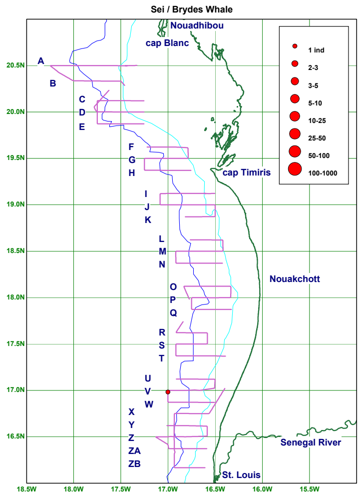
Table 5.11 Species under attack during aerial pursuits of Long-tailed and Parasitic Jagers and Pomarine Skuas, Mauritanian shelf, 4-14 Sep 2015

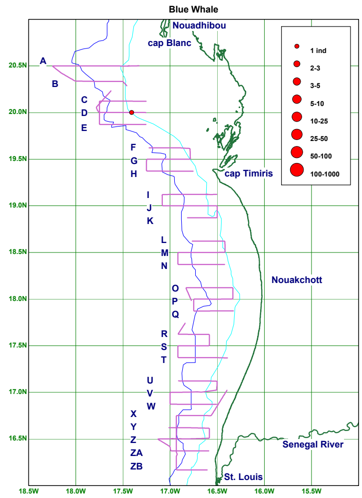
Target species in aerial pursuit	Long-tailed Jaeger	Parasitic Jaeger	Pomarine Skua
Scopoli's/Corys shearwater			2
Cape Verde Shearwater	1	2	3
Great Shearwater			2
Sooty Shearwater		1	2
Manx Shearwater			1
Wilson's Storm-petrel		1	
Long-tailed Jaeger			1
Parasitic Jaeger		3	
Pomarine Skua			1
Black Tern	1	2	
Common Tern	2	12	4
Royal Tern		1	1
unidentified flying fish, dark wings			1

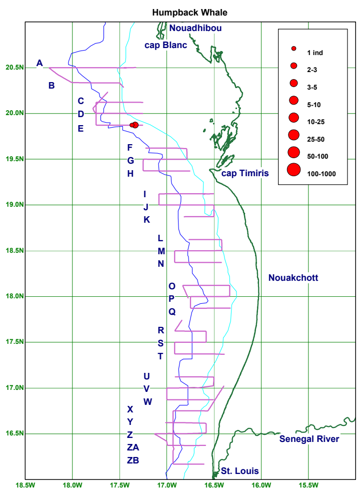
5.3.7 Marine mammals Cetacea

Toothed whales (Odontoceti) were by far the most numerous cetaceans encountered and 11 species were positively identified in September 2015. By contrast, only seven baleen whales (Mysticeti) were encountered, but this included the rare Blue Whale *Balaenoptera musculus* that was recently (re-)discovered as a wintering species in Mauritanian waters (Woodside 2003, Camphuysen et al. 2013, Baines & Reichelt 2014).









Blue Whale *Balaenoptera* musculus, 14 Sep 2015 (HV)

→

Fig. 5.34 Sightings of large baleen whales (Mysticeti), 4-14 Sep 2015.

Large unidentied baleen whale baleine *large whale* (2)

Large, but unidentified *Balaenoptera*-whales were seen twice, both within the Neritic zone, 13 Sep 2015 (1 individual 20°07'N, 17°35.3'W, 101m deep, SST 26.2°C, poskey 180004234), and 14 Sep 2015 (1 individual, 20°00'N, 17°27.0'W, 56m deep, SST 25.0°C, poskey 180004284 (1). Vertical tall blows characteristic for Fin or Blue Whales was all that could be seen in the distance.

Blue Whale Baleine Bleue *Balaenoptera musculus* (1)

Blue Whales, of the *Balaenoptera* genus, are the largest animals that have ever existed. One Blue Whale was observed at very short range on 14 Sep 2015 in fairly shallow waters (20°00’N, 17°24.4’W, 45m deep, SST 25.4°C, poskey 180004280) The two unidentified baleen whales and the Blue whale were seen just to the northeast of the Timiris Canyon system over the Arguin mud wedge (**Fig. 5.35**). Some photos of the dorsal fin are available, but the angle was difficult and tracing this individual in a Blue Whale catalogue is probably impossible (*cf.* Sears *et al.* 2005).

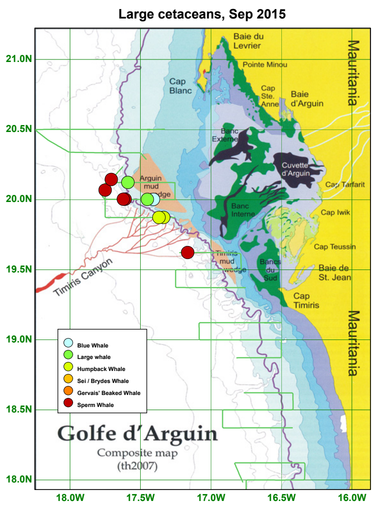


Fig. 5.35 Sightings of large cetaceans superimposed over a chart with detailed bathymetry and bottom features, 18-21°N, 4-14 Sep 2015.

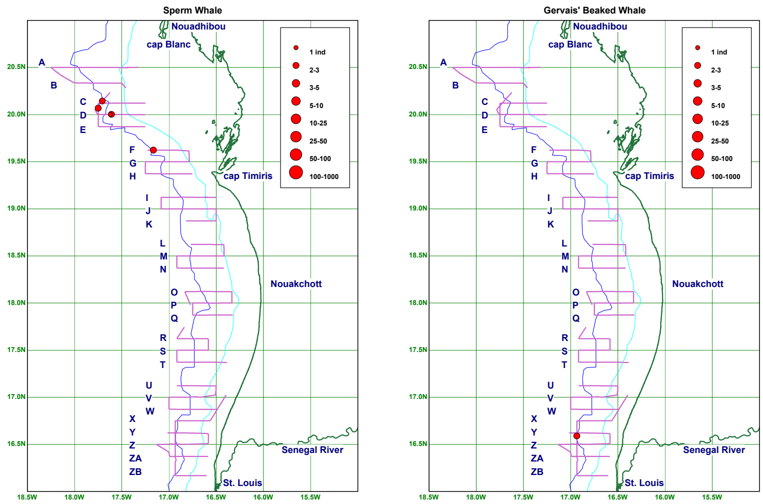


Fig. 5.36 Sightings of Sperm Whales and beaked whales, deep-diving Odontocetes, off the Mauritanian coast, 4-14 Sep 2015.

Sei / Brydes Whale Rorqual Tropical/de Rudolphi *small Balaenoptera spec.* (1)

A smaller baleen whale was observed briefly on 7 Sep 2015 (16°59’N, 17°00.0’W, 1574m deep (Oceanic), SST 29.5°C, poskey 180003356)

Humpback Whale Baleine a bosse *Megaptera novaeangliae* (3)

Humpback Whales are medium-sized baleen whales. Three Humpback Whales, including one adult/calf combination were seen on the edge of the Neritic zone over the Timiris Canyon system on 13 Sep 2015 (19°52’N, 17°20.1’W, 105m deep, SST 25.3°C, poskey 180004159, adult and calf; 19°52’N, 17°22.1’W, 115m deep, SST 25.6°C, poskey 180004162). There were no opportunities to obtain ventral fluke-shots that could be of any use for individual identification.

Fig. 5.36 Blowhole of adult male Sperm Whale, just ahead of the ship, 14 September 2015 (CJC)

Sperm Whale Cachalot *Physeter macrocephalus* (9)

Sperm Whales are the largest species within the toothed whale group Odontoceti. Large, probably all male Sperm Whales were seen on five occasions and the sightings comprised four duos and a solitary individual (**Fig. 5.36**). The water depth ranged from 625m (Shelf-break) to 1115m (Oceanic zone), and the water temperatures (SST) varied from 24.4-27.3°C, On sighting of two individuals on 12 Sep 2015 (19°37'N, 17°9.9'W, 625m deep, SST 27.3°C, poskey 180004146), two individuals on 13 Sep 2015 (20°04'N, 17°45.0'W, 1115m deep, SST 26.6°C, poskey 180004214), three sightings of respectively two, one and two individuals on 14 Sep 2015 (20°00'N, 17°36.5'W, 722m deep, 25.4°C, poskey 180004298 (2), 20°00'N, 17°37.3'W, 665m deep, 25.5°C poskey 180004299 (1), and 20°09'N, 17°42.4'W, 942m deep, 25.9°C, poskey 180004330 (2)). The sightings are superimposed over a chart with detailed bathymetry and bottom features in **Fig. 5.35**.

Gervais' Beaked Whale Mesoplodon de Gervais *Mesoplodon europaeus* (2)

Beaked whales are elusive, deep-diving, medium-sized odontocetes. A possible sighting of Gervais' Beaked Whale *Mesoplodon europaeus* on 9 Sep 2015 12:25h, 16°35'N, 16°56.0'W (796m deep, SST 29.6°C, poskey 180003637), involved two slowly moving beaked whales, appearing greyish brown in bright sunlight, moderately scarred, with no visible blow, that stayed close together. One animal surfaced twice with the tip of a fairly short beak clearly visible. Distinct teeth were seen at ca. 1/3 of the mouth length from the tip. An inconspicuous melon is also visible on photo's (**Fig. 5.37**). The concave dorsal fin was set well back, in shape curved nearly as in Minke Whale *Balaenoptera acutorostrata*. There were no peculiar marked patterns or colours visible at the animals for as far as they appeared at the surface. Given teeth, shortish beak, inconspicuous melon, moderate scarring (in adult male), and distribution range, Gervais Beaked Whale is perhaps the most likely species. The animals were seen at close range for several minutes, surfacing more than 15 times, and often together (simultaneously).

Fig. 5.37 Diving sequence of a possible Gervais' Beaked Whale, 9 Sep 2015 (CJC)

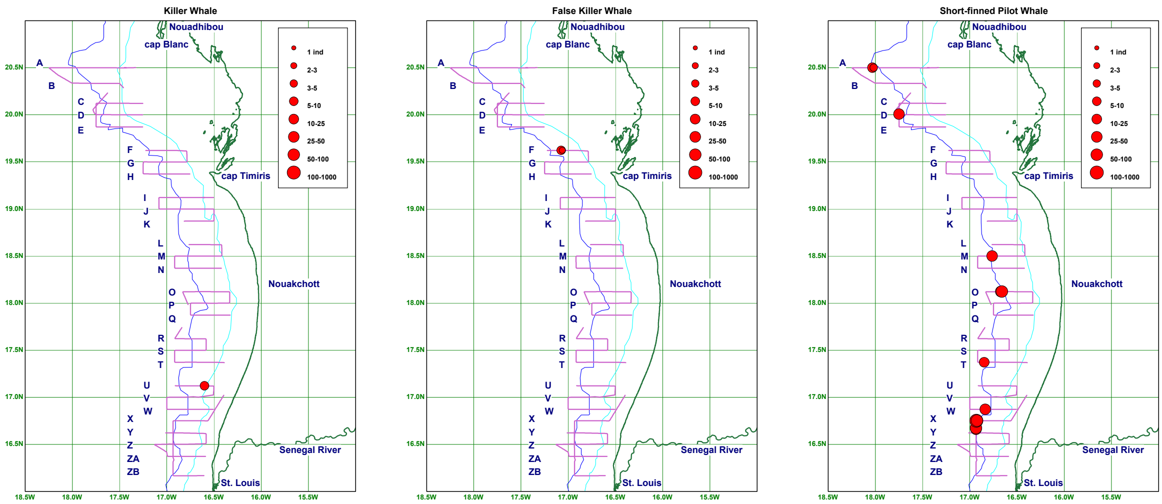


Fig. 5.38 Sightings of blackfish: killer and pilot whales off the Mauritanian coast, 4-14 Sep 2015.

Killer Whale Orque *Orcinus orca* (6)

Killer Whales are large, predatory toothed whales belonging to the oceanic dolphin family. A small pod of six Killer Whales was seen on 7 Sep 2015 (17°7'N, 16°36.0'W, 98m deep (Neritic), SST 29.3°C, poskey 180003397). The pod comprised of one adult male with a sharp-tipped dorsal that was bending over slightly to the right. A clear dent in the anterior side of the dorsal, approximately half way, formed a further feature that could be used in individual identification (**Fig. 5.39**). A further feature was a relatively large and bright light saddle behind the fin. The rest of the pod comprised at least three adult females and two smaller individuals (immatures or sub-adults).

Fig. 5.39 Tip of dorsal fin of adult male Killer Whale, 7 Sep 2015, showing some features that would allow for individual identification (HV).

False Killer Whale Faux-orque *Pseudorca crassidens* (11)

Two sightings, five minutes apart, of two and later nine individuals but of what was probably just one pod on 12 Sep 2015 (19°37'N, 17°3.7-4.4'W, 383-492m deep (a particularly steep part of the Shelf-break), SST 27.3°C, poskey 180004137-8). The animals were fast-swimming at first, generating high splashes, but switched to a highly secretive swimming mode at closer distances from the ship, while swimming as a tight pack. While their appearance was pitch black during the sightings, photo's later revealed considerable scarring on at least two individuals.

Short-finned Pilot Whale Globicéphale tropical *Globicephala macrorhynchus* (527)

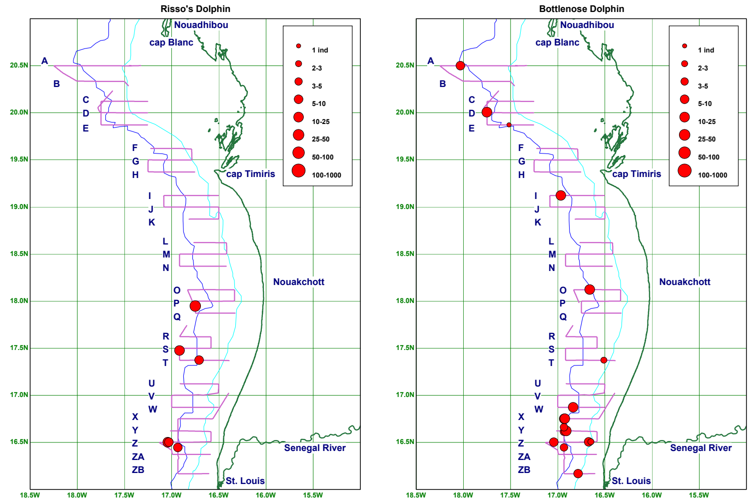
With 12 sightings, Short-finned Pilot Whale pod size averaged 43.9 ± 32.2 individuals (range 3-113 animals). Four sightings were within 5 minutes from each other, suggesting that these pods were either in close contact, or perhaps were a single, larger aggregation. Correcting for these sightings, pod size averaged 65.9 ± 57.8 individuals (range 14-178, *n*= 8). Most sightings were within the Oceanic zone (mean water depth 879 ± 97m, range 760-1114m) and a majority of the sightings were in the southern half of the study area, where sea surface temperatures were relatively high (all sightings mean SST 28.8 ± 1.5°C, range 26.1-30.0°C; **Fig. 5.38**). Six pods of Short-finned Pilot Whales were joined by a relatively slender, oceanic type of Bottlenose Dolphins. The pod size of the associated dolphins averaged 16.7 ± 13.1 individuals (range 4-41, *n*= 6). There was only a tendency, but no significant correlation of a larger number of dolphins associated with larger pod size of pilot whales (R_S= 0.49, n.s., *n*= 8).

Pilot whale pods typically moved very slow at the surface, and a recent re-appearance at the surface after a prolonged, probably deep dive was suggested several times from the active, hyperventilating behaviour of numerous individuals within pods. Small calves were seen repeatedly, and especially younger individuals were often engaged in spy-hopping or tail-slapping behaviour. All sightings were within a fairly narrow depth zone at the outer edge of the Continental shelf, suggesting that this was the key habitat for this species in early autumn. There was no indication that the Timiris canyon system, *i.e.* the area in which Sperm Whales were congregating, had any particular significance for pilot whales.

Fig. 5.40 Adult male Short-finned Pilot Whale at close range (HV)

Risso's Dolphin Dauphin de Risso *Grampus griseus* (78)

Five pods of Risso's Dolphins (average pod size 15.6 ± 8.7 individuals, range 8-26, *n* = 5) were encountered, four of which in deep Oceanic waters (average water depth 1098 ± 228m, range 892-1336m, *n*= 4), and one over the Shelf-break (363m depth). Sightings were all in areas where sea surface temperatures was relatively high (SST 29.2 ± 0.2°C, range 28.9-29.5°C) in the southern half of the study area (**Fig. 5.41**). A single pod of Risso's Dolphins was accompanied by a small pod of Bottlenose dolphins of the slender, oceanic type (892m deep waters, SST 29.5°C).



Risso's Dolphin (HV)

Fig. 5.41 Sightings of larger dolphins off the Mauritanian coast, 4-14 Sep 2015.

Bottlenose Dolphin Grand dauphin *Tursiops truncatus* (170)

Two types of Bottlenose Dolphins were encountered: a fairly slender and often relatively dark oceanic type over the Shelf-break and in deeper (Oceanic) waters and a more bulky, often more scarred and overall lighter grey inshore type within the Neritic zone. Not all pods could be assigned to anyone type, but all Bottlenose Dolphins associated with Short-finned Pilot Whales were of the oceanic type.

Fig. 5.42 Slender, oceanic type Bottlenose Dolphin porpoising, 5 Sep 2015 (CJC)

Seventeen pods of Bottlenose Dolphins were encountered (average pod size 10.0 ± 9.8 individuals, range 1-41, *n* = 17), five of which in the Neritic zone that were all assigned to the inshore type (average pod size 4.6 ± 3.7, range 2-10, water depth 77 ± 33m, range 38-115m, SST 29.1 ± 0.4°C, range 28.6-29.4°C, *n*= 5). Twelve groups were either unassigned or of the oceanic type (average pod size 12.3 ± 10.8, range 1-41, water depth 895 ± 186m, range 610-1260m, SST 28.7 ± 1.5°C, range 26.1-29.9°C, *n*= 12). The inshore type was only seen in the south, whereas the oceanic type was more widespread, but with a higher frequency in the south

(**Fig. 5.41**). A single pod of Risso's Dolphins was accompanied by a small pod of Bottlenose dolphins of the slender, oceanic type (892m deep waters, SST 29.5°C). Inshore Bottlenose Dolphins were not seen to associate with any other marine mammals.

Slender, unidentified oceanic dolphins dauphin ***Delphinus/Stenella* spp.** (630)

Smaller, oceanic dolphins were seen in large numbers and this included at least Common Dolphins *Delphinus delphis*, Pantropical Spotted Dolphins *Stenella attenuata*, Atlantic Spotted Dolphins *S. frontalis*, and Clymene Dolphins *S. clymene*. Six pods, totalling around 630 dolphins (10 encounters that were recorded as 8 discrete pods), could not be specifically identified. The unidentified dolphins were characterised by a mean pod size of 80 ± 120 individuals (range 2-468m depth, range 87-1158m) with a high sea surface temperature (SST 29.4±0.3°C, range 28.9-

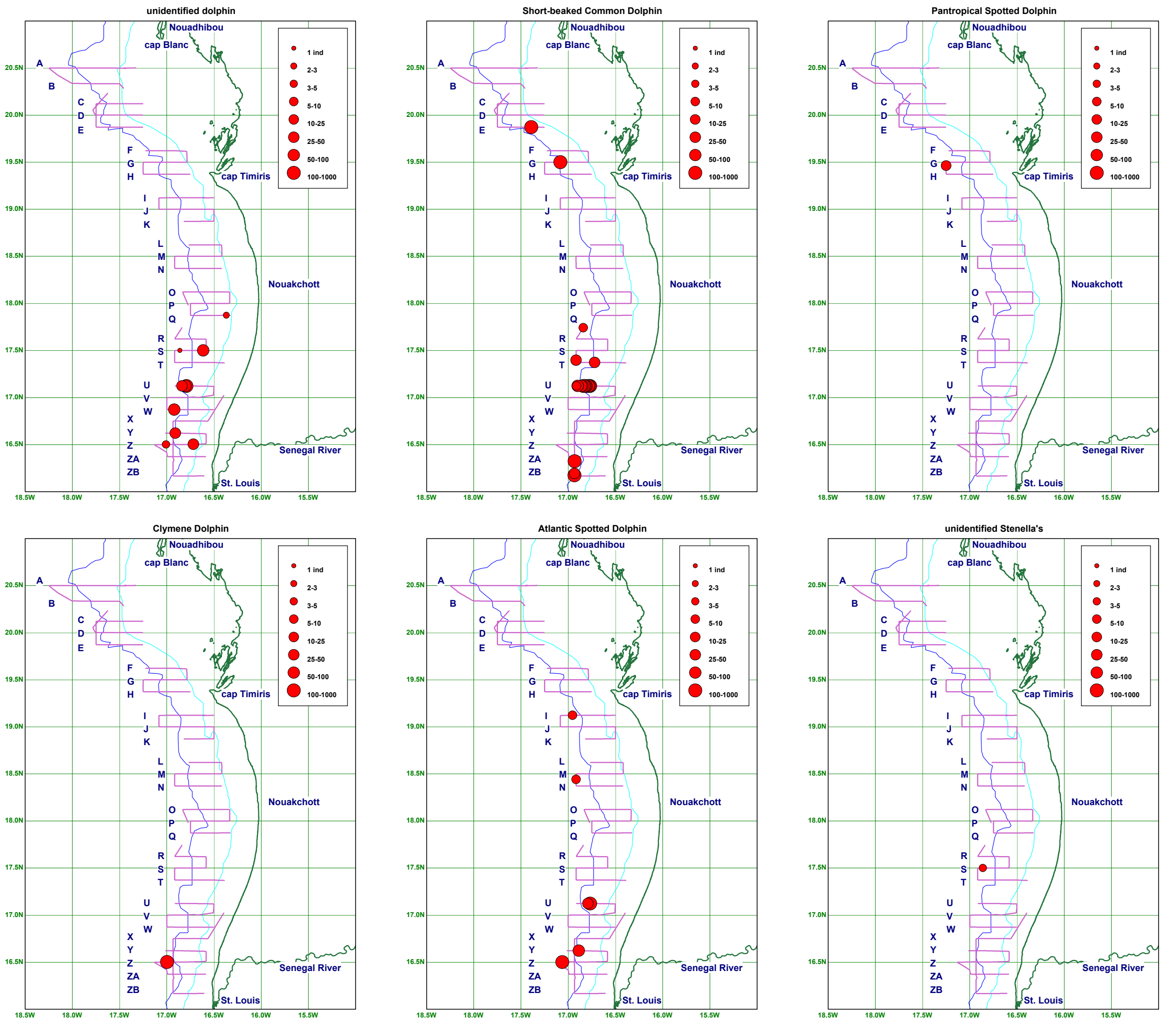


Fig. 5.43 Sightings of smaller, oceanic dolphins off the Mauritanian coast, 4-14 Sep 2015.

29.7°C). Overseeing all oceanic, slender dolphins (the oceanic type Bottlenose Dolphins excluded from the analysis), pod size averaged 201 ± 334 individuals (range 2-1511, *n*= 25 pods and an estimated 5023 dolphins), again mostly in deeper waters (726 ± 436m, range 87-1376m, *n*= 25) with a high sea surface temperature (29.0 ± 0.9°C, range 25.8-29.7°C, *n*= 25). All sightings are plotted in **Fig. 5.43**, and it is clear that these slender oceanic dolphins were much more numerous to the south of 18°N than further to the north.

The dolphin herds were often 'stampeding' (swimming closely together with high speed, in line or half circle formations), suggesting active foraging activities. Relatively few seabirds were attracted, however, and the classical dolphin-seabird interactions (with dolphins as beaters, driving forage fish towards the surface) were not particularly impressive in size on the side of seabirds involved. Associated seabirds included Wilson's Storm-petrel 6x, 80 individuals in total), Leach's Storm Petrel (1x, 2 ind), Pomarine Skua (1x, 1ind), Black Tern (3x, 22 ind), and Common Tern (8x, 40 ind). The absence of shearwaters (notably Cape Verde Shearwaters, common and widespread in the same general area) was particularly striking (cf. Clua & Grosvalet 2001).

Fig. 5.44 Linear formation of "stampeding" Common Dolphins, 9 Sep 2015 (CJC).

Common Dolphin Dauphin commun *Delphinus delphis* (3270)

Common Dolphins were assumed all Short-beaked Common Dolphins *Delphinus delphis delphis*. The Mauritanian type is a rather dull variety in which the characteristic flank pattern is not always particularly easy to see (Burton & Camphuysen 2003, **Fig. 5.45-6**). Common Dolphins were the most numerous and most frequently encountered oceanic dolphin species, with 21 encounters that in fact could be related to 8 pods (5-750 individuals at a time) and a megapod (at least 1500 individuals involved). The megapod comprised at least 12 smaller pods and passing this concentration of Dolphins took just under one hour at 8 knots (7 Sep 2015, 17°07.2'N, 16°46.7-54.7'W, 327-939m depth (steep decline during passage), SST 29.2°C). Overall, Common Dolphin pod size averaged 357 ± 491 individuals (range 6-1511, *n*= 9 pods and an estimated 3210 dolphins), mostly in deeper waters (636 ± 366m, range 153-1239m, *n*= 9) with a high sea surface temperature (28.6 ± 1.2°C, range 25.8-29.3°C, *n*= 9). With one exception within the neritic zone (early morning, 13 Sep 2015, 19°52.3'N, 17°23.5'W, 153m depth, SST 25.8°C), all sightings were over the Shelf-break or within Oceanic waters. The exception is interesting, because the research vessel was accompanied nearly every evening and night (after sunset) by Common Dolphins (that could be heard through the hull and that could be seen porpoising alongside the ship in torchlights) before an anchoring station was reached by the ship in shallow waters in preparation of the next day's first leg. Their mid-night habitat was most certainly different from that at daytime.

Fig. 5.45 Typical, fairly faint and overall rather dark flank pattern in Common Dolphins off the Mauritanian coast, 7 Sep 2015 (CJC)

Fig. 5.46 Typical, fairly faint and overall rather dark flank pattern in Common Dolphins off the Mauritanian coast, 7 Sep 2015 (HV)

Common Dolphins would bowride in sometimes very large numbers, but especially in larger pods the turnover at the bow was very high. One travelling pirogue over the Shelf-break was seen accompanied by Common Dolphins (**Chapter 4.6**).

Pantropical Spotted Dolphin Dauphin tacheté pantropical *Stenella attenuata* (14)

One small pod of 14 immature Pantropical Spotted-Dolphins, bow-riding for a long time on 12 Sep 2015 (19°28'N, 17°15.0'W, 1298m deep, SST 28.5°C, poskey 180004056). Extensive video footage has been obtained.

Clymene Dolphin Dauphin de Clymene *Stenella clymene* (560)

The Clymene dolphin is endemic to warm Atlantic Ocean waters and is one of the least known delphinids (Weir *et al.* 2014). Following photographic verification, Weir *et al.* (2014) described the characteristics of 84 confirmed and 8 probable at-sea sightings of Clymene dolphins in the Eastern Tropical Atlantic. The documented records ranged from ~19°N in central Mauritania to 14°26'S in southern Angola and sightings occurred in water depths of 437–5,000 m, at distances of 21–937 km from the nearest shore, corresponding with a continental slope and oceanic habitat. Group size ranged from 3–1,000 animals, with 60.9% of groups comprising *c.* 50 animals. The mega-pod now reported for Mauritania (*c.* 560 individuals) would represent the second largest group ever recorded and documented, according to this recent review. One large pod was seen, 560 individuals, 8 Sep 2015 12:10h, 16°30'N, 16°59.8'W, 1102 m deep, poskey 180003488.

Fully in line with Fertl *et al.* (2003), did we encounter serious difficulties to identify the Clymene dolphins initially and digital photographs were used during the event to verify that indeed this species was involved. We obtained extensive photographic and video evidence and

Fig. 5.47 Porpoising Clymene Dolphins, approaching the research vessel, 8 Sep 2015 (HV)

Characteristic moustache markings (left) and dark cape (right) (CJC)

Blackish streak along tailstock (individual on the right), indicative for adult males? (CJC)

Fig. 5. 48 Dark grey dorsal cape, mid-grey lateral field rounded convex dip in the ventral margin (left and below; CJC)

Fig. 5.49 Acrobatic leaps in Clymene's Dolphins, 8 Sep 2015 (CJC)

all key features used to identify Clymene dolphins, listed by Weir *et al.* (2014), including the tripartite colour pattern (dark grey dorsal cape, mid-grey lateral field, and white ventral surface); a rounded convex dip in the ventral margin of the dorsal cape below the dorsal fin and the distinctive ''moustache'' marking on the dorsal surface of the beak were documented. Given the pigmentation characteristics discussed by Weir *et al.* (2014), several of which that had not been emphasized in most previous descriptions of the species, some more stills are reproduced in this report for consultation and verification purposes. The pod approached the research vessel at considerable speed, numerous individuals were bow-reading, acrobatic leaps were common, including summersaults and splash-breaches. A small number of associated seabirds (22 Common Terns, 20 Black Terns), searching for prey (code 49) while following the front rows of the mega-pod, did not seem to have any feeding success

Atlantic Spotted Dolphin Dauphin tacheté Atlantique *Stenella frontalis* (599)

Atlantic Spotted Dolphin pod size averaged 100 ± 134 individuals (range 6-360, *n*= 6 pods and an estimated 600 dolphins), mostly in deeper waters (845 ± 500m, range 277-1376m) with a high sea surface temperature (29.0 ± 0.7°C, range 27.5-29.7°C, *n*= 6). All sightings are plotted in **Fig. 5. 43.**

Fig. 5.50 Atlantic Spotted Dolphin, immatures (left) and adult (right), 8 Sep 2015 (HV),

5.3.8 Further charismatic megafauna Turtle, sharks, rays, and fish

unidentified sea turtle Tortue *sea turtle* (3)

Loggerhead Turtle Tortue carette *Caretta caretta* (2)

Hard-shelled marine turtles are in the family Cheloniidae. Only five sea turtles were encountered during the September 2015 surveys, including two Loggerhead Turtles and three unidentified individuals. All turtles were seen in the north (19-20°N, **Fig. 5.51**), two within the Neritic zone (62-66m deep waters) and three in the Oceanic zone (854-1355m depth), in a narrow range with rather moderate sea surface temperatures (26.5 ± 0.4°C, range 26.1-27.1°C, *n*= 5). Encounters with sea turtles were typically very brief and few notes could be made regarding their behaviour, even their identity, or any other features. One Loggerhead Turtle was overgrown with shell-crust forming organisms, including goose barnacles (**Fig. 5.51**).

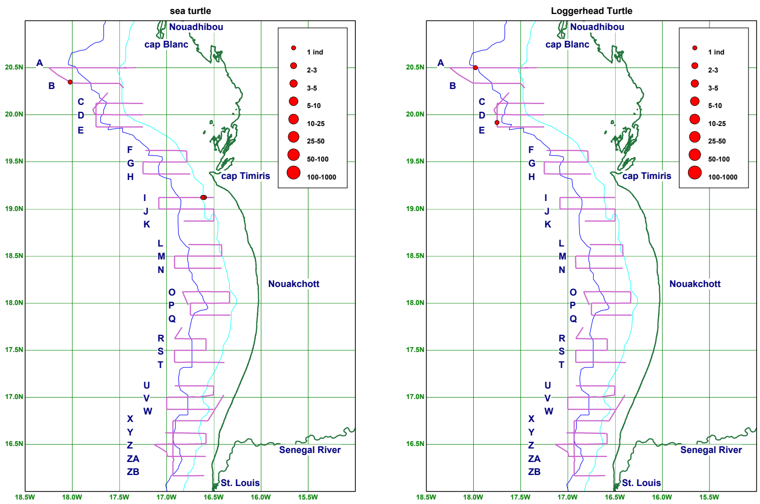


Fig. 5.51 Sightings of sea turtles off the Mauritanian coast, 4-14 Sep 2015 and a Loggerhead Turtle seen 13 Sep 2015 (top right, HV).

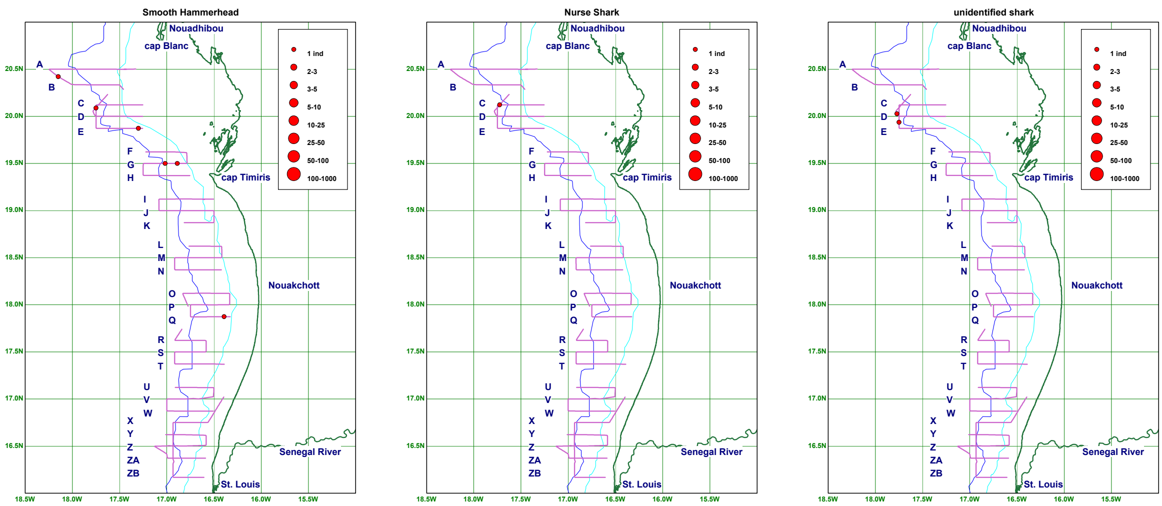


Fig. 5.52 Sightings of sharks off the Mauritanian coast, 4-14 Sep 2015.

Smooth Hammerhead Shark Requin-marteau commun *Sphyrna zygaena* (6)

Nurse Shark Requin-nourrice *Ginglymostoma cirratum* (1)

unidentified shark Requin *unidentified shark* (2)

Hammerheads are Requiem Sharks Charcharhinidae. Six Smooth Hammerhead Sharks were seen (**Fig. 5.52**), in water depths varying between 73 (Neritic) and 1172m (Oceanic, average 461.7 ± 525m, SST 26.7 ± 1.2°C, range 25.2-28.9°C, *n*= 6). Unidentified (2) and a Nurse Shark (1) were seen within the Oceanic zone (990-1210m depth, SST 26.1-27.0°C). The nurse shark is a common inshore bottom-dwelling shark, found in tropical and subtropical waters on the continental and insular shelves. None of the sharks were participating in MSFAs with seabirds involved, and none were seen within the short-lived tuna driven feeding frenzies far offshore. One Hammerhead Shark triggered 'an explosion' of small flying fish to take wing, suggesting a subsurface attack on these fish.

Lesser Guinean Mobula Petit diable de Guinee *Mobula rochebrunei* (6)
Swordfish Espadon *Xiphias gladius* (3)
Ocean Sun-fish La môle *Mola mola* (1)

Mobula is a genus of ray in the eagle ray family, in appearance similar to that of manta rays, which are in the same family. Six Lesser Guinean Mobula were observed during the September 2015 surveys, all breaching clear out of the water (667-795m deep water, SST 27.8-29.6°C). Swordfish are large, highly migratory, predatory fish characterized by a long, flat bill. These fish are found widely in tropical and temperate parts of the Atlantic, Pacific, and Indian Oceans. Three large Swordfish were observed (1x breaching, 871-1243m deep water, SST 26.8-27.9°C). The Ocean sunfish or Common Mola *Mola mola* is the heaviest known bony fish in the world. It has an average adult weight between 247 and 1000kg. The species is native to tropical and temperate waters around the globe. One Sun-fish (720m deep, 30.1°C). All sightings are plotted in **Fig. 5.53**.

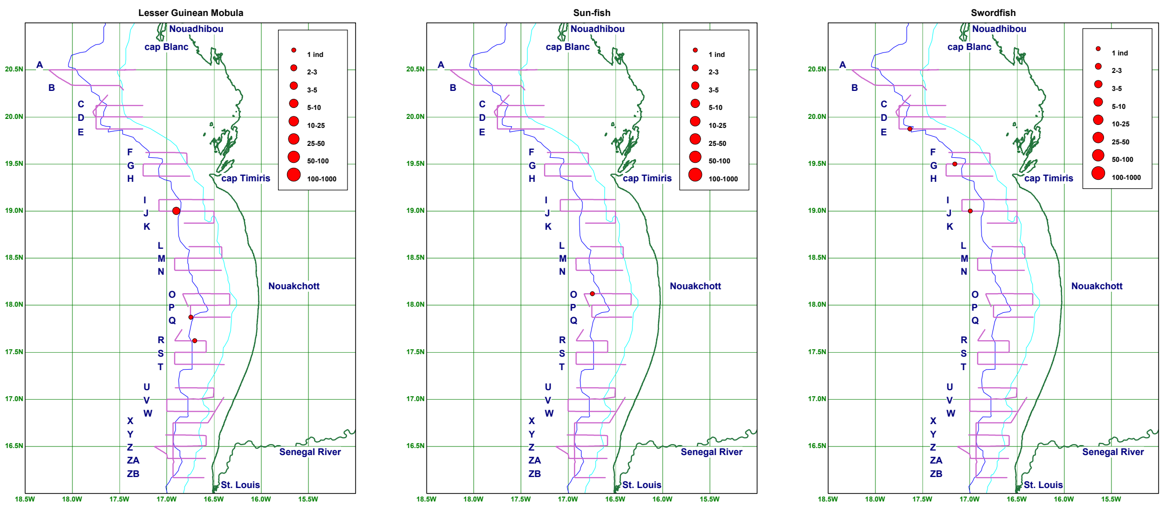


Fig. 5.53 Sightings of rays, sun-fish and swordfish off the Mauritanian coast, 4-14 Sep 2015.

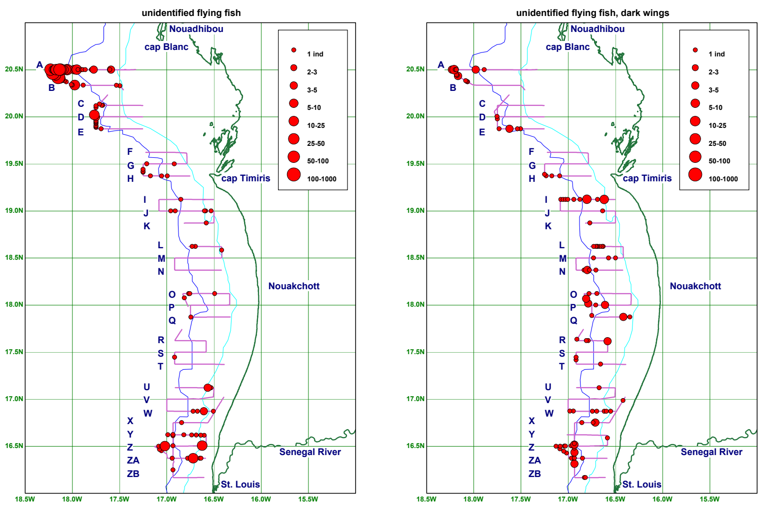


Fig. 5.54 Sightings of flying fish off the Mauritanian coast, 4-14 Sep 2015. Left: flying fish with transparent wings, right flying fish with blackish wings.

unidentified flying fish, light wings Exocet, poisson volant (1213x light wings, 179x dark wings)

The Exocoetidae are a family of marine fish known as flying fish. About 64 species are grouped in seven to nine genera. Flying fish can make powerful, self-propelled leaps out of water into air, where their long, wing-like fins enable gliding flight for considerable distances above the water's surface (Wikipedia). Numerous flying fish were seen during the Sep 2015 survey, and species-specific identification proved to be impossible. Several types were seen, but only a distinction was made between individuals with dark, blackish wings (fins) and individuals with fully transparent, more silvery wings. The transparent winged type was seen in larger groups (10.9 ± 34.6 individuals per sighting, range 1-270*, n*= 111) than the dark-winged variety (1.8 ± 1.5, 1-10, *n*= 102). The dark-winged individuals were virtually absent in relatively cooler waters (SST light winged 27.3 ± 1.8°C, range 21.6-30.1°C, dark-winged 28.4 ± 1.3°C, 25.5-30.0°C), but the water depth range was considerable in both types (light winged 779 ± 470m, range 25-1401m, dark-winged 763 ± 467m, 19-1533m). Flying fish were attacked by Cape Verde Shearwaters, Pomarine Skuas, Lesser Black-backed Gull (**Fig. 5.55**), and Smooth Hammerhead Sharks.

Fig. 5.55 Dark-winged type flying fish under attack of 2nd cy Lesser Black-backed Gull, 8 Sep 2015 (HV)

Skipjack Tuna (Bonito) Bonite a ventre raye *Katsuwonus pelamis* (1111)

Tuna Scombridae are large, heavily muscled, powerful fish occurring worldwide from cold temperate to tropical seas (Waller 1996). Bonitos are a tribe of medium-sized, ray-finned tuna (**Fig. 5.56**). Hunting bonitos driving forage fish towards the sea surface were commonly encountered in Oceanic waters and occasionally over the Shelf-break during the September 2015 surveys (**Fig. 59**). The bonitos were normally only partially visible, but photographs of breaching individuals revealed that the majority were Skipjack Tuna *Katsuwonus pelamis*, rather than Atlantic Bonito's *Sarda sarda* (**Fig. 5.57-8**). One photo (not reproduced here) showed a plain (grey) bonito that could not be identified. Bonito's were not seen in the vicinity of hunting dolphins, but given the spectacle generated by the megapods of dolphins, the fish may have been overlooked. The forage fish driven towards the surface by these bonitos were quickly discovered and immediately exploited by nearby seabirds (terns mostly, rarely skuas and shearwaters).

Fig. 5.56 Skipjack Tuna driving fish towards the surface with associated Black Tern, 6 Sep 2015. Water depth *c.* 1400m (HV)

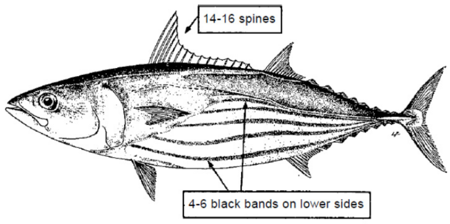


Fig. 5.57 Skipjack Tuna *Katsuwonus pelamis* characteristics from Schneider (1990). Field guide to the commercial marine resources of the Gulf of Guinea. FAO Regional Office for Africa, Rome. Skipjack Tuna (above) have 4-6 long broad stripes over the belly from the scaly area to the tail.

Fig. 5.58 Atlantic Bonito *Sarda sarda* from Wikipedia.; Atlantic Bonito's have a white belly and thin stripes over the back and sides (internet image, identification following Wheeler 1978).

It was quite impossible to estimate the number of bonitos involved in forage fish hunts. In total, 50 encounters with Skipjack Tuna were recorded in which the targeted forage fish was tiny and silvery (see below). The feeding frenzies generated typically included Black Terns, they were generally in deep waters (1105 ± 300m, range 409-1574m, n=50) with a rather high sea surface temperature (SST 29.0 ± 0.8°C, 26.8-30.2°C). Three frenzies involved rather larger reddish forage fish (see below). Foraging frenzies induced here were in shallower, cooler water (141 ± 59m, range 101-209m; SST 26.1 ± 0.1, range 26.0-26.2°C, n = 3).

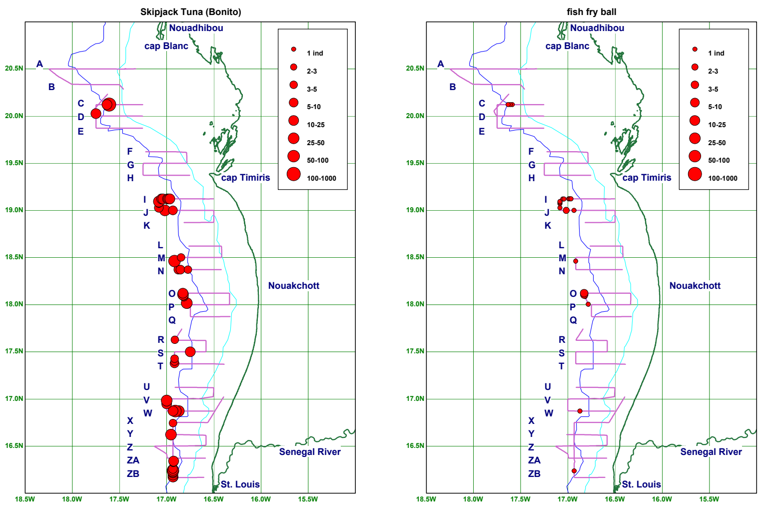


Fig. 5.59 Sightings of tuna and tuna-driven forage fish off the Mauritanian coast, 4-14 Sep 2015.

Forage fish ball banc de petit poisson (26)

"Boiling water events" occurred frequently seawards of the shelf break (**Fig. 5.59**). The 'boiling water' was caused by forage fish at the surface and in nearly all cases, chasing bonitos could be detected (see above). The fish balls were all formed by hunting bonitos and two distinct types were seen: silvery forage fish balls (**Fig. 5.60**) in which individual fish could not be seen or with great difficulty when captured by terns, and reddish fish balls (**Fig. 5.61**) in which dark reddish individual fish could be seen at the surface and more clearly when the forage fish were lifted from the water by feeding seabirds. The silvery fish balls were all in oceanic waters and were specifically targeted by Black Terns and Common Terns. The reddish fish balls were more northerly in slightly cooler waters and over the Shelf-break and these forage fish were targeted primarily by skuas and shearwaters, plus small numbers of Common terns. A total of 50 "silvery" forage fish balls were observed, 43x in Oceanic waters, 7x over the Shelf break, with a mean (± SD) water depth of 1105 ± 300m and with a mean SST of 29.0 ± 0.8°C. Only three "reddish" forage fish balls were observed, 1x over the Shelf break and 2x within the Neritic zone, in 141 ± 59m deep water with a mean SST of 26.1 ± 0.1°C. From the few observations that fish were lifted and were photographed, the silvery forage fish were approximately 3cm in total length, whereas the reddish forage fish were between 6 and 8cm in length.

Fig. 5.60 Forage fish (circular seemingly boiling water) driven towards the surface by Skipjack Tuna, with a developing offshore feeding frenzy with mostly Black Terns and some Common Terns, 5 Sep 2015. Water depth 1047m (CJC)

Fig. 5.61 Reddish forage fish (circular seemingly boiling water) in more northerly waters, targeted by skuas, Common Terns and Cape Verde Shearwaters, 13 Sep 2015. Water depth 209m. (CJC) A single reddish fish is dangling from the beak of the shearwater. The forage fish stirred up by tuna in these more northerly areas was clearly larger and was apparently not attractive for Black Terns, but did attract some Common Terns and larger seabirds.

6. Discussion

From the accumulated data, some conclusions could be drawn with regard to specific habitats and habitat characteristics of some of the key players during these surveys: the commoner seabirds, the various groups of whales and dolphins, and the tuna-driven feeding frenzies that were found to support particular assemblages of seabirds.

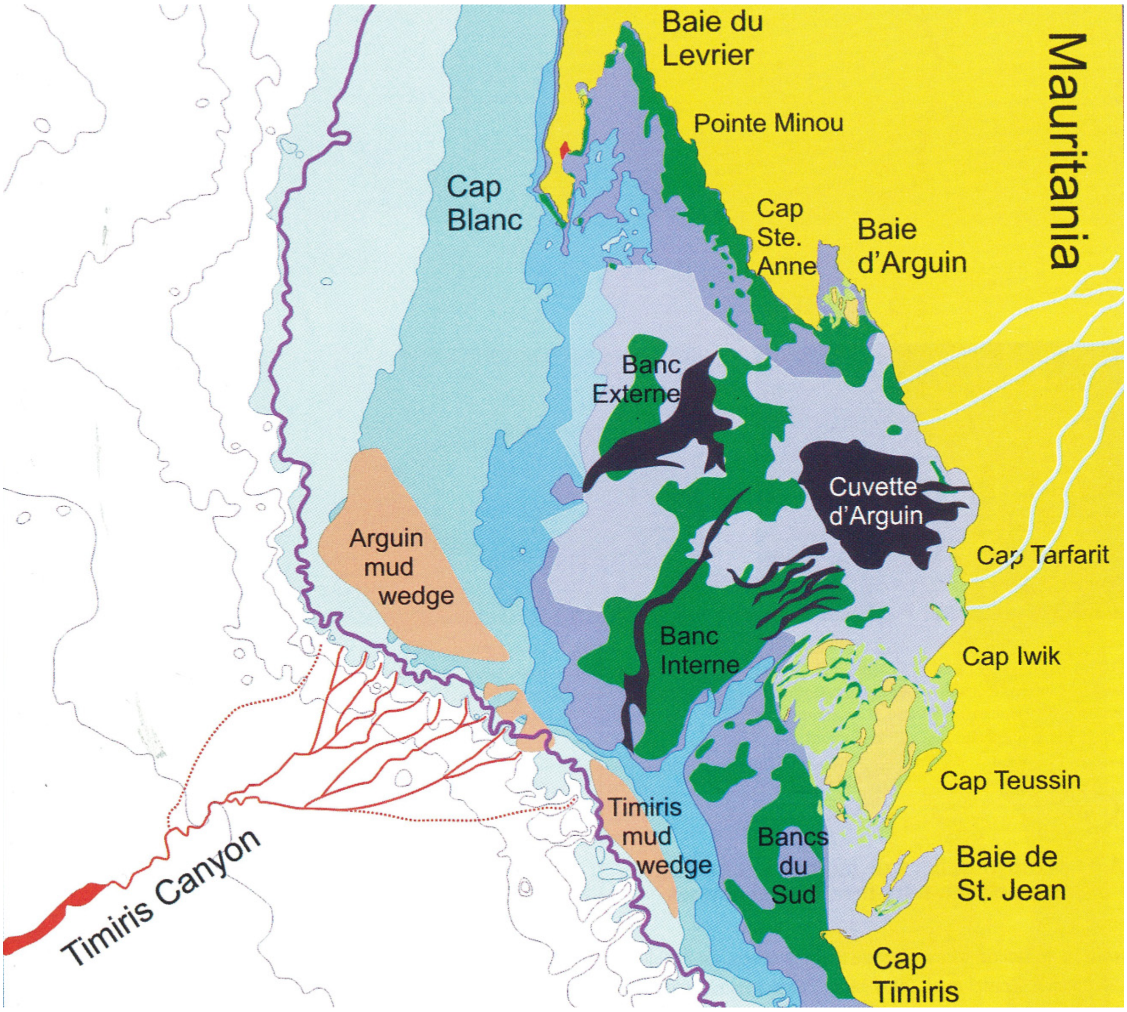


Fig. 6.1 Bathymetry, morphology, and sedimentation (seafloor) off the Banc d'Arguin (from Anon. 2013).

6.1 Offshore key habitats

Sea surface temperatures (SST) measured during the September 2014 cruise, were superimposed over a detailed bathymetry chart in **Fig. 5.2**. The cut-off point was *c.* 18°N, because the variability in SST and habitat characteristics (**Fig. 6.1**) were so much lower, further to the south (**Figs. 4.3-6**). Interesting features are the area of cooler surface waters along the northernmost legs, relatively strong temperature gradients along the other legs down to *c*. 19°N, the Shelf-break extension and the Timiris Canyon system to the west of the Banc d'Arguin, and Cap Timiris itself. Prominent sea floor characteristics are shown in **Fig. 6.1** (from Anon. 2013, see also Westphal *et al.* 2012.

The upwellings off Cap Blanc are persistent throughout the year, but are strongest from November to February (Mittelstaedt 1991). Baines & Reichelt (2014) reported canyon features close to the shelf edge that are associated with a highly productive upwelling zone, and suggested that these topographic features create optimal habitats for zooplankton that in turn attract charismatic and endangered species such as Blue Whales. The observations in September 2015 revealed a mix of seabirds, including some remaining Antarctic species (Wilson's Storm-petrel and Antarctic Skua), plus high arctic species such as Sabine's Gulls, Pom arine Skuas, Long-tailed Jaegers, and Grey Phalaropes. Numerous boreal species, including most notably the Northern Gannet and the Great Skua, but also abundant winter visitors such as Lesser Black-backed Gulls and Sandwich Terns had not yet arrived at all, or not yet in numbers of any significance. A notable feature was the widespread occurrence of a local seabird, the Cape Verde Shearwater, a scarce winter visitor, rarely seen in earlier offshore surveys in the region but now abundant.

As in earlier surveys, the shelf-break was the area of most significance to seabirds and cetaceans alike (**Table 6.1**). Several species (and the overall biodiversity) peaked in the northern part of the study area, where cool water reached the surface and where foraging opportunities were clearly most diverse and attractive.

Cape Verde Shearwater in active moult, 13 Sep 2015 (HV)

Table 6.1. Species diversity (*n*) and overall densities (*n* km^{-2}) for groups of seabirds and other visible aspects over the Neritic zone, the Shelf-break and in deep waters (Oceanic). Peak densities in **bold**.

	Species diversity (*n*)			**Overall densities** (*n* km^{-2})		
Group	Oceanic	Shelf-break	Neritic	Oceanic	Shelf-break	Neritic
shearwaters	7	7	6	0.15	**0.19**	0.10
storm-petrels	4	5	4	0.13	**1.75**	1.20
pelicans			1			0.02
phalaropes	1	1	1	0.03	**0.69**	0.40
skuas	3	3	4	0.11	**0.72**	0.55
gulls	1	1	3	0.01	**0.09**	0.04
terns	4	5	7	**8.40**	3.42	2.89
cetaceans	10	9	6	1.78	**6.68**	0.04
turtles	1			0.01	0	0
sharks	2	2	1	0.01	0.01	0.01
various visible fish	3	2	1	**1.84**	0.43	0.73
fishnets	+	+	+	0	0.01	**0.39**

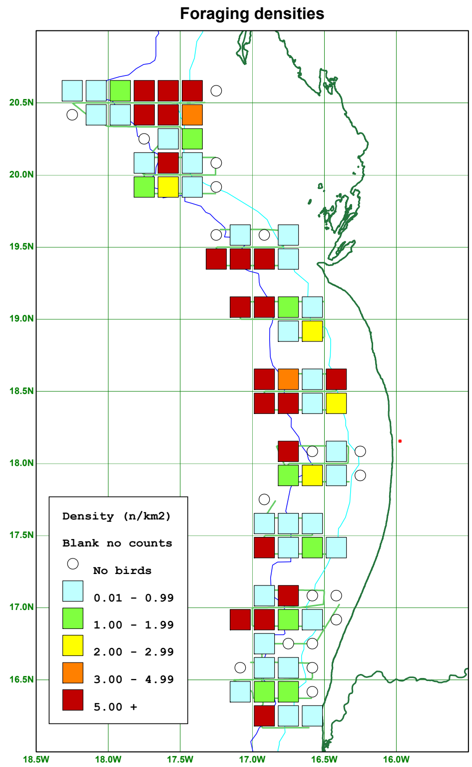


Fig. 6.2 Overall densities of foraging seabirds (all species combined).

On the map of overall *actively foraging* seabird densities, arguably the areas that matter most to marine birdlife (**Fig. 6.2**), a rather patchy distribution of important areas can be found. The northernmost area is a mix of mostly shearwaters and phalaropes, attracted by the cooler, nutrient rich waters of the more or less permanent upwelling in the northernmost area. Further south, the mostly deep water patches with high numbers of foraging seabirds are dominated by Black Terns and to a lesser extent Common Terns. The arguably very crude estimates over estimated overall abundance are summarised in **Table 6.2.**

Table 6.2. Observed numbers, overall densities (n km^{-2} ± SD), numeric proportion (%), proportion by biomass, estimate of total numbers following area extrapolations and (ecological) guild for the most numerous seabirds observed, 4-14 September 2015. Species or groups of species marked with an asterisk (*) had more than 50% of the records labelled as 'ship-associated'.

Species		*n*	Density *n* km^{-2}			% numeric	% biomass	Estimate	Guild
Black Tern	Guifette noire	1308	2.01	±	5.23	26.7	15.8	83000	piscivore
Common Tern	Sterne pierregarin	1271	2.07	±	4.94	27.4	25.9	85000	piscivore
Wilson's Storm-petrel	Océanite de Wilson	522	1.82	±	2.35	24.1	4.8	74800	planktivore
Red Phalarope	Phalarope à bec large	192	0.72	±	1.86	9.5	2.1	29500	planktivore
Pomarine Skua*	Labbe pomarin	128	0.25	±	0.79	3.3	18.5	10400	omnivore
"Cory's" shearwaters (all)*	Puffin cendré	109	0.27	±	0.73	3.6	18.6	11300	piscivore
Cape Verde Shearwater	Puffin du Cap-Vert	60	0.13	±	0.28	1.7	7.5	5400	piscivore
Long-tailed Jaeger	Labbe à longue queue	57	0.09	±	0.25	1.2	0.3	3800	piscivore?
Parasitic Jaeger	Labbe parasite	57	0.08	±	0.26	1.1	4.0	3500	piscivore
Sandwich Tern*	Sterne caugek	36	0.05	±	0.34	0.7	1.3	2100	piscivore
Sabine's Gull	Mouette de Sabine	23	0.03	±	0.10	0.4	0.7	1300	piscivore?
Mauretanian Royal Tern*	Sterne royale	10	0.01	±	0.10	0.2	0.5	600	piscivore

*>50% ship- or fishing vessel associated records

6.2 Multi-species foraging associations (MSFAs)

Studies of communities typically focus on counting and identifying member species and then address their interactions and mechanisms for coexistence (Ballance *et al.* 1997, Ballance 2002). In contrast with many terrestrial species, almost nothing is known about this aspect of the ecology of cetaceans. There are regularly occurring species assemblages. For example, Pantropical Spotted and Spinner Dolphins in the eastern tropical Pacific are frequently found in mixed-species schools in association with yellowfin tuna *Thunnus albacares* accompanied by large and speciose flocks of seabirds. There are variations in typical co-occurrence patterns elsewhere in the world (Harrison *et al.* 1991, Camphuysen *et al.* 1995, Clua & Grosvalet 2001, Vaughn *et al.* 2007, O'Donoghue *et al.* 2010, Vaughn *et al.* 2011), but the nature of the interactions between species in these assemblages, why they associate, and the reasons for variations in community membership patterns are almost completely unknown (Ballance 2002). Coexisting species, particularly those that are closely related or have similar ecological roles, potentially compete for resources. Ecological theory states that stable communities of coexisting species must differ in resource utilization in some way: prey species or size specialization, differential habitat use, or diel pattern. To understand community structure, the mechanism by which species partition resources are of principal interest. This is an area that remains almost completely unexplored for cetaceans and the communities in which they are found (Balance 2002).

Fig. 6.3 Breaching Skipjack Tuna and a feeding frenzy of Black Terns and Common Terns in Oceanic waters off the Mauritanian coast, 6 Sep 2015 (HV).

In Mauritanian waters, MSFA drivers potentially facilitating aerial (skuas), plunge diving (gannets and terns) and pursuit plunging (shearwaters) seabirds are various species of Oceanic dolphins (*Stenella* spp., *Delphinus delphis*) and fish, notably tuna Scombridae, that drive small prey fish and possibly zooplankton towards the surface and within reach of seabirds (Camphuysen & Webb 1999). This mechanism of facilitation and resource sharing is characteristic for numerous tropical seabird and cetacean communities (Ballance *et al.* 1997, Clua & Grosvalet 2001). A study in the Azores showed that the encircling of prey initiated by common dolphins, often mixed with spotted dolphins *Stenella frontalis*, resulted in the formation of a bait ball of several thousands of prey fish close to the surface (Clua & Grosvalet 2001). Seabirds were always present throughout the few minutes during which the entire collective food hunt took place. North Sea MSFAs were similarly short-lived and the roles of each of the seabird species of seabirds in the speciose flocks could be documented and turned out to be particularly consistent (Camphuysen & Webb 1999). Knowing that short-lived MSFAs are an important foraging mechanism for tropical seabirds, the observation team was on a constant lookout for indications that MSFAs would be formed, had been formed, or were just disintegrated during a passage. All behavioural characteristics of MSFA participants were computer coded and can thus be easily quantified.

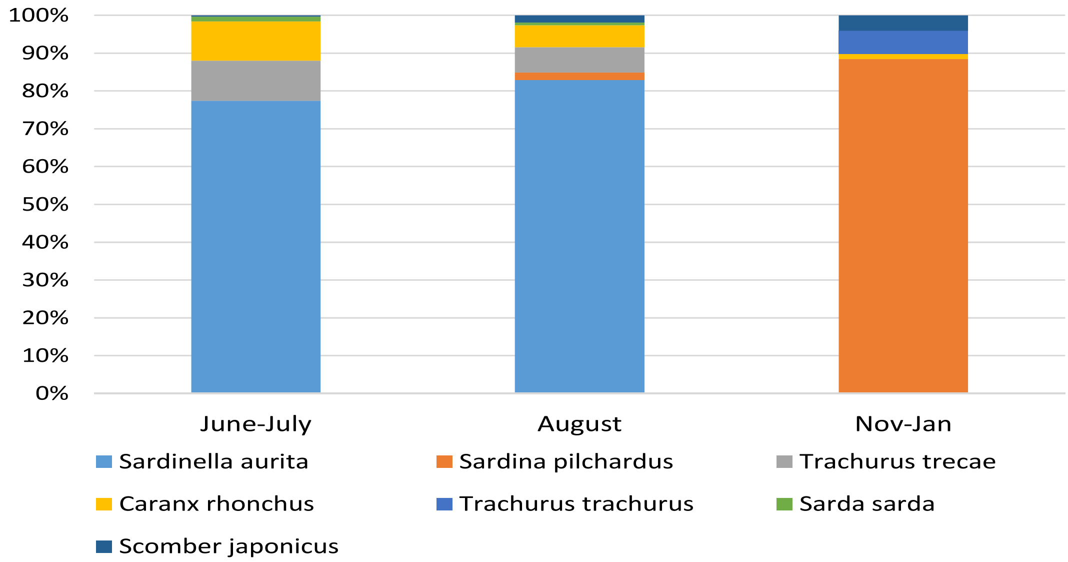


Fig. 6.4 Species composition (%, based on specimens x 10^9) of abundant fish larvae off Mauritania (16-21°N) in summer, late summer and winter, after Arkhipov (2009)

We consider the prominent link between foraging terns (notably Black Terns) and tuna (notably Skipjack Tuna) a major finding of the project (**Fig. 6.3**). Black Terns were known to overwinter in deep water areas, and more or less disappear out of sight during a good part of the Northern Hemisphere winter, but the evident link with tuna feeding frenzies is new. Our data suggest that tuna are selected that target suitable prey (producing forage fish), suitable for Black Terns that is. The more northerly feeding frenzies, where shearwaters and skuas profited from the tuna, were more or less ignored by Black Terns. The size of fish seen [see photo reddish forage fish under Skipjack Tuna species account] suggests that these tuna produced forage fish of an unsuitable size for the fragile, small marsh terns. The slightly larger Common Terns did participate and feed in the more northerly MSFAs. While our acoustic data suggest that the more northerly waters were clearly more productive (cooler SST indicative for upwelling, higher concentrations of plankton and fish in the water column), the Black Terns concentrated on offshore areas with the highest SST (~30°C), relatively poor areas given the acoustic results, with fewer competitors (other seabirds), and apparently abundant prey of suitable size and quality. Arkhipov (2009) studied the species composition of fish larvae throughout the year in Mauritanian waters and concluded that *Sardinella aurita* was the most abundant species in late summer (**Fig. 6.4**). The tiny fish driven by Skipjack Tuna in September 2015 were clearly responding to the predators and in a post-larval stage as small nekton and the fish therefore picked up by Black Terns were probably *Sardinella*. A confirmation of this suggestion is possible if prey items could be retrieved from dropping collected on coastal roosts. Incidentally, even though massive numbers of Black Terns were seen to roost near Nouadhibou, our at-sea surveys suggest that perhaps many of these birds forage mostly nearshore (as our shore-observations seemed to confirm). In Oceanic waters nearest Nouadhibou, Black Terns were comparatively scarce. Hence, droppings of Black Terns produced on roosts should be collected further to the south, perhaps near cap Timiris, Nouakchott or the Senegal river delta.

6.3 Ship-attracted species

We observed a remarkable discrepancy between the relative abundance of Black Terns and Common Terns engaged in foraging flights towards Oceanic waters (**Fig. 5.23**) and within the MSFAs targeting tuna-driven forage fish (see **Fig. 5.23-4**). There are a number of possible explanations for this discrepancy. One is that the two species of terns have a different foraging options in deep Oceanic waters, another is that the detection probability is different as a result of behaviour or visibility (more or less ship-attracted, or a cryptic grey versus largely white plumage), or that Black Terns have a greater tendency to remain in Oceanic waters overnight. Some observations are relevant here:

- Common Terns outnumbered Black Terns in westward foraging flights in the morning hours (CT:BT= 3.2 : 1)
- Black Terns outnumbered Common terns in tuna driven MSFAs over the Shelf-break and in Oceanic waters (BT:CT= 2.3 : 1)
- Common Terns outnumbered Black Terns in overall densities (*n* km^{-2}) within the Neritic zone (CT:BT= 24.8 : 1!) and over the Shelf-break (CT:BT= 2.5 : 1), but the reverse was true in Oceanic waters (BT:CT= 3.2 : 1) **Fig. 6.6**
- In Oceanic waters, foraging Black Terns, not evidently associated with tuna/forage fish (non-tuna-MSFAs), outnumbered Common Terns (BT:CT= 2.6 : 1)
- In Shelf-break waters, foraging Common Terns (away from tuna MSFAs) outnumbered foraging Black Terns, but only marginally (CT:BT= 1.3: 1)
- In the Neritic zone, foraging Common Terns (away from tuna MSFAs) grossly outnumbered foraging Black Terns (CT:BT= 37.1 : 1!)
- Away from the Neritic zone, Black Terns outnumbered Common terns both at tuna-driven MSFAs (BT:CT= 2.0 : 1) and otherwise (1.6 : 1).
- Common Terns outnumbered Black Terns as 'ship-associated' birds (*i.e.* birds attracted by the observation platform (CT:BT= 17.6 : 1!)

The results suggest that Common Terns do not have highly different foraging options than Black Terns in deep-water Oceanic conditions. Only in cooler waters (~20°N), where Black Terns were scarce, Common Terns were able to profit from feeding frenzies in which the forage fish was 'larger', joining shearwaters and skuas. This does not explain the observed differences in overall abundance and foraging flights in most of the area. Common Terns were generally outnumbered by Black Terns in Oceanic waters under all conditions (non-feeding, feeding), Black occurred in higher overall densities (**Fig. 6.5**) and were most abundant in feeding frenzies. Common Terns were much more numerous as ship-attracted species (birds that are excluded from all these calculations), and a more general interest in vessels in one species relative to another is a more likely explanation (**Fig. 6.6**). This is a fairly wordy explanation for a general phenomenon: ship-

Sabine's Gull in full summer plumage, 8 Sep 2015 (HV)

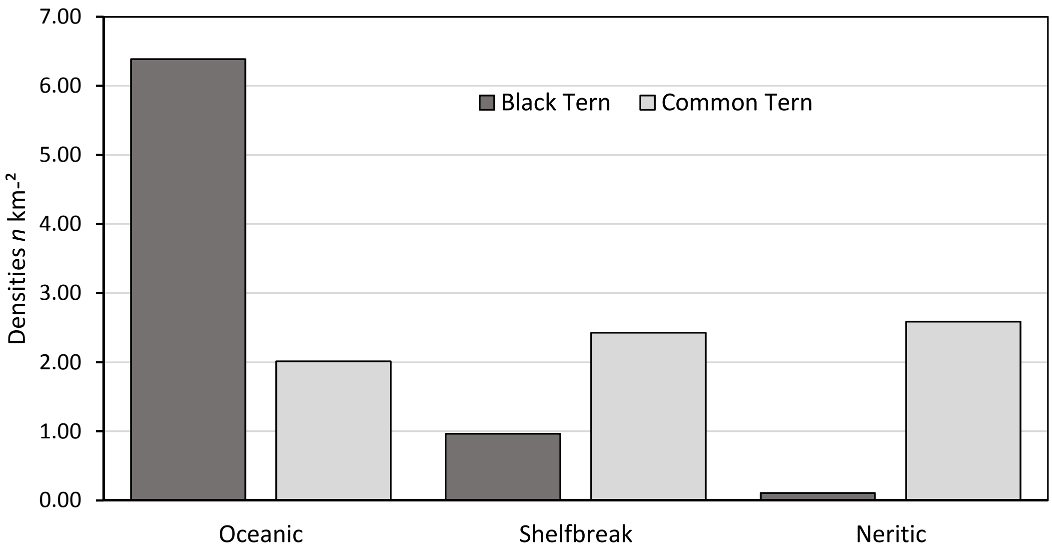


Fig. 6.5. Overall densities (n km^{-2}) of Black Terns and Common Terns in different depth zone throughout the study area, 4-14 Sep 2015.

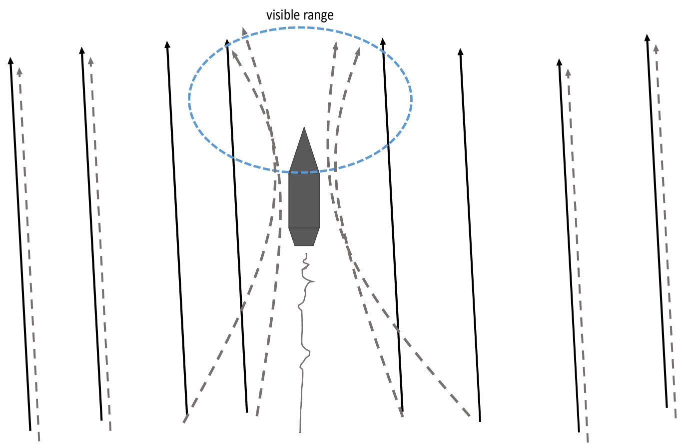


Fig. 6.6 Hypothetical difference in behaviour between Black Terns (ship-ignorant, black arrows) and Common Terns (ship-attracted, grey dashed arrows), given observed differences in numbers flying west and densities at sea at the final destination. Altering course to check a vessel (grey polygon) by one but not by another species could bias numbers within visible range of the ship-interested taxa.

attracted species may be over-estimated, because they respond to vessels such that it may not even be obvious to the observers that try to eliminate this effect (see Tasker *et al.* 1984, Camphuysen & Garthe 2004). Relatively few ship-attracted birds were recorded on the September 2015 surveys (see Species Accounts), certainly in comparison to earlier surveys in winter (Camphuysen 2000, Burton & Camphuysen 2003, Camphuysen & Van der Meer 2005, Camphuysen *et al.* 2013). However, more subtle forms of attraction (altering course, come closer, and resume the original course after a brief inspection) may be more prominent in some species in comparison to others. It is very difficult to fully eliminate the effect from a 'potentially attractive' observation platform. If the elimination would be too drastic, observed densities will underestimate the real abundance, while the reverse will be true if too many in fact ship-attracted individuals are included in the transect counts. If the recorded number of actually ship-attracted individual birds can be seen as a proxy for their tendency to at least approach vessels, the ranking of bird species would be as in **Table 6.3**.

Table 6.3. Proportion (%) of ship-attracted seabirds, associated with the observation platform ('own ship'), or with fishing vessels as a fraction of the total number of individuals recorded (Sample, *n*), sorted by their tendency to associate with a vessel (from high to low, >50% with a grey background).

Species	Sample	% Own ship	% Fishing vessel	% Attracted any vessel
Mauretanian Royal Tern	355	17	75	92
Lesser Black-backed Gull	17	12	76	88
Sandwich Tern	281	6	75	81
Scopoli's/Corys shearwater	370	2	74	76
Pomarine Skua	808	9	44	52
Parasitic Jaeger	265	4	37	40
Cape Verde Shearwater	577	20	20	40
Sabine's Gull	146	10	27	36
Common Tern	5441	9	26	35
Cory's Shearwater	28	29	0	29
Wilson's Storm-petrel	1147	7	18	25
Long-tailed Jaeger	248	6	14	20
Great Shearwater	68	1	10	12
Sooty Shearwater	25	0	4	4
Manx Shearwater	31	3	0	3
Black Tern	3714	1	0	1
Red Phalarope	372	1	0	1
Leach's Storm-petrel	28	0	0	0

6.4 Sensitivity to oil pollution

Environmental perturbations such as oil spills occurring within the main foraging areas of the seabirds and marine mammals that depend on Mauritanian waters have the potential to negatively impact seabird populations within and outside NW Africa. To understand why certain oil spills have been more devastating than others in terms of their effect on marine wildlife, it is important to consider that different species and different geographical areas vary in terms of their sensitivity to oil (Camphuysen 2007b). The sensitivity of seabirds depends largely on behavioural characteristics and species-specific differences in the exposure to oil pollution. The sensitivity of sea areas depends mainly on the numbers and behaviour (e.g., feeding, roosting, passage) of sensitive seabird species occurring there in combination with the likely persistence of hydrocarbons in the marine environment. The sensitivity of seabirds has been examined by ranking multiple factors affecting their survival and to translate these values into so-called Oil Vulnerability Indices (IVIs). The first publication to systematically address this issue for seabirds was that by King & Sanger (1979), but others have followed. Anon. (2002) compared the various oil vulnerability indices and significant relationships between OVIs calculated for the same species in different parts of the world were found. For Mauritanian waters, and for the marine species utilising the NW African continental shelf and adjacent sea areas, a species-specific OVI still has to be developed. If, however, in the absence of region-specific analyses, NW European OVI values are deployed (see Camphuysen 1998, 2007b) in order to make a crude assessment of the presence or absence and overall densities of highly oil-sensitive species, the data would suggest that September is a relatively 'calm' period. Overall densities of seabirds were low, the offshore avifauna is dominated by terns, skuas, phalaropes and storm-petrels, all seabird species with a relatively low OVI in NW Europe (OVI 37-54 within a species spectrum ranging from 36-86 on a scale 0-100). Exposure to environmental impacts is different for some of the key wintering species in Africa (where they spend a long time) than it is in Europe (where they are passage migrants), and area-specific OVIs should be developed soon in order to quantify the potential risks more thoroughly. Species of prime concern with regard to oil pollution in September, given their population size, given their tendency to roost and sleep at sea, the aggregations that they form or given their restricted breeding range that they may have, are

- Cape Verde Shearwater [listed as Near Threatened given moderately small population and range size; http://www.birdlife.org/datazone/species/factsheet/30221]
- Pomarine Skua
- Sabine's Gull, and
- Red Phalarope

All species were relatively widespread (**Figs. 5.11, 5.17, 5.18**), but concentrations of phalaropes were observed within the upwelling zone, around 20°N (**Fig. 5.17**). Note that three species were listed as 'Least Concern' by Birdlife International given their "extremely large range", as a result of which these species do not approach the thresholds for Vulnerable under the range size criterion[2]. It is especially in winter that these birds tend to aggregate and concentrate in relatively small sea areas, where an oil-spill could easily impact a huge part of the biogeographical populations of these species.

6.5 Seasonality and species composition

The September 2015 surveys were an important step in our mission to obtain a better oversight of the seasonal changes in biodiversity in arguably one of the most important areas for seabirds and marine mammals in the world. By using a consistent and highly standardised census technique, comparisons can be made with similar surveys in contrasting periods of the year. Still more work has to be done to complete the circle and to collect sufficient data for a more comprehensive and advanced statistical analysis of the accumulated material.

A quick comparison of the species composition found per month as a result of 'similar surveys' shows not only that there are marked changes in the relative abundance of certain groups of seabirds, but also that these changes may go extremely fast. Some existing gaps are therefore more 'alarming' than others. For example, the month of February can be foreseen as an intermediate between the results of January and March, when we expect a gradual reduction in the numbers of Northern Gannets and Lesser Black-backed Gulls and a gradual (relative) increase in the number of skuas (**Fig. 6.7**). What happens in October, however, given the

[2] http://www.birdlife.org/datazone/species/factsheet/22694479, --factsheet/3065, and –factsheet/22694240

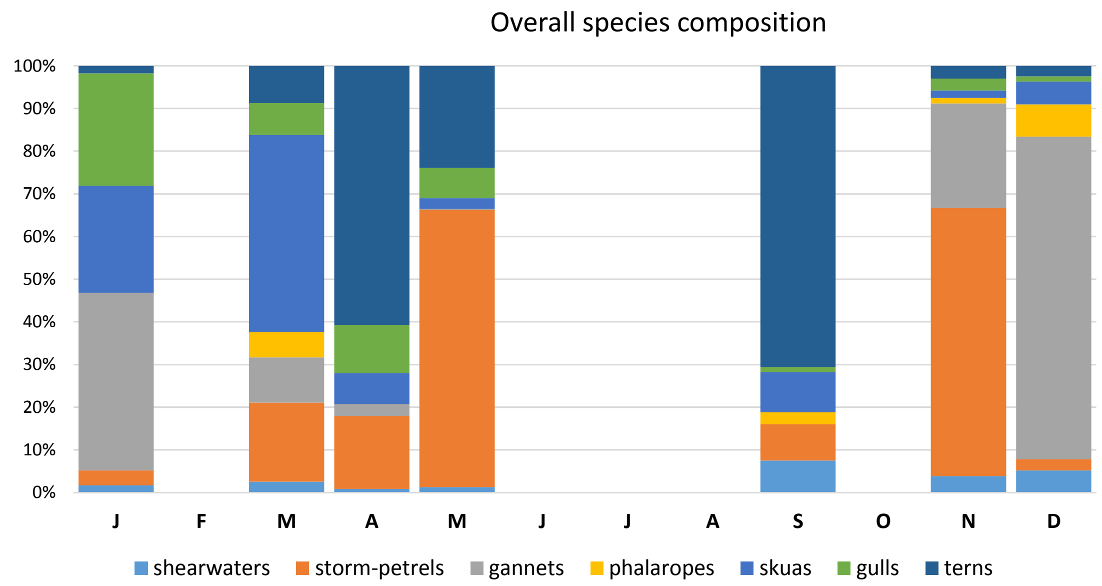


Fig. 6.7 Species composition (% of all individuals seen, ship-following individuals excluded from the analysis) from strip-transect surveys in Mauritanian waters (1988-2015; 16-22°N, <18°30'W)

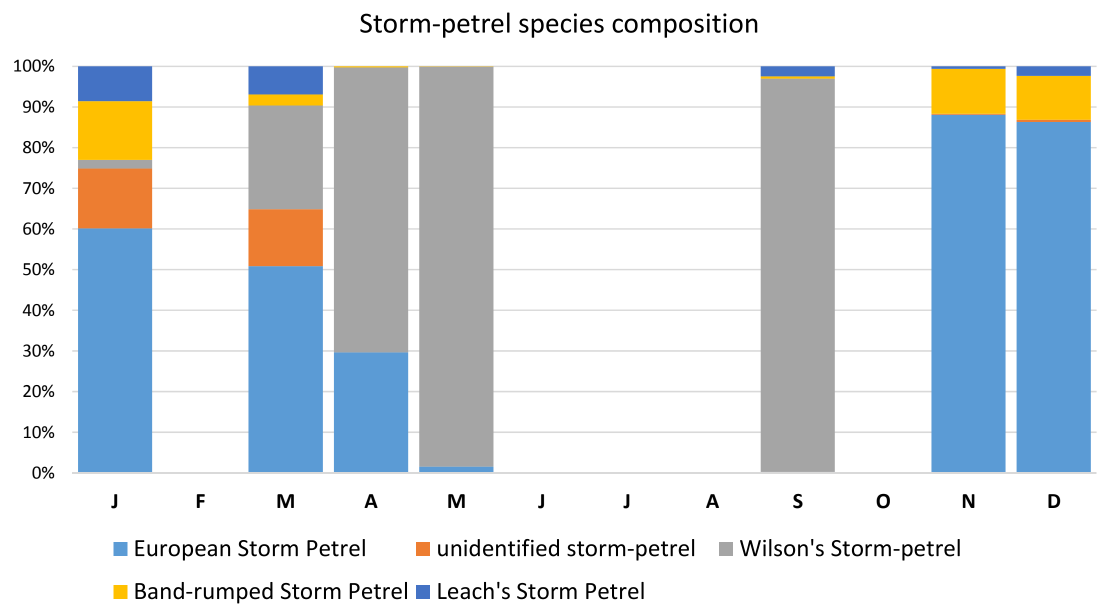


Fig. 6.8 Species composition in the storm-petrel family Hydrobatidae (% of all individuals seen, ship-following individuals excluded from the analysis) from strip-transect surveys in Mauritanian waters (1988-2015; 16-22°N, <18°30'W)

completely different species-spectra found in November (2012) and September (2015) respectively, is not easy to predict. A similar conclusion could be drawn from a more detailed comparison, in this case the species composition found in the storm-petrel family (Hydrobatidae; **Fig. 6.8**). A gradual shift in February could be foreseen, a predominance of Wilson's Storm-petrels (the Antarctic species) throughout summer may be expected (see also Wynn &. Krastel

2012), but the change that will have to occur in October would require urgent attention. It goes without saying that mid-summer surveys (for example in July) are another high priority for as far as seabirds are concerned.

For marine mammals, a similar overview would be premature, because not all surveys have covered each of the core habitats in sufficient detail. The large cetaceans (Blue Whales in particular) would require additional effort time in winter (Nov-Mar), whereas the smaller oceanic dolphins require more attention in the summer months, and these surveys should than most certainly include the off-shelf, deeper oceanic areas. An analysis of all data that have accumulated from MMO-observations on board seismic vessels would be useful to try and fill in gaps.

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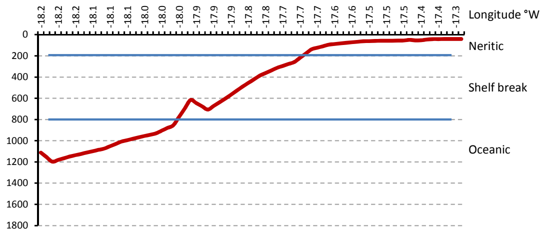
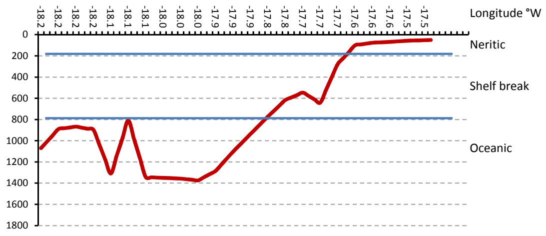
Appendix 1: Water depth profiles (m), legs A-Z, ZA and ZB, 4-14 Sep 2015

Leg A

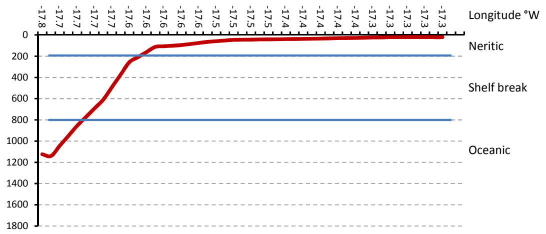


Leg B

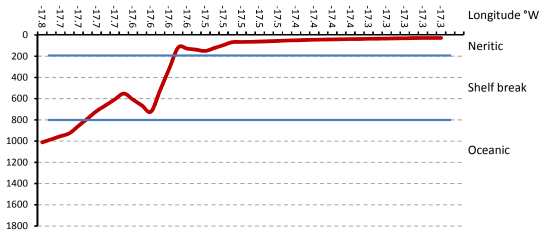


Leg	Dd	Mm	Yy	Counts	Hrs	Latitude		Longitude				Depth			Area		Distance		Speed	
A	4	Sep	2015	74	6.2h	20.5	°N	18.2	-	17.3	°W	41	1197	m	29.4	km^2	97.9	km	8.6	knots
B	4	Sep	2015	68	5.7h	20.4	°N	18.2	-	17.5	°W	50	1374	m	25.6	km^2	85.2	km	8.1	knots

Leg C

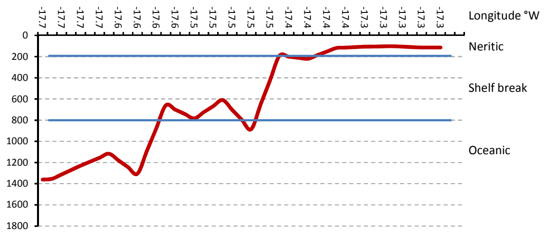


Leg D

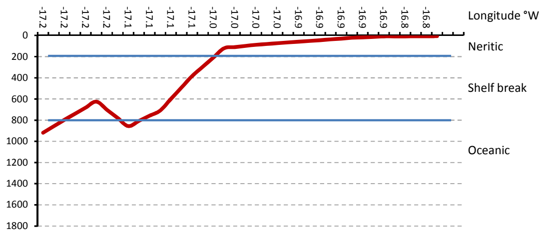


C	13	Sep	2015	47	3.9h	20.1	°N	17.8	-	17.3	°W	20	1140	m	16.0	km^2	53.3	km	7.3	knots
D	14	Sep	2015	45	3.8h	20.0	°N	17.8	-	17.3	°W	28	1011	m	15.7	km^2	52.2	km	7.5	knots

Leg E

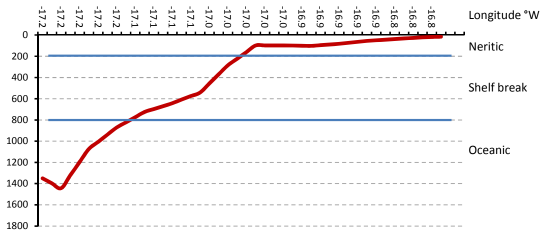


Leg F

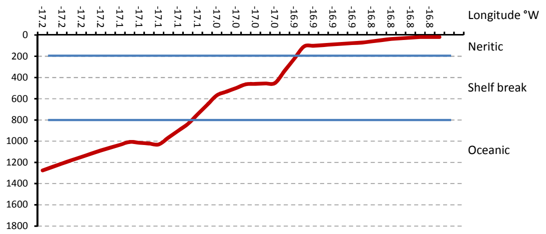


E	13	Sep	2015	43	3.6h	19.9	°N	17.7	-	17.3	°W	102	1361	m	15.7	km^2	52.2	km	7.9	knots
F	12	Sep	2015	38	3.2h	19.6	°N	17.2	-	16.8	°W	7	919	m	13.8	km^2	46.0	km	7.8	knots

Leg G

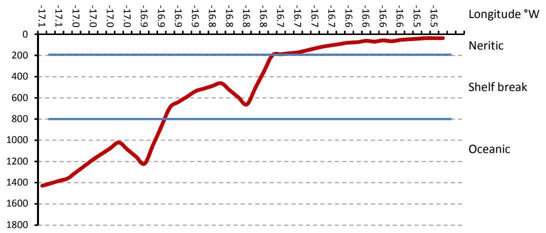


Leg H

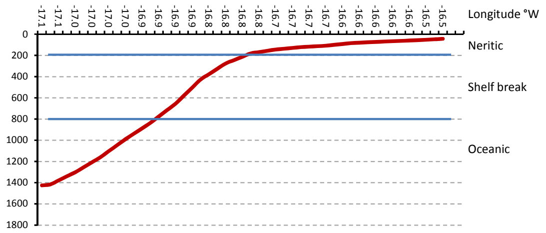


G	12	Sep	2015	44	3.7h	19.5	°N	17.2	-	16.8	°W	16	1443	m	15.0	km^2	49.9	km	7.4	knots
H	12	Sep	2015	42	3.5h	19.4	°N	17.2	-	16.8	°W	19	1275	m	15.7	km^2	52.5	km	8.1	knots

Leg I

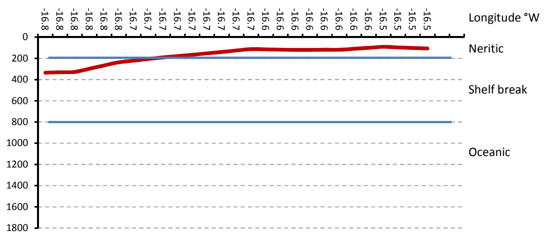


Leg J

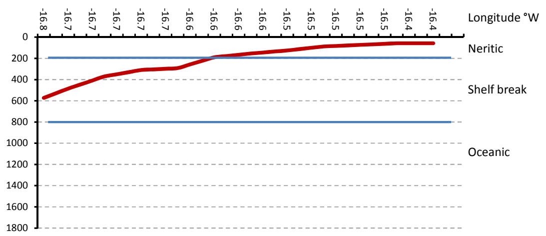


I	5	Sep	2015	48	4.0h	19.1	°N	17.1	-	16.5	°W	37	1429	m	18.8	km^2	62.7	km	8.5	knots
J	5	Sep	2015	49	4.1h	19.0	°N	17.1	-	16.5	°W	43	1425	m	18.4	km^2	61.3	km	8.1	knots

Leg K

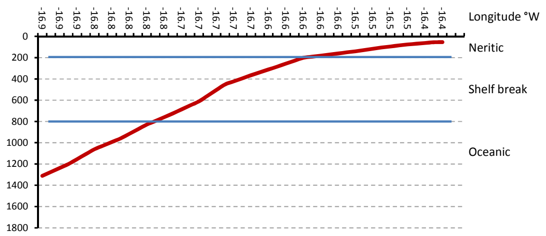


Leg L

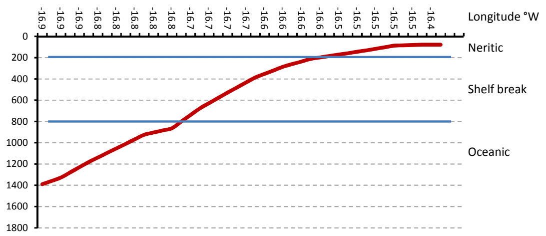


Leg	Dd	Mm	Yy	Counts	Hrs	Latitude		Longitude				Depth			Area		Distance		Speed	
K	5	Sep	2015	27	2.3h	18.9	°N	16.8	-	16.5	°W	91	335	m	10.1	km²	33.8	km	8.1	knots
L	11	Sep	2015	33	2.8h	18.6	°N	16.8	-	16.4	°W	58	573	m	11.5	km²	38.3	km	7.5	knots

Leg M

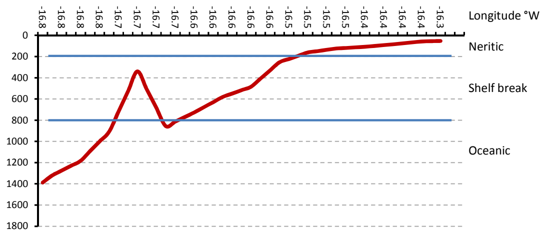


Leg N

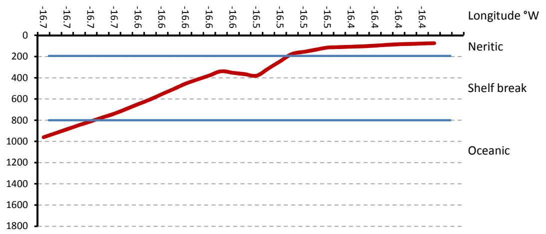


M	11	Sep	2015	47	3.9h	18.5	°N	16.9	-	16.4	°W	54	1311	m	15.8	km²	52.8	km	7.3	knots
N	11	Sep	2015	44	3.7h	18.4	°N	16.9	-	16.4	°W	78	1390	m	15.8	km²	52.8	km	7.8	knots

Leg O

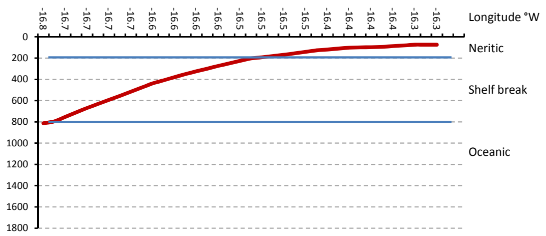


Leg P

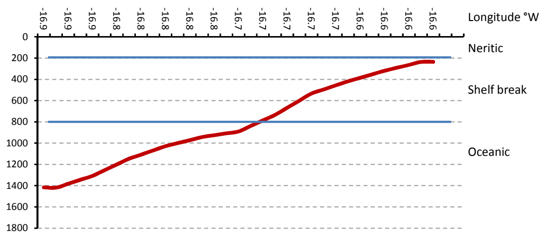


O	6	Sep	2015	43	3.6h	18.1	°N	16.8	-	16.3	°W	53	1388	m	16.3	km²	54.4	km	8.2	knots
P	6	Sep	2015	34	2.8h	18.0	°N	16.7	-	16.3	°W	74	960	m	13.2	km²	43.9	km	8.4	knots

Leg Q

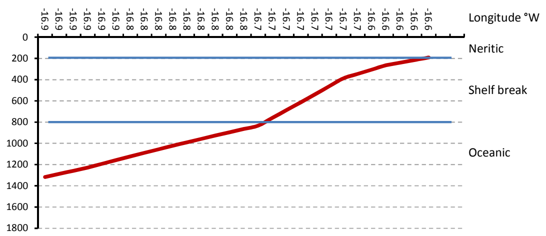


Leg R

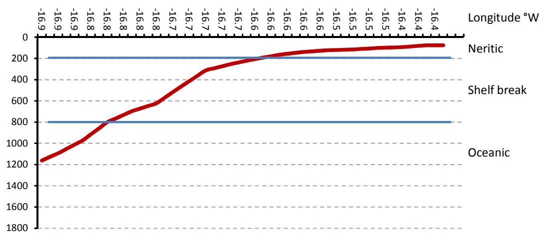


Q	6	Sep	2015	37	3.1h	17.9	°N	16.8	-	16.3	°W	74	813	m	14.1	km²	47.0	km	8.2	knots
R	10	Sep	2015	33	2.8h	17.6	°N	16.9	-	16.6	°W	235	1419	m	11.0	km²	36.7	km	7.2	knots

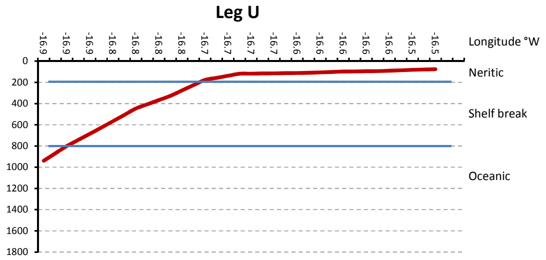
Leg S

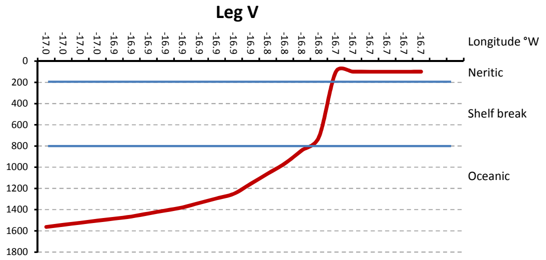


Leg T

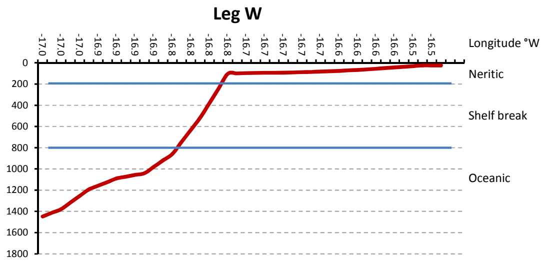


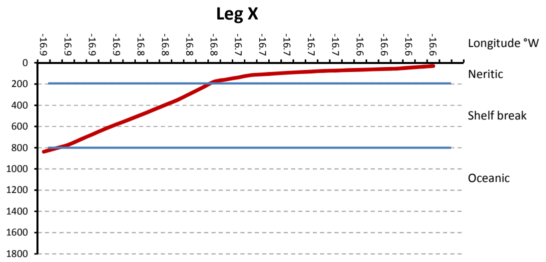
S	10	Sep	2015	28	2.3h	17.5	°N	16.9	-	16.6	°W	191	1317	m	10.9	km²	36.2	km	8.4	knots
T	10	Sep	2015	50	4.2h	17.4	°N	16.9	-	16.4	°W	76	1162	m	16.9	km²	56.4	km	7.3	knots



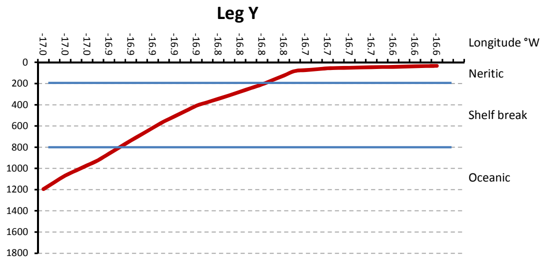


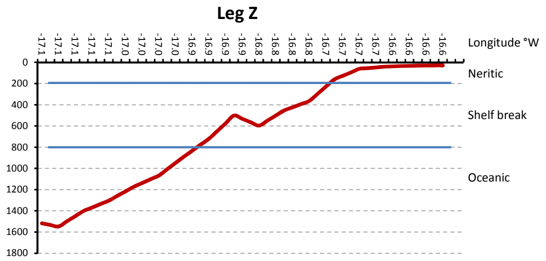
Leg	Dd	Mm	Yy	Counts	Hrs	Latitude		Longitude				Depth			Area		Distance		Speed	
U	7	Sep	2015	35	2.9h	17.1	°N	16.9	-	16.5	°W	76	939	m	13.3	km²	44.4	km	8.2	knots
V	7	Sep	2015	23	1.9h	17.0	°N	17.0	-	16.7	°W	99	1563	m	8.3	km²	27.7	km	7.8	knots



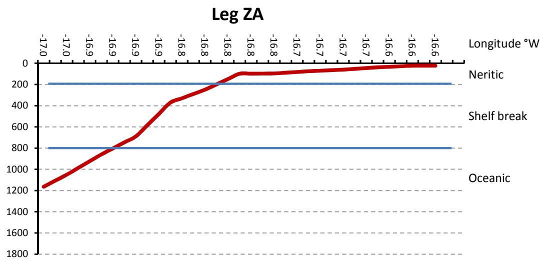


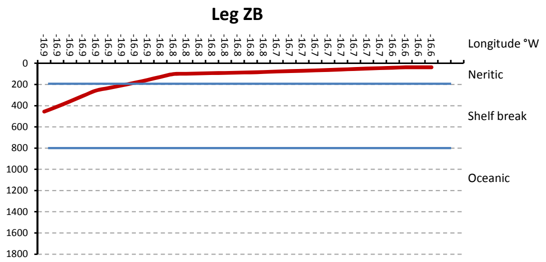
W	7	Sep	2015	44	3.7h	16.9	°N	17.0	-	16.5	°W	25	1448	m	16.3	km²	54.4	km	8.0	knots
X	9	Sep	2015	33	2.8h	16.8	°N	16.9	-	16.6	°W	30	838	m	12.4	km²	41.3	km	8.1	knots





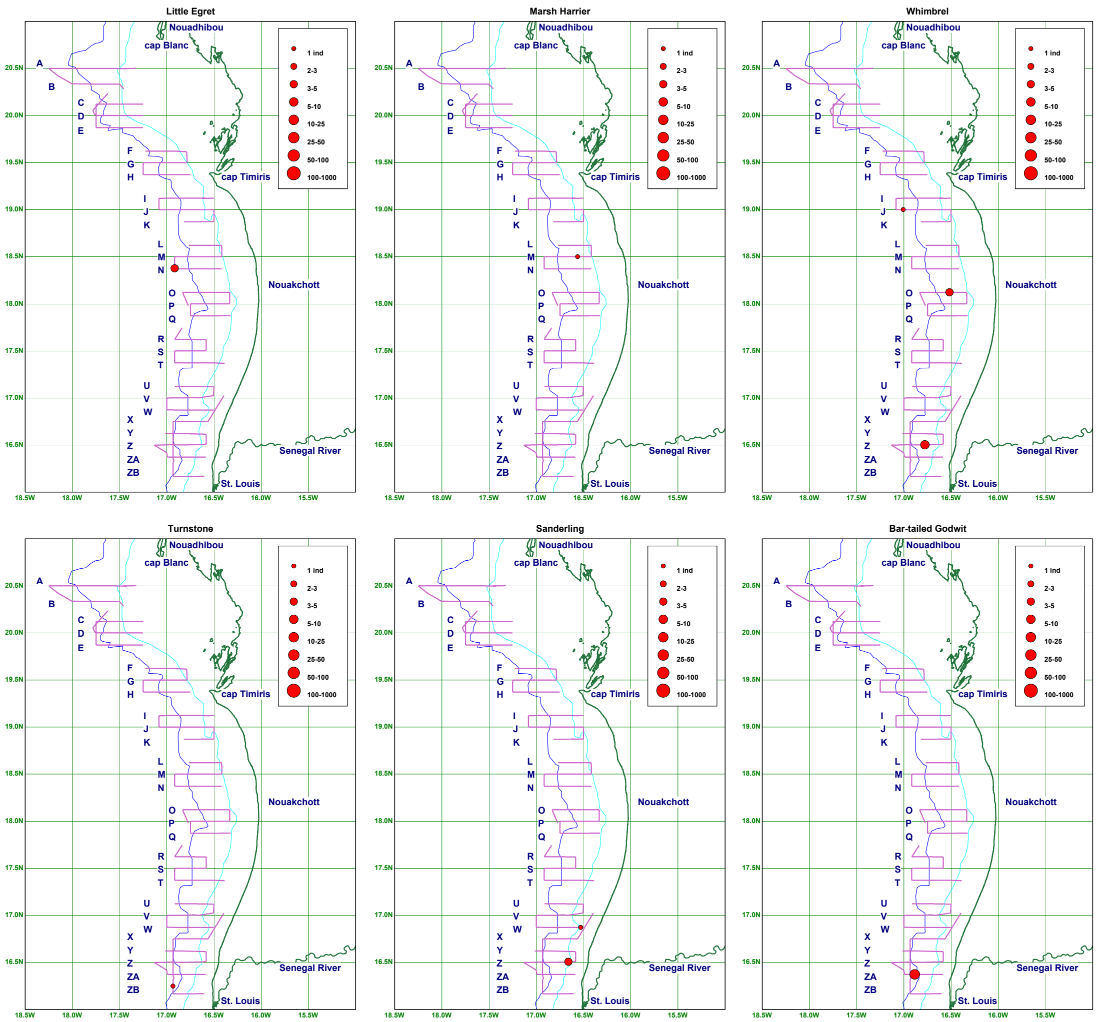
Y	8	Sep	2015	37	3.1h	16.6	°N	17.0	-	16.6	°W	33	1195	m	13.8	km²	46.1	km	8.1	knots
Z	8	Sep	2015	49	4.1h	16.5	°N	17.1	-	16.6	°W	29	1547	m	18.2	km²	60.7	km	8.0	knots





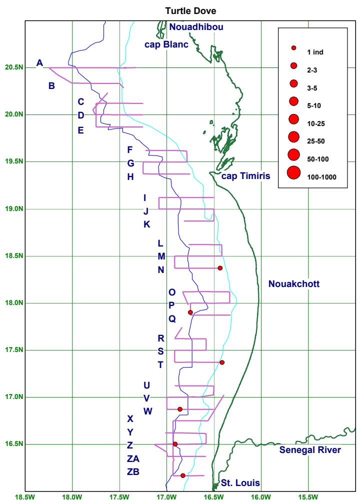
ZA	8	Sep	2015	35	2.9h	16.4	°N	17.0	-	16.6	°W	23	1164	m	13.2	km²	43.9	km	8.1	knots
ZB	9	Sep	2015	31	2.6h	16.2	°N	16.9	-	16.6	°W	38	455	m	11.0	km²	36.6	km	7.7	knots

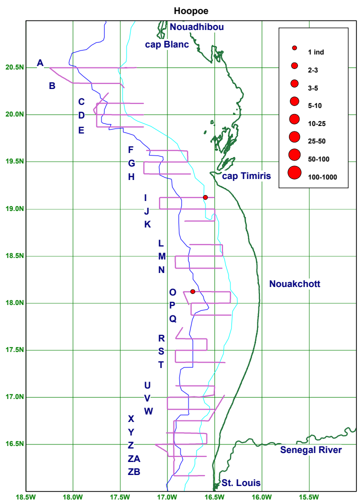
Appendix 2: Terrestrial and intertidal birds (migratory non-seabirds)



Sightings of herons, raptors and migratory shorebirds off the Mauritanian coast, 4-14 Sep 2015.

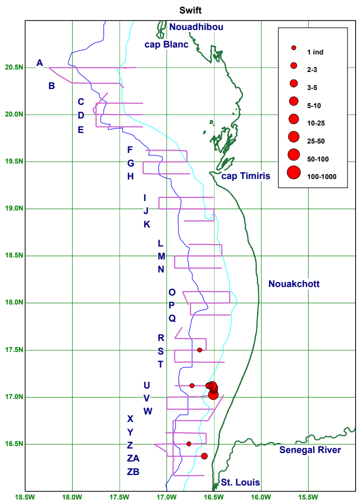
Little Egret	Aigrette garzette	*Egretta garzetta*	5
Western Marsh Harrier	Busard des Roseaux	*Circus aeruginosus*	1
			1
Bar-tailed Godwit	Barge rousse	*Limosa lapponica*	8
			1
Whimbrel	Courli corlieu	*Numenius phaeopus*	2
Ruddy Turnstone	Tournepierre a collier	*Arenaria interpres*	1
Sanderling	Becasseau sanderling	*Calidris alba*	4

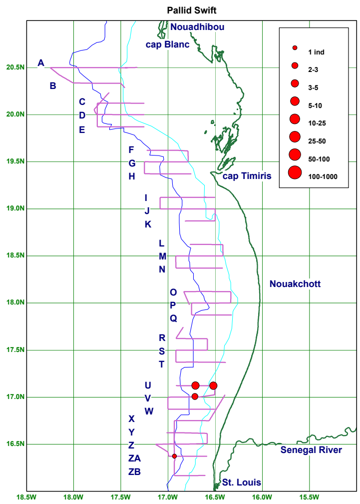


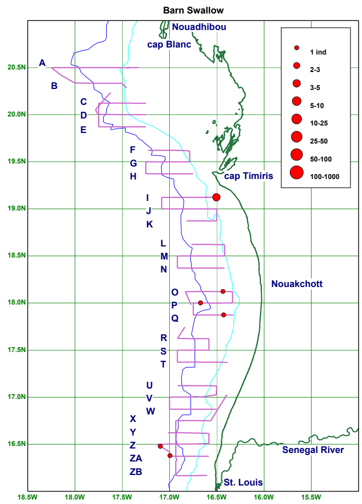


Eurasian Hoopoe (CJC)

Sightings of pigeons and hoopoes off the Mauritanian coast, 4-14 Sep 2015.



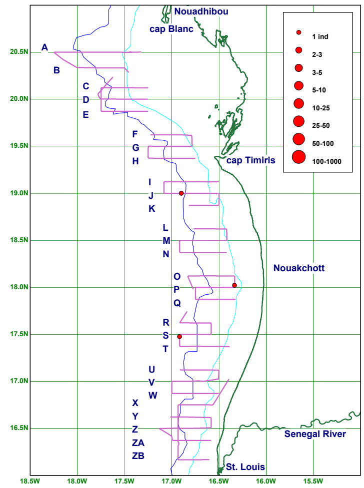




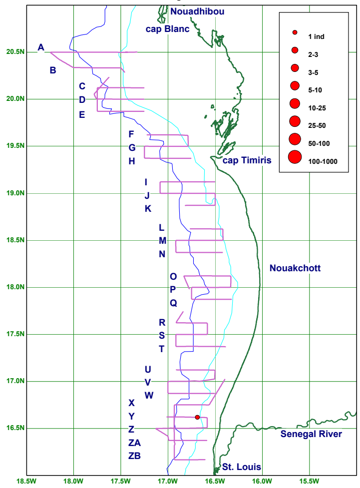
Sightings of doves, hoopoes, swifts and swallows off the Mauritanian coast, 4-14 Sep 2015.

European Turtle Dove	Tourterelle des bois	*Streptopelia turtur*	6
Common Swift	Martinet noir	*Apus apus*	43
Pallid Swift	Martinet pale	*Apus pallidus*	12
Eurasian Hoopoe	Huppe fasciee	*Upupa epops*	2
Barn Swallow	Hirondelle rustique	*Hirundo rustica*	8

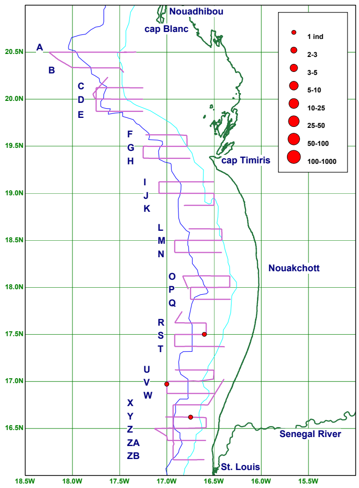
Willow Warbler



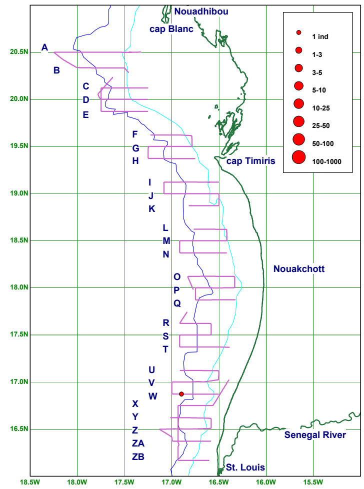
Sedge Warbler



Reed Warbler

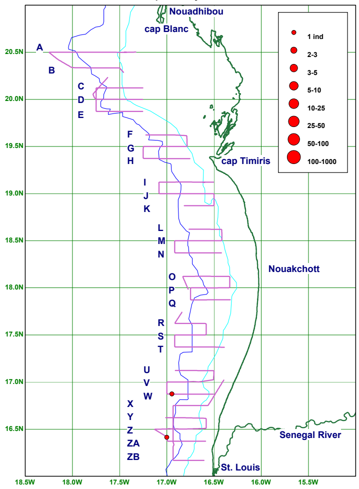


Rufous Scrub-Robin

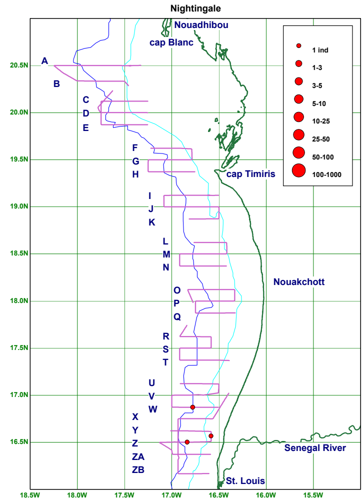


Rufous-tailed Scrub-Robin (HV)

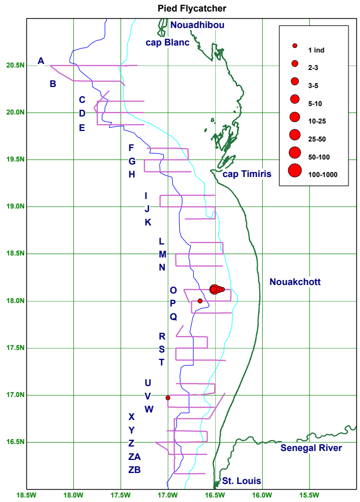
Spotted Flycatcher



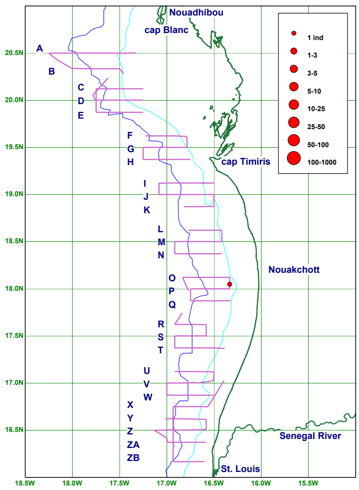
Nightingale



Pied Flycatcher



Redstart



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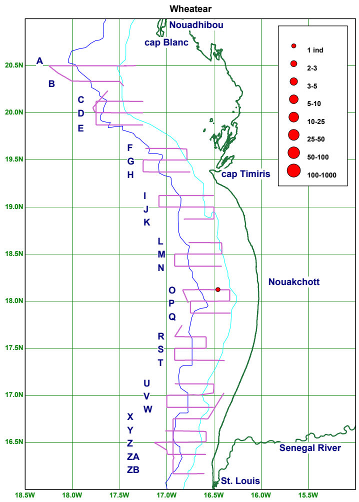

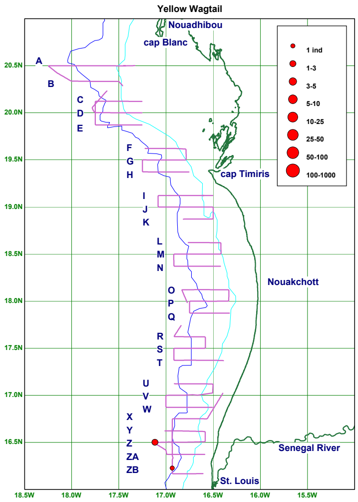

Yellow Wagtail (CJC)

Sightings of thrushes, warblers and flycatchers, wagtails and wheatears off the Mauritanian coast, 4-14 Sep 2015.

Willow Warbler	Pouillot fitis	*Phylloscopus trochilus*	3
Sedge Warbler	Phragmite des joncs	*Acrocephalus schoenobaenus*	1
Eurasian Reed Warbler	Rousserolle effarvatte	*Acrocephalus scirpaceus*	3
Rufous-tailed Scrub Robin	Agrobate roux	*Cercotrichas galactotes*	1
Spotted Flycatcher	Gobemouche gris	*Muscicapa striata*	2
Common Nightingale	Rossignol philomele	*Luscinia megarhynchos*	3
Pied Flycatcher	Gobemouche moir	*Ficedula hypoleuca*	24
Common Redstart	Rougequeue a front blanc	*Phoenicurus phoenicurus*	1
Northern Wheatear	Traquet motteux	*Oenanthe oenanthe*	1
Western Yellow Wagtail	Bergeronette printaniere	*Motacilla flava*	3

Contents