A survey of the Atlantic humpback dolphin (*Sousa teuszii*) in the Saloum Delta Biosphere Reserve, Senegal, 21 October to 7 November 2015

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1. INTRODUCTION

1.1. Background

Cetacean research in West Africa (Mauritania to Nigeria) is still in its infancy with relatively little scientific survey work being carried out in the region. Senegal has one of the better-documented cetacean faunas, due predominantly to the work of French scientists such as Cadenat, Dupuy and Maigret who published information on stranded and captured specimens (and some sightings) in the 1950s to the 1970s. However, recent information remains scarce. At least 13 delphinid species have been recorded from Senegalese waters (Table 1), with several additional species (e.g. false killer whale *Pseudorca crassidens*, Risso's dolphin *Grampus griseus*, and pantropical spotted dolphin *Stenella attenuata*) also expected to occur but currently unconfirmed.

Table 1. Summary of the delphinid species documented in Senegalese waters.

English name	Scientific name	Example References
Killer whale	*Orcinus orca*	Cadenat, 1957, 1959; Dupuy and Maigret, 1976; Maigret, 1990
Short-finned pilot whale	*Globicephala macrorhynchus*	Cadenat, 1957, 1959; Dupuy and Maigret, 1976, 1982
Melon-headed whale	*Peponocephala electra*	van Bree and Cadenat, 1968
Pygmy killer whale	*Feresa attenuata*	Cadenat, 1958; Fraser, 1960
Atlantic humpback dolphin	*Sousa teuszii*	Cadenat, 1959; Maigret, 1980; Van Waerebeek et al., 2004
Rough-toothed dolphin	*Steno bredanensis*	Cadenat, 1959; Dupuy and Maigret, 1976
Bottlenose dolphin	*Tursiops truncatus*	Cadenat, 1959; Dupuy and Maigret, 1976; Van Waerebeek et al., 2000
Atlantic spotted dolphin	*Stenella frontalis*	Dupuy and Maigret, 1976
Spinner dolphin	*Stenella longirostris*	Cadenat, 1959
Clymene dolphin	*Stenella clymene*	Cadenat, 1959; Weir et al., 2014
Striped dolphin	*Stenella coeruleoalba*	Van Waerebeek et al., 2000
Common dolphin	*Delphinus* sp.	Cadenat, 1959
Fraser's dolphin	*Lagenodelphis hosei*	Van Waerebeek et al., 2000

Of the species listed in Table 1, most inhabit deep, oceanic waters far from the coast. The killer whale (*Orcinus orca*), the bottlenose dolphin (*Tursiops truncatus*) and the common dolphin (*Delphinus* sp.) are more cosmopolitan in their habitat requirements and can occur from the coast to oceanic waters. However, one species, the Atlantic humpback dolphin (*Sousa teuszii*), inhabits only nearshore waters in water depths typically less than 20 m (Weir and Collins, 2015). This species therefore has a restricted habitat requirement and its overall abundance across its geographic range (Western Sahara south to Angola; Weir and Collins, 2015) seems to be low. These factors, together with evidence of mortality of the species in artisanal fisheries (both directed and unintentional takes: Van Waerebeek et al., 2004), have led to increasing concern over the conservation status of *Sousa teuszii* (Van Waerebeek et al., 2004; Weir et al., 2011). It is currently listed as 'vulnerable' by the International Union for

Conservation of Nature (IUCN), although this status is currently under review by the IUCN Cetacean Specialist Group and may soon be revised.

Senegal has an important history with regard to *Sousa teuszii*. The type specimen for the species originated from Cameroon in 1892, with only the skull being described. Over 50 years passed before the next record of the species, when the skull was acquired of a dolphin caught in nets off M'bour in Senegal during 1943 (Fraser, 1949; Cadenat, 1956). The vast majority of subsequent records of the species were from bycatch and captured specimens landed at Joal and M'Bour (e.g. Cadenat, 1947, 1949, 1956, 1957, 1959; Fraser, 1949; Cadenat and Paraiso, 1957; van Bree and Duguy, 1965), including the first full fresh specimen of the species in 1955 which was described by Cadenat (1956). A number of skulls from these early specimens are stored at the IFAN museum in Dakar (Van Waerebeek et al., 2000). The first extensive information on at-sea sightings of *Sousa teuszii* anywhere in its range also originated from Senegal, with sightings particularly concentrated around the Saloum Delta (Cadenat 1959; Dupuy and Maigret, 1976; Maigret, 1980; Dupuy, 1983; Van Waerebeek et al., 2004), where Cadenat (1959) considered it to be abundant. Dupuy (1983) and Maigret (1980) also reported a regular occurrence of the species in the Saloum Delta. In an overview of incidental records from the Saloum Delta, Maigret (1980) published the first consideration of the ecology of *Sousa teuszii*, including group size, behaviour, population size and movements. He guessed that there were no more than 100 individuals inhabiting the Saloum Delta.

In a recent compilation of all available published and unpublished records, Weir and Collins (2015) located 76 by-catch, capture, specimen and sighting records (those with a specific position, date and group size) for Senegalese waters, of which the clear majority originated from the southern portion of the Saloum Delta from Île des Oiseaux to Djinack.

Despite the relatively extensive history of *Sousa teuszii* records in Senegal, there has never been a systematic scientific sighting survey of the species in the region. Consequently, knowledge of the distribution and ecology of the species in the Saloum Delta has been limited to interpretation of the infrequent opportunistic records.

This report describes the results of a baseline scientific study carried out in the Saloum Delta Biosphere Reserve (SDBR) during October and November 2015 to assess the occurrence of dolphin species in the region. The study was sponsored and carried out by Sylvatrop Consulting, in partnership with the Direction des Parcs Nationaux (DPN) and the Direction des Aires Marines Communautaire Protégées (DAMCP).

1.2. Objectives

The overall objective of the initial study was to obtain a broad overview of dolphin occurrence in the SDBR. The three specific objectives were:

1. To collect data on the spatial distribution of dolphin species (particularly *Sousa teuszii*) within the SDBR, especially regarding their use of coastal waters versus waterways. Establishing the occurrence of dolphins within the waterways was of particular interest, due to the confined spatial nature of those environments and the initiation of commercial construction and dredging projects in some upstream areas.

2. To calculate the relative abundance (i.e. the number of individuals encountered per kilometre of survey effort) of dolphin species within the study area, to identify hotspots of occurrence.
3. To trial the use of non-intensive photo-identification methods within the SDBR in order to collect information on the minimum number of individuals inhabiting the area.

Completion of these objectives would: (1) provide a baseline dataset against which future trends in distribution and relative abundance could be monitored; and (2) form the basis for the future development of more focussed surveys aimed at establishing population size and habitat use.

2. METHODS

2.1. Study area

The study area comprised the Saloum Delta Biosphere Reserve (SDBR) which also encompasses a National Park and Ramsar Site (the Parc National du Delta du Saloum). The northern limit of the SDBR is approximately 4 km south of Joal-Fadiouth, while the southern limit is at the border with Gambia (13.59°) where it is contiguous with Niumi National Park (Figures 1 and 2). The south-western corner is approximately 24 km from the mainland coast. The total linear length (north to south) of the SDBR is approximately 60 km, including 72.5 km of Atlantic coastline and stretching over 35 km inland.

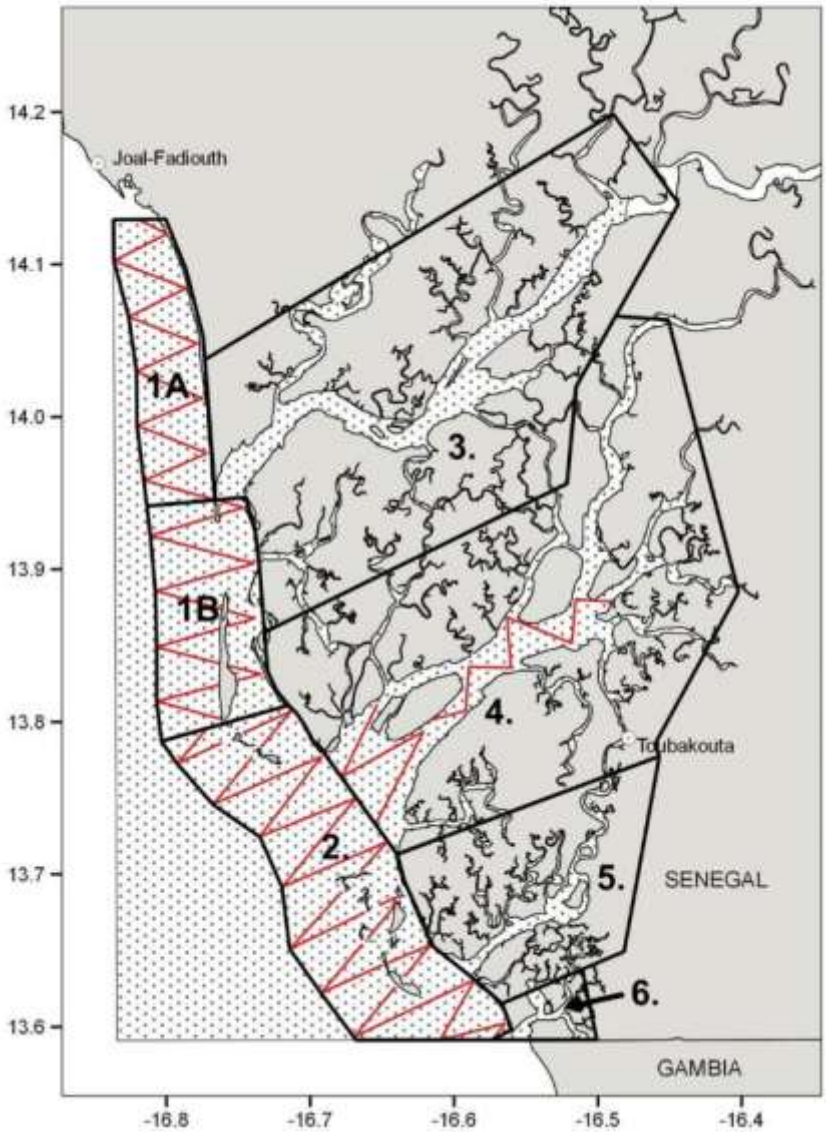
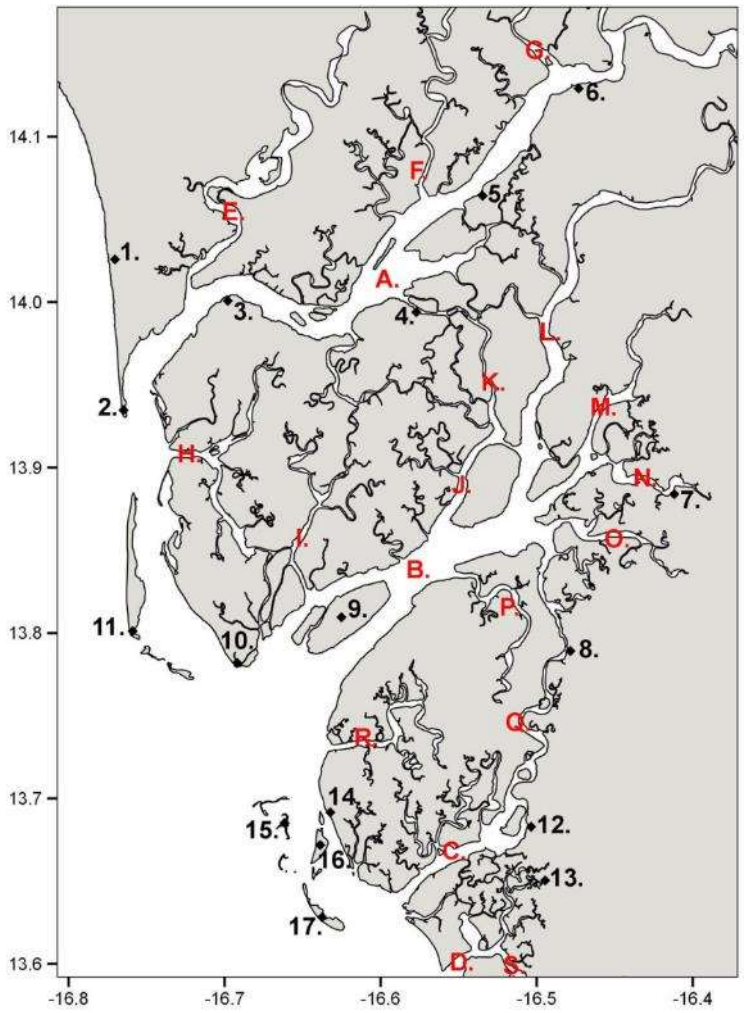


Figure 1. The Saloum Delta Biosphere Reserve (dotted area), showing the location of the six survey zones (black) and dolphin transects (red).

Places:



1. Palmarin
2. Djiffer
3. Palgan
4. Fellan
5. Rofange
6. Foundiougne
7. Fandion
8. Toubacouta
9. Île de Poutaké
10. Pointe Jackonsa
11. Pointe de Sangomar
12. Missirah
13. Bagadadji
14. Bétenti
15. Île de Diamanio
16. Île aux Bœufs
17. Île des Oiseaux

Waterways:

A. Saloum
B. Diomboss
C. Bandiala
D. Djinack
E. Marigot de Ndangane
F. Marigot de Faoye
G. Khabak
H. Bolon Gokehor
I. Bolon Diogane
J. Bolon Labor
K. Bolon Sangako
L. Diomboss river (upper)
M. Bolon Irragago
N. Bolon Sokone
O. Bolon de Sangako
P. Bamboung Bolong
Q. Bandiala river (upper)
R. Bolon Soukoto
S. Bolon Mansarinko

Figure 2. The Saloum Delta study area, showing the location of place names and major waterways mentioned in this report.

The SDBR incorporates an area of 180,000 ha, of which 95,000 ha is water (marine, rivers or inundated areas, 30,000 ha of which is intertidal) and 85,000 ha is terrestrial savannah or forest (including the mainland and islands). It comprises a variety of habitats including marine areas, islands, intertidal sand and mud flats, sandy coast, sandbars, savannah, tropical dry and deciduous forest, and extensive estuarine habitat characterised by mangrove dominated by *Rhizophora racemosa*, *R. mangle*, *R. harrisonii* and *Avicennia nitida*.

The Saloum Delta comprises four main branches; the Saloum, Diomboss, Bandiala and Djinack (from north to south). The Saloum and the Diomboss are extensive, both extending over 40 km inland from the coast and being over 1 km wide in places. The lower Diomboss has two arms, separated by the Île de Poutaké and there are large areas of shallow sandbank and sea grass extending from its mouth and out to sea. The Bandiala and the Djinack are much smaller in spatial extent, and their mouths comprise a system of narrow navigable channels bordered by sandbars. Throughout the region there is a complex network of seawater mangrove creeks or ‘bolongs’, many of which are interconnected. Several major channels connect different branches of the Saloum Delta, for example the Bolon Sangako which extends between the Saloum and the Diomboss, and the upper Bandiala River which extends between the Diomboss and the Bandiala. While tidal in nature, these channels are navigable by pirogue at all but the lowest tides and can be passed through by dolphins.

The Saloum is the most developed of the four branches, having a commercial shipping lane (marked by navigational buoys) upstream to at least Foundiougne (Figure 3) and with a ferry crossing at Foundiougne operating continuously throughout the day. The centre of the Saloum (from 14°02.714'N 16°34.054'W to 14°00.074'N 16°40.398'W) has very high densities of crevette fishing.

Figure 3. Large vessels transit through the Saloum River like this salt container on 24 October.

The coastal habitat comprises sandbars, sandbanks and low-lying islands that change in extent over time according to water currents, storms and sea level. In 1987 the Sangomar sandbar was breached by strong waves, resulting in a new sea channel between Djiffer and the Pointe de Sangomar. In the southern part of the SDBR between Bétenti and Djinack the seabed is particularly shallow-sloping and a complex system of tidal sand flats and sandbars create a dynamic and tidally-variable habitat.

The Saloum Delta has an extended dry season and a short rainy season from July to October. The rainfall has decreased since the 1920s, and combined with high evaporation and the shallow slope of the estuary, the Saloum Delta has an inverse salinity gradient (range 36–140) and is hypersaline, with the salinity in the upstream areas being far higher than that in coastal waters (Pagès and Citeau, 1990; Ecoutin et al., 2010). Water temperatures are in the region of 23 to 30°C depending on season and location (Ecoutin et al., 2010).

The SDBR supports a diverse estuarine fish assemblage, including species of both marine and freshwater origin. During sampling throughout the Saloum Delta carried out by Simier et al. (2004), sardines (*Sardinella maderensis)* represented 69.4% of the total numbers and nearly 52% of the total biomass, followed by Bonga shad (*Ethmalosa fimbriata*) (11.5% of the abundance, 9.5% of the biomass) and *Ilisha Africana* (5.2% of the abundance and 3.1% of the biomass). The biomass of some inner areas such as the Bamboung Bolong is dominated by locally-reproducing species in particular the mullets (e.g. *Liza falcipinnis*), *Ethmalosa fimbriata* and the tilapines (e.g. *Sarotherodon melanotheron*) (Brochier et al., 2013).

Fishing activities in the Saloum Delta are very intense, practiced by full-time or seasonal professional fishermen, and by occasional fishermen (Ecoutin et al., 2010). Fishing activity increased by 50% from the 1990s to the early 2000s, linked with a considerable increase in fishing effort (number of fishermen, canoes, and fishing gear) (Ecoutin et al., 2010). A

significant (40%) reduction in total fish biomass occurred over the same period, suggesting that fish catches are no longer sustainable.

One Marine Protected Area (MPA) is situated within the Diomboss delta. The Bamboung Bolong is a mangrove area designated as a MPA in 2003, at which time it was closed to fishing. An increase in large predatory fish has been observed within the MPA since the fishery closure, and there has also been a spill-over of fish into adjacent non-protected waters estimated at 11 tons (~33% of the fish biomass) (Brochier et al., 2013).

2.2. Survey coverage

The survey coverage was planned to: (1) cover as much of the SDBR spatially as was feasible (i.e. within the logistical constraints); (2) be repeatable during future monitoring surveys; and (3) achieve representative coverage in terms of habitat (i.e. sampling different habitat types, water depths and distances from shore). Due to safety constraints with the boat available for the survey, the extent of the coastal survey coverage was limited to approximately ~5 km from land (mainland or outlying islands).

Given the very different topography and habitat characteristics in coastal waters, rivers and bolongs, the study area was split into six zones (Table 2; Figure 1). Zone 1 was further split into two sub-zones in recognition of the slightly different habitats occurring along the northern coast.

Table 2. Description of the six study area zones (and sub-zones) defined for the dolphin study in the Saloum Delta Biosphere Reserve (SDBR).

Zone	Area	Habitat type
1	Northern limit of the SDBR to Pointe de Sangomar; coast running north-south	Coast and outer Saloum estuary
1a	*Petite Côte from Joal-Fadiouth to Djiffer*	*Coast*
1b	*Djiffer to Pointe de Sangomar*	*Coast and outer Saloum*
2	Pointe de Sangomar to the southern limit of the SDBR; coast running north-west to south-east	Coast and outer Diomboss
3	Saloum system	Rivers and bolongs
4	Diomboss system	Rivers and bolongs
5	Bandiala system	Rivers and bolongs
6	Djinack system	Rivers and bolongs

Due to the very different environments, the dolphin surveys in the coastal zones (Zones 1 and 2) were planned differently from those in the rivers and bolongs (Zones 3 to 6) in accordance with published guidance (see Dawson et al., 2008).

A zigzag pattern of predetermined transect lines was used to attempt to equalise the survey coverage in coastal waters (Zones 1 and 2; Figure 1). Since the density gradient of *Sousa* dolphins in other geographic coastal regions is usually perpendicular to the shoreline (Chen et al., 2008), the transect lines were placed along the coast and therefore were at slightly different angles in Zone 1 (north to south coast) compared to Zone 2 (north-west to south-east coast). In accordance with other *Sousa* dolphin studies, the spacing between the apex of the transects was approximately 4 km (Chen et al., 2010, 2011). While pre-determined, it was accepted that the transect lines may have to be adapted in the field according to the conditions encountered (e.g. navigating around tidal sandbanks). Additional coastal coverage,

particularly close to the shoreline where it was expected that *Sousa teuszii* might most regularly occur (e.g. Weir, 2009, 2015), was achieved whenever possible while transiting to and from the transects.

A more flexible survey approach had to be adopted for waterways (Zones 3 to 6), which by their nature were sinuous, tidal and had sandbanks. Although problematic to survey efficiently, investigating the occurrence of dolphins within the waterways was of importance since sightings (unknown species) have been reported as far upstream as Foundiougne (Maigret, 1980; Van Waerebeek et al., 2000) and Toubacouta (Maigret, 1980). The four main estuary systems and associated major branches were surveyed upstream until they became less than ~200 m wide. Where waterways were less than 2 km width, it was planned that the boat would travel upstream along one bank and downstream along the opposite bank, at distances of ≤500 m from the shoreline. However, in practice it was usually the case that one side of the river was much shallower than the other and it was not possible to implement this approach. Consequently, the boat often travelled upstream and downstream along a similar route. In the central and outer Diomboss where the waterways exceeded 2 km width, predetermined zigzag transects were followed where conditions allowed (shallow sandbanks impacted some transects).

2.3. Survey methods

2.3.1. Survey team

Three personnel were present on the boat on every single day of the survey:

1. A marine mammal scientist, Caroline Weir, who has specialist knowledge of cetacean surveys and species field identification, and particular expertise with *Sousa teuszii*;
2. A boat captain, Maurice Faye, highly experienced at navigating around the Saloum Delta and fluent in French and Wolof;
3. A multi-lingual assistant, El Hadji Malick Dia, who provided translation skills between French and English. Malick also assisted with the GPS navigation and many general logistics related to the survey.

Additionally, the survey team was joined for temporary periods by:

1. A drone pilot, Jean-Sébastien Fauchet, from 21 October to 1 November inclusive. Jean-Sébastien also assisted with the GPS navigation and many general logistics related to the survey.
2. Staff and ecoguards of the Direction des Parcs Nationaux (DPN) and the Direction des Aires Marines Communautaire Protégées (DAMCP). Between one and three personnel from the DPN or DAMCP joined the boat daily during surveys from Palmarin, Toubacouta and Bagadadji. While most individuals attended for a single day, Lieutenant Fode Cissokho (Toubacouta), Lieutenant Moussa Samb (Bacadadji) and ecoguard Adama Lene (Missarah) each attended for three survey days.
3. Yoann Mutone from Sylvatrop on 28 October and 6 November.

2.3.2. Survey methodology

Boat surveys were carried out on 18 consecutive days between 21 October and 7 November (just after the end of the rainy season). A 7.25 m boat with a 40 horsepower outboard engine provided by the DAMCP was used to carry out the surveys (Figure 4). The boat had low eye height (~1.5 m when standing) and was very exposed to the weather. Survey speeds of between 11 and 20 km/hr (6 to 10.7 knots) were maintained during the search effort.

Figure 4. The boat used to carry out the dolphin surveys.

Visual search effort was restricted to daylight hours. A single experienced cetacean observer (CW) scanned the area ahead of the bow (defined as 0°) between 270° and 90° continuously with the naked eye and 10x42 binoculars whenever the survey was underway. All other members of the survey team assisted with looking for dolphins and were asked to report any possible sightings.

During each survey, a Garmin GPSMAP 76CSx was used to log the position and time at 1-min intervals. Weather conditions (Beaufort sea state, swell height and sun glare) were recorded at the commencement of the survey and whenever they changed. Survey effort was continuously logged as either: (1) Search Effort, whenever dedicated boat-based searches were underway for dolphins; (2) Encounter Effort, when dolphins had been detected and the boat approached animals for photo-identification, group size estimation and behavioural observations; or (3) Off-Effort, when efforts to find or follow dolphins had ceased.

Whenever dolphins were observed the Search Effort ceased immediately and the survey switched to Encounter Effort. Standardised information was recorded including date, time, initial distance and angle to the sighting, position, group size and behaviour. As soon as most individuals in the group had been photographed (or due to logistical constraints or changes in animal behaviour) then the encounter was terminated and the Search Effort resumed.

2.3.3. Dolphin photo-identification

Whenever dolphins were encountered in the field, effort was made to photograph the dorsal fins of as many animals as possible. This technique, known as photo-identification, allows for the identification of individual animals via features including the distinctive patterns of markings along the trailing edge of the fin, scars, pigmentation and fin shape (see Würsig and Jefferson, 1990). For the purposes of this baseline study, the objectives of the photo-identification work were to:

1. Trial the technique on the population of dolphins inhabiting the Saloum Delta (i.e. to determine whether individuals were sufficiently well-marked and approachable for photo-identification to represent a viable survey method for future monitoring).
2. Provide a minimum estimate of the number of animals occurring within the Saloum Delta.
3. Provide an initial investigation of dolphin movements and group stability within the study area via any re-sightings of individual animals.

During photo-identification, the intention was to approach dolphin groups slowly from the side and take images of the dorsal fins when animals were parallel (i.e. side-on) with the boat whenever possible using a Canon 5D Mark III SLR camera and a 100–400 mm lens. *Sousa teuszii* is generally considered to be a sensitive species, and therefore a non-intensive approach was used, whereby effort was made to try and sample different dolphins within the group but the approaches were stopped if dolphins exhibited consistent signs of disturbance. Although this method cannot be certain to photographically-capture every animal in the group (because individuals are not systematically targeted and approached), it was felt (based on previous work with *Sousa teuszii* in Angola and Guinea: Weir, 2009, 2015) that it was the most appropriate method for working with this species without causing overt avoidance.

Where possible (if dolphins remained in a small spatial area), the engine was switched off and photos taken while the boat drifted. However, this was not feasible along the coast (due to the danger from currents and sandbanks) or whenever dolphins were moving longer distances between surfacing.

In general (see Results and Discussion), it proved difficult to try and carefully approach individual or sub-groups of dolphins for photo-identification in the Saloum Delta, due to the very dispersed nature and unpredictable surfacing of most groups. Additionally, there was a tendency for dolphins to simply subtly alter course to maintain a distance of several tens of metres from the boat. Consequently, most photo-identification was achieved at distance or simply when the movements of the dolphins brought them in sufficient proximity to the boat, rather than when we tried to actively approach them. This has a number of implications for the success of the technique which are discussed later in this report.

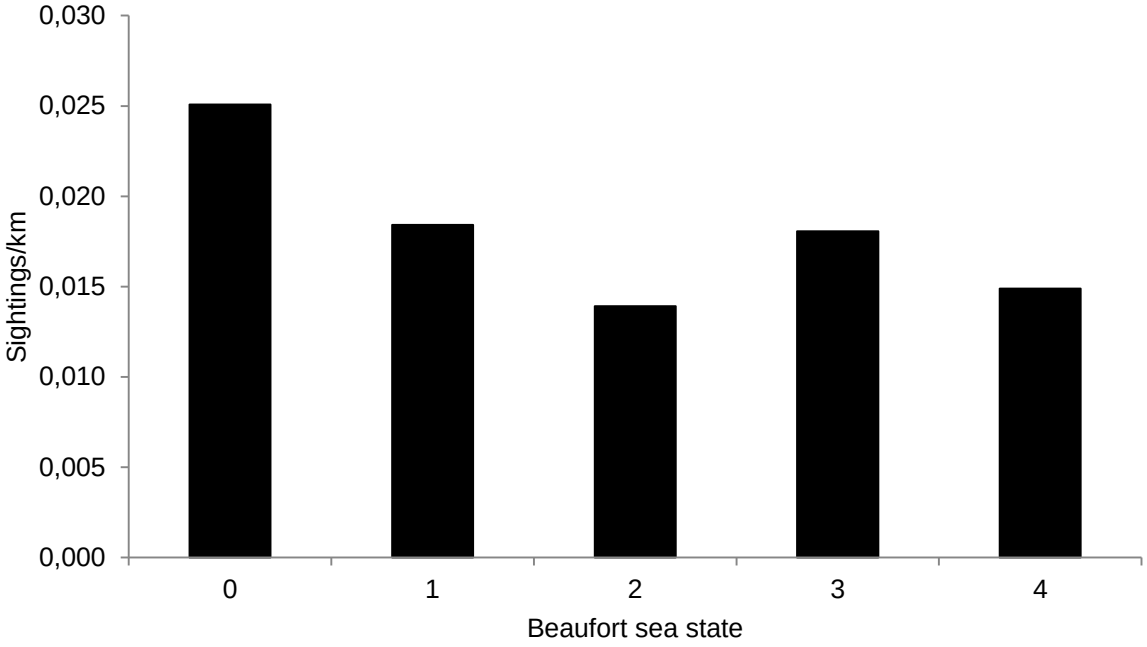
2.3.4. Data analysis

Sousa teuszii encounters were considered to be separate sightings when photo-identification confirmed that the individual dolphins involved had not previously been seen that day. The encounters were considered to be re-sightings when photo-identification confirmed that the same dolphins had already been recorded earlier on the same day. All initial dolphin sighting positions were recalculated from the bearing and distance information using the Position Estimator tool available from GIS in Ecology (http://www.gisinecology.com/useful_tools.htm).

To correct for variation in the amounts of survey effort, the relative abundance was calculated as sightings and individuals per kilometre of survey effort using only data collected while in dolphin 'search' mode and excluding any re-sightings. The group size of each sighting used for analysis was either the best visual estimate or the minimum photo-identification count (whichever was highest). Sea state is known to affect the detection of small odontocetes at sea, and the data were therefore initially examined to look for effects of Beaufort sea state. While the sighting rate was clearly highest in Beaufort sea state 0, there was no clear evidence for a consistent decrease in sighting rate with increasing sea state (Figure 5A). This was presumably due to there being a few sightings in sea states 3 and 4 despite there being only a small amount of survey effort in those sea states. In contrast, the number of individuals per km of effort did show a consistent decrease with increasing sea state (Figure 5B). This was probably because of the dispersed nature of the *Sousa* groups, with more distant animals being overlooked when sea states were higher. Consequently, the calculations of relative abundance were limited to search effort and sightings recorded in Beaufort sea states ≤2, which also ensured that the results were comparable with Weir (2009, 2015).

A total of 3,111 photographs taken during dolphin encounters were examined to identify individually-recognisable animals based on permanent (e.g. nicks, notches and damaged fins) or temporary (e.g. de-pigmentation, skin lesions, scars, scratches and tooth rakes) features on their dorsal fins. Each animal was assigned a distinctiveness value (DV) from 1 (deep nicks in the fin trailing edge) to 8 (calves identified from their association with a marked adult) (Table 3). The photographs were examined once to identify all individuals and compile an initial catalogue, and then the entire batch of images was inspected for a second time (when the animals were better known to the author) in order to re-assess poorer-quality images and identify any false positives or false negatives. The best available image (both left and right sides where available) of any individually-distinct animals was compiled into two catalogues (Würsig and Jefferson, 1990), one for the permanently-marked animals and another for the temporarily-marked animals.

(A)



(B)

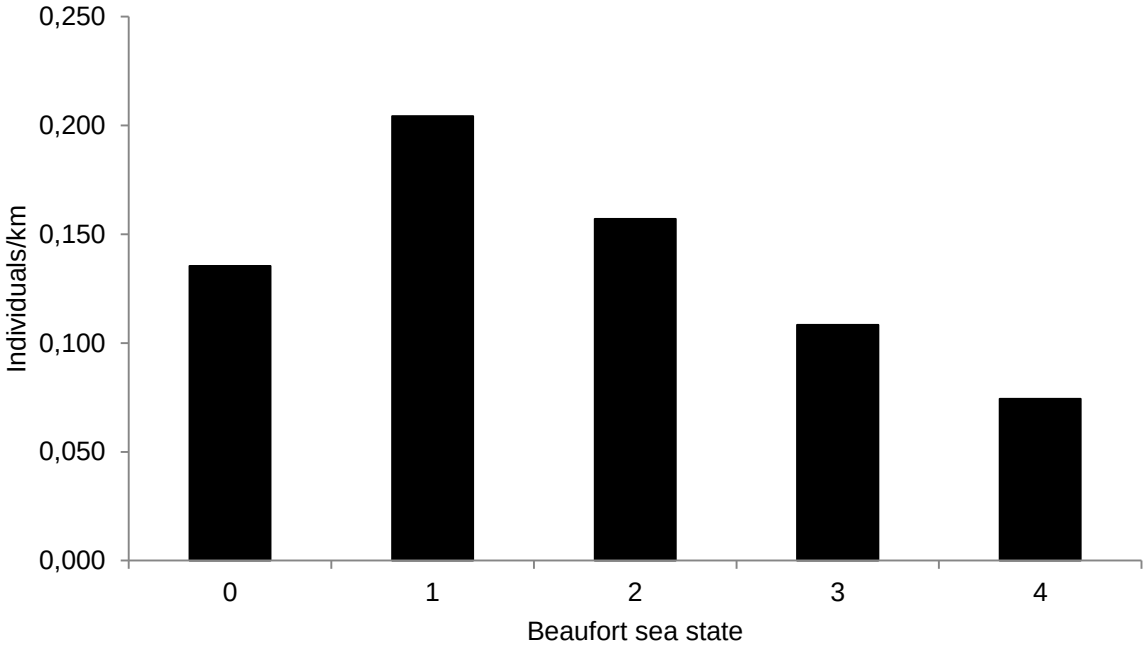


Figure 5. The relative abundance of *Sousa teuszii* in the Saloum Delta, according to Beaufort sea state: (A) sightings / km; and (B) individuals / km.

Table 3. Definitions of distinctiveness value (DV) used in the dolphin photo-identification analysis.

DV	Description	Note on image quality
Permanent markings		
1	Deep nicks and cuts	Evident even in poor-quality images
2	Small but still obvious nicks	Evident in moderate and high quality images only (but see note*)
3	Subtle nicks/notches	Evident only in high quality images (but see note*)
4	Unique shape	Evident in images of various quality (but see note*)
Temporary markings		
5	Possible nicks or notches; but identified using scar pattern	Usually captured in poor-quality images where there was evidence of nicks but identification was based primarily on obvious and unique scar patterns
6	No nicks or notches; identified on scar pattern only	Sometimes evident even in poor-quality images, depending on extent of scarring
Unmarked		
7	Juveniles and adults with no obvious markings	A lack of markings required a good quality image to confirm.
8	Calves identified by their associations with known adults	N/A

*Note. Individuals in these categories were sometimes identifiable in lower quality images based on distinctive scar patterns.

Images of all quality and individuals of all DV were included in the photo-identification analyses (see Weir et al. 2008 for discussion). However, only left- or right-side images (whichever had the highest count) of DV5, DV6 and DV7 animals were used to identify individuals and assess group size within each encounter. The total minimum population size was defined and calculated as the number of individually-distinct *Sousa teuszii* frequenting the study area (Weir et al. 2008; Weir, 2015), including: (1) all animals bearing permanent dorsal fin markings (DV1–4); (2) animals with temporary markings on their left sides (DV5–6); and (3) unmarked animals, comprising all calves and unmarked adults where the left side had been photographed. The left side was chosen since there were more temporarily-marked individuals photographed on both sides (n = 2) or left side only (n = 22), than on the right side only (n = 20).

3. RESULTS

3.1. Survey effort

A total of 1,617.5 km of on-effort survey coverage was achieved in the Saloum Delta between 21 October and 7 November 2015 (Table 4). The majority (87.2% of hours; 94.7% of km) of effort was search effort, with a far lower amount of dolphin encounter effort.

Table 4. Summary of dolphin survey effort in the Saloum Delta, 21 October to 7 November 2015.

Effort type	Hours	Coverage (km)
Search	107.2	1,532.4
Encounter	15.7	85.1
Total	122.9	1,617.5

The survey coverage was widely distributed throughout the Saloum Delta, including bolongs, estuaries and coastal areas (including around coastal islands) (Figures 6 and 7), ensuring that a variety of potential dolphin habitats were sampled.

The visual detection of *Sousa teuszii* at sea has been shown previously to be affected by sea conditions (Weir, 2009). The weather conditions during the survey work were generally favourable for the detection of cetaceans, with the majority (84.8%) of search effort being conducted in Beaufort sea states ≤2 where whitecaps are absent (Table 5). Swell height was less than one metre for the large majority of the survey, but was 1.0–1.5 m during 38.2 km of search and encounter effort in the coastal waters at the southern end of the survey area on the 3 and 4 November. This area had complex bathymetry, with a series of sand banks, sandbars and small tidal islands. In this area, the swell combined with the tide to produce standing waves, and had a significant impact on the survey effort and detection of dolphins. Visibility was excellent throughout the survey.

Table 5. Dolphin search effort according to Beaufort sea state, 21 October to 7 November 2015.

Beaufort sea state	Hours	Coverage (km)	% of total km search effort
0	14.3	199.3	13.0
1	41.3	597.0	39.0
2	35.6	502.9	32.8
3	11.1	166.1	10.8
4	4.8	67.2	4.4
Total	107.2	1532.4	100.0

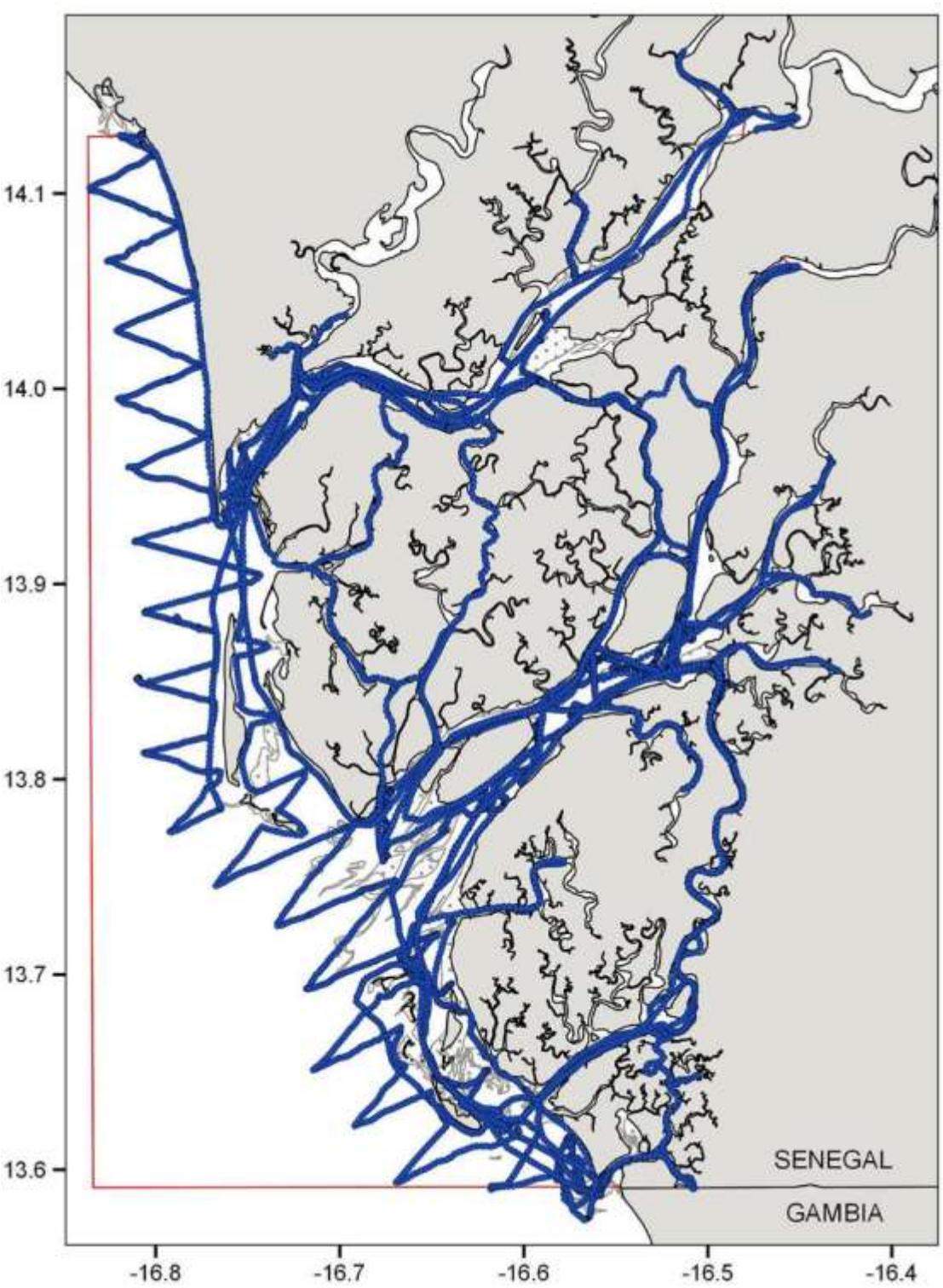


Figure 6. The spatial distribution of all dolphin survey coverage (search and encounter effort) in the Saloum Delta, 21 October to 7 November 2015. The approximate positions of tidal sandbanks are shown in pale grey.

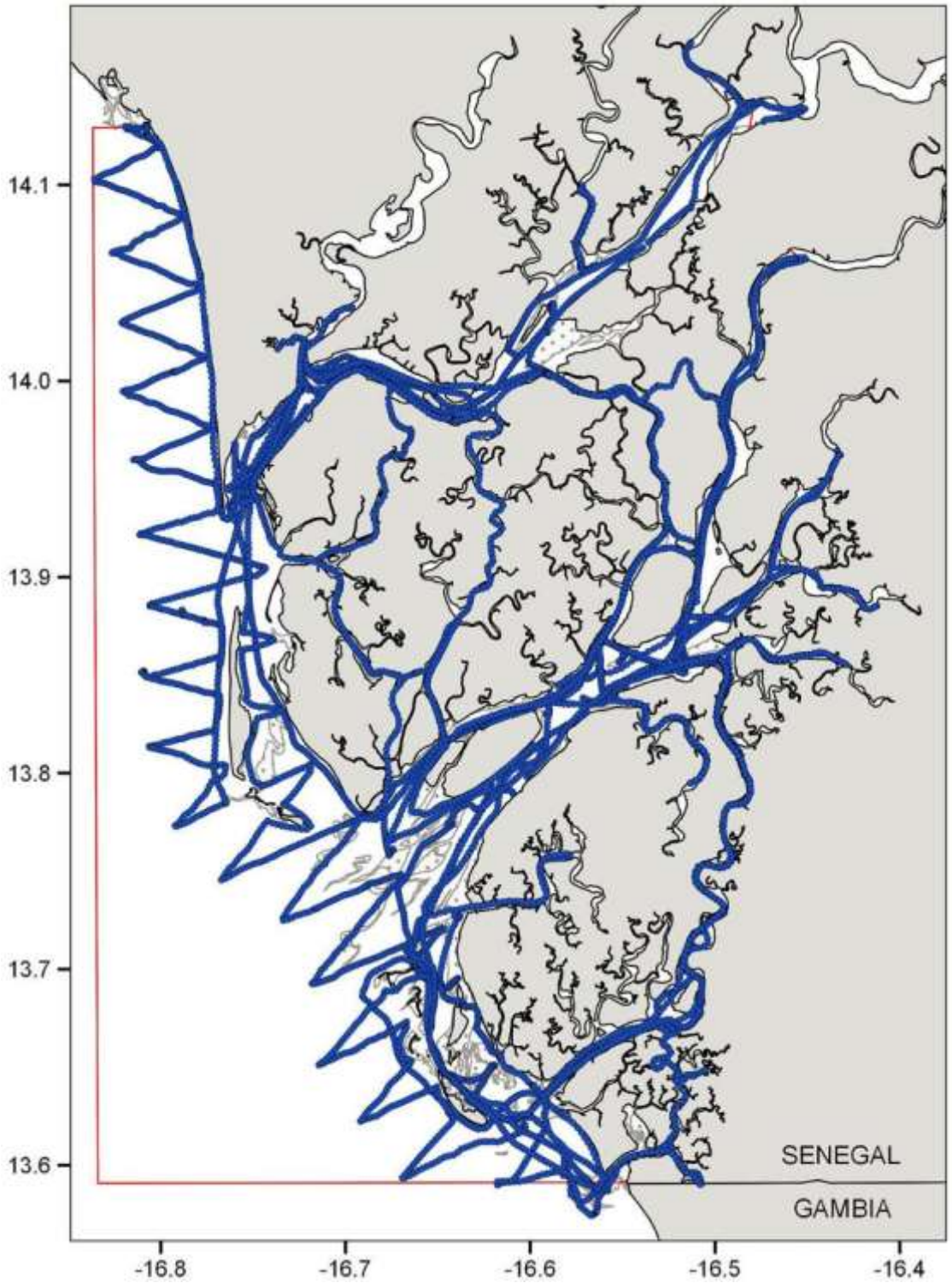


Figure 7. The spatial distribution of all dolphin search effort in the Saloum Delta, 21 October to 7 November 2015. The approximate positions of tidal sandbanks are shown in pale grey.

A total of 253.2 km of on-effort survey coverage was achieved on the predetermined survey transects described in Figure 1 (Table 6). All of the transects were completed with the exception of some sections in the coastal areas in the south of Block 2 (Figure 7). It was not possible to follow the transects in these areas due to the very shallow waters and standing waves associated with sandbanks and tidal islands.

Table 6. Search effort on the survey transects, 21 October to 7 November 2015 (see Figure 1 for transect locations).

Transect zone	Search effort		
	Hours	Total km	Km in Beaufort ≤2
1a	4.5	55.6	34.3
1b	3.9	53.2	49.5
2	7.1	100.6	95.6
4	2.9	43.9	35.5
Total	18.4	253.2	215.0

Sea conditions during the transect surveys were generally favourable for detecting cetaceans, with 84.9% of the total transect effort occurring in Beaufort sea states 0–2 where no whitecaps are present. However, the percentage of transects surveyed in Beaufort sea states of 0–2 varied from 61.7% in Zone 1a to 95.1% in Zone 2.

All except one of the short inner Diomboss transects in Zone 4 were surveyed twice, since sea conditions during the first survey on 31 October increased to Beaufort 3–4 after completion of the first (westernmost) transect and were considered unsuitable for the reliable detection of humpback dolphins. These transects were re-surveyed on the 6 November in more suitable sea conditions (Beaufort 0–2), although sea state again increased slightly to Beaufort 3 causing the final two (westernmost) transects to not be completed. These inner Diomboss transects are only included once each in Table 6 and Figure 8, with the best sea conditions selected for each of the short transects.

3.2. Dolphin sightings

Only a single species of cetacean, the Atlantic humpback dolphin *Sousa teuszii*, was recorded during the Saloum Delta surveys. A total of 30 sightings were recorded, all of which occurred while the survey team was actively on-effort and searching for dolphins.

While unclear (though suspected) in the field, three of the sightings were later confirmed from the photo-identification analysis to be re-sightings of animals encountered earlier on the same day: (1) Sighting Ref. 21 on 2 November was a re-sighting of Ref. 20; (2) Sighting Ref. 28 on 6 November was a re-sighting of Ref. 26; and (3) Sighting Ref. 29 on 6 November was a re-sighting of Ref. 27. While Ref. 20 and 21 both comprised the same four dolphins and represent a straightforward re-sighting, the encounters on 6 November were rather more complicated. One individual (P41) was photographed in Ref. 26 but then moved away from the initial group and joined another group (Ref. 27) that otherwise comprised 'new' animals. This was the only animal confirmed to move between these two groups on this date, but it is possible that other unrecorded animals also moved. Additionally, both of the re-sightings on

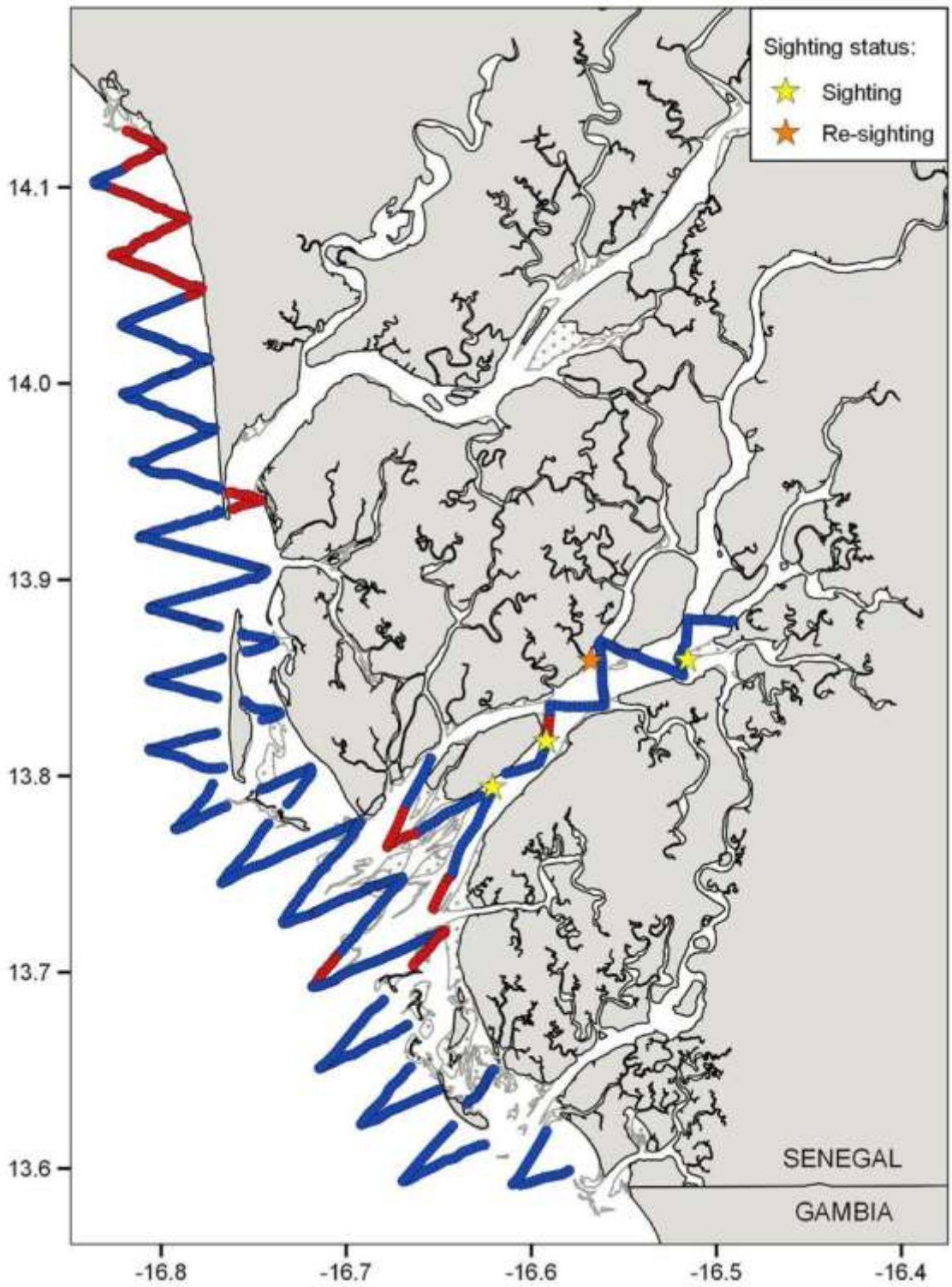


Figure 8. The spatial distribution of all search effort and sightings on the transects in the Saloum Delta, 21 October to 7 November 2015. Black lines represent transect sections that were not completed. The data are coded blue for Beaufort sea states 0–2 (favourable) and red for Beaufort sea states 3 and 4 (unfavourable). The approximate positions of tidal sandbanks are shown in pale grey.

6 November contained an individual that had not been photographed during the original sightings, while there were also individuals during the original sightings that were not photographed during the re-sightings (although these may simply have been missed). Consequently, although the four sightings on 6 November have been treated in the relative abundance analyses as two sightings and two re-sightings based on the identification of the majority of animals in the groups, it is clear that some individuals did move around and that the situation was more complex.

3.3. Dolphin distribution

3.3.1. Survey data

Sousa teuszii sightings were recorded widely across the study area (Figures 9 and 10), but their distribution had several key features:

1. No sightings were recorded on any of the coastal transects, which were purposefully placed in order to sample marine waters up to 5 km from the coastline (or islands) (Figure 8). Only three sightings (and one re-sighting) occurred on transects, and all were recorded on the Diomboss transects in Zone 4 (Figure 8). While the species was not sighted during the coastal zigzag transects, we cannot conclude that *Sousa teuszii* does not use those areas since fishermen reported the occurrence of dolphins in these areas during other seasons (see Section 3.3.2). But during the period of this survey *Sousa teuszii* was predominantly shore-associated with almost all sightings recorded within a few hundred metres of land. Where encounters included areas further from the shore (Figure 10), these were always associated with tidal sandbanks and sandbars inside estuary mouths or at the entrances to rivers and bolongs.
2. *Sousa teuszii* was recorded in all of the four main branches of the Saloum Delta (Figures 9 and 10). Sightings were recorded in the Saloum and Diomboss estuaries (Figure 8). While no sightings were recorded in the Bandiala during the search effort, a group of *Sousa teuszii* observed between the Bandiala mouth and Île des Oiseaux on 4 November (Ref. 24) was tracked (at distance) for over an hour. Approximately half an hour after terminating the encounter, the dolphins were seen entering the Bandiala river mouth during a binocular scan. No dolphins were seen during search effort in the Djinack. However, a group of *Sousa teuszii* observed on 5 November (Ref. 25) was followed at distance for almost 2 hours as they moved south towards Gambia. Those dolphins entered the Djinack mouth and appeared to search unsuccessfully for prey, before departing again and continuing southwards. Consequently, it is apparent that *Sousa teuszii* inhabits all of the main waterways within the SDBR.

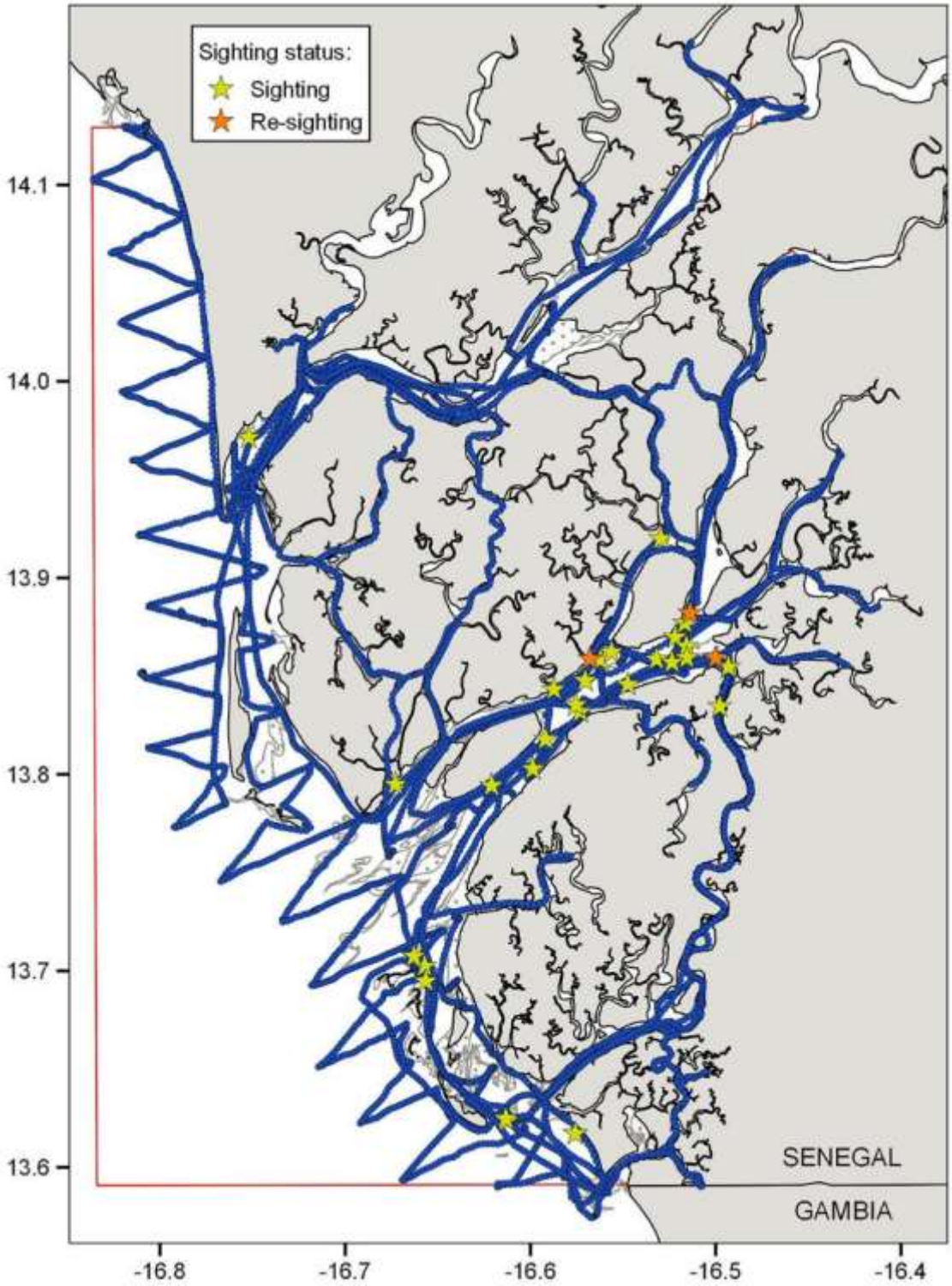


Figure 9. Locations of the initial *Sousa teuszii* sightings (with search effort) in the Saloum Delta, 21 October to 7 November 2015. The approximate positions of tidal sandbanks are shown in pale grey.

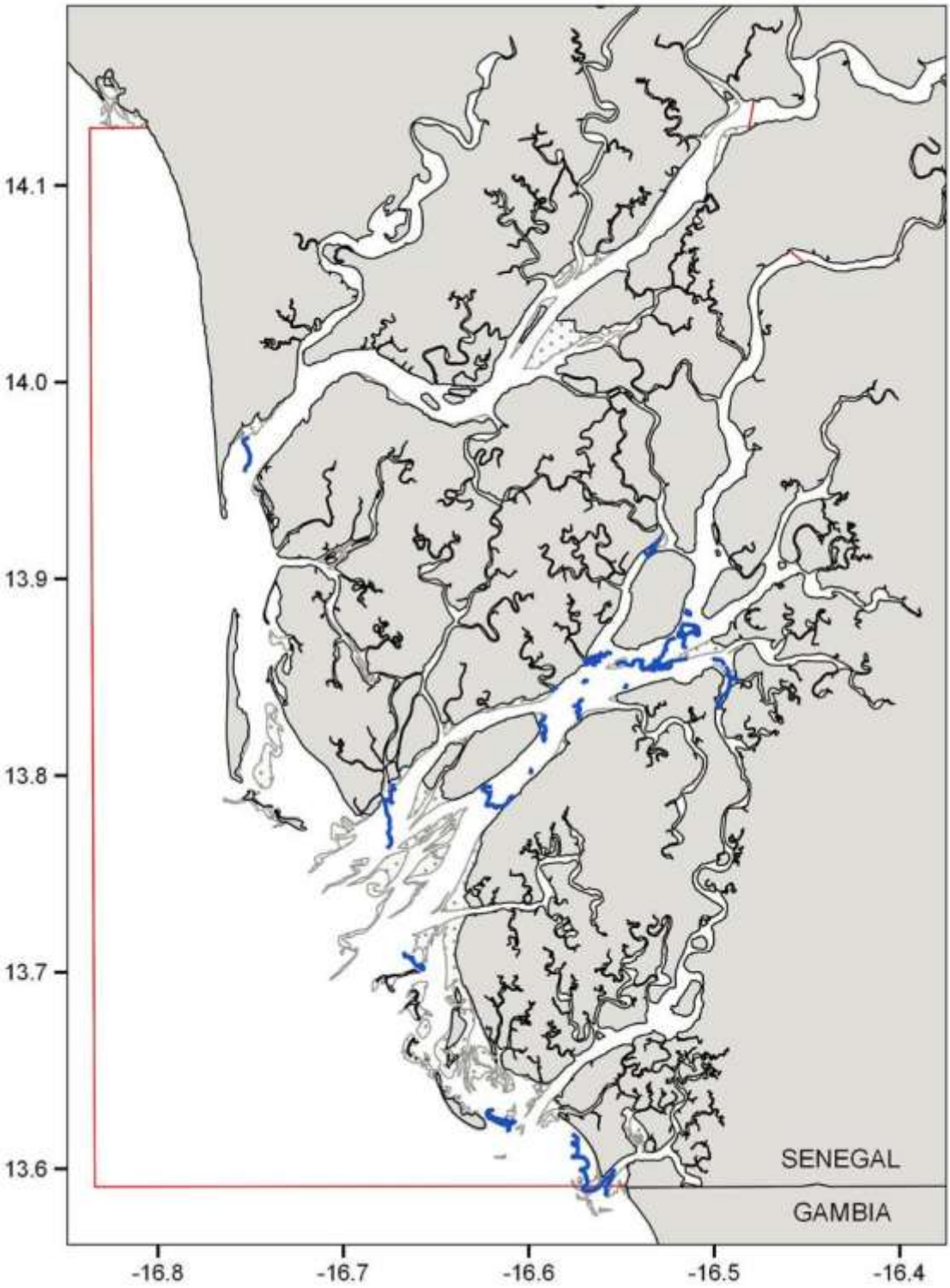


Figure 10. The spatial distribution of all *Sousa teuszii* encounter effort in the Saloum Delta, 21 October to 7 November 2015. The approximate positions of tidal sandbanks are shown in pale grey.

3. Although considerable search effort occurred in the upstream sections of the main waterways, there were no sightings of *Sousa teuszii* in those areas. Interviews with fishermen (see Section 3.3.2) suggested that dolphins do occur in those areas but that their presence there is seasonal and they were absent at the time of this survey. *Sousa teuszii* sightings did occur inside two narrow confined channels: (1) at the northern end of the Bolon Labor at the confluence of another narrow channel leading to the upper Diomboss River; and (2) in the narrow channel between the Diomboss and the Bandiala, near to the northern entrance. There are a significant number of interconnected bolongs and channels in the SDBR, and locating dolphins in such a large and complex habitat is problematic. Dedicated focal follows of dolphin groups is likely the best method of establishing how regularly and how far upstream the dolphins use such narrow waterways, but the evidence collected during this survey suggests that they do at least regularly use those channels that connect between the main rivers (such as the channel between the Diomboss and the Bandiala that passes Toubacouta).

4. The distribution of *Sousa teuszii* within the waterways of the SDBR was not evenly-spread. The sighting map in Figure 9 shows clearly that, despite survey coverage being well-distributed, the majority of *Sousa teuszii* sightings occurred within the Diomboss, particularly the inner area to the east of Île de Poutaké. The Diomboss appeared to be the most important area for *Sousa teuszii* within the SDBR at this time of year. Only a single sighting was recorded in the Saloum River, despite extensive survey effort there during the first week of the survey. The southernmost part of the survey area comprising the waters around Bétenti, Île de Diamanio, Île aux Bœufs, Île des Oiseaux and south along the coast to the Gambia border also seemed to be of importance for *Sousa teuszii*. This area was considerably more difficult to survey than anywhere else in the SDBR due to the very complex topography and bathymetry which in addition to the tide and coastal swell produced a very dynamic habitat with variable areas of standing waves and breaking surf. Consequently, it was difficult to work with dolphins in this area. For example, on occasion the boat was simply unable to follow dolphins when they entered an area of sandbanks and standing waves and the encounter had to be aborted (Figure 11). The occurrence of *Sousa teuszii* in this region might have been under-estimated due to these problematic conditions.

5. While the southern SDBR boundary is located at the border with Gambia, one group of *Sousa teuszii* on 5 November (Ref. 25) was tracked southwards along the coast from south of the Bandiala River mouth and was seen to enter Gambian waters (Figure 10). It was not possible to follow these dolphins southwards as they moved further into Gambia, but this sighting provided firm evidence (in addition to that of Van Waerebeek et al., 2004) that the population of *Sousa teuszii* inhabiting the SDBR is transboundary and is also using Gambian waters. Consequently, it is possible that additional dolphins from the SDBR were not recorded during the survey work because they were in Gambian waters at this time.

Figure 11. *Sousa teuszii* (Ref. 22) travelling into an area of sandbanks and standing waves off the Bandiala River mouth on 3 November 2015. The boat was simply unable to follow in these conditions, and the dolphin encounter was terminated.

3.3.2. Information from questionnaires

In addition to the findings of the small boat survey work, some information on dolphin distribution in the SDBR was also gained by brief opportunistic interviews with fishermen and other coastal inhabitants. These interviews were usually carried out in areas where we didn't observe dolphins ourselves (particularly in narrow waterways and the innermost regions of the rivers), in order to find out whether or not dolphins were ever seen there. The results of the questionnaires are provided in Table 7, and the locations where the questionnaires were carried out are shown in Figure 12.

Local people confirmed that dolphins are seen throughout the SDBR, including areas visited during the boat survey work where we did not find dolphins. For example, interviews carried out far upstream at Foundiougne in the Saloum River, the innermost Diomboss River and at campements upstream in the Bolon Irragago and the Bolon de Sangako all provided positive confirmation of dolphin occurrence. Additionally, some coastal fishermen interviewed west of Sangomar Island also confirmed dolphin occurrence in those coastal waters. Almost all of the interviewees were consistent in stating (without prompting from us) that dolphins were only seen in these upstream areas when the 'small fish' came. Some people suggested that the small fish, and subsequently the dolphins, could come at any time of year. Others were specific about it occurring seasonally, with most citing the February to April period. There is uncertainty over the species identification for these sightings, with some reports being highly suggestive of bottlenose dolphins (for example '50 animals often leaping'; Interview 11) while other people positively-identified (though not always convincingly) the humpback dolphin from a species identification chart that showed humpback, bottlenose and common dolphin.

Little can be concluded at this stage, except that it seems clear that dolphins (species unknown but potentially including both humpback and bottlenose dolphins) do occur far upstream throughout the SDBR when suitable prey species are present.

Table 7. Results of some opportunistic questionnaires carried out with local people regarding the occurrence of dolphins. See Figure 12 for the locations where the questionnaires were carried out.

Date and Time	Position	Information
23 Oct 13:51	1	Three fishermen in a pirogue reported that they had seen 10–12 dolphins between 12:00 and 13:00 today (23rd Oct) at Palgan. They said that currently there are not plenty dolphins of dolphins upstream of this location due to the lack of small fish.
23 Oct 14:29	2	Fishermen in a pirogue said that they never see dolphins in this area.
23 Oct 15:30	3	Fishing village where numerous people were interviewed. They said that dolphins are only here in this area when there are plenty of small fish around. One month ago there were plenty of dolphins here in the Saloum River and sometimes they come into this river. They also reported lots of manatees in the river where they come to drink. They try to catch manatees but the animals can hear the engine and move away.
23 Oct 16:43	4	Stopped at the north ferry terminal and interviewed several people. They recognised two species of dolphin (including the Atlantic humpback dolphin) as occurring here. They said that dolphins are only seen off Foundiougne seasonally from February to May. They are most common in February. Dolphins can be seen all the way from Foundiougne to Djiffer.
24 Oct 08:32	5	Fishermen said it is a long time since they saw dolphins here – perhaps 3 months ago. There is no particular time of year to see them. It depends when the small fish are around, because the dolphins follow the small fish.
24 Oct 08:50	6	Spoke with fishermen at the north ferry terminal. They said that they see dolphins between February and April and that they are always heading upstream. On the river (north-west of Foundiougne) they see manatee but not dolphins. One man said that they sometimes take tourists to see dolphins, and they go to the Bolon Fellan. One week ago he went there with tourists and they saw dolphins. The dolphins are there all year round. He does not know how many there are in the group because they are always moving. He would not provide an estimate of 'typical' group size.
24 Oct 09:45	7	Four fishermen on a pirogue. They said that at high water the dolphins come and that they follow the small fish. Some dolphins enter this river occasionally. There is no particular time to see them – their presence depends upon the small fish.
24 Oct 10:45	8	Fishing village of Rofangue. Maurice (boat driver) says he comes here to smoke fish in December and that there are often dolphins here in December and January. In December there are many fish here. The fishermen said they only see dolphins here during the summer. They would not provide an estimate of group sizes, they just said 'many'.
24 Oct 11:21	9	Three fishermen in a pirogue. They said that they do not see dolphins here (because it is so shallow). In front of Fellan they do see dolphins. At the moment they are not seeing any dolphins here, although they do see them at other times in the main Saloum channel. They swim around the green navigation buoy (50 m NW of position 14°01.145'N 16°35.563'W).
25 Oct 10:28	10	Coastal fishermen. They said that one month ago (September) there were many dolphins along the coast here, but they are not in this area at the moment. They see up to 30 at a time and they recognised the species on the chart as *Sousa teuszii*. They see them in this location but they could not be specific about what distance from the coast the dolphins travel. They reported that dolphins follow the small fish.

Date and Time	Position	Information
31 Oct 13:13	11	Interview with a salt merchant. He said that dolphins are seen here at this location during August and December. He said there can be up to 50 animals and they are often leaping.
31 Oct 14:14	12	Stopped at a campement which was empty except for one boy. He said that he saw dolphins here once in January 2014, and that there were up to 10 of them. He did not provide any other information.
1 Nov 10:53	13	Three women in a boat. They said that they saw dolphins at this location yesterday morning between 08:00 and 09:00 and also the previous day. They would not provide an estimate of group size but said 'many'. The dolphins were swimming downstream out of the river. They said that they often see dolphins here, but never during the rainy season (Jul-Sep).
1 Nov 11:34	14	Two fishermen in a pirogue. They were unable to provide much information on dolphins, stating that they are always concentrating instead on their fishing. However, they did at least confirm that dolphins are seen this far upstream on an occasional basis, usually on the high tide.

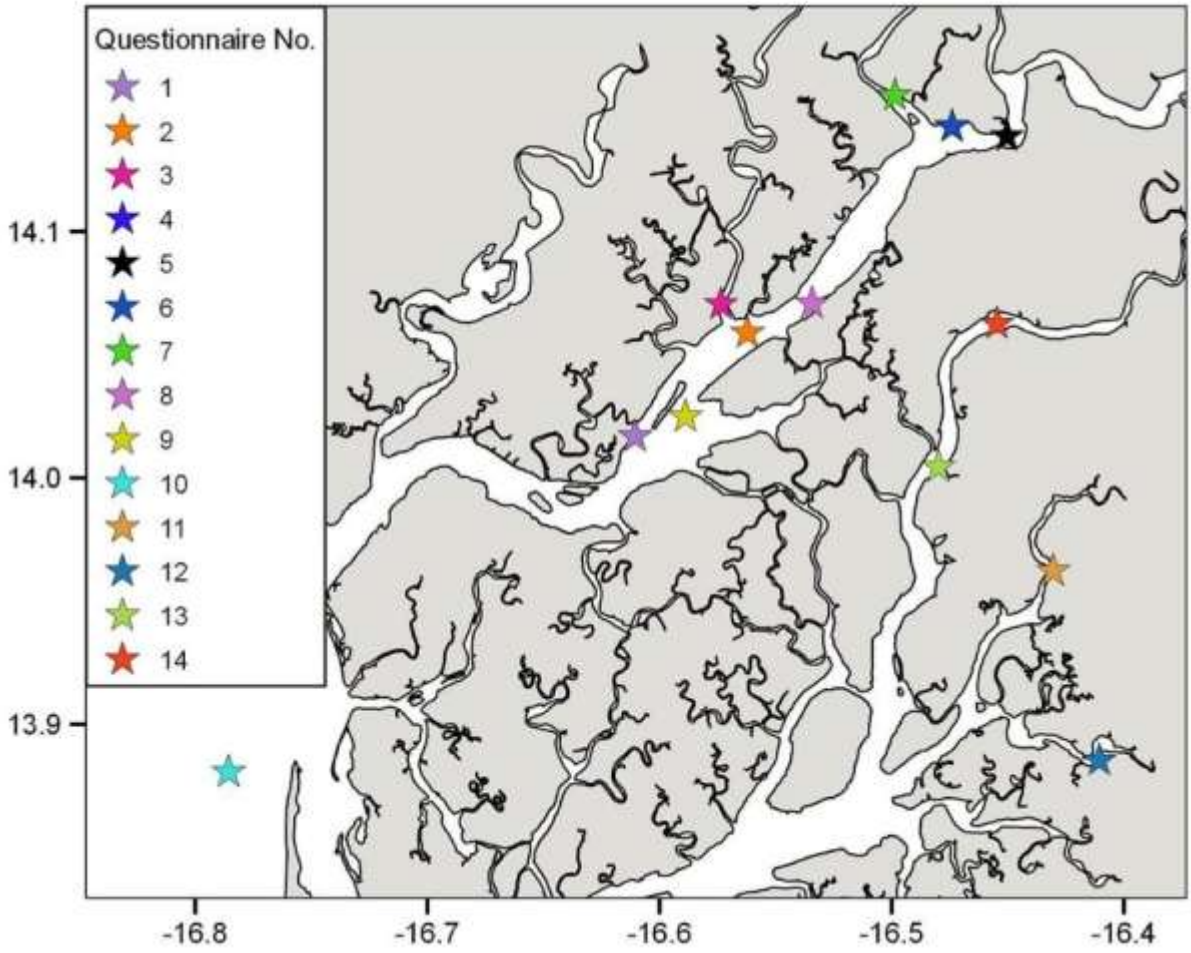


Figure 12. Locations of opportunistic questionnaires (see Table 7).

3.4. Dolphin relative abundance

The overall relative abundance of *Sousa teuszii* in the Saloum Delta using search effort from all areas was 0.018 sightings/km and 0.175 individuals/km (Table 8). The relative abundance varied according to zone, with no sightings recorded during search effort in Zones 1, 5 or 6. *Sousa teuszii* relative abundance in Zone 3 (Saloum River) was low; only a single on-effort sighting was recorded in that area. The sightings/km was almost double in Zone 4 compared to Zone 2 (0.021 and 0.037; Table 8), and there was also a difference in the individuals/km between those two zones (0.281 and 0.331; Table 8).

Consideration of the relative abundance on the survey transects is limited by the fact that dolphins were only recorded on the transects in Zone 4 (in the Diomboss). However, the relative abundance produced on the Zone 4 transects is the highest generated for *Sousa teuszii* anywhere in its geographic range to date (0.084 sightings/km and 1.069 individuals/km: Table 8), confirming the importance of the inner Diomboss for this species.

Table 8. Relative abundance of *Sousa teuszii* in the Saloum Delta. All calculations are limited to search effort and sightings* in Beaufort sea state ≤2.

Area	Search effort (km)	No. of dolphins		Relative abundance*	
		Sightings	Individuals	Sightings / km	Individuals / km
Zone 1	156.3	0	0	0	0
Zone 2	241.9	5	68	0.021	0.281
Zone 3	296.6	1	6	0.003	0.020
Zone 4	464.7	17	154	0.037	0.331
Zone 5	98.0	0	0	0	0
Zone 6 (incl. Gambia)	41.7	0	0	0	0
Total All	*1299.2*	*23*	*228*	*0.018*	*0.175*
Zone 1a Transects	34.3	0	0	0	0
Zone 1b Transects	49.5	0	0	0	0
Zone 2 Transects	95.6	0	0	0	0
Zone 4 Transects	35.5	3	38	0.084	1.069
Total Transects	*215.0*	*3*	*33*	*0.014*	*0.154*

*Three re-sightings were omitted from the calculations.

Although all studies have used only on-effort 'search' data collected in Beaufort sea states ≤2, a comparison of the relative abundances calculated in the Saloum Delta with those from other geographic areas is limited by differences in the habitats sampled (Table 9). In southern Angola, Weir (2009) calculated a relative abundance of 0.038 sightings/km and 0.113 individuals/km from boat-based survey effort in a relatively small and solely coastal habitat (Table 9). In contrast, surveys in Guinea and the Saloum Delta have included large portions of survey effort in some habitats which might be less favoured by *Sousa teuszii* (at least at the time of those surveys). For example, the values for the Saloum Delta include large amounts of survey effort collected in upstream waterways and up to 5 km offshore along the coast, which were habitats that were apparently unoccupied by the species at the time of the survey. Similarly, the value for Guinea included a significant amount of survey effort in bolong habitat that the species was not occupying during that survey period.

Table 9. Overall relative abundance of *Sousa teuszii* calculated from boat surveys in three geographic areas.

Site	Study	Habitat type(s)	Relative abundance	
			Sightings / km	Individuals / km
Namibe Province, southern Angola	Weir (2009)	Coastal	0.038	0.113
Río Nuñez, Guinea	Weir (2015)	Coastal, estuary, rivers, bolongs	0.006	0.104
Saloum Delta, Senegal	This study	Coastal, estuary, rivers, bolongs	0.018	0.175

While acknowledging those limitations, this broad comparison does offer some insight into the importance of the Saloum Delta for *Sousa teuszii*. In particular, the relative abundance measured as individuals/km was far higher in the Saloum Delta than either the Angola or Guinea study areas. Within all of these geographic sites there have been particular core areas of higher use by *Sousa teuszii*. For example, within the Guinea study area the waters off West Taïdi produced high relative abundance values of 0.042 sightings/km and 0.634 individuals/km, while the Zone 4 transects located in the inner Diomboss estuary produced values of 0.084 sightings/km and 1.069 individuals/km (Table 8). Both West Taïdi and the inner Diomboss are in need of additional survey effort at other times of year in order to clarify their year-round importance for *Sousa teuszii*.

3.5. Dolphin group size and composition

The visual estimates of *Sousa teuszii* group size in the Saloum Delta ranged from 1 to 28 animals (Table 10), with a mean of 8.8 animals and a median of 7 animals. In most cases (n = 15) the group size estimated visually was higher than the group size provided by photo-identification (Table 10). There are numerous reasons why this was the case which are outlined further in Section 4.3 of the Discussion. There were some occasions where the group sizes from photo-identification and visual estimation matched exactly (n = 8), usually when small groups (≤5 animals) of *Sousa teuszii* were encountered for fairly long periods. However, there were also some instances (n = 7) where the group size originating from photo-identification was higher than that estimated visually (Table 10). These were always related to the largest groups of *Sousa teuszii* (≥10 animals) which tended to surface unpredictability and to be widely-dispersed and were difficult to count.

The analysis group size (Table 10) produced a slightly higher mean of 9.3 animals (n = 27, median=7.0, range=1–29 animals). Using the analysis group size, groups most frequently comprised between 2 and 10 animals (63% of sightings), with single animals and large groups exceeding 25 animals being less common (Figure 13). This matches well with the findings of Dupuy (1983) and Maigret (1980). The latter study also found that groups comprising 2 to 10 animals were most common in the Saloum Delta, but with occasional sightings of single animals or schools exceeding 20 (Maigret, 1980).

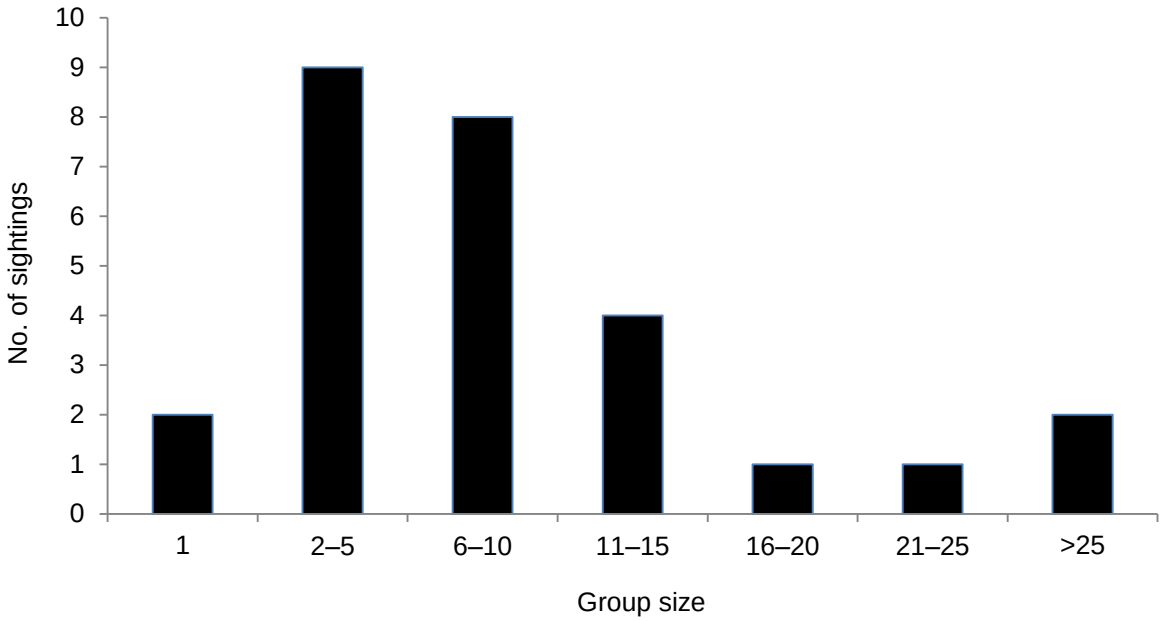


Figure 13 Variation in analysis group size in 27 *Sousa teuszii* sightings (three re-sightings were omitted).

Group composition was rarely fully assessed, due to the dispersed nature of *Sousa teuszii* groups and the priority for the author to concentrate on photo-identification. However, calves and/or juveniles were present in most of the groups encountered. Of the 27 sightings (i.e. not including the three re-sightings), four sightings were identified as adult-only groups. All of those sightings comprised either single or pairs of adults. A further four sightings were seen too briefly to assess their composition, and all animals were logged as unknown age. Of the 19 remaining groups, 17 contained juveniles (comprising 8.3–28.6% of the total aged animals in each group) and 15 contained calves (comprising 6.7–33.3% of the total aged animals in each group). It was very easy to miss small calves at sea (especially while focussing on photo-identification work), since they frequently surfaced within the adult's body profile and were not obvious unless animals were seen at close range.

Some information on the presence of calves was also acquired from the photo-identification data. Ten calves were identified from the images in association with catalogued adult dolphins who were assumed to be their mothers (Table 11; Figure 14). Of particular interest was the presence of at least three very small neonate calves that were observed and photographed on 5 and 6 November. These neonates could be recognised from their awkward surfacing behaviour, small size, visible foetal folds and bent dorsal fins which had not yet fully straightened (Figure 14).

Based on several sightings of young animals, Maigret (1980) suggested that *Sousa teuszii* in the Saloum Delta give birth during March and April. However, the presence of neonates (and other small calves) in November during this study indicates that calving is not limited to March/April but also occurs in other periods.

Table 10. Group size (via visual estimation and photo-identification) and distinctiveness value (DV) of *Sousa teuszii* during 30 encounters in the Saloum Delta.

Ref.^	Date	No. of images taken	Group size			No. of animals photo-identified							
			Visually-estimated (best estimate)	Minimum from photo-ID	Analysis	DV1	DV2	DV3	DV4	DV5*	DV6*	DV7*	DV8
1	22/10/2015	15	6 (6–8)	4	6	1	0	0	0	2 (L)	1 (L)	0	0
2	22/10/2015	158	10 (9–12)	10	10	1	2	4	1	1 (L)	0	0	1
3	24/10/2015	151	7 (6–8)	5	7	0	1	4	0	0	0	0	0
4	26/10/2015	276	28 (28–35)	29	29	3	9	9	1	4 (R)	2 (R)	0	1
5	27/10/2015	94	15 (15–20)	13	15	0	5	4	0	2 (L)	2 (L)	0	0
6	27/10/2015	84	7	7	7	1	2	3	0	0	0	0	1
7	29/10/2015	159	12 (10–15)	13	13	3	2	3	0	3 (L)	1 (L)	0	1
8	30/10/2015	280	15 (15–20)	20	20	6	5	4	2	2 (L)	1 (L)	0	0
9	30/10/2015	3	1	1	1	0	1	0	0	0	0	0	0
10	30/10/2015	0	1	–	1	–	–	–	–	–	–	–	–
11	30/10/2015	11	2	1	2	0	0	0	1	0	0	0	0
12	30/10/2015	79	12	9	12	0	3	4	0	1 (L)	1 (L)	0	0
13	30/10/2015	0	2	–	2	–	–	–	–	–	–	–	–
14	31/10/2015	134	9 (8–11)	7	9	1	0	3	0	2 (R)	1 (R)	0	0
15	31/10/2015	0	3	–	3	–	–	–	–	–	–	–	–
16	31/10/2015	0	2	–	2	–	–	–	–	–	–	–	–
17	31/10/2015	99	3	3	3	0	0	2	0	0	0	0	1
18	01/11/2015	205	9 (8–10)	10	10	0	2	5	1	2 (L)	0	0	0
19	02/11/2015	91	5 (5–6)	5	5	0	1	2	0	2 (L)	0	0	0
20	02/11/2015	17	4	4	4	0	1	2	0	1 (L)	0	0	0
21R	02/11/2015	217	4	4	4	0	1	2	0	1 (L)	0	0	0
22	03/11/2015	103	13 (11–18)	8	13	2	0	1	1	3 (R)	0	0	1
23	03/11/2015	0	2	–	2	–	–	–	–	–	–	–	–
24	04/11/2015	208	23 (20–28)	24	24	7	3	3	2	6 (L)	1 (L)	0	2
25	05/11/2015	311	25 (23–30)	27	27	8	3	4	1	4 (L)	3 (L)	1 (L)	3
26	06/11/2015	93	9 (8–11)	7	9	0	3	1	0	0	0	0	3
27	06/11/2015	118	8 (6–10)	10	10	0	2	5	0	2 (R)	0	0	1
28R	06/11/2015	148	4	4	4	0	2	1	0	0	0	0	1
29R	06/11/2015	56	13 (12–15)	9	13	0	2	5	0	2 (L)	0	0	0
30	07/11/2015	0	5 (5–6)	–	5	–	–	–	–	–	–	–	–

^Reference numbers with R beside them are re-sightings. *Only the combined left or right side (whichever had the highest count) for these categories is included for each encounter. Where both sides were even, the left side is depicted.

Table 11. Information on 10 *Sousa teuszii* calves photographed in the Saloum Delta.

Calf ID	Calf size	Adult ID	First sighting date (Ref.)	Re-sighting 1 date (Ref.)	Re-sighting 2 date (Ref.)	Re-sighting 3 date (Ref.)	Notes
U2	Small	P29	29 Oct (7)	N/A	N/A	N/A	–
U3	Small	P16	26 Oct (4)	N/A	N/A	N/A	–
U4	Large	P41	22 Oct 15 (2)	27 Oct (6)	31 Oct (17)	06 Nov (26, 27)	1
U5	Small	P45	3 Nov (22)	4 Nov (24)	5 Nov (25)	N/A	–
U7	Neonate	P50	6 Nov (26)	N/A	N/A	N/A	2
U8	Neonate	P52	6 Nov (26,28)	N/A	N/A	N/A	3
T55	Large	P48	4 Nov (24)	5 Nov (25)	N/A	N/A	4
U11	Small / neonate	P46	5 Nov (25)	N/A	N/A	N/A	–
U12	Neonate	P57	5 Nov (25)	N/A	N/A	N/A	–
U13	Large	P56	4 Nov (24)	N/A	N/A	N/A	5

[1]P41 was also seen briefly on 29 November (Ref. 29) but calf U4 was not photographed although conditions for photographing animals were unfavourable. [2]P50 was observed briefly on 26 October (Ref. 4) but calf U7 was not photographed. It may simply have been present on the other side of P50 and out of view, but given its small size, bent dorsal, and awkward surfacing behaviour then it is also possible that it was born in the intervening period. [3]P52 was observed very briefly on 27 October (Ref. 6) but calf U8 was not photographed. Again, it was seen on 30 October (Ref. 9) when it was apparently completely alone. The calf observed on 6 November was extremely small and with a bent dorsal fin and foetal folds and was considered to be very new. [4]P48 was also photographed on 4 November (Ref. 24) but calf T55 was not photographed (although the images taken on 4 November were poor). [5]P56 was photographed several times on 5 November (Ref. 25) without any associated calf, so it is not completely certain that this adult is the mother of calf U13.

Figure 14. *Sousa teuszii* calves recorded in the Saloum Delta.

3.6. Dolphin photo-identification

Photo-identification was attempted during 24 of the 30 *Sousa teuszii* sightings, with between 1 and 29 individuals identified on each occasion (Table 10). On six occasions either the behaviour of the dolphins or the weather conditions prohibited any attempt at photo-identification.

Sousa teuszii in the Saloum Delta were generally sufficiently well-marked for photo-identification work (Table 12). Some examples of the markings present on specific animals are provided in Figure 15. The success of the photo-identification method was primarily limited by the fact that dolphin groups were often very widely dispersed and surfacing unpredictably which made it challenging to get within sufficient proximity to individuals to acquire good quality photographs.

Table 12. Distinctiveness Value (DV) of 113 marked animals in the Saloum Delta.

DV	No. of individuals	% of total
1	16	14.2
2	22	19.5
3	26	23.0
4	5	4.4
5	34	30.1
6	10	8.8

Fewer animals were identified photographically in most encounters than were visually estimated in the field (Table 10). This was almost certainly due to limited photographic success rather than because the visual group sizes were over-estimated. The reasons why the photo-identification success was limited are considered fully in Section 4.3 of the Discussion.

3.6.1. Minimum population size

The total minimum population size recorded in the Saloum Delta over the study period was 103 animals, comprising 69 permanently-marked (DV1–4) dolphins, 24 animals with temporary markings (DV5–6) on the left side, and 10 unmarked animals (calves and adult left side; DV7–8). However, this minimum population size is undoubtedly an under-estimate of the true number of dolphins using the study area, as indicated by both the discovery curve (Figure 16) (which has not levelled off and therefore indicates that sampling of the population is incomplete) and the acknowledgement during the fieldwork that not all individuals within each group were photo-identified. Several other apparently unique individuals were photographed during the survey, but the images were too poor-quality to be certain of the marks or to permit cataloguing the animals.

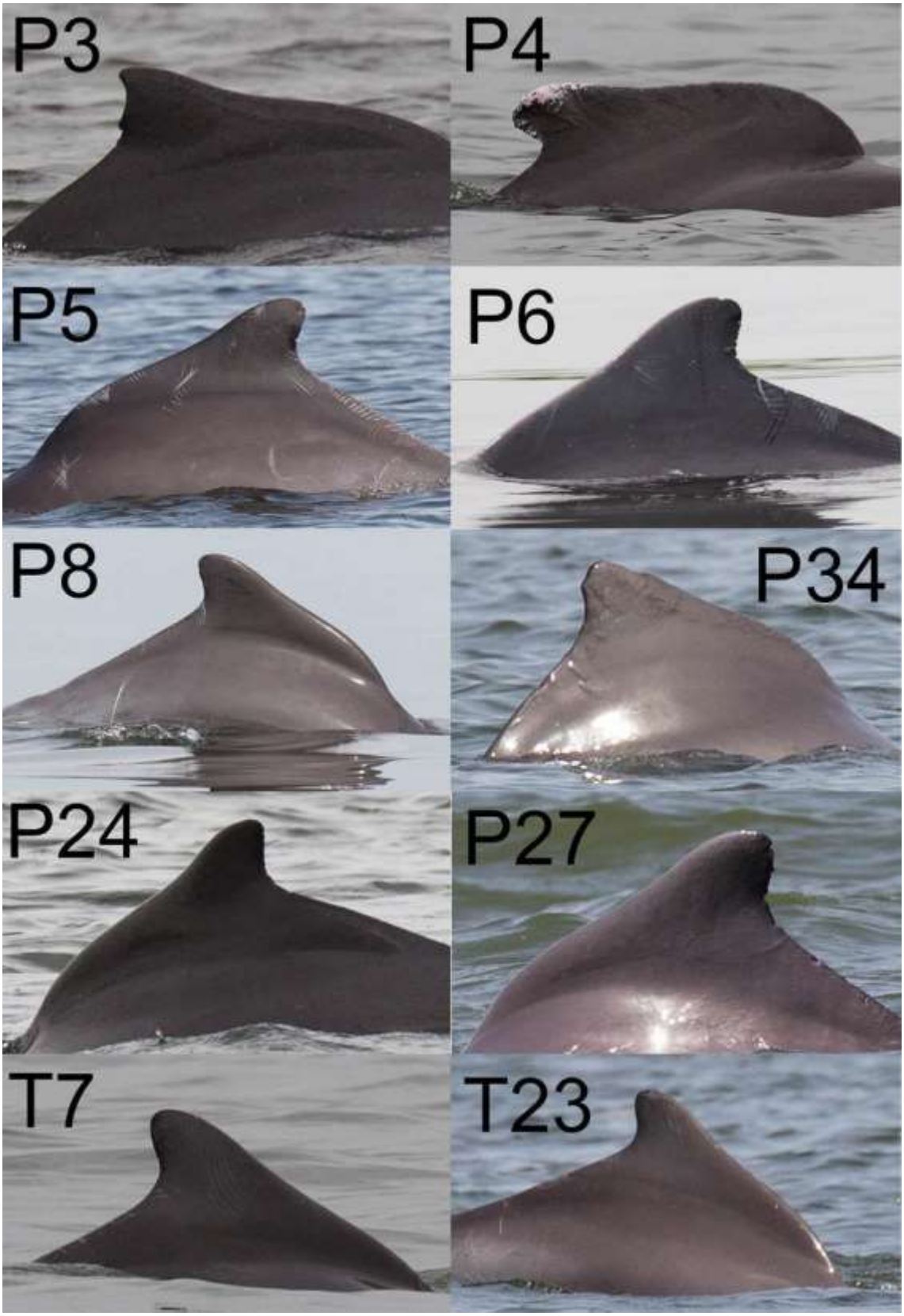


Figure 15. Examples of some of the photo-identification markings found on dorsal fins of individual *Sousa teuszii* in the Saloum Delta.

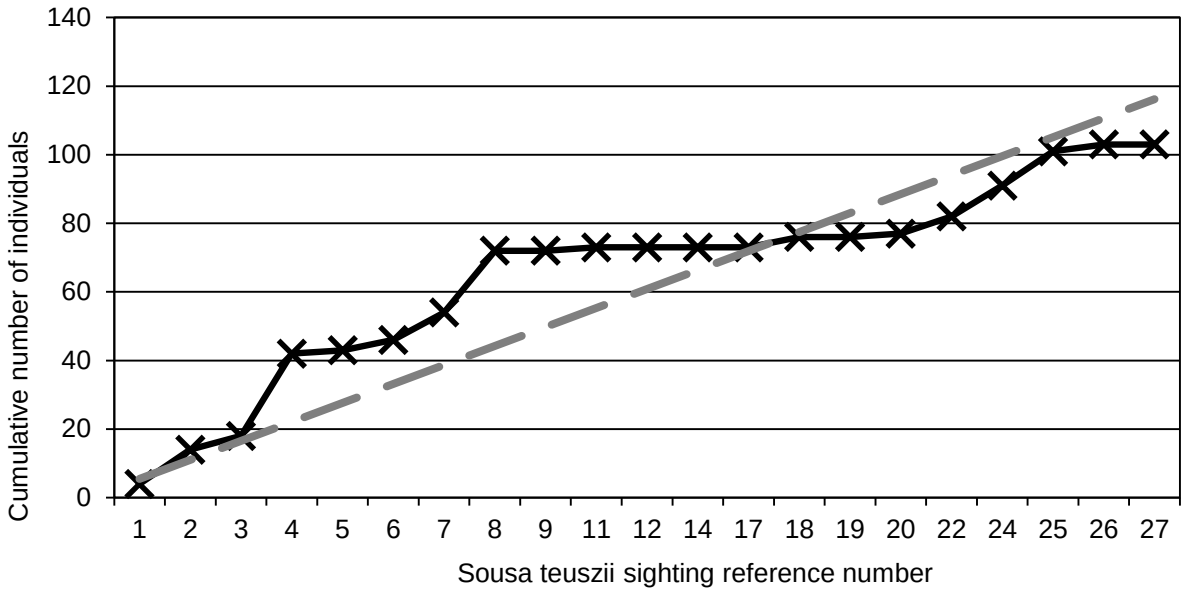


Figure 16. Cumulative rate of discovery ('discovery curve') of *Sousa teuszii* photo-identified in the Saloum Delta, comprising permanently-marked (n = 69), temporarily-marked (left side only, n = 24) and unmarked (calves and adult left side; n = 10) individuals. Re-sightings of the same animals on the same day (Refs 21, 28 and 29) have been omitted.

Of the 69 permanently-marked (DV1–4) dolphins, approximately one third (34.8%) were photographed only once (Figure 17). However, three animals were encountered five times. It should be noted that the number of re-sightings was not obviously related to the DV of the individual. All nine of the animals that were re-sighted 4 or 5 times during the survey were of DV 2 or 3, while the most distinctive individuals (DV 1 and DV4) were seen between 1 and 3 times. Some highly distinctive animals in the SDBR were seen only once during the survey (Figure 18), indicating the high potential for less distinctive individuals to have been missed altogether.

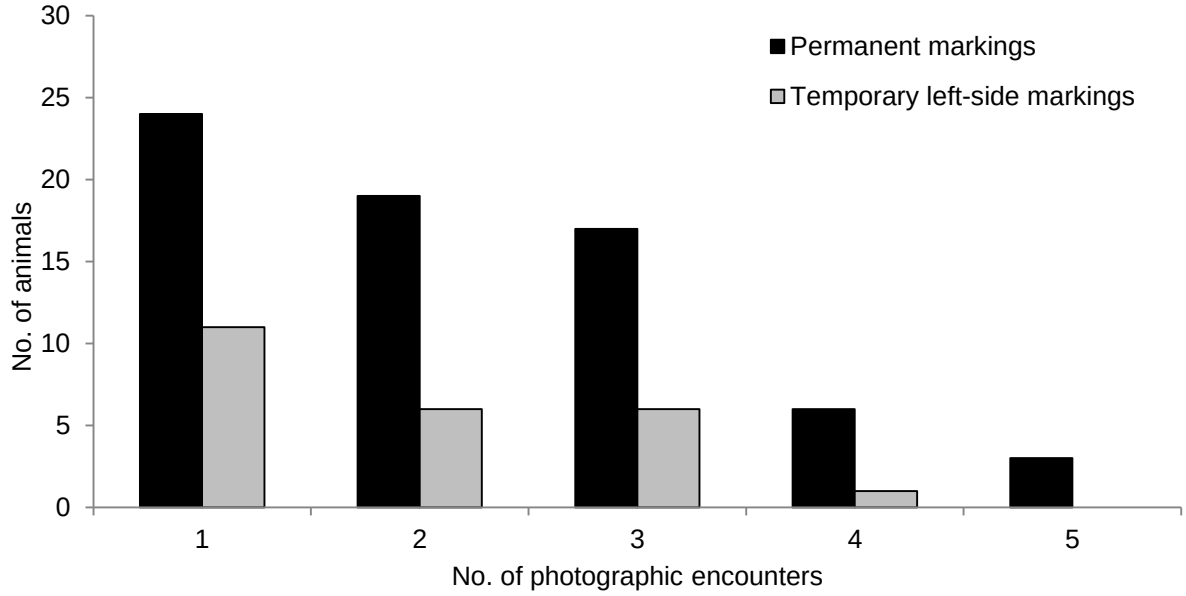


Figure 17. Number of photographic encounters (not including three re-sightings) of 93 individual *Sousa teuszii* in the Saloum Delta.

The proportion of animals seen only once was much higher (45.8%) for the left-side temporary-marked (DV5–6) dolphins. This supports the difficulties of re-sighting animals that are identified only from (sometimes inconspicuous) scar patterns, where high-quality images and good light are needed.

Figure 18. A *Sousa teuszii* in the Saloum Delta with highly-distinctive markings (i.e. a pronounced hump, a missing dorsal fin and obvious white scar tissue colouration). Despite its distinctiveness, this individual (P40) was encountered only once during the survey (on 30 October). It is unlikely that this animal could have been present yet overlooked, and consequently it is assumed that it moved elsewhere and simply was not encountered again.

3.6.2. Movements within the Saloum Delta

Most of the individual *Sousa teuszii* photographed in Zones 2, 3 and 4 (southern coastal waters, Saloum River and Diomboss) were only re-encountered within the same Zone. Of the total 58 marked individuals (45 permanently-marked and 13 left-side temporarily-marked) used in the population analysis for which there was at least one photographic recapture during the survey, 42 (72.4%) were seen in only one Zone. A finer-scale analysis of spatial distribution indicates that a high percentage of these individuals (24.1 and 25.9% respectively) were photographically captured only in the combined Inner and Outer Diomboss or solely in the Inner Diomboss (see Figure 19A for definitions of these areas) (Table 13).

However, these data must be treated with caution because: (1) the number of re-sightings of most individuals was low; (2) the quality of the photographic encounters varied between zones; and (3) the survey was relatively short in total duration and provided little opportunity to examine dolphin movements. Nevertheless, there were sufficient data for some individuals to suggest rather small home ranges over the duration of the study. For example, of eight individuals for which there were 4 or 5 sightings in total (excluding re-sightings), all were found only in Zone 4 and seven were found exclusively and repeatedly in the inner Diomboss (Figures 19A and 19B).

Table 13. Regions (see Figure 19A for definitions) where 45 permanently-marked (DV1–4) and 13 left-side temporarily-marked (DV5–6) dolphins were recorded and then photographically recaptured at least once within the Saloum Delta.

Region	No. of animals	% of animals
Saloum and Outer Diomboss	1	1.7
Inner Diomboss	15	25.9
Outer Diomboss	2	3.4
Inner Diomboss, Outer Diomboss	14	24.1
Inner Diomboss, Outer Diomboss and Islands	4	6.9
Outer Diomboss and Islands	1	1.7
Outer Diomboss, Islands and South	1	1.7
Outer Diomboss and South	9	15.5
Islands and South	2	3.4
South	9	15.5

However, the photo-identification data did confirm the movement of some individual *Sousa teuszii* between the study area zones over the duration of the survey. Of the 58 marked dolphins for which there were recaptures, 16 animals were seen in more than one zone (Table 13). One highly-distinctive animal (P1) moved between Zone 3 (Saloum River) and Zone 4 (Diomboss), confirming movements between those two major waterways (Figure 19A). The remaining animals moved between the Diomboss (Zone 4) and the islands and/or southern coastal area between the Bandiala and the Djinack (Zone 2). For example, animal P18 occurred widely throughout the Diomboss and was also seen off the islands west of Bétenti (Figure 19C), while P30 was seen in the outer Diomboss, off the islands and in the vicinity of the Bandiala River mouth (Figure 19D). The movements of these dolphins suggest that individuals could potentially range widely throughout the SDBR (and beyond). More studies are required to clarify the home ranges, site fidelity and movements of *Sousa teuszii* in and around the SDBR.

While an in-depth analysis of social affiliation was not possible with this opportunistic dataset, the photo-identification analysis indicated that some individual *Sousa teuszii* in the SDBR were not consistently found in the same groups. Rather, some individuals and small sub-groups of animals moved between groups, while social units appeared to frequently aggregate and split up to form larger and smaller groups.

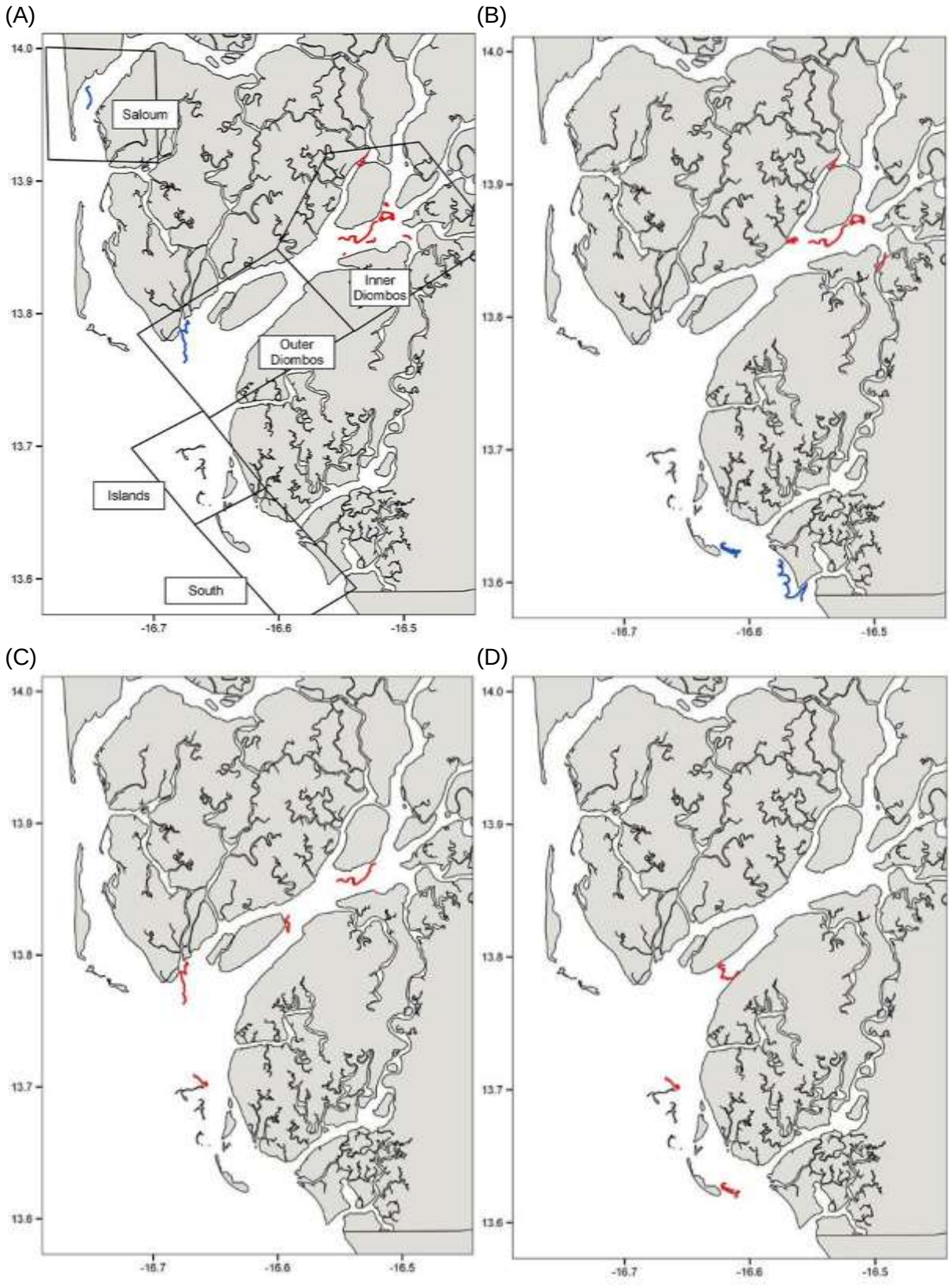


Figure 19. Spatial distribution of encounters with individual *Sousa teuszii* identified by photo-identification: (A) P1 (blue) and P6 (red); (B) P45 (blue) and P5 (red); (C) P18; and (D) P30.

4. DISCUSSION

4.1. Survey effort and logistics

Several limitations of the survey should be considered when interpreting the results presented in this report. Most importantly, this was a single short survey carried out at one time of year. Consequently, the results of this survey apply only to the October and November period, and the occurrence of dolphins during other seasons remains unclear. Fishermen consistently informed us that dolphins were present in upstream areas primarily in the spring and that they followed 'small fish' that were absent from the region at the time of this survey. Further survey work is required in other seasons in order to better document the year-round occurrence and population size of dolphins in the SDBR.

Some logistical limitations also deserve mention. The boat used during the survey, while adequate, had a very low eye height and would not be suitable for applying a rigorous line transect methodology. The low eye height of the boat reduced the detection of dolphins to an effective strip width of just a few hundred metres, particularly when any waves were present. Ideally, a boat with a raised observation platform and shade would be sourced for future work in the area, although the availability of such boats in the region is likely to be limited.

It should also be highlighted that the southern coastal part of the study area was very difficult to survey compared to the inner waterways and less variable coast in the northern part of the study area. The area from Bétenti south to the Gambian border (including the islands) was very shallow, with multiple complex sandbanks and sandbars that hindered access by boat and was greatly affected by tide. Dolphins were present in this area, but following and photographing them was very problematic due to high standing waves and motion of the boat. The logistical challenges of working in this area meant that photo-identification was less successful, and the detection rate and group size estimation was also likely to be lower than elsewhere because dolphins often surfaced out of the back of the swell waves where they were difficult to see. There is no doubt that this area is important for *Sousa teuszii*, and careful consideration should be given to planning future work around tides and weather in order to maximise the possibilities of collecting useful data.

4.2. Dolphin distribution and movements

The distribution of *Sousa teuszii* sightings during October/November 2015 highlights the Diomboss, particularly the inner Diomboss, as the most important area within the Saloum Delta for dolphins during this period. Sightings from the Diomboss have been previously reported (Weir and Collins, 2015), but not to the extent observed during this survey. Rather, Maigret (1980) considered that *Sousa* were more frequent in the Bandiala than the Diomboss, while the comprehensive review of *Sousa teuszii* records in Senegalese waters by Weir and Collins (2015) revealed that most existing records originated from the southern coast of the Saloum Delta from Île des Oiseaux to Djinack. However, those reviews did not take into account any measure of ‘effort’, and the records may therefore simply reflect where the largest number of observers was located or where interest in reporting dolphins was higher for some

reason. Without incorporating a measure of survey effort, it is impossible to establish whether areas of apparent concentration are genuinely more important areas for dolphins or simply reflect some other bias in reporting. The survey work carried out in October and November addressed this discrepancy by aiming for a representative distribution of survey coverage across the entire Saloum Delta region rather than specifically targeting areas where dolphins were thought most likely to occur. Consequently, the distribution of dolphin sightings reported here is likely a true reflection of the relative importance of different parts of the Saloum Delta during this particular period. However, it should be emphasised that dolphin distribution during other seasons may be entirely different and, in the absence of year-round survey coverage, remains unknown.

There are several reasons why the Diomboss might provide particularly suitable habitat for *Sousa teuszii*. Firstly, it is the widest system in the Saloum Delta and offers a much larger expanse of habitat than the Bandiala or the Djinack. It may simply be able to support higher numbers of dolphins than those areas, while also offering shelter from the coastal swells. While the Saloum is also a large system, the higher levels of anthropogenic disturbance (e.g. shipping, ferry, human habitation, coastal development, fishing) may potentially make it less attractive to *Sousa teuszii* (or their prey species) than the Diomboss. The Diomboss is also located centrally in the Saloum Delta and with bolongs that connect it to the other main systems (Saloum and Bandiala) to the north and south. Consequently, if dolphins are indeed moving regularly between the different systems within the Saloum Delta then the Diomboss could represent an important central transit route for the population. The Diomboss also has a very diverse array of habitats, with open water, sheltered banks and a large number of bolongs and branches. There are complex tidally-exposed sandbanks and also subsurface mud and sand banks with vegetation. It is likely that dolphins are able to use this variety of features to find and exploit prey at all stages of the tide. In particular, the inner Diomboss was frequently inhabited by dolphins. Interestingly, Simier et al. (2004) found that the highest fish species richness in the Saloum Delta was located at the confluence between the upper Bandiala, several small seawater creeks and the inner Diomboss. They suggested that this diversity of influences probably favoured settlement of many fish species in the area, which may also support dolphins.

Maigret (1980) suggested that *Sousa* move into the bolongs on the rising tide and depart again at low tide to disperse at the bolong mouths and in coastal waters around sandbanks and in the channels between Sangomar and Gambia. That the same groups of dolphins may travel between different areas depending on tide was also suggested by the ecoguard Adama Lene, who reported that *Sousa* in the southernmost Saloum Delta were usually seen around the islands at low tide and along the mainland coast and bolong mouths during the high tide. We spent time tracking (at distance, so as not to influence their movements) two large (>20 animals) groups of *Sousa* (Refs 24 and 25) in this region to try and document some of these movements:

1. On 4 November a group of 20–28 animals (Ref. 24) was followed for 62 min. The boat travelled 5.1 km while working with them, but for the latter half of the encounter the boat was mostly drifting and allowing the dolphins to travel without disturbance. The straight line distance that the dolphins covered during the encounter was 1.6 km. The dolphin encounter began at 09:17, when the animals were foraging between Île des Oiseaux and Bandiala. The dolphins worked this area throughout the encounter, slowly

moving towards the entrance to the Bandiala. The low tide at Sangomar on this date was at 09:25. The encounter was terminated at 10:19 in order to continue with the survey coverage, but at 10:47 the animals were seen entering the channel (between sandbars) and swimming into the Bandiala with the incoming tide.

2. On 5 November, a group of 23–30 animals (Ref. 25) was detected close to the beach between the Bandiala and the Djinack, and was subsequently followed for 111 min in order to track their movements and try to confirm a movement into the Djinack or into Gambian waters. The boat travelled 11.1 km while travelling alongside this dispersed group. The straight line distance that the boat travelled was 3.8 km. The dolphins were detected at 09:48 and the low tide was at 10:45. During the encounter they travelled and foraged opportunistically along the coast. At 10:37 the leading animals rounded the first sandbar at the entrance to the Djinack mouth and began to enter the channel system leading to the Djinack bolong. From 11:07 to 11:24 various dolphins were inside the Djinack channel, carrying out some exploratory dives (tail-up dives observed) but seemingly without finding prey. They continued southwards along the coast and into Gambian waters, at which point we were no longer able to follow them and terminated the encounter at 11:39.

These two encounters provide some insights on dolphin movements within the Saloum Delta. *Sousa teuszii* here and elsewhere (Weir, 2009, 2015) tend to move along the coast in behaviours alternating quickly and unpredictably between directed travel and dispersed foraging. It is likely that dolphins are continually scouting for food while moving through an area, and forage opportunistically whenever conditions allow. Dolphins seemed to be foraging when first encountered on 4 November, before moving into the Bandiala on the incoming tide. In contrast, the dolphins on 25 November (which consisted of some of the same individuals as the previous day) were foraging in opportunistic bursts as they travelled southwards along the coast, and did not seem to find food in Djinack shortly after the low tide. The dolphins on 25 November travelled a convoluted distance of over 11 km in the space of less than 2 hours. With directed travel they may therefore be able to move significant distances. For example, a movement from the Gambian border to the Diomboss would be easily achievable in several hours, while the swimming distance of approximately 50 km from the Gambian border to the Saloum mouth could be completed well within a day. Clearly, there is considerable potential for a single group of dolphins to occupy very different areas and habitats within a relatively short amount of time, which has important implications when considering the total population size in the Saloum Delta. For example, different fishermen reporting dolphins from Île des Oiseaux, Bandiala and Djinack on the same day could all potentially be seeing the same group of dolphins rather than separate groups of dolphins.

Several areas where dolphins (species uncertain) had been previously reported in the Saloum Delta were visited during the survey work without producing any sightings. These included the waters around Sangomar Island and upstream areas (such as at Foundiougne). In addition, the entrance to the Djinack bolong, an area described by Van Waerebeek et al. (2003) as the location “where humpback dolphins are most regularly sighted”, was visited several times but produced no sightings (a group of dolphins were tracked here from Bandiala on 5 November, but paused only briefly in the Djinack entrance before continuing south). Local people (including the ecoguard Djere Sonko who had received training on dolphin recording from Ruth Leeney) reported that no dolphins had been seen off Djinack village since the end of June. Either the use of Djinack by dolphins has decreased since the visits of Van Waerebeek, or

else these differences reflect seasonal changes in dolphin distribution which have not been previously reported.

Maigret (1980) proposed a hypothesis for a migration of *Sousa teuszii* along the coast northwards between the Saloum Delta and Mauritania. This hypothesis was based largely on confirmed sightings of *Sousa* in the Saloum between January and April, a reduction of sightings in May and June, and an absence of reports from July onwards. However, Maigret (1980) did note that systematic survey effort was lacking to support an absence of dolphins in the latter part of the year. The survey work reported here confirms that *Sousa teuszii* is present in the Saloum Delta during October and November. Consequently, the species is almost certainly found in the SDBR throughout the year. Whether there are seasonal changes in density within the SDBR (i.e. if part of the SDBR population moves seasonally out of the SDBR towards Gambia or northwards) remains unknown in the absence of dedicated year-round survey effort.

4.3. Photo-identification

Van Waerebeek et al. (2003) reported that a group of *Sousa teuszii* observed at Djinack in November 1999 “showed surprisingly few scars, nicks or other skin blemishes and no pox 'tattoo' marks, predicting limited prospects for photo-identification purposes”. However, seemingly that statement was made without obtaining suitable comprehensive photo-identification images to facilitate a thorough examination of dorsal fin markings. In contrast, the photo-identification work in October and November 2015 found that markings were present on almost all individuals for which suitable-quality photographs were obtained, including those dolphins present in the Bandiala-Djinack-Gambia region.

Maigret (1980) considered that the total population of *Sousa teuszii* in the Saloum Delta is very low and not likely to exceed 100 animals. That estimate of abundance was a speculative opinion based on observations in the region, without having any information about whether it was the same or different animals being seen in each encounter. Nevertheless, this population size of 'no more than 100 animals' has been widely-cited in reports and literature. Generating a scientifically-valid cetacean population abundance estimate for management purposes can be achieved using only established robust methods such as: (1) rigorous line transect surveys using teams of trained observers from a suitable vessel or aerial platform (see Dawson et al., 2008); or (2) regular mark-recapture analysis using photo-identification (see Würsig and Jefferson, 1990). Unfortunately, *Sousa teuszii* is a very problematic species to work with, given that its habitat presents considerable logistical difficulties for vessel (due to sandbanks, shallow depths, narrow waterways etc) and aerial (water turbidity) transect surveys, and that individuals are difficult to approach systematically and sufficiently close for photo-identification. Maigret’s (1980) guess of 100 animals should therefore be considered speculative and not as an accepted scientific estimate of population size at that time.

The minimum population size estimate of 103 animals presented here provides a basic indication of the minimum number of animals present in the SDBR at the time of the survey. However, there are several reasons to consider that there may be significantly more animals than this: (1) the discovery curve had not levelled off, indicating that the 103 photo-identified animals represented only a portion of the total number using the SDBR; (2) it was very

apparent during the fieldwork that not all individuals in each group were photographed (see below); (3) some poor-quality images were suggestive of 'new' animals but were of insufficient quality to add to the catalogue; (4) movements of animals out of the SDBR and into Gambia were documented, suggesting that not all of the SDBR population was necessarily present in the SBDR at the time of the survey; (5) some highly-distinctive individuals were seen only once during the survey, highlighting the strong likelihood of groups and individuals having been missed altogether; and (6) some highly-distinctive individuals (e.g. P4; Figure 15) were seen only very briefly during relatively long (~1 hr) photo-identification encounters, highlighting the potential for less obvious individuals to be missed. Nevertheless, the 103 animals recorded during the survey is the highest scientifically-derived population size for *Sousa teuszii* anywhere in its geographic range to date, and significantly greater than the 10 animals documented in southern Angola (Weir, 2009) and the 47 animals documented in Guinea (Weir, 2015). However, the latter study in Guinea sampled just a very small spatial area on several occasions, and by no means represents the total population size for that country.

Several limitations were encountered during the photo-identification work which meant that not all animals in each group could be photographically captured:

1. *Sousa* groups were often very dispersed in nature, with individuals and small units spread out over several hundred metres. Additionally, they behaved unpredictably in terms of surfacing behaviour with animals re-surfacing at variable distances, angles and after variable amounts of time. Consequently, it was very difficult to systematically move from one individual to the next to obtain a photograph, and in most encounters there were individuals that were never knowingly approached at all. We also had challenges with trying to manoeuvre the boat to travel parallel alongside a *Sousa* group (as is usually required for successful photo-identification work with dolphins), since the animals only very rarely travelled in a predictable direction as a concise group.
2. There was evidence during some encounters of subtle avoidance of the boat by the dolphins. Maigret (1980) noted that *Sousa teuszii* in the Saloum Delta did not flee from approaching boats, but split up and moved away to maintain a distance of 15–20 m from the vessel. We observed similar behaviour, although on a few occasions when small *Sousa* groups (3–4 animals) were feeding in a specific location then animals spent prolonged periods surfacing close to the boat while it was drifting with the engine switched off. It may therefore be engine noise that *Sousa* prefer to keep distance from, rather than the boat itself. The tendency for *Sousa* to move subtly away from the boat affected the entire photo-identification analysis since there was a high proportion of poor- or moderate-quality images in the catalogue (i.e. dorsal fins being too small in the image due to distance, bad angles as animals were orientated away from the boat, and poor focussing due to unpredictable surfacing).
3. While almost all of the individuals had dorsal fin markings of some kind, there were many animals who had rather subtle markings (tiny nicks or light scarring) that would not appear in anything other than the highest-quality images. Because of the other limitations described here, high quality images were relatively scarce and consequently there was a lower potential to capture those individuals compared with the highly-distinctive animals.
4. There was some evidence that individual *Sousa teuszii* varied in their tolerance of the boat. Certain individuals (e.g. P41) were very well-represented in the photographic

dataset despite having relatively subtle dorsal fin markings, suggesting that they were less inclined to surface away from the vessel and therefore had higher availability for photographic capture. Similarly, shyer individuals could potentially have a lower chance of being sampled.

5. The habitats occupied by *Sousa teuszii* in the SDBR (as elsewhere) were very challenging to work in. Breaking waves and shallow sandbanks often limited our efforts to approach animals, and sometimes resulted in having to abort the encounter completely for safety reasons. The environment had to be constantly monitored to ensure safe water depth and wave patterns, and this made manoeuvring the boat around dolphins very difficult. The motion of the small boat in the waves (and high amounts of salt spray) also physically limited the possibility to use a camera at times. This was particularly the case at some states of tide in the open Diomboss and for much of the time in the southern coastal area between Bétenti, the islands, Bandiala and Djinack. Photo-identification in those areas was significantly more difficult (and therefore less successful) than efforts in the inner Diomboss and bolongs.
6. Photo-identification encounters were sometimes interrupted by other events, such as launching a drone or approaching fishing boats, resulting in cessation of photo-identification effort.
7. Finally, both the photo-identification and the overall monitoring (detection of animals, completion of data forms, group size estimates etc) were carried out primarily by a single observer. At times it was problematic to attempt to do many tasks at the same time, and as a result some photo-identification opportunities were missed due to pausing to complete data forms or trying to make a visual estimate of the group size. Ideally, there would have been at least two people with suitable DSLR cameras (and experience in using them) to maximise the photo-identification potential.

There are scientific implications of not having an equal likelihood of having sampled every animal in a group, which break the fundamental assumptions of mark-recapture analysis and limit the options for analysing the data to produce a more robust modelled population size. Consequently, the analysis of the photo-identification here was limited to the calculation of a minimum population size.

Photo-identification is a very labour-intensive method to study cetaceans, involving significant effort in the field and a large amount of time in post-survey processing. However, in contrast to the other available methods (e.g. visual-only surveys, aerial surveys, acoustic surveys etc), photo-identification provides a wealth of information not only on the spatio-temporal distribution of dolphins but also on population size, dolphin movements and group composition that are essential to understanding and managing the population. Furthermore, without having the photo-identification data then it is very difficult to determine whether dolphin groups encountered at sea represent re-sightings of animals seen previously or new animals. This was experienced firsthand during the current survey, when there was confusion in the field whether several sightings of *Sousa teuszii* in the inner Diomboss on 6 November represented new groups or re-sightings. The analysis of photo-identification data after the survey was able to demonstrate conclusively that those sightings included two re-sightings of the same groups. This information is a crucial factor in estimating the total number of animals present in the study area. Photo-identification is therefore a viable and recommended method for the continuing study of *Sousa teuszii* in the Saloum Delta.

It should be noted that for photo-identification to be a viable method for long-term monitoring of the Saloum Delta dolphin population, it needs to be carried out on a regular basis. Many of the individuals in the SDBR were identified primarily by scar patterns rather than by nicks (this was even the case for some marked animals which had heavy scarring that showed up in poor-quality images, for example P5 and P6 in Figure 15). However, scars heal over time and animals constantly acquire new scars during social interactions. A recent study of *Sousa chinensis* in the waters off Hong Kong and Taiwan suggested that tooth-rake scars on dorsal fins healed and disappeared within 7 months (Wright, 2014). Therefore regular sampling is required in order to track these changes and ensure that individuals continue to be recognised over time rather than being incorrectly logged as 'new' animals. Several individuals in Senegal acquired new scars during the course of this study, some of which were significant enough to initially lead to them being catalogued as separate individuals. For example, a juvenile (P8) photographed on 24 October (Ref. 3) acquired new scars on the dorsal fin and body prior to being photographed again on 1 November (Ref. 18). Another animal (T8) acquired some fresh new wounds between being photographed on 26 (Ref. 4) and 29 October (Ref. 7) (Figure 20).

4.4. Managing the *Sousa* dolphin population

Despite the vulnerable conservation status of the species and the clear importance of this region, the Saloum Delta *Sousa teuszii* population has been under-studied to date and no strategy is currently in place for their long-term management. Maigret (1980) emphasised the need for strict protection of the species and its habitat in order to ensure its continued survival in the Saloum Delta. The survey reported here indicates that a reasonably healthy population exceeding 100 animals is present in the SDBR, and that this population is using the area for both breeding (evidenced by calves) and feeding (evidenced by observations of foraging and fish capture) purposes, almost certainly throughout the year. We also documented movements between Senegal and The Gambia which have important implications for future management.

The data described here can provide the baseline for future monitoring projects aimed at studying the dolphin population and clarifying its conservation status. In terms of future management, some immediate questions that require additional study include:

(1) How many dolphins are present in the Saloum Delta?

(2) Are groups stable or fluid in terms of membership? I.e. do animals stay together long-term or are the groups more dynamic? This is important to understand because there are a small number of highly-distinctive individuals that could be used by trained observers to quickly identify a group if the membership is stable.

(3) Are there regular movements of individuals or groups between the different river systems or are different stable communities found in each area? How often are animals moving between areas and communities?

(4) Do groups show fidelity to relatively small home ranges? Are there some core areas that incorporate the spatial range of a number of dolphin groups and would be suitable for consideration as dolphin Marine Protected Areas?

(5) How many, and how often, do animals from the Saloum Delta move into Gambia?

(6) Are the Saloum Delta humpback dolphins: (a) an isolated population; (b) part of a Saloum-Gambian population; or (c) part of a much wider-ranging population that includes other areas of Senegal (and beyond)?

(7) What are the main threats to the Saloum Delta's dolphins and how can they be mitigated? There is some consideration of likely threats in the Recommendations.

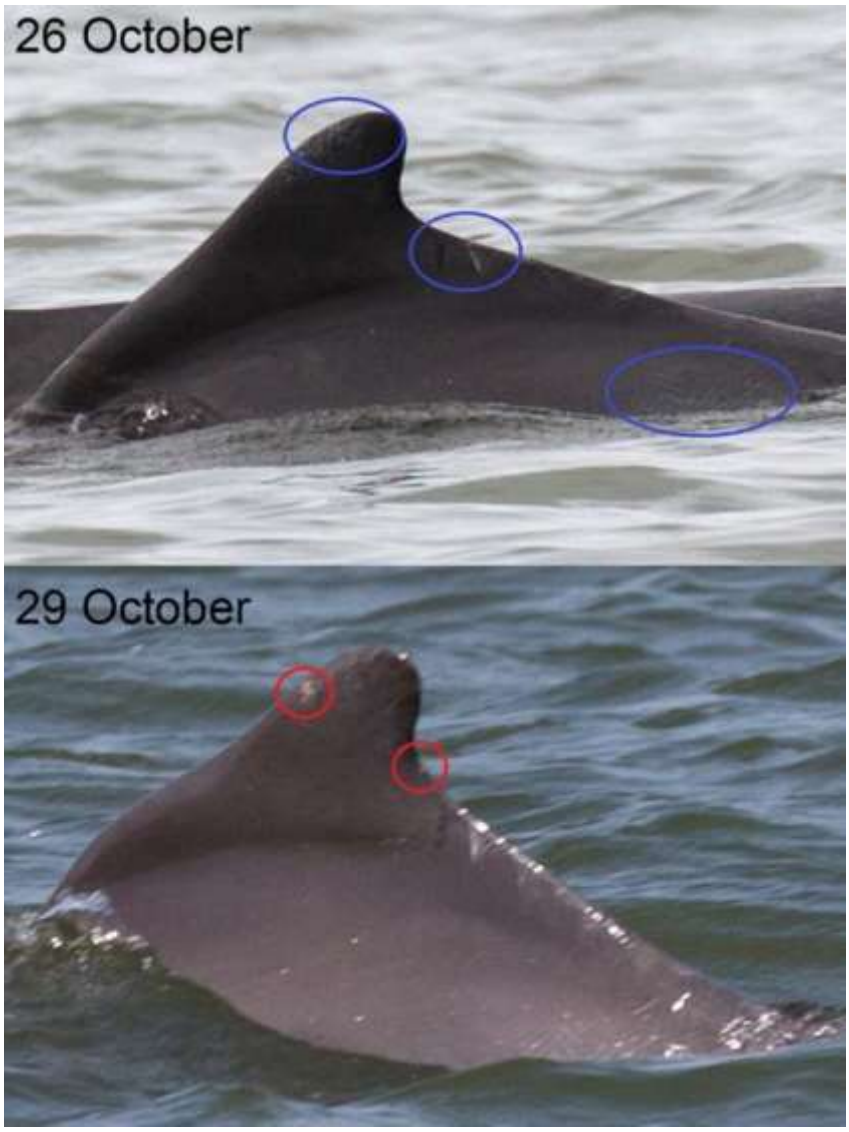


Figure 20. New wounds (circled in red) acquired by individual T8 during the survey, demonstrating how the features used to identify individuals can change over time. Existing scars used to match this animal between the two dates are circled in blue.

4.5. Bottlenose dolphins

The total absence of bottlenose dolphin sightings during the SDBR survey was unexpected. It is certainly not to be concluded that this species is absent from the Saloum Delta. Indeed, Cadenat (1949) considered it to be the most common species along the coast of Senegal, or at least the most frequently-observed during the dry season (December to June). Dupuy

(1983) also regarded it as common off Senegal, while Van Waerebeek et al. (2000) reported that it occurs “in most of the Saloum Delta” and that it is sighted as far inland as the salt creeks near Foundiougne during the rainy season (July to September) when the salinity drops and shrimps are abundant. However, Van Waerebeek et al. (2000) also stated that it needs to be clarified which of the two dolphin species the Foundiougne records refer to (i.e. it could be *Sousa teuszii* and not the bottlenose dolphin, or both).

Although there were no sightings of bottlenose dolphins during the survey work, we found some convincing evidence for its contemporary occurrence in the region. For example Adama Lene reported seeing the species around Sangomar, and some descriptions from fishermen of dolphins ‘jumping a lot’ seem more likely to relate to this species than to *Sousa teuszii*. It seems likely that the occurrence of the bottlenose dolphin in the SDBR is either seasonal or else is related to the movement of 'small fish' and therefore varies depending on environmental conditions. Further survey work at different times of year is required in order to establish the factors determining the occurrence of bottlenose dolphins in the area.

5. RECOMMENDATIONS

A series of recommendations arise from the fieldwork and are summarised below.

5.1. Future work

The survey work carried out in October/November 2015 provided a good baseline dataset of the distribution and minimum population size of *Sousa teuszii* in the SDBR at that time. However, many questions remain unanswered and require clarification before a full evaluation of the status of the population will be possible. Most crucial is establishing the distribution and population size of *Sousa teuszii* within the SDBR during other seasons, since the evidence from interviews suggested that dolphin occurrence in the area varies seasonally. It is therefore recommended that the surveys carried out in October/November should be fully repeated (i.e. following the same routes, including the coastal transects) at least twice more at different times of year, with February/March and June/July providing a good seasonal comparison. This would also allow a better evaluation of the occurrence of bottlenose dolphins within the SDBR.

In terms of future work, it is also recommended that:

1. Effort is made to survey the full extent of the Saloum Delta Biosphere Reserve. Due to safety constraints with the available boats, survey coverage during the initial October/November survey was limited to within ~5 km of land (mainland or outlying islands). Consequently, the area of the Biosphere Reserve furthest from shore did not receive any survey coverage. This area should be surveyed in the future, since the water depths there are sufficiently shallow for *Sousa teuszii* to potentially be present.
2. There should be a *team* of trained observers on future surveys to allow regular rest (through a rota of roles) and to maximise the efficiency of dolphin detection and of any photo-identification work carried out.
3. A boat with a shelter from the sun and a raised platform (to increase eye height) should be sought if possible.

5.2. Fishing and fisherman awareness

The most obvious potential anthropogenic pressure on *Sousa teuszii* in the SDBR is the widespread fishing that occurs in the region. Consequently, it is recommended that an awareness campaign is carried out in fishing communities throughout the Saloum Delta to inform local people of the presence of dolphins and of their legal protection and conservation status. All cetacean species in Senegal are protected under LOI No. 86-04 *Portant code de la chasse et de la protection de la faune*, being specifically named under Article D-36 of *Decret No. 86-844* as species for which hunting and capture is formally prohibited.

The issues of disturbance, over-fishing, by-catch and directed hunting of dolphins should all be raised with fishing communities as part of an awareness campaign:

- *Disturbance*. *Sousa teuszii* is widely-considered to be sensitive to human disturbance (Van Waerebeek et al., 2004). In the Saloum Delta this species frequently enters narrow waterways and channels at the entrances to bolongs and rivers where the potential for disturbance from boats is high. Fishermen are one of the main stakeholders using the marine environment in the SDBR, and some simple guidance could be provided to them in order to minimise potential disturbance to dolphins. For example, steering their boats around areas where dolphins are feeding, instead of driving directly through the animals (see dolphin-watching guidelines in the following section). Dolphins are acoustically-sensitive animals and the noise from boat engines can cause disturbance by masking their communication signals and the sounds that the animals produce in order to navigate and locate food.
- *Over-fishing.* The removal of large amounts of fish from the environment for human protein can potentially have a direct impact on dolphin populations which may be feeding on the same prey species. Ecoutin et al. (2010) reported a 40% decrease in the Saloum Delta fish biomass between 1992 and 2002, and a reduction in the maximum observed lengths of most fish species. Such over-fishing of prey species is likely to impact on dolphins and other predators, but is difficult to study and to address. Fishing communities need to be made aware that excessive fish removal will affect both themselves and other predators such as dolphins.
- *By-catch*. Van Waerebeek et al. (2000) noted that by-catch (the accidental capture of cetaceans in fishing gear) was a major source of human-related mortality among small cetaceans in Senegal. Investigations should be made to establish whether or not dolphin by-catch is a significant problem in the Saloum Delta. In a number of questionnaire interviews carried out in the Saloum Delta communities during 2011, almost half of respondents (48%) asserted that other fishermen sometimes captured dolphins accidentally (Leeney et al., 2011). Additionally, Van Waerebeek et al. (2000) reported that the meat of dolphins (whether caught deliberately or accidentally) is consumed locally in some Senegalese towns including Djiffer. Consequently, the issue of dolphin by-catch deserves more detailed investigation via interview surveys in fishing communities and an awareness campaign to make fishermen aware of the problem and how to minimise it (i.e. by choice of fishing gear and where/when it is deployed). Simply checking for dolphins before deploying nets and making sure to avoid those areas where dolphins regularly feed could immediately reduce by-catch. Ecoutin et al. (2010) noted that fishing activity is increasing in the Saloum Delta. However, the technological range of the fishing gear has also changed, with a sharp decrease in the proportion of passive gear (set gillnets) in favour of more active gear, targeting particular fish species (encircling gillnets, beach seines) (Ecoutin et al., 2010). Set gillnets are one of the major causes of dolphin by-catch worldwide (Reeves et al., 2013), and any reduction in their use within the Saloum Delta is therefore likely to be beneficial to dolphins. Since active fishing gear is, by definition, manned by fishermen, there is an option to check whether dolphins are present in an area prior to deploying such gear.
- *Directed hunting*. There was no evidence for targeted hunting of *Sousa* during the survey (although we did not specifically ask about this) nor during interviews carried out in the Saloum Delta by Leeney et al. (2011). Certainly in the past some *Sousa* have been deliberately harpooned in the Saloum Delta, for example one at the mouth of the

Bandiala in 1942 (Cadenat, 1947). However, it is not clear whether or not this is currently an issue in the SDBR. An awareness campaign explaining the legal protection of dolphins throughout Senegalese waters might help to ensure that dolphin hunting does not resume.

Additionally, and as recommended previously by Leeney et al. (2011), effort should be made to encourage fishermen to land any dolphins caught accidentally in their nets so that maximum data can be extracted from these unfortunate events. Accidental entrapment in fishing gear (as opposed to deliberate takes) is easy to prove (by net marks on the animal's body and absence of other wounds), and it may be more productive in the long-term to encourage the open reporting to authorities and landing of carcasses in these circumstances than to penalise fishermen for having caught a dolphin. In this way, the scale of dolphin bycatch in various fisheries could be better assessed and the carcass would also yield much-needed life-history data (e.g. longevity, age at sexual maturity, calving parameters) that are needed for population management. Training in how to carry out necropsies should be provided to selected suitable local people.

5.3. Ecotourism awareness

The scale of dolphin-watching in the Saloum Delta is currently unknown, but locals informed us that it occurs on an *ad hoc* basis when tourists request it. The conduct of dolphin-watching boats around dolphins is also unknown, since no dolphin-watching was directly observed during this survey. However, as in other areas (e.g. the Gambia River; Van Waerebeek et al., 2000), an increase in the number of dolphin-watching platforms should be anticipated.

While dolphin-watching has a number of benefits in raising awareness of the marine environment, providing an additional source of local income and encouraging local people to protect dolphins, there are also some concerns. In particular, ecotourism boats can cause disturbance to dolphins both acoustically (from increased levels of engine noise) and by physically chasing after dolphins in order to obtain close views. There are also increased risks of injuries to dolphins from propeller strikes if boats are manoeuvred carelessly around animals.

Consequently, it is strongly recommended that a licensing system and some guidelines for appropriate conduct around dolphins by ecotourism vessels should be developed in the Saloum Delta. Additionally, a general awareness campaign could be carried out in the villages most visited by tourists and where marine ecotourism is most likely to develop. In order to present some educational information to tourists, ecotourism operators could attend a training course on the field identification and behaviour of dolphins, and on their safe conduct around dolphins.

A review of whale- and dolphin-watching guidelines from around the world can be found online at: http://uk.whales.org/sites/default/files/whale-watching-guidelines-review-2008.pdf
Examples of appropriate conduct that could be included in dolphin-watching guidelines for the Saloum Delta include:

- Only a single boat should be around a dolphin group at any time.

- Do not herd (circle), separate, scatter, or pursue a group of marine mammals, particularly mothers and young.
- Avoid sudden or repeated changes in direction, speed or changing gears when close to marine mammals.
- If cetaceans approach the vessel or bow-ride, maintain a slow, steady speed without changing course.
- Where a vessel stops to enable the passengers to watch a cetacean, the engines should be placed in neutral. If the animals remain in a local area, and if it is safe to do so, the vessel's engine should be stopped. Propeller guards should be considered for use on regular dolphin-watch vessels.
- Cetaceans should never be approached head-on, but from the rear or the side.
- Except in circumstances where the cetaceans themselves choose to approach, vessels should always maintain themselves at a particular distance from the animals being watched. 50 m is the recommended distance for dolphins.
- The time spent watching dolphins should be limited to periods of 20 or 30 min.
- Contact with cetaceans should be abandoned at any stage if they show signs of becoming disturbed or alarmed. This is particularly the case when young calves are present.
- When departing from watching cetaceans it is of importance to determine where the animals are relative to the vessel to avoid collisions. In some circumstances it may be necessary to wait for animals to return to the surface from a dive to be certain as to their position. Departing vessels should proceed slowly until at safe distance.
- No rubbish, sewage or other polluting substances (including oil) or food should be disposed of in the proximity of the cetaceans.
- Do not attempt to feed, swim with or touch cetaceans.

5.4. Commercial developments and EIAs

Companies involved with commercial developments within the SDBR should be made aware during their licence application of the presence of a dolphin species of high conservation concern. Given its limited spatial distribution, inshore distribution, small population sizes and sensitivity, *Sousa teuszii* is vulnerable to habitat loss and disturbance throughout its range (Weir et al., 2011). Commercial projects impacting the marine environment within the SDBR should explicitly include *Sousa teuszii* within their Environmental Impact Assessment and ensure that adequate measures are in place to mitigate for any impacts on the species. Such projects may include (but are not limited to) coastal development, harbour expansions, dredging operations and any activities generating high levels of underwater noise such as the use of explosives, seismic airguns or loud sonars.

Some responsibility for ensuring that commercial companies are aware of the animals occurring in a potential development site also lies with the people studying them. Effort should always be made to ensure that wildlife studies are published in peer-reviewed scientific

journals so that the presence of sensitive species in the region is highlighted during the standard literature searches carried out for EIAs.

5.5. Marine Protected Areas

The survey carried out in October and November highlighted two main areas of importance for *Sousa teuszii*; (1) the Diomboss, especially the inner Diomboss; and (2) the area between Île des Oiseaux, Bandiala, Djinack and the Gambian border. However, more data are required before the year-round importance of these two areas for *Sousa teuszii* can be confirmed.

One Marine Protected Area (MPA), the Bamboung Bolong MPA, already exists in the inner Diomboss, aimed at protecting a high fish diversity. During their modelling of the effects of the Bamboung Bolong MPA on fish communities, Brochier et al. (2013) incorporated dolphins as 'very large predators' that may enter the MPA on occasion for foraging purposes. They noted that due to the very high mobility of top predators their population dynamics would not be limited to the MPA or even to the surrounding waters, and therefore concluded that "population-wide MPA benefits for these species are negligible". However, their model did predict that the biomass of the very large predators group (sharks and dolphins) increased after the fishery closure. The potential beneficial impacts of the MPA on dolphins should be properly assessed, since the evidence in this report indicates that the inner area of the Diomboss is of particularly high importance for *Sousa teuszii* including foraging mothers with calves. Consequently, in contrast to the conclusions of Brochier et al. (2013), there is good reason to consider that the Diomboss estuary may represent an important core habitat for a significant portion of the Saloum Delta *Sousa teuszii* population. While dolphins may not frequently enter the MPA itself (perhaps due to the single, spatially-limited point of entrance and exit from the MPA), the large spill-over of fish biomass from the Bamboung Bolong MPA (Brochier et al., 2013) into the surrounding area may provide increased foraging opportunities for dolphins and potentially have positive repercussions for the wider population.

At this stage, the inner Diomboss stands out as an important area for dolphins and would appear to represent a suitable area for protecting the species. Although further survey work is needed to establish the longer-term use of this area by dolphins, the advantages (to dolphin conservation) and disadvantages (in terms of impacts on local fishing communities) of designating a MPA aimed specifically at protecting the dolphin population within the Diomboss region should be investigated. Similar may also be true of the Île des Oiseaux-Bandiala-Djinack region if further study confirms a significant year-round dolphin presence. Designating dolphin MPAs could have positive impacts for dolphins by increasing the available prey (i.e. through protection of fish stocks), reducing any potential fishing impacts (i.e. lessen by-catch of dolphins by prohibiting certain types of fishing gear) and reducing potential disturbance (if boat traffic is regulated via a suitable code of conduct).

5.6. Local dolphin monitoring scheme

Several local people that are interested in dolphins were encountered during the survey, including Adama Lene at Murissa and Djere Sonko at Djinack. Both had previously received some training in dolphin surveys and field identification from Ruth Leeney (see Leeney et al.,

2011 for a summary of training during June 2011), and expressed their sincere enthusiasm for the subject. Adama reported that dolphin monitoring surveys had been carried out monthly during 2011 (through Wetlands International) but that, although the participants had wanted to continue, no funding had emerged to carry on the work.

It is highly recommended that a new phase of advanced field training (including important methodologies such as line transects, photo-identification and necropsies) is implemented for these interested and knowledgeable individuals, and funding sought to plan and carry out an ongoing monitoring programme aimed specifically at producing data of a scientific-standard that would inform future dolphin management. The involvement of local people is crucial to the success of any dolphin research programme in the Saloum Delta, but it is important that the selected people are trained to a very high standard in order for the project to generate the type of data required to detect long-term trends in the dolphin population.

5.7. Senegalese-Gambian dolphin partnership

There is now reliable evidence from multiple sources that *Sousa teuszii* from the Saloum Delta are also using Gambian waters. Local people at Djinack village and the ecoguard Adama Lene considered that dolphins were most common at Djinack from June to August and suggested that they move into Gambian waters at other times. Movements of dolphins between the Saloum Delta and Senegal have been documented previously (Van Waerebeek et al., 2004) and on the 5 November then a group of approximately 25 dolphins was observed crossing into Gambia during the current survey. Consequently, Saloum Delta *Sousa teuszii* are undoubtedly also using Gambian waters, although it remains unclear to what extent. In recognition of this, Van Waerebeek et al. (2004) proposed a 'Saloum-Niumi stock' of *Sousa teuszii*.

The transboundary status of this population has important implications for the future monitoring, management and conservation of the Saloum Delta dolphins. Firstly, the extent to which dolphins from the Saloum Delta are using Gambian waters needs to be investigated, in particular to establish the number of animals using the waters of both countries, their seasonal movements and the relative importance of each area. If a significant number of dolphins from the Saloum Delta are regularly using Gambian waters then effective future management and protection of the Saloum Delta dolphin population must include a joint management approach between Senegal and Gambian authorities.

During the current survey there was considerable confusion over whether or not the survey boat was permitted to cross the border into Gambian waters (both within the Djinack estuary protected areas and in coastal waters). Consequently, on one occasion a *Sousa teuszii* group was seen travelling south from the Saloum Delta into Gambia and the survey boat was unable to follow. It is recommended that effort is made to establish a joint Senegalese-Gambian dolphin initiative, and that the necessary permits are acquired to allow future dolphin surveys to include (at least) the northern part of Gambia if possible.

5.8. Routine recording of opportunistic sightings

It is recommended that standardised databases of dolphin sightings should be maintained by both Sylvatrop (and other organisations working in the SDBR) and the DPN, given: (1) the deficit of information on dolphins in this area; (2) the concerning conservation status of *Sousa teuszii*; and (3) the fact that some data collected by organisations previously appear to be missing. Dolphins seen opportunistically by personnel while on missions in the Saloum Delta should be properly recorded and routinely entered into a database. Additionally, anecdotal information provided by fishermen (e.g. “dolphins were seen here yesterday”) should be acquired whenever possible and should also be logged routinely in a database. The minimum information required to make such data useful to scientists (and therefore for conservation of the species) is: date, time (local), location (written description or GPS latitude and longitude), species (or just ‘dolphins’ if unknown) and estimated group size (or just ‘minimum’ and ‘maximum’).

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