

Killer whales (*Orcinus orca*) in Angolan and Gulf of Guinea waters, tropical West Africa

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Killer whales *Orcinus orca* are considered to be relatively uncommon in tropical waters. Few sightings have been reported from the west coast of Africa due to a paucity of survey coverage. We present data on 32 killer sightings from tropical waters off Angola ($N = 18$), Gabon ($N = 7$), São Tomé ($N = 6$) and Cameroon ($N = 1$), comprising a combination of dedicated survey sightings ($N = 21$) and reliable anecdotal records ($n = 11$). Killer whales were reported from coastal waters, the shelf edge and deep, oceanic areas. Sightings indicate a probable year-round occurrence of killer whales within the region. Mean group size was 5.6 animals. There was no difference in group size between sightings in waters >200 m deep and those on the continental shelf. No photo-identification matches were found between Angola, Gabon and São Tomé. Re-sightings of two individuals occurred annually in São Tomé during 2002–2004. Killer whales had external appearance consistent with the Type A nominate species form. Antagonistic encounters were recorded between killer whales and hump-back whales *Megaptera novaeangliae* off Angola, Gabon and Cameroon, and with sperm whales *Physeter macrocephalus* off Angola. Predation on ocean sunfish *Mola mola* was recorded in São Tomé, and possible predation on sharks was recorded twice in Gabon.

Keywords: killer whale, *Orcinus orca*, predation, Angola, Gabon, São Tomé, Cameroon, Gulf of Guinea, south-east Atlantic

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INTRODUCTION

Killer whales (*Orcinus orca* Linnaeus, 1758) are distributed throughout the world's oceans, being concentrated towards higher latitudes in cold temperate and sub-polar waters (Dahlheim & Heyning, 1999; Forney & Wade, 2006). Although considered relatively less numerous in tropical waters, there are records verifying the widespread occurrence of killer whales throughout tropical regions (e.g. Katona *et al.*, 1988; Ilangakoon *et al.*, 1992; Fertl *et al.*, 1996; O'Sullivan & Mullin, 1997; Guerrero Ruiz *et al.*, 1998; Dahlheim & Heyning, 1999; Visser & Bonaccorso, 2003; Baird *et al.*, 2006; Forney & Wade, 2006).

Knowledge of killer whales along the west coast of Africa in the South Atlantic is limited largely to temperate regions. There are records for the coasts of north-west Africa (DeKeyser, 1955; Cadenat, 1959; Aloncle, 1964; Dupuy & Maigret, 1976; Bayed & Beaubrun, 1987; Hammond & Lockyer, 1988; Maigret, 1990; Jefferson *et al.*, 1997; Robineau & Vely, 1998) including the Cape Verde Islands (Reiner *et al.*, 1996; Hazevoet & Wenzel, 2002), and from the coasts of Namibia and South Africa in the southern hemisphere (Rice & Saayman, 1987; Findlay *et al.*, 1992). However,

records from tropical waters within the Gulf of Guinea south to Angola are scarce, consisting only of occasional reports from Liberia (Hammond & Lockyer, 1988), the Côte d'Ivoire (Cadenat, 1959; Hammond & Lockyer, 1988; Anon, 2000), Ghana (Hammond & Lockyer, 1988; Jefferson *et al.*, 1997), Annobón Island (Equatorial Guinea: Reeves & Mitchell, 1988; Anon, 2000) and Gabon (Reeves & Mitchell, 1988).

Records kept during Antarctic whaling operations between November and May provide limited information on the off-shore distribution of killer whales in the temperate/tropical south-east Atlantic. Budylenko (1981) reports small groups of killer whales off northern Namibia during December and February, while Mikhalev *et al.* (1981) report a single record well offshore Gabon during November.

The paucity of sighting records of killer whales off tropical West Africa is reflected by a lack of information on basic aspects of their ecology, life-history and morphology. A variety of forms and ecotypes of killer whales have been described worldwide, based primarily on morphology, behaviour, genetics and dietary specialization of different populations (Hoelzel *et al.*, 1998; Ford *et al.*, 1999; Baird, 2000; Pitman & Ensor, 2003). These forms are particularly well studied in the north-east Pacific where whales have been broadly defined into fish-eating and mammal-eating groups (Ford *et al.*, 1999; Baird, 2000; Jones, 2006). In Antarctica, killer whales have similarly been divided into Types A, B and C according to the relative size and shape of the eye

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patch, the presence or absence of a dorsal cape, habitat preferences and prey specializations (Pitman & Ensor, 2003). Different forms occur throughout the known range of killer whales, and both the distribution and the ecotype exhibited by particular groups appears to relate to dietary specialization upon favoured prey species, which includes an extensive list of marine mammal, fish, cephalopod, bird and marine turtle species (Jefferson *et al.*, 1991).

Here we provide details of killer whale sightings from Angola, Gabon and São Tomé located in tropical waters on the west coast of Africa, an area for which killer whale occurrence is largely unrecognized (IUCN, 2008). Information on the distribution, seasonality, group composition, behaviour and morphology of killer whales in this region is described.

MATERIALS AND METHODS

Killer whale sightings were collected from three separate study areas off West Africa (Figure 1). Cetacean surveys off northern

Angola were conducted concurrently with geophysical seismic surveys. Dedicated cetacean research surveys were carried out off Gabon and the offshore island of São Tomé. Anecdotal records from Angola, Gabon and Cameroon were also reported to the authors.

Angola

Dedicated marine mammal surveys were conducted off northern Angola (latitude 5–11°S; Figure 2) in association with four geophysical seismic exploration operations carried out between 1 August 2004 and 28 July 2007. Most data were from water depths of 1000–3000 m but limited effort occurred throughout the wider area from the coast to 4000 m depth. A total of 5664.1 hours of dedicated survey data were collected, comprising: (1) 288-days of marine mammal observation between 1 August 2004 and 15 May 2005; (2) a 44-day period of observation between 10 August and 27 September 2005; (3) 30-days of observation between

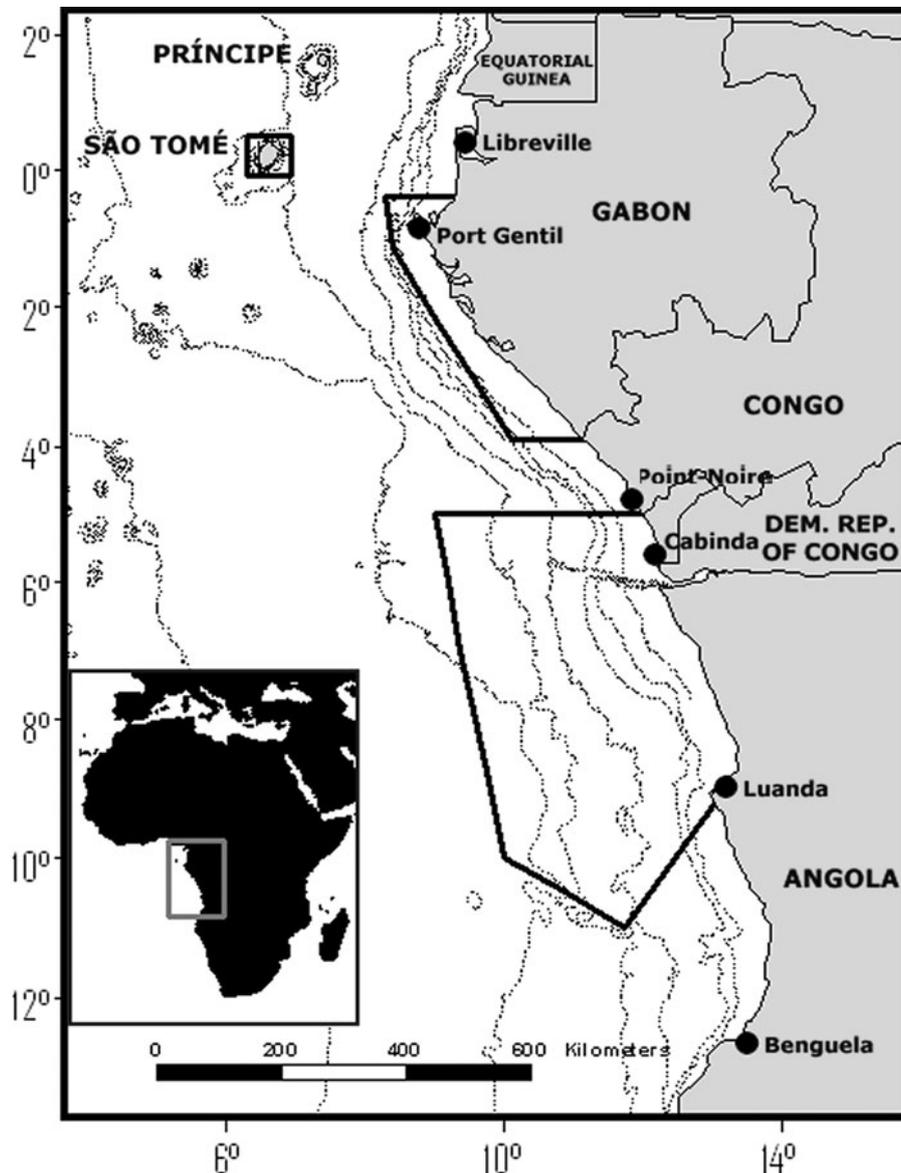


Fig. 1. Location of the three dedicated study areas off West Africa.

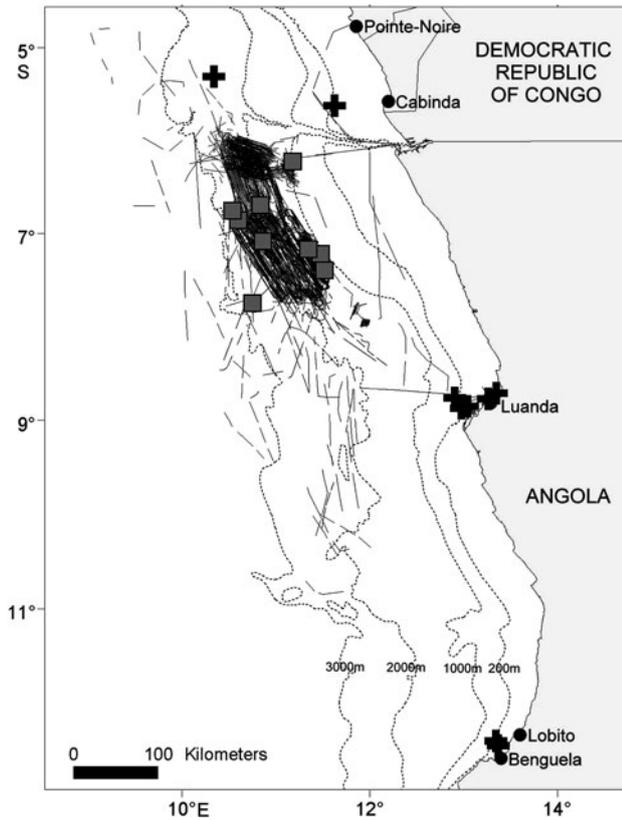


Fig. 2. Location of survey effort (2004–2007) and killer whale records off Angola from dedicated surveys (square) and anecdotal sightings (cross).

30 December 2005 and 28 January 2006; and (4) 217-days of observation between 28 November 2006 and 28 July 2007.

The same three experienced observers (C.W. and two other biologists) carried out the survey work using standardized methodology. A single observer situated at eye height of between 11 and 20 m, used 10×42 binoculars to scan 360° around the vessel for cetaceans throughout daylight hours and in all weather conditions, while the vessel was travelling at 4–5 knots. Effort logs (comprising position, water depth, airgun activity and environmental data including Beaufort sea state) were completed for every watch. For marine mammal sightings the position, species, group size and composition, behaviour, water depth and associated environmental data (sea state, swell height and visibility) were recorded. Digital photographs were taken where possible using a 100–400 mm lens.

Anecdotal records of killer whales off Angola were provided by observers on platforms including the coast, sports fishing vessels, fishery research vessels and seismic survey ships. These records were reported predominantly from central Angola (Figure 2).

Gabon and São Tomé

Dedicated cetacean surveys off Gabon and São Tomé focused on seasonal aggregations of breeding humpback whales *Megaptera novaeangliae* during the winter months, and both used similar methodology. Gabonese survey bases included Port Gentil, Iguela, the Nyanga River and Mayumba (Figure 3), most of which are characterized by a gently sloping continental shelf that reaches 200 m depth

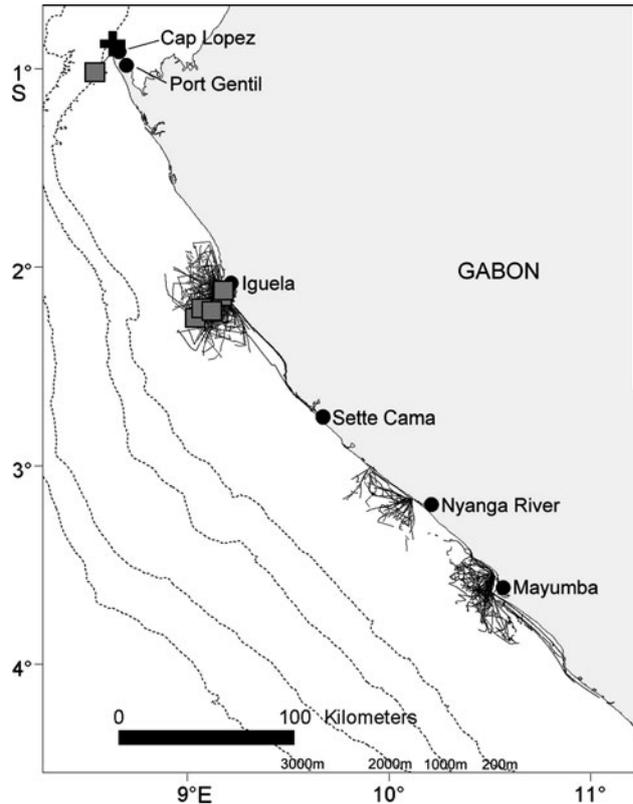


Fig. 3. Location of survey effort (2001–2006; effort not available for 2000) and killer whale records off Gabon from dedicated surveys (square) and anecdotal sightings (cross).

approximately 50 km offshore. The exception is Port Gentil located on the peninsula of Cap Lopez, where the continental shelf edge is only 10 km offshore. The volcanic island of São Tomé is situated about 300 km north-west of mainland Gabon (Figure 1), and has pronounced seabed relief with a narrow (<3 km) continental shelf dropping off steeply over 10 km into deep water (2000 m).

Surveys off Gabon and São Tomé were carried out using small (6–9 m) boats. In Gabon, surveys were typically conducted by three researchers (led by T.C.) and a boat pilot, while the São Tomé surveys involved a minimum of two dedicated cetacean observers (led by I.C.) and a boat pilot. The survey routes taken were weather-dependent and no attempt was made to evenly distribute the effort. An effort log (position, research activity and environmental data) was completed throughout each survey. During cetacean encounters the vessel detoured to approach the animal(s) to collect data on species, group size and composition, and behaviour. Survey effort therefore comprised both dedicated survey effort and encounter time (where research effort was focused on a particular group of animals and other species were only noted opportunistically). Photographs were taken with 35 mm film or digital SLR cameras fitted with autofocus lenses in the 70–300 mm range.

A total of 2018.3 hours of dedicated survey effort was collected off Gabon between 2000 and 2006, with most effort occurring off Iguela and Mayumba during 2001–2006 (Figure 3). All data were collected in the winter and spring months between July and October (90.1% of effort occurred during August and September). Survey effort was mostly limited to shelf waters, with over 99% of effort occurring in water depths of <100 m (Figure 3). Anecdotal records from

Port Gentil were provided by a reliable observer based on sports fishing vessels.

A total of 499.9 hours of dedicated search effort (203 boat surveys) was collected around São Tomé between August 2002 and October 2005, primarily in shelf and shelf edge habitat (Figure 4). Due to the varying location of the survey base, during 2002 and 2003 survey work was concentrated around southern São Tomé, while during 2004 and 2005 most effort occurred around the northern region. The majority of data (59.2%) were collected during September and October, with only around half that coverage (10.7–14.4% each) during January, August and November and a small amount (4.1%) during December 2002.

Photo-identification

Photographic methods were used to identify individual killer whales in each study area, based primarily on nicks and notches along the trailing edge of the dorsal fin (Hammond *et al.*, 1990; Würsig & Jefferson, 1990). Animals were photographed on an opportunistic basis and no attempt was made to ensure that every animal within each group was photographed. A catalogue of identifiable individuals was developed within each study area, and a single researcher (T.C.) then compared killer whale images between the three study areas. Images were not graded for quality but were simply assessed by eye to determine whether the features were clear enough to facilitate potential matches.

Humpback whale fluke analysis

Humpback whale fluke images from the 2000 to 2004 Gabonese photo-identification catalogue were analysed for

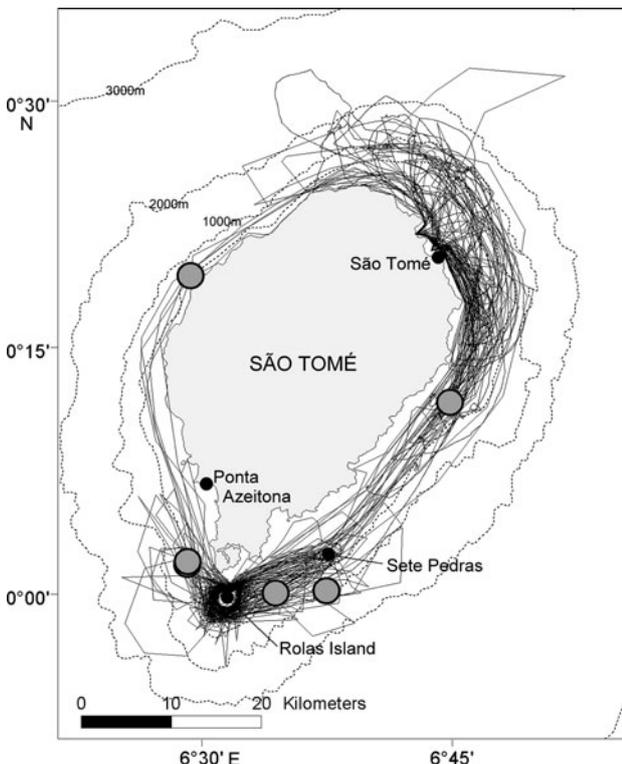


Fig. 4. Location of survey effort (2002–2005) and killer whale records off São Tomé during dedicated surveys.

the presence of killer whale tooth rake scars. All images were rated for quality (including photographic, orientation and distinctiveness quality factors). Incidence of killer whale scarring was assessed according to Steiger *et al.* (2008), who defined a rake mark as a 'set of three or more parallel lines or marks in close proximity'.

RESULTS

There have been 31 confirmed sightings of killer whales from Angola, Gabon and São Tomé (Table 1), and a single anecdotal record from Cameroon. Most sightings have been recorded since 2001 corresponding with the onset of dedicated survey work in the region, but anecdotal reports dating back to 1991 testify to a long-term presence of killer whales off tropical West Africa. Several other anecdotal records from the region were omitted from this paper due to lack of details.

Spatial distribution

Nine killer whale groups (depths of 969–2609 m) were recorded during dedicated deep-water surveys off northern Angola (Figure 2). A further 9 anecdotal sightings were documented in 1991–2008, occurring from Cabinda south to Benguela (Figure 2). Most anecdotal records were from the continental shelf, with single records from deep (2500 m) and shelf edge (345 m) waters. It is noteworthy that the nine dedicated and two anecdotal killer whale sightings reported from seismic vessels off Angola occurred only when the airguns were either off, or were active at very low volume (during either an airgun test or a soft start). It is therefore possible that killer whales avoided the survey vessel during periods of active airgun use (as was shown for another delphinid species, the Atlantic spotted dolphin *Stenella frontalis*, during some of these surveys; Weir, 2008a) and may therefore have been under-recorded in Angolan waters.

Six killer whale sightings occurred during dedicated survey work in Gabon. Five were located off Iguela and one off Cap Lopez (Figure 3). The records occurred over a depth-range of 10–400 m, with four groups recorded in water depths of less than 50 m. A single anecdotal record occurred off Cap Lopez in approximately 100 m water depth. Six killer whale sightings were recorded around São Tomé. Four occurred around the island of Rolas in the south and there were single sightings on the east and north-west coasts (Figure 4). Four sightings occurred in shelf edge habitat (270–790 m), and there were single sightings from the shelf (55 m) and deep-water (>1200 m). A single anecdotal record off

Table 1. Summary of killer whale *Orcinus orca* records in the study area, 1991–2008.

| Region | Total sightings (sum of best estimate of individuals) | | |
|----------|---|------------------|-------------------|
| | Total records | Dedicated survey | Anecdotal records |
| Angola | 18 (89) | 9 (47) | 9 (42) |
| Gabon | 7 (42) | 6 (39) | 1 (3) |
| São Tomé | 6 (37) | 6 (37) | 0 |
| Cameroon | 1 (10) | 0 | 1 (10) |
| Total | 32 (178) | 21 (123) | 11 (55) |

Cameroon occurred around 35 km south of the coast (approximate position 04°11'N 08°26'E) in about 30 m depth.

Analysis of the combined dataset reveals that killer whales off West Africa inhabited waters from 10 to 2609 m, and may therefore be considered as widespread over the larger study area.

Temporal occurrence

The month of the sighting was available for 31 of the West African records. The seasonal distribution of dedicated and anecdotal sightings indicates a probable year-round occurrence of killer whales within the larger region (Figure 5).

In Angola, year-round dedicated survey effort produced most (89%) sightings during the spring and summer months, and sighting rate was highest in the November to January period (Figure 5A). Anecdotal records from (predominantly coastal) Angolan waters occurred in six widely spread months of the year suggesting that this species may be present year-round at least in shelf waters.

Off Gabon and São Tomé, the majority of survey effort occurred between August and October, corresponding with the humpback whale breeding season. Off Gabon, sightings occurred in July (1), August (3) and September (2), clearly reflecting survey effort (Figure 5B). A single anecdotal record also occurred in August. However, sightings off São Tomé were distributed in November (1), December (4) and January (1), rather than during the period of peak survey effort (Figure 5C). The relatively high number of sightings during December 2002 reflects repeated encounters on successive dates with a single group of killer whales (as supported by photo-identification match data).

Group size

Using the combined dataset the mean best estimate of killer whale group size off West Africa was 5.56 animals (range = 1–17, SD = 3.48, N = 32). The mean group size was similar between regions, comprising 4.9 animals (SD = 3.23, N = 18) in Angola, 6.0 animals (SD = 5.16, N = 7) in Gabon and 6.2 animals (SD = 1.33, N = 6) in São Tomé. There was no significant difference between killer whale group size in waters >200 m deep ($x = 5.53$, SD = 2.15, N = 17) and on the continental shelf ($x = 5.60$, SD = 4.64, N = 15) (Mann–Whitney $U = 103.0$, N = 32, $P = 0.370$).

Behavioural observations

Many of the killer whale groups recorded off West Africa were simply observed travelling with steady surfacing sequences. However, about one-third (N = 12) of the records involved observations of killer whale in (direct or indirect) association with other species as summarized in Table 2. Of these, five involved co-occurrence with humpback whales, three involved sperm whales *Physeter macrocephalus*, two involved sharks and there were single observations with Bryde's whale *Balaenoptera cf. brydei* and ocean sunfish *Mola mola* (Table 2). In most cases, killer whales either travelled past other species without obvious interaction (N = 2) or the nature of the interaction with killer whales could not be clearly ascertained (N = 5).

However, five encounters were considered antagonistic in nature, two of which involved humpback whales. The first

of these occurred off Gabon on 3 September 2003, when a group of three to four killer whales circled a pair of adult humpback whales for over an hour. One humpback whale was seen to repeatedly tail-lob and tail swipe. The humpback pair always dived together, with the killer whales circling above and then diving to follow. No direct interactions were observed, but the pattern persisted until the observations ceased due to deteriorating sea conditions. The second interaction involved video footage provided by oil industry divers from a platform off Cameroon, showing a group of ten killer whales harassing a humpback whale and its young calf for over 6.5 hours. The humpbacks swam within metres of the platform in an apparent evasive attempt, and appeared to perceive the killer whales as a threat. The adult humpback was observed thrashing its tail through the water although whether this was directed at the boat containing the divers or at the killer whales was unclear. The outcome of the interaction is not known.

Off Angola, a group of five killer whales was observed harassing a large school of 18–20 sperm whales for over an hour (after which they were lost from sight while still interacting). Blood-filled spray was observed twice as sperm whales rolled vigorously in the water. Throughout the interaction, the sperm whales showed no obvious defensive formation (i.e. rosette formation), but remained crowded together and blowing frequently with all animals usually orientated in the same direction facing the killer whales and moving steadily forwards. A further relevant record involves a neonate (with umbilicus still attached) sperm whale calf stranded at Sette Cama, Gabon (Figure 6) on 27 March 2005. The calf was fresh, bleeding profusely from the mouth and showed signs of significant bruising. Tooth rakes on the tail flukes were consistent with known scarring patterns from killer whales (e.g. Best *et al.*, 1984; Visser, 1999a), although false killer whales *Pseudorca crassidens* (Palacios & Mate, 1996) and short-finned pilot whales *Globicephala macrorhynchus* (Weller *et al.*, 1996) have also been reported in antagonistic interactions with sperm whales.

The remaining two aggressive encounters involved direct interaction between killer whales and prey. The first of these involved a juvenile killer whale photographed pushing a small live shark (possibly a copper shark *Carcharhinus brachyurus*) along the surface off Gabon. It is unclear whether the killer whales subsequently consumed this shark. The second encounter comprised a predation event observed off São Tomé during January 2003, when an adult–calf pair of killer whales was observed feeding on an ocean sunfish at the surface.

Morphology

The killer whales observed off Angola, Gabon and São Tomé presented similar external appearance (Figure 7) The animals exhibited the typical black and white coloration of killer whales worldwide, lacking a defined dorsal cape but having a variable pale grey 'saddle' behind the dorsal fin. The eye patch on West African animals was generally oval in shape, medium-sized, and orientated parallel to the body axis.

Photo-identification

Photography of individual killer whales resulted in the identification of six animals in Angola, 14 animals in Gabon and 13 animals around São Tomé. No re-sights were recorded within

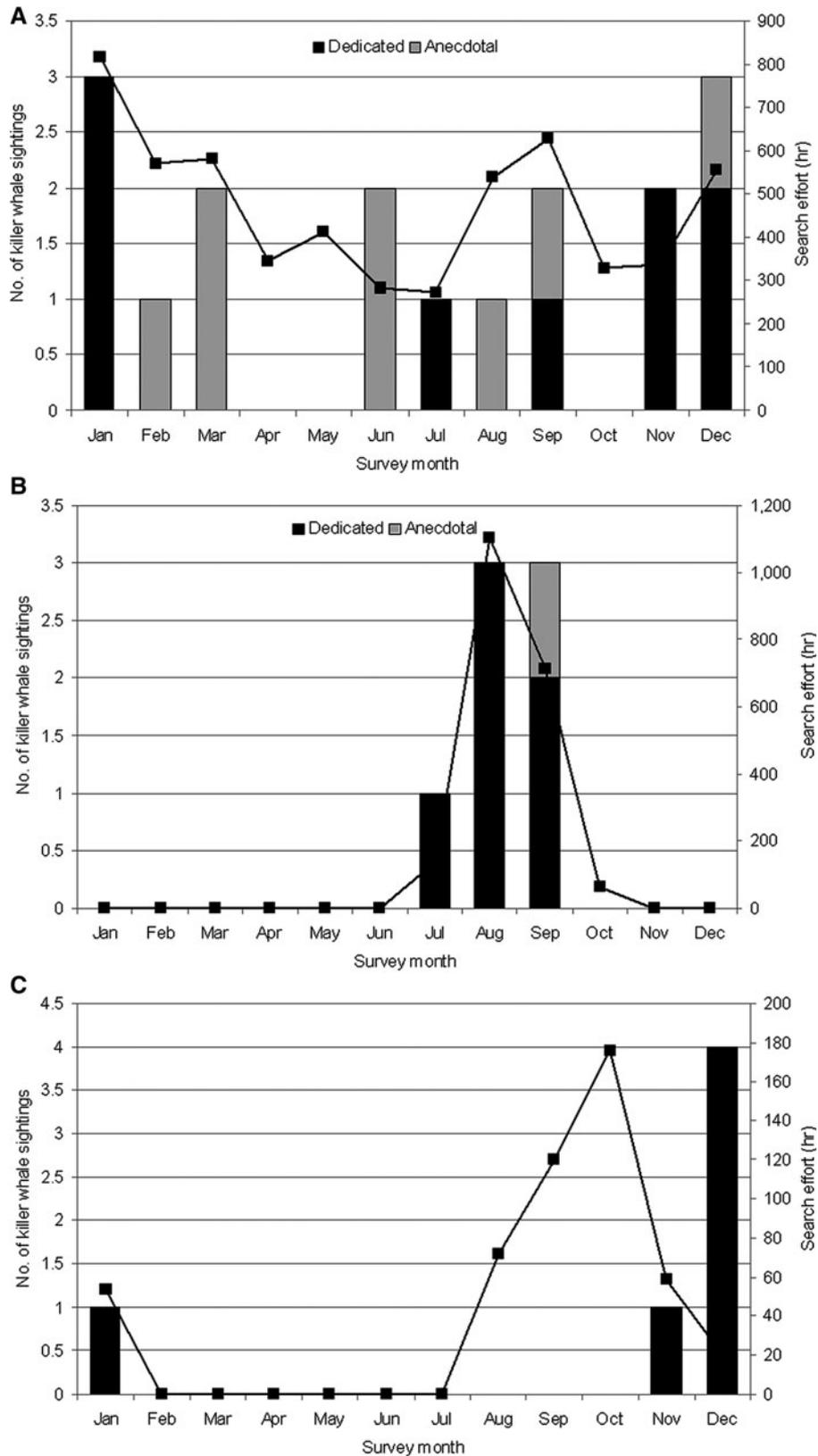


Fig. 5. Seasonality of survey effort, killer whale sighting rate and anecdotal records off: (A) Angola (N = 17); (B) Gabon (N = 7); and (C) São Tomé (N = 6).

Angolan or Gabonese waters, although one killer whale group recorded off Iguela in Gabon during August 2005 was reported by a local boat pilot to have been present in the region for at least two weeks. In São Tomé, the same group of killer whales was involved in at least four of the six

encounters. Two animals from this group were first identified together from photographs in 2002 and were subsequently re-photographed in 2004; one of these individuals was also photographed in 2003. There were no matches of individuals between the study areas.

Table 2. Summary of killer whale *Orcinus orca* observations off West Africa, 1991–2008, involving multi-species associations.

| Ref | Region | Observer | Record status | Date | Water depth (m) | Killer whale group size | Species association (*identification not certain) | Details of interaction |
|-----|----------|-------------|---------------|-------------------|-----------------|--------------------------------|--|--|
| 1 | Gabon | T. Collins | On-effort | 30 August 2001 | 15 | 3 (incl. 1 bull; 1 juv.) | Humpback whale | Killer whales passed within 25 m of a single adult humpback without obvious direct interaction |
| 2 | Gabon | T. Collins | On-effort | 30 August 2001 | 15 | 3 (incl. 1 bull; 1 juv.) | Copper shark* | Juvenile killer whale photographed pushing the shark along the surface |
| 3 | São Tomé | I. Carvalho | On-effort | 10 January 2003 | 1200 | 3–5 | Ocean sunfish | A killer whale adult–calf pair observed feeding on an ocean sunfish at the surface. The other whales in the group did not participate |
| 4 | Gabon | T. Collins | On-effort | 3 September 2003 | 50 | 3–4 | Humpback whale | Killer whales swimming close behind and circling two adult humpbacks for over one hour (after which observations ceased while interaction was ongoing) |
| 5 | Cameroon | Divers | Anecdotal | 21 October 2003 | 30 | 10 + | Humpback whale | Killer whales herding an adult humpback and very young calf persistently until the humpbacks sought refuge under an oil platform. The outcome of this interaction was not observed |
| 6 | Angola | N. Gricks | On-effort | 23 September 2004 | 2011 | 8–10 (incl. 1 bull) | Bryde's whale | Killer whales travelling through the same area (and within 4 km) as a Bryde's whale. No obvious interaction apparent |
| 7 | Angola | N. Gricks | On-effort | 30 December 2004 | 2459 | 4 (incl. 1 juv.; no bulls) | Sperm whales | Killer whales travelling slowly in direction of seven logging sperm whales. Sperm whales fluked prior to killer whales reaching them. Outcome of any interaction was not observed due to distance |
| 8 | Angola | C. Weir | On-effort | 5 January 2005 | 2200 | 8–10 (incl. 2 bulls; one juv.) | Sperm whales | Killer whales moving directly towards a distant (>8 km) group of 11 sperm whales. Distance precluded observation of subsequent interactions |
| 9 | Angola | C. Weir | On-effort | 8 January 2005 | 2609 | 5 (incl. 1 juv.) | Sperm whales | Harassment of 18–20 sperm whales for over 1 hour (after which observations ceased while interaction was ongoing) and observation of blood-filled spray |
| 10 | Gabon | S. Elwen | On-effort | 13 August 2005 | 40 | 4–5 | Humpback whale | No direct interaction observed. The four adult humpback whales maintained a tight group structure and exhibited tail-swiping, but it was unclear whether this was directed at the killer whales or whether one or both species was feeding on the numerous sardine (<i>Sardinella</i> sp.) shoals in the region |
| 11 | Gabon | 3rd party | Anecdotal | 10 September 2006 | 120 | 3 (incl. 1 bull) | Bull shark* | Killer whales focused on 2-m long shark in the vicinity of a fishing boat, which they approached and swam around. Departure of all animals precluded observation of the outcome |
| 12 | Angola | J. Schmidt | Anecdotal | 13 September 2008 | 110 | 8 | Humpback whale | No direct interaction observed. However, the killer whales spent over 3 hours in direct proximity to a single adult humpback whale which was seen manoeuvring tightly in various directions and exhibiting some longer dives with frequent belly-up rolls, headstands, tail-thrashing and flipper-slapping |

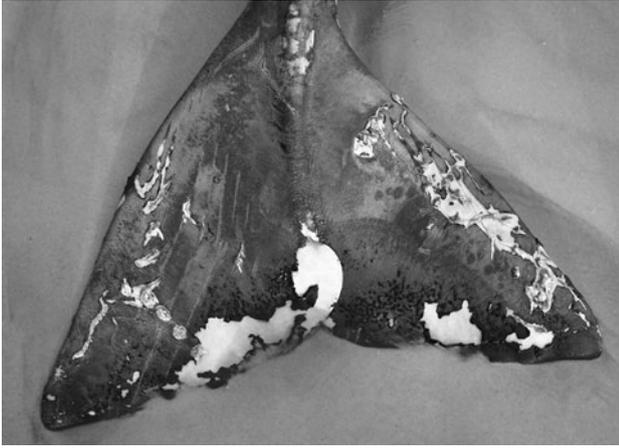


Fig. 6. Tail flukes of a stranded sperm whale calf in Gabon, showing tooth rake marks possibly originating from killer whales.

Humpback whale fluke analysis

A total of 17.3% ($N = 682$; scarring incidence = 118) of humpback whale flukes photographed off Gabon showed evidence of killer whale tooth rake marks using the category 1–3 scars defined by Steiger *et al.* (2008). Although not distinguished between, it is possible that some of the scars recorded were caused by false killer or pilot whales rather than killer whales.

DISCUSSION

A review by Forney & Wade (2006) suggests that killer whale densities increase by 1–2 orders of magnitude between the

tropics and the highest sampled latitudes in the Arctic and Antarctic. Nevertheless, although relatively scarce in tropical waters, the 32 sightings reported here from a relatively poorly-studied area in tropical West Africa suggest that the species is a regular component of the cetacean fauna of this region. Reports of 94 killer whale sightings from similar latitudes in the Pacific Ocean (Visser & Bonaccorso, 2003) indicate that killer whales may not be as uncommon in some low latitude tropical waters as previously thought.

Spatio-temporal occurrence

Killer whales were found to be widely dispersed off West Africa, inhabiting coastal, shelf and oceanic waters and also occurring in proximity to the offshore island of São Tomé which is separated from the Gabon mainland by 240 km and over 2000 m water depth. It is currently unclear whether individual killer whale groups routinely inhabit all water depths, or whether there are distinct offshore and inshore populations as found in the north-east Pacific (Baird, 2000). The absence of definite matches of individual whales between the three study areas is inconclusive given the small sample size and poor quality of many images. Some killer whales are known to travel very wide distances, for example, individuals repeatedly travelled linear distances of 2660 km between California and south-east Alaska in the eastern Pacific (Baird, 2000), and movements between Angola, Gabon and São Tomé would be well within their capability.

Repeated sightings of the same group of killer whales around São Tomé suggest at least a regular seasonal use of that area by a particular group of whales. Although killer whales have been recorded off São Tomé and Gabon in most months that have been surveyed, there are currently no survey data available for the January to June period to indicate whether their occurrence in these areas is genuinely seasonal or whether they are present year-round. In Angola, offshore survey effort was collected throughout the year, yet on-effort killer whale sightings occurred primarily between September and January. However, anecdotal records from Angola suggest that killer whales do occur in most months of the year, at least in coastal waters.

Mikhalev *et al.* (1981) suggested that southern hemisphere killer whales might spend the austral summer months feeding in Antarctica but depart to lower latitudes in February and March to spend the winter. Of the three Antarctic killer whale forms described by Pitman & Ensor (2003), Type A whales appeared to depart from Antarctic waters during the winter and move northwards into temperate waters and possibly beyond. The movements of Types B and C are less well understood, but a group of killer whales sighted in New Zealand waters bore morphological similarities to Antarctic killer whales (Visser, 1999b), and a definite record of one of these two Types is known from tropical waters south of Tahiti (Pitman & Ensor, 2003). The external appearance of tropical West African killer whales is consistent with the Type A 'nominant' killer whale form described by Pitman & Ensor (2003), lacking a dorsal cape and showing a medium-sized eye patch. Although a migration of Antarctic killer whales as far north as the Gulf of Guinea seems unlikely, the influence of the cold water Benguela Current extends along the coast of West Africa as far as northern Angola and these productive waters could feasibly attract killer

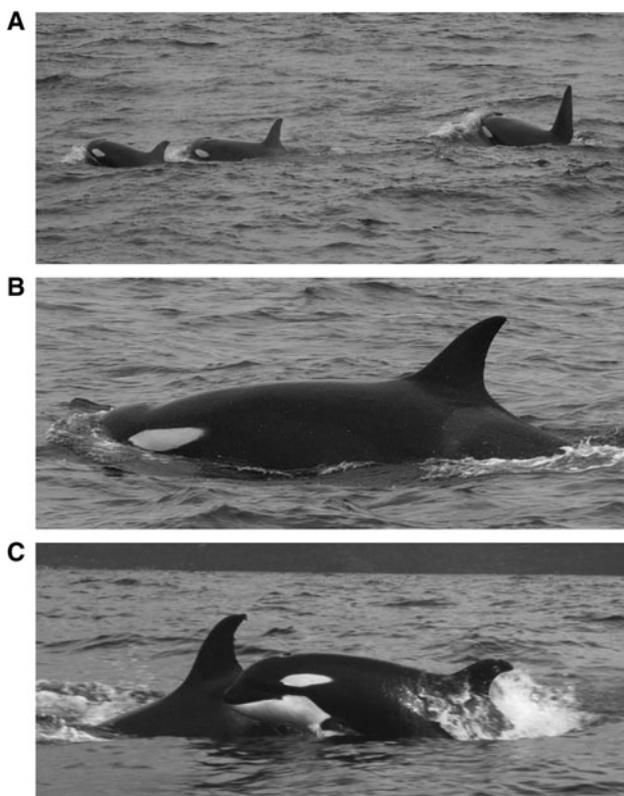


Fig. 7. Morphological appearance of killer whales from: (A) Angola; (B) Gabon; and (C) São Tomé.

whales from other seasonally less profitable regions. However, as Type A whales occur worldwide, it is also plausible that the killer whales observed in the study area routinely inhabit this region without demonstrating extensive seasonal movements.

Killer whale prey off West Africa

Killer whale groups are known to make spatio-temporal movements in response to the movements of specific prey, for example fish migration (Nottestad & Axelsen, 1999), pinniped breeding (Baird & Dill, 1995; Iñíguez, 2001) and cetacean migration (Goley & Straley, 1994). However, evidence of killer whale diet in tropical areas is lacking. The larger Gulf of Guinea region contains rich fisheries, and densities of turtles and elasmobranchs, all of which comprise known diet of killer whales in other areas (Jefferson *et al.*, 1991). In the western tropical Pacific, Visser & Bonoccorso (2003) documented killer whales feeding upon hammerhead sharks *Sphyrna lewini*, grey reef sharks *Carcharhinus amblyrhynchos*, manta rays *Manta birostris* and other fish species, but considered that mammalian prey was also a likely, though currently unrecorded, source of food. Yukhov *et al.* (1975, cited in Mikhalev *et al.*, 1981) examined the stomach contents of killer whales from warm and temperate zones of the southern hemisphere and concluded that they fed mostly on dolphins and pinnipeds. Marine mammals are also a known prey source in tropical waters off the Galapagos Islands (Brennan & Rodriguez, 1994) and Costa Rica (Pitman *et al.*, 2007). Our data indicate a regular occurrence of killer whales between the Gulf of Guinea and Angola, which raises questions over their diet in this tropical region.

Although pinnipeds are largely absent from the Gulf of Guinea, Cape fur seals *Arctocephalus pusillus* frequently occur in seasonally high numbers along the coast of southern Angola to the south of Luanda (personal observation) and could feasibly attract killer whales. Several cetacean species that occur throughout the study area are already confirmed prey of killer whales, including pantropical spotted dolphins *Stenella attenuata* (Pitman *et al.*, 2003), short-beaked common *Delphinus delphis* and common bottlenose dolphins *Tursiops truncatus* (Visser, 1999a), humpback whales (Whitehead & Glass, 1985; Florez-Gonzalez *et al.*, 1994), Bryde's whales (Silber *et al.*, 1990) and sperm whales (Pitman *et al.*, 2001).

Of particular interest during several observations off Angola and Gabon was the simultaneous presence of killer whales with humpback and sperm whales. Actual predation was not documented during any of these interactions, although the outcomes of the encounters were not observed. However, repeated harassment of humpback and sperm whales is indicative of at least some form of agonistic interaction between these species and killer whales. The 17.3% incidence of presumed killer whale scarring on humpback whale flukes photographed off Gabon is also testimony to regular interaction between these species, although it is likely that at least some of this scarring occurs on the Antarctic feeding grounds where agonistic encounters between the species are also reported (Pitman & Ensor, 2003). Humpback whales migrate annually during the austral winter to breeding grounds along the west coast of Africa. Killer whale predation of humpback whales on their tropical breeding grounds has been recorded elsewhere (e.g. Florez-Gonzalez *et al.*, 1994; Paterson & Paterson, 2001;

Baird *et al.*, 2006) and it is plausible that killer whales purposefully exploit this predictable, seasonally available prey source. It has been suggested that the lengthy migrations undertaken by some baleen whale species to tropical breeding grounds are an adaptive response to avoid predation by killer whales on young calves (Corkeron & Connor, 1999; Paterson & Paterson, 2001; Pitman *et al.*, 2007), based on the lower densities of killer whales in tropical waters compared with higher latitude feeding grounds. However, our data indicate that killer whales are certainly present on humpback whale breeding grounds off West Africa during the breeding season.

The co-occurrence of three offshore killer whale sightings with sperm whales off Angola was also notable, with at least one of these encounters resulting in an apparent predatory attempt. The behaviour of both killer and sperm whales observed during this interaction was similar to that described by Arnborn *et al.* (1987) off the Galapagos Islands, with the exception of the much smaller killer whale group size off Angola. Indications of apparent killer whale involvement in the stranding of a sperm whale calf in Gabon suggest that agonistic interactions between these species also occur in other areas of West Africa. Although Jefferson *et al.* (1991) concluded that killer whales are not a serious threat to sperm whales other authors have clearly demonstrated the vulnerability of sperm whales to killer whale predation in the Pacific Ocean (e.g. Arnborn *et al.*, 1987; Brennan & Rodriguez, 1994; Pitman *et al.*, 2001) and Indo-Pacific region (Best *et al.*, 1984; Visser, 1999a). However, the absence of killer whale sightings in deep water off Angola during the peak period of sperm whale occurrence between March and May (Weir, 2008b), suggests that sperm whales may not be the primary target for killer whales in the area.

Observations of killer whales preying upon ocean sunfish and possibly sharks off Gabon and São Tomé indicate that (at least some) killer whales in the region are unlikely to be marine mammal specialists. Baird *et al.* (2006) suggested that killer whales occupying tropical low-productive areas should exhibit low dietary specialization and opportunistically take a wide range of prey species. Although speculative at this stage, observations of killer whales in tropical West Africa concur with Baird *et al.* (2006) and suggest that a range of prey species are taken by the species as a whole, although group-specific dietary specialization cannot be excluded.

To conclude, killer whales may be considered a regular component of the cetacean community off Angola and the Gulf of Guinea. However, more survey work is required throughout the region to clarify their status and biology off tropical West Africa.

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