Journal of the Marine Biological Association of the United Kingdom, 2014, 94(6), 1161–1174.
doi:10.1017/S0025315413000337

The cetaceans of Aruba, southern Caribbean

JOLANDA A. LUKSENBURG

George Mason University, Department of Environmental Science and Policy, Fairfax, Virginia, USA

*Aruba is one of the most densely populated islands in the Caribbean. However, very little is known about its cetaceans. In 2010 and 2011, a total of 19721 km (1686 h) boat-based surveys over nearshore transects resulted in 117 positively-identified sightings comprising eight species. New records are also added for one of three previously-documented species. Five additional species were documented from strandings or reports by others. This brings the total number of cetacean species identified in Aruban waters to 16, of which nine are authenticated here for the first time. Atlantic spotted dolphin (*Stenella frontalis *(N = 59) and bottlenose dolphin (*Tursiops truncatus*) (N = 33) were the most frequently observed species, with sightings of both year-round, followed by spinner dolphin (*S. longirostris*) and false killer whale (*Pseudorca crassidens*). Additional species recorded are pantropical spotted dolphin (*S. attenuata*), striped dolphin (*S. coeruleoalba*), common dolphin (*Delphinus capensis*), rough-toothed dolphin (*Steno bredanensis*), short-finned pilot whale (*Globicephala macrorhynchus*), killer whale (*Orcinus orca*), Risso's dolphin (*Grampus griseus*), humpback whale (*Megaptera novaeangliae*), Bryde's/Eden's whale (*Balaenoptera brydei/edeni*), sperm whale (*Physeter macrocephalus*) and an unidentified beaked whale (*Mesoplodon sp.*). All cetaceans were sighted within 22 km of the coast in relatively shallow waters. Sighting rate was low (0.69 cetacean sightings per 100 km). Sightings of calves and neonates indicate that Aruba may be a nursing or breeding area for some species. The presence of several species of cetaceans in Aruba's coastal waters year-round indicates that status and threat assessments are needed to protect them.*

Keywords: Caribbean Sea, Leeward Antilles, cetacean community, marine mammals, diversity, distribution, occurrence

Submitted 27 January 2013; accepted 19 February 2013; first published online 29 April 2013

INTRODUCTION

Cetaceans play an important role in the structure, function and productivity of marine ecosystems (Smetacek & Nicol, 2005; Baum & Worm, 2009; Roman & McCarthy, 2010). As top predators, cetaceans are highly vulnerable to numerous human activities (Lewison *et al.*, 2004; Reynolds *et al.*, 2005; Estes *et al.*, 2006), of which fisheries are the most important (Read 2005; see also Plagányi & Butterworth, 2005). As a consequence, the conservation status of many species of cetaceans is of great concern. One in three species is known to be threatened, but the majority of species (45 species) is listed as data deficient (Schipper *et al.*, 2008; IUCN, 2011). Inadequate information on their distribution is a major source of uncertainty, particularly in tropical regions (Reeves *et al.*, 2003; Davidson *et al.*, 2012). Therefore, it is important that gaps in knowledge about the distribution of marine mammals are identified and filled.

The Caribbean Sea supports a diverse cetacean fauna including at least 29 of the world's 87 species (Ward *et al.*, 2001). However, knowledge about the cetaceans inhabiting the Caribbean Sea is fragmentary and the distribution and movement patterns of most of those species have not yet been described (Jefferson & Lynn, 1994; Ward *et al.*, 2001). The poor state of knowledge on Caribbean cetaceans is largely due to the paucity of systematic surveys in the region (Tangley & Miller, 1998; Romero *et al.*, 2001). A review in 2001 concluded that detailed research on species occurrence, abundance and status in the Caribbean should be a high priority, especially in poorly studied areas within the region (Ward *et al.*, 2001).

Aruba is situated 27 km off the Venezuelan coast in the southern Caribbean. It is the third-most densely populated island in the Caribbean and more than 1.5 million tourists visit the island each year. The number of visitors will almost certainly grow during the next 2–4 decades (Cole & Razak, 2009; *CIA World Factbook*, 2011). Aruban waters are used intensively for anchoring, transport, recreation, and deep-sea fishing (personal observation). Marine activities around Aruba may pose multiple threats to cetaceans, including habitat degradation, pollution, noise, disturbance and boat collisions (Lewison *et al.*, 2004; O'Hara & O'Shea, 2005; Estes *et al.*, 2006; Read, 2008).

Scientific information on the occurrence of cetaceans in Aruban waters is limited to a small number of reports of sightings and strandings. Until recently, only three species had been documented for Aruba, each based on a single stranding (Debrot & Barros, 1994; Debrot *et al.*, 1998). Luksenburg (2011) documented three additional species and several other species have been reported but not verified (Agudo & Ponson, 1996; Barros & Debrot, 2006; Debrot *et al.*, 2011). In contrast, 15 species have been reported in the waters of Curaçao (Debrot, 1998; Debrot *et al.*, 1998) and 24 off the coast of Venezuela (Romero *et al.*, 2001; Bolaños & Villarroel-Marin, 2003; Bermúdez-Villapol *et al.*, 2008a, b).

In the light of the minimal number of studies of cetaceans in the southern Caribbean and to enhance understanding of cetaceans in Aruban waters, a 20-month field study was conducted to document their occurrence and distribution.

Corresponding author:
J.A. Luksenburg
Email: j.luksenburg@yahoo.com

MATERIALS AND METHODS

Aruba (12°30′N 69°58′W) is a small island located approximately 27 km north off the Paraguaná Peninsula of Venezuela and is part of the Leeward Antilles, southern Caribbean (Figure 1). Aruba is situated in the north-westward-flowing Caribbean current. It also is situated in the trade wind belt with prevailing easterly winds (Kohsiek *et al.*, 1987). Aruba has three major coastlines: a rocky north-east coast on the island's windward side and the leeward south-west and north-west coasts with white sand beaches, some sea grass beds, and some coral reef islands (Dorenbosch *et al.*, 2006). Upwelling occurs along the north coast of South America (Colombia and Venezuela) (Miloslavich *et al.*, 2010). Seawater temperature around the island varies between 25°C in February and 28°C in September (Van Vliet, 2006).

Sighting data were collected from 9 April 2010 to 22 November 2011 on a near daily basis. Data were collected by the author during deep-sea fishing trips from boats chartered by tourists. The boats were designed for sport fishing; they ranged from 10.7 m to 16.5 m in length and were powered by inboard engines. Observations were made from a flying bridge deck approximately 4 m above sea level. Trips typically lasted four hours, at an average speed of 12 km/h. Data were collected in the morning (7.30–12.00) and/or the afternoon (12.30–16.30), up to 31 km offshore on all sides of the island.

While on watch, the author continuously scanned the area from the flying bridge with the naked eye and 10 × 42 binoculars (Leica). Throughout each trip, the boat position using a GPS recorder (Garmin Vista HCx), Beaufort sea state, and swell were monitored and recorded. For each sighting GPS position (when first sighted and when at or near the group), time, species, group size (minimum, maximum and best estimate), behaviour, direction of movement (at the start and end of the sighting), and the presence of calves and/or neonates were recorded. A group was defined as animals engaging in the same activity and interacting with one another over time scales sufficiently short that there were few or no changes in group membership (Karczmarski *et al.*, 2005). Three age-classes were distinguished: adults, calves and neonates. Calves were less than or equal to 75% of the total length of an adult individual and neonates less than or equal to 50% (Herzing, 1997). Behaviour was classified in five categories: socializing, resting, milling, traveling, and foraging (Degrati *et al.*, 2008). The group's behaviour was based on the behaviour of the majority of individuals in the group. Whenever possible, photographs were taken for species identification using a digital camera (Nikon D200) and a 70–300 mm zoom lens (Nikon 1:4.5–5.6 AF-S). Sightings that could not be identified as to species, either by observation at close range or from photographs, were recorded as 'unidentified'.

Records of sightings and strandings from other sources were included if photographs or video material were available. Records of killer whales without photographic documentation were accepted only from observers with a demonstrated familiarity with the diagnostic characters of the species (size, colour pattern and dorsal fin shape). Records from third parties were excluded from statistical analyses because sampling effort was unknown.

The bottom depth at the sighting location was derived from the General Bathymetric Chart of the Oceans Digital Atlas system (GEBCO, 2012) at a resolution of 30 arcseconds. Distance from shore was obtained using the distance tool of Mapsource® software, taking the shortest distance to shore. For each species, the sighting rate was calculated as the number of sightings per 100 km survey effort. To measure species diversity, the Shannon–Wiener index was calculated using only sighting data from the surveys, as follows (Ricklefs, 2007):

$$H = -\sum P_i \log_e P_i$$

where H is a measure of diversity and P_i is the proportion of individuals belonging to species i.

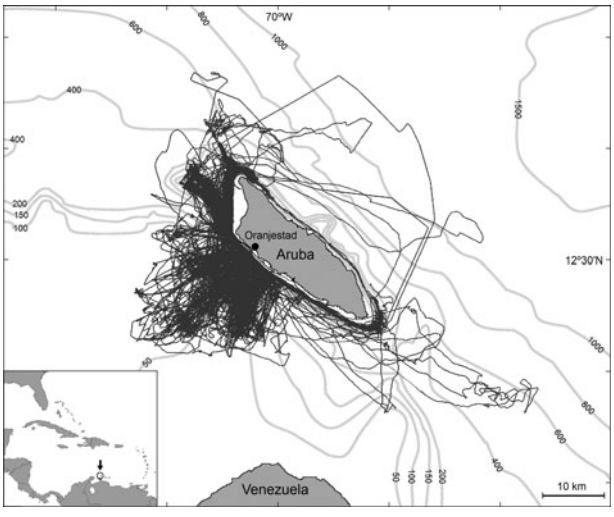

Fig. 1. Location of the study area showing survey effort during 2010 and 2011 (dark lines) and depth contours (in metres).

RESULTS

A total of 415 boat-based surveys were conducted in all months of the year, covering 19,721 km of trackline (2183 km²) in 1686.25 h of effort (Figure 1). All surveys were carried out in Beaufort sea state ≤5 (52.3% in Beaufort 3) (Table 1). Surveys were within 31 km from shore. Most surveys (316; 76.1%) were entirely on the north-west and south-west sides of the island, because weather conditions often precluded boat surveys on the north-east side (windward) of Aruba. The water depth covered by the surveys ranged between 6 m and 1200 m, with 15 surveys (3.6%) covering water depths >400 m. 291 surveys (70.1%) were conducted in the

Table 1. Sighting rate in relation to sea state (Beaufort).

Sea state	km	Number of sightings	Sighting rate (per 100 km)
Beaufort 0	127.90	1	0.782
Beaufort 1	1622.11	9	0.555
Beaufort 2	4673.18	38	0.813
Beaufort 3	10,324.17	59	0.571
Beaufort 4	2804.51	27	0.963
Beaufort 5	169.76	1	0.589
Total	19,721.63	135	0.685

https://doi.org/10.1017/S0025315413000337 Published online by Cambridge University Press

Table 2. Number of sightings per species obtained from the boat-based surveys and from third parties.

Species	Boat-based surveys		1998–2011	
	2010	2011	Third party	Total
Stenella frontalis	25	34	0	59
Stenella attenuata	1	2	0	3
Stenella longirostris	9	3	1	13
Tursiops truncatus	15	18	3	36
Delphinus capensis	0	1	0	1
Steno bredanensis	0	2	9*	11
Pseudorca crassidens	5	0	0	5
Orcinus orca	0	2	7	9
Megaptera novaeangliae	0	0	1	1
Delphinidae sp.	5	13	0	18
Total	60	75	21	156

*, excluding three live stranding events.

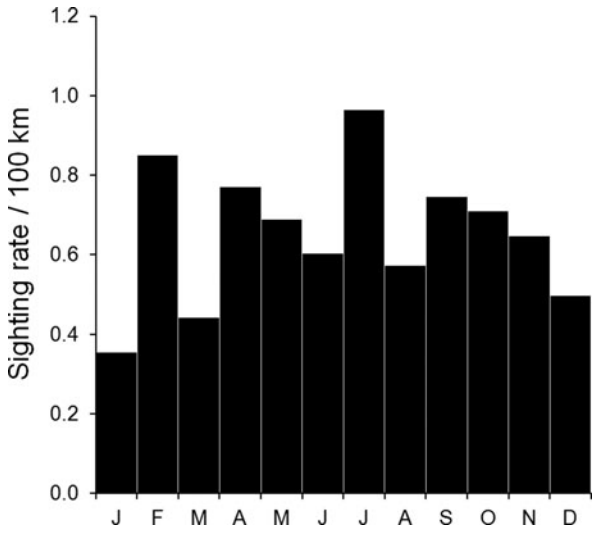

Fig. 2. Sighting rate (number of sightings per 100 km) per month.

morning (7.30–11.30), 90 (21.7%) in the afternoon (12.30–16.30), and 34 (8.2%) surveys lasting from six to nine hours beginning in the morning and continuing into the afternoon.

The surveys resulted in 135 sightings of cetaceans of eight identified species (Table 2). Sightings were made during 117 surveys (28.2%). Sighting rate was not related to sea state (Kruskal–Wallis test, n.s.) (Table 1). Sighting rate also did not differ significantly between months (Kruskal–Wallis test, n.s.) (Figure 2). All identified species were photographed. For 111 sightings (82.2%) photographs of the animals were taken either for confirmation of species identity or to identify individuals. In 120 sightings (88.9%), the animals responded to the vessel by approaching it (100; 83.3%), avoiding it (6; 5%) or first approaching the vessel and then actively avoiding it when the boat attempted to approach them (14; 11.7%). Five stranding events involving three species were recorded during the survey period (described below).

The Shannon–Wiener diversity index was 1.29. The Shannon–Wiener index stabilized at ~1.26 after six months of fieldwork (September 2010; corresponding to 35 sightings), whereas the final number of species observed at sea (8) was reached after 15 months of fieldwork (June 2011) (Figure 3). The Atlantic spotted dolphin *Stenella frontalis* was the dominant species, followed by the spinner dolphin *Stenella longirostris* and the bottlenose dolphin *Tursiops truncatus* (Figure 3).

An additional 21 sighting records were compiled based on photographic or video documentation provided by others (Table 2).

Atlantic spotted dolphin (*Stenella frontalis*)

Atlantic spotted dolphins were sighted on 59 occasions (0.299 sightings/100 km) (Table 3; Figure 4A). Adult individuals were identified as *Stenella frontalis* based on the presence of a spinal blaze and clear white spots on the dorsal side (Mignucci-Giannoni *et al.*, 2003). These dolphins were observed only along the island's north-west and south-west coasts in shallow waters (<250 m deep) close to shore: 38 (64.4%) within 5 km from shore, 16 (27.1%) between 5 and 10 km and five (8.5%) between 10 and 15 km (Table 3). This species was observed in all months of the year and groups including neonates (Figure 5) were observed in June (one sighting), July (three sightings), August (four sightings)

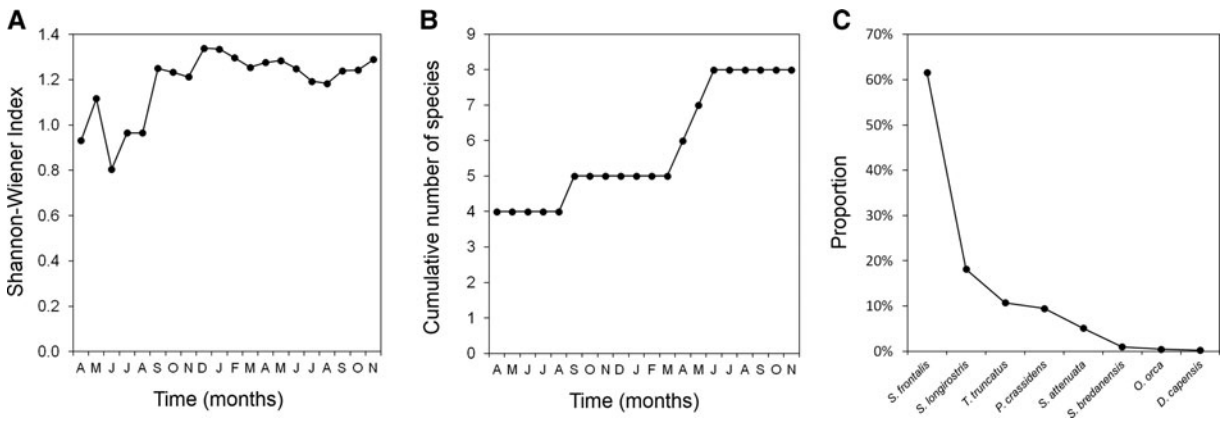

Fig. 3. (A) Cetacean diversity based on the cumulative number of individuals observed from April 2010 to November 2011 and estimated with the Shannon–Wiener index; (B) cumulative number of species observed during boat-based surveys from April 2010 to November 2011; (C) relative abundance of eight species in coastal waters off Aruba (proportion of all individuals observed).

https://doi.org/10.1017/S0025315413000337 Published online by Cambridge University Press

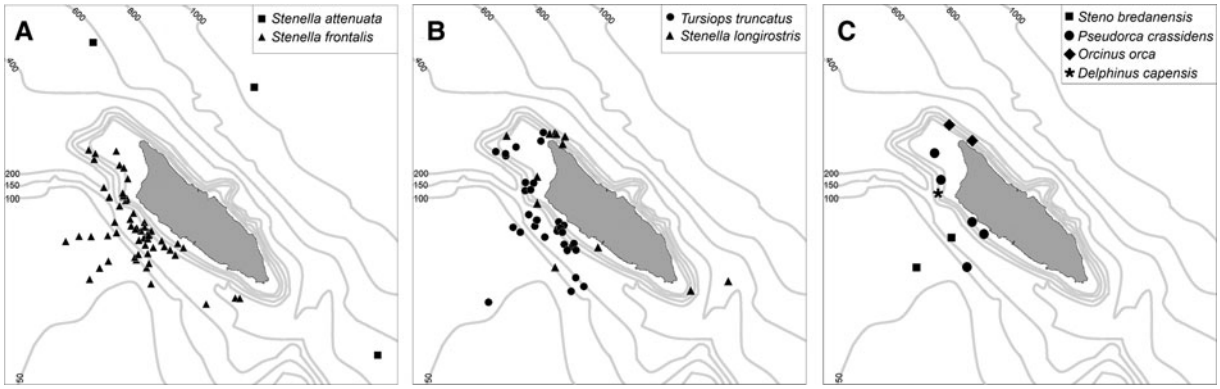

Fig. 4. Sighting locations of (A) *Stenella attenuata*, *Stenella frontalis*; (B) *Tursiops truncatus*, *Stenella longirostris*; (C) *Steno bredanensis, Pseudorca crassidens*, *Orcinus orca*, and *Delphinus capensis*. Depth contours are in metres.

Table 3. Water depth, distance from shore, group size, and sightings per unit effort of cetacean species sighted in 2010–2011 off Aruba. Values are mean ± SD (range).

Species	N	Water depth (m)	Distance from shore (km)	Group size	Sightings per 100 km
Stenella frontalis	59	132 ± 60 (27–235)	4.9 ± 3.2 (1–15.1)	22.1 ± 16.9 (1–80)	0.299
Tursiops truncatus	33	129 ± 58 (17–191)	4.5 ± 3.4 (0.9–18.6)	7.0 ± 5.4 (1–22)	0.167
Stenella longirostris	12	127 ± 141 (20–550)	3.0 ± 2.8 (0.3–8.5)	32.7 ± 37.0 (4–100)	0.061
Pseudorca crassidens	5	68 ± 28 (28–104)	3.2 ± 2.5 (0.9–7)	40.8 ± 37.0 (7–80)	0.025
Stenella attenuata	3	712 ± 303 (505–1060)	19.4 ± 2.1 (18.0–21.8)	36.7 ± 15.3 (20–50)	0.015
Steno bredanensis	2	100 ± 54 (62–138)	9.1 ± 5.4 (5.3–12.9)	10.5 ± 6.4 (6–15)	0.010
Orcinus orca	2	73 ± 10 (66–80)	2.1 ± 1.6 (1.0–3.2)	5 ± 0	0.010
Delphinus capensis	1	91	2.8	5	0.005
Delphinidae sp.	18	99 ± 59 (13–192)	5.8 ± 5.1 (0.8–18.6)	3.7 ± 2.7 (1–10)	0.091
Total	135				0.685

and October (three sightings). Sighting rate was highest in February (0.47 sightings/100 km), June (0.50 sightings/100 km) and July (0.46 sightings/100 km) and lowest in January (0.12 sightings/100 km), September (0.14 sightings/100 km) and December (0.17 sightings/100 km). Behaviour for 45 sightings was determined; the most common were foraging ($N = 22$; 48.9%) and travelling ($N = 20$; 44.4%).

Fig. 5. Pantropical spotted dolphin (*Stenella attenuata*), north-east of Aruba, 10 November 2011 (photograph by J.A. Luksenburg).

Pantropical spotted dolphin (*Stenella attenuata*)

Pantropical spotted dolphins were observed on three occasions (0.015 sightings/100 km) (Table 3; Figure 4A). They were identified based on the absence of a spinal blaze and a subdivision of the peduncle into upper dark and lower light halves (Mignucci-Giannoni *et al.*, 2003; Figure 5). The first group of about 40 animals was sighted on 25 September 2010 in waters 570 m deep and 18.0 km from the north coastline. The second group of about 20 animals, including two calves, was observed on 19 September 2011 in waters 505 m deep and 21.8 km from shore off the south-east coast. The third group of about 50 animals was observed on 10 November 2011 in waters 1060 m deep and 18.5 km from the north-east coast (Table 3). All three groups were travelling, but feeding behaviour was observed also in two cases.

Spinner dolphin (*Stenella longirostris*)

With 12 sightings, the spinner dolphin was the third most frequently recorded species (0.061 sightings/100 km) (Table 3; Figure 4B). The animals were identified based on their long, narrow beaks; their slightly falcate triangular or sub-triangular dorsal fins; and the absence of a 'moustache' mark on the dorsal part of the rostrum (Perrin, 1998; Jefferson *et al.*, 2008). Eight of the sightings of this species were in waters ≤100 m deep. Sighting rate was lower during afternoons

https://doi.org/10.1017/S0025315413000337 Published online by Cambridge University Press

(0.019 sightings/100 km) than during mornings (0.075 sightings/100 km), but the difference was not statistically significant. This species was observed on all sides of the island but seven of the 12 sightings (58.3%) were off the north-east coast. Nine sightings (75%) were within 5 km from shore. Spinner dolphins were sighted in April, July, August, September, November and December, with the highest sighting rate in July (0.18 sightings/100 km) and lowest in April (0.05 sightings/100 km). Groups with calves or neonates were observed in July (one neonate), September (one calf, one neonate), November (one calf) and December (one calf). Travelling ($N = 5$) and feeding ($N = 4$) were the most frequently observed behaviours. Travelling animals were observed in larger groups (30–100 individuals) than feeding animals (4–15 individuals). An additional sighting was obtained with unknown group size on 25 June 2010 in waters 24 m deep and about 1.8 km off the north-west coast.

Striped dolphin (*Stenella coeruleoalba*)

Details of a striped dolphin stranded on 3 September 2009 at the California sand dunes along the north-east coast were provided by A. Henriquez and E. van der Wal (in litt.; *Diario* 7 September 2009) (Figure 6). The animal was identified based on the dark stripe running laterally from its eye to the underside of its tail stock (eye-to-anus stripe), a thin streak behind the eye, and a moderately long beak (Jefferson *et al.*, 2008; T.A. Jefferson, in litt.).

Bottlenose dolphin (*Tursiops truncatus*)

The bottlenose dolphin was the second most frequently observed species with 33 sightings (0.167 sightings/100 km) (Table 3; Figure 4B). These dolphins were identified based on their grey coloration, fairly short beak, rounded forehead, and robust body (Jefferson *et al.*, 2008; Figure 7). Bottlenose dolphins were observed in shallow waters (<200 m deep) along all sides of the island (Table 3). The majority of sightings ($N = 23$ 69.7%) were within 5 km from shore, 9 (27.3%) were between 5 and 10 km, and one sighting was 18.6 km. Bottlenose dolphins were observed in almost every month except June and December. Calves were seen on nine occasions (27.3%) during seven months of the year, with

Fig. 6. Striped dolphin (*Stenella coeruleoalba*), California Sand Dunes, Aruba, 8 September 2009 (photograph by E. van der Wal).

Fig. 7. Bottlenose dolphin (*Tursiops truncatus*), south-west of Aruba, 10 September 2010 (photograph by J.A. Luksenburg).

most observations in September ($N = 3$). Two neonates were positively observed during one sighting in October 2011. Sighting rate was highest in September (0.37 sightings/100 km) and lowest in August (0.06 sightings/100 km). All five behaviours were observed, with foraging ($N = 6$; 26.1%) and travelling ($N = 13$; 56.5%) the most common. Third parties provided three additional records of bottlenose dolphins along the north-east and south-west coasts. Group size for two of those sightings was estimated to be seven and 15 animals. All three sightings were made close to shore (0.3 km, 0.8 km, 1.9 km) in shallow water (16 m, 28 m, 80 m).

Long-beaked common dolphin (*Delphinus capensis*)

Long-beaked common dolphins were encountered on one occasion during the surveys. On 16 June 2011, a group of four to six animals was observed 2.8 km from the island's western coast in waters 90 m deep (Table 3; Figure 4C). They were identified based on their relatively long rostrum and the diagnostic characteristics in their colour pattern (Heyning & Perrin, 1994; Figure 8). The group consisted of adults only and swam rapidly around the boat, surfacing only to breathe.

Rough-toothed dolphin (*Steno bredanensis*)

Rough-toothed dolphins were observed on two occasions (0.010 sightings/100 km) (Table 3; Figure 4C). They were identified based on their sloping melon and narrowed dorsal cape between the blowhole and dorsal fin (Jefferson, 2002; Figure 9). On 27 May 2011, a group of about six individuals, including one calf, was observed hunting around an oil tanker anchored on the south-west side of the island 12.6 km from shore in waters 62 m deep. They took bait (ballyhoo *Hemiramphus brasiliensis*) off lines from the survey boat, which was used primarily for recreational fishing. On 13 September 2011, a group of about 15 individuals, including two calves, was observed at 5.3 km from the south-west coast in waters 138 m deep. This group exhibited hunting and social behaviours and slow travel.

Third parties provided details of 12 additional sightings between 1998 and 2011. The sightings occurred in the

https://doi.org/10.1017/S0025315413000337 Published online by Cambridge University Press

Fig. 8. Long-beaked common dolphin (*Delphinus capensis*), north-west of Aruba, 16 June 2011 (photograph by J.A. Luksenburg).

Fig. 9. Rough-toothed dolphin (*Steno bredanensis*), south-west of Aruba, 13 September 2011 (photograph by J.A. Luksenburg).

months February, March, April, July, September, and October within 3 km of the north-west and south-west coasts. All the animals sighted were in water depths ranging from 4 to 80 m. Group size ranged from one to 50 individuals and included neonates in the months of September, October and March. Three of the 12 records involved individuals that died after stranding alive (September 1998, July 2000, September 2007). All these records are confirmed by using photographs and/or videos clearly revealing the diagnostic characteristics of rough-toothed dolphins.

False killer whale (*Pseudorca crassidens*)

False killer whales were observed on five occasions (0.025 sightings/100 km) (Table 3; Figure 4C). They were identified based on their overall black colour, lack of 'white lips', long head with a rounded beak, and large dorsal fin with a rounded tip (Jefferson *et al.*, 2008). The sightings were all in shallow waters (28–104 m) close to shore (mean 3.2 km; Table 3). All sightings were along the north-west and south-west coasts. During four sightings the group consisted of several subgroups of 5–10 animals that were in close range (within 2 km reach) and exchanging individuals. The sightings were in April ($N = 1$), July ($N = 2$), and December ($N = 2$) of 2010. The groups included calves in April and December. In both July and December, false killer whales were observed twice on the same day. On both of those days several individuals were re-sighted during the day. Several individuals sighted in April were re-sighted in July and December, based on their identification using naturally occurring marks on the dorsal fin and bodies and the shape of the dorsal fin. Two behaviours for false killer whales were documented, hunting ($N = 2$) and travelling ($N = 4$). During hunting behaviour, a fish in a whale's mouth and food sharing between an adult and what appeared to be a juvenile were observed.

Killer whale (*Orcinus orca*)

Killer whales were sighted on 13 and 14 April 2011 (0.010 sightings/100 km) off the north-east coast of Aruba near the island's northern tip (Table 3; Figures 4C & 10). On both days, a group of about five individuals—at least four males and one female—was observed in the morning in shallow (66–80 m) water close (1.0–3.2 km) offshore. The sightings almost certainly involved the same group although the poor quality of the 13 April photographs made it impossible to match individuals on the two dates. They appeared to be hunting on 14 April. Black-capped petrels (*Pterodroma hasitata*) were observed associating with them, flying as low as 10 cm over the animals when they surfaced. Flying fish (Exocoetidae), albacore tuna (*Thunnus alalunga*), and fish oil were observed on the surface near the sightings, which would be consistent with the observation that the killer whales were hunting. Local informants provided seven additional records of killer whales in Aruban waters (Table 4). Except for one of those records, the informants indicated that the killer whales were recorded within 5 km from shore in shallow waters. Their group size ranged from one to ten animals.

Short-finned pilot whale (*Globicephala macrorhynchus*)

A. Henriquez (in litt.) provided details of two previously unreported strandings of short-finned pilot whales. They were

Fig. 10. Killer whale (*Orcinus orca*), north-east of Aruba, 14 April 2011 (photograph by J.A. Luksenburg).

https://doi.org/10.1017/S0025315413000337 Published online by Cambridge University Press

Table 4. Killer whale sighting records in Aruban waters (1997–2012).

Date	Area	Group size	Evidence	Comments	Source[a]
1997	West of Aruba	1	Description	4 km from shore; 170 m depth	P. Sweetnam
2000	South-west of Aruba	1	Description	11 km from shore; 105 m depth	P. Meyer, J. Leacock
26 Aug 2007	North-east of Aruba	1	Description	1–2 km from shore; 55 m depth. Description of a tall dorsal fin of a male.	A.D.L.F. Ho, A. Giel
03 Nov 2009	South-west of Aruba	8–10	Photographs	4.7 km from shore; 186 m depth	G. Werleman
27 Dec 2010	Eastpoint	1	Description	2.8 km from shore; 79 m depth. Description of a very tall dorsal fin of a male	M. Heyden[b]
13 Apr 2011	North-east of Aruba	5	Photographs	1 km from shore; 80 m depth. Four males and one female	This study
14 Apr 2011	North-east of Aruba	5	Photographs	3.2 km from shore; 66 m depth. Four males and one female	This study
17 Apr 2011	North-east of Aruba	2	Description	3.5 km from shore; 90 m depth. One Male and one female travelling in eastly direction toward deeper waters	L. Croes[b,c]
26 Jan 2012	South-west of Aruba	3	Description	2 km from shore; 155 m depth	J. Tromp

[a], all observers are experienced fishermen; [b], personal communication to J.A. Luksenburg; [c], this sighting was in the same area as the sightings of 13 and 14 April 2011 and refers almost certainly to the same group of killer whales. The observer was present during the 13 and 14 April 2011 sightings.

Fig. 11. Short-finned pilot whale (*Globicephala macrorhynchus*). Dutch marine camp off Commandeurs Reef, Aruba, 23 May 2003 (photograph by A. Henriquez).

identified based on their broad-based dorsal fin, rounded bulbous head, and long, slender sickle-shaped pectoral fins (Jefferson *et al*., 2008) (Figure 11). One was a juvenile found stranded at Colorado Point, along the south-east Aruba coast on 12 February 1998. The other was a female of approximately 3.7 m found drifting near Commandeurs Reef along the south-west coast on 23 May 2003. The female had severe bite marks, most probably from a killer whale (I. Visser, in litt.).

Risso's dolphin (*Grampus griseus*)

Agudo & Ponson (1996) published the only stranding record of a Risso's dolphin (Table 6). The stranding occurred on 13 November 1993 at Arashi beach along the north-west coast. The original identification is here corroborated based on two photographs published in the local newspapers *Diario* (15 November 1993) and *Bon Dia Aruba* (16 November 1993) and written documentation provided by the original observer (B. Boekhoudt, in litt.). The photographs reveal a very tall prominent dorsal fin with a rounded tip and a strong concave trailing edge, long pectoral fin, a rounded head without prominent beak, a relatively robust body and narrow tail stock, pale ventral coloration, a description indicating the animal was 'grey to blackish all over the body, except for ventral areas which were light grayish and had sporadic whitish spots'. The typical vertical crease or cleft down the anterior surface of the melon and the body scarring are not visible on the photographs (Baird, 2002; Jefferson *et al*., 2008), but the characteristics apparent in the photographs are consistent with the identification of *G. grampus* and sufficient to rule out all similar species (T.A. Jefferson, in litt.).

Unidentified beaked whale (*Mesoplodon* sp.)

Park rangers from Arikok National Park at Rincon found two animals stranded on the north-east coast on 23 January 2004 (Figure 12). The animals were identified as females based on the presence of mammary slits (A.D.L.F. Ho, in litt.). No teeth were visible in either animal. Their length was estimated to be 4.40 m and 3.45 m (A.D.L.F. Ho, in litt.), indicating they were an adult and juvenile. *Ziphius cavirostris* and *M.*

https://doi.org/10.1017/S0025315413000337 Published online by Cambridge University Press

Fig. 12. Unidentified beaked whale (*Mesoplodon* sp. cf. *M. europaeus*), Rincon, north-east coast of Aruba, 23 January 2004 (photographs by A.D.L.F. Ho).

densirostris were ruled out based on the combination of a distinct, narrow beak, lack of a prominent arched contour of the lower jaw, and a dark patch around the eyes (Figure 12B). The main features visible on photographs are a small head with a pronounced but narrow rostrum, sloping forehead with a slightly bulging melon and indentation at blowhole, and mouth line arching downward at the proximal end. The dorsal side, lateral sides, patch around the eye, pectoral flippers, and upper jaw were darkly pigmented. The ventral side and lower jaw were lightly pigmented (perhaps whitish), with white blotches on the belly. Both animals had extensive scarring. External measurements of the specimens were provided by A.D.L.F. Ho (in litt.). Based on external measurements, they appeared to be an adult and a juvenile. Measurements for the adult female were as follows: total length 440 cm, length of the pectoral fin (anterior insertion to tip) 44 cm, snout to angle of mouth 44 cm, fluke width 103 cm, dorsal fin height 29 cm, girth 264 cm. Measurements for the juvenile were: total length 345 cm, length of the pectoral fin (anterior insertion to tip) 36 cm, snout to angle of mouth 31 cm, fluke width 70 cm, dorsal fin height 20 cm, girth 184 cm. These traits indicate that these animals were either Gervais' beaked whale *M. europaeus* or True's beaked whale *M. mirus*. Specific identification was not possible based on the photographic material (T.A. Jefferson, in litt.; J.G. Mead, in litt.).

Fig. 13. Humpback whale (*Megaptera novaeangliae*), north-west of Aruba, 19 February 1999 (video still by N. Thijssen).

Humpback whale (*Megaptera novaeangliae*)

N. Thijssen observed four humpback whales close to the north-western shore of the island (within 6 km from shore) on 19 February 1999 (Table 2). Video documentation of one of the individuals (Figure 13.) provided a basis for identifying it as *Megaptera novaeangliae* based on the hump in front of the dorsal fin, the low, broad-based dorsal fin and fluke with S-shaped, knobbly trailing edge (Jefferson *et al.*, 2008).

Rorquals (*Balaenoptera* sp. and *Balaenoptera brydei/edeni*)

Five stranding events were recorded between 2001 and 2011, four of which occurred on the north-east coast (Table 5). Four of the events were documented by photographs, although most of the photographs lacked sufficient detail to identify the species. The animals were identified as *Balaenoptera* sp. based on a distinct, slender, erect dorsal fin sloping backwards, set at approximately 2/3 towards the back of the body, or the whitish or yellowish throat groves. Photographs of the individual that stranded on 12 February 2001 reveal the lateral ridges on the head that are diagnostic for the Bryde's/Eden's whale complex (*Balaenoptera brydei/edeni*) (Figure 14). Skin and bone samples were taken from three specimens for molecular analysis. The five strandings occurred during winter, spring, or summer. Four were adults, the fifth being an individual 5 m in length that stranded 42 days after an adult female (12 February 2001); it may have been her calf (A. Henriquez, personal communication).

Sperm whale (*Physeter macrocephalus*)

An adult sperm whale was found stranded on Santana di Cacho beach on the south-east coast on 30 March 2003. The whale was entangled in a fishing trawler line wrapped around its torso and right flipper (A. Henriquez, in litt.; F. Franken, in litt.). In addition, two dead sperm whales, an adult and a calf or subadult without teeth, were found drifting on 15 July 2010, 7 km off the south-west coast. Both individuals were entangled in a gill net with a mesh size of at least 10 × 10 cm. Gas formation and sloughing skin indicate that the two whales had been dead for approximately two to three

https://doi.org/10.1017/S0025315413000337 Published online by Cambridge University Press

Table 5. Stranding records of *Balaenoptera* sp. in Aruba (1998–2011).

Date	Area	Evidence	Comments*	Source
12 Feb 2001	Daimari (NE coast)	Photographs; partial skeleton at Arikok Park National	Adult female *brydei/edeni* of approximately 14 m. Necropsy revealed uterus prolapsed, indicating recent calving	A. Henriquez, F. Franken, R. Derrix
26 Mar 2001	Near Daimari (NE coast)		Calf of approximately 5 m	A. Henriquez
16 Aug 2002	Boca Matividiri (NE coast)	Photographs; lower jaw bone with F. Franken	Adult of approximately 13.5 m	A. Henriquez, F. Franken, R. Carmen, F. Croes
4 Apr 2011	Rogers beach (SW coast)	Photographs	Live stranding, the animal was found in very shallow waters in a bay less than 10 m from shore and was dragged back to sea by local fishermen	A. Henriquez, Amigoe (5 April 2011), *Diario* (5 April 2011)
13 Apr 2011	Boca Calcof (NE coast)	Photographs; partial skeleton at Arikok Park National	Adult in an advanced state of decay. This individual may be the same as that stranded on 4 April 2011	A. Henriquez, J.A. Luksenburg

*, none of the strandings except the first could be identified to species.

Fig. 14. Bryde's whale (*Balaenoptera edeni/brydei*), Daimari, north-east coast of Aruba, 12 February 2001 (photograph by R. Derrix).

days (F. Gulland, personal communication). Another dead adult sperm whale was found drifting off Cerro Colorado about 3 km off the south-east coast on 21 January 2011 (Figure 15). Its intestines were protruding through a large cut (approximately 1/5 of the animal's body length) on the left side of the body. The tongue was missing and several bite marks were visible on its back, left flank, the base of the left flipper and jaw (A. Henriquez, in litt.). Tissue samples were collected for future studies. All the animals were identified as sperm whales based on their large squarish head, small humplike dorsal fin and wrinkly skin (Jefferson *et al.*, 2008). Photographs were taken of each stranded individual.

Fig. 15. Sperm whale (*Physeter macrocephalus*), south-west coast of Aruba, 21 January 2011 (photograph by A. Henriquez).

https://doi.org/10.1017/S0025315413000337 Published online by Cambridge University Press

DISCUSSION

Species richness and diversity

This report summarizes the first dedicated field study of cetaceans in Aruban waters. It documents the presence of fourteen species, eight that were identified at sea during the study period and six others that were identified from stranding incidents or reported by others. Together with two previously documented species for which no further records were obtained, this brings the total number of cetaceans documented in Aruban waters to 16 species (Table 6). This report authenticates nine of those species for the first time and three species were identified during this study and documented by Luksenburg (2011) for the first time (Table 6).

Of the 16 species documented for Aruba, nine are known only from sightings at sea whereas seven species are known only from strandings. Both types of data are useful for assessing cetacean species richness. Pyenson (2011) suggested that stranding records may provide a better basis for characterizing the cetacean species in an area than sighting data, provided that sampling extends across large latitudinal gradients (>2000 km) and for periods longer than 10 years. However, Aruba is a small island with only 68.5 km of coastline, which argues that stranding events are not particularly likely. This study added substantially to our understanding of cetacean diversity around Aruba, indicating that 20 years of stranding data (Debrot & Barros, 1994) are useful but not sufficient for that purpose.

The diversity of cetaceans in Aruba, as measured by the Shannon–Wiener index, was unstable during the first months of fieldwork but stabilized after six months (Figure 3A). This indicates that, even in a relatively small area, up to six months of intensive sampling may be required to obtain a robust estimate of cetacean species diversity. Various studies have used the Shannon–Wiener index to measure local diversity of Cetacea (Dulau-Drouot *et al.*, 2008; Gannier, 2009; Kizka *et al.*, 2010), but comparisons are hampered by differences in sampling effort among survey areas. I suggest that the trend of the cumulative diversity index over time may provide a means to evaluate the robustness of the final diversity index, and thus may help to assess whether sampling has been sufficient or insufficient. Further studies based on standardized methods (distance sampling techniques) are required to evaluate whether trends in the cumulatieve curve are indeed a reliable method to evaluate the robustness of the final diversity index.

Table 6. Overview of cetacean species reliably documented for Aruba.

Species	Type	First documented
Stenella frontalis	Sighting	Luksenburg, 2011
Stenella attenuata	Sighting	This study
Stenella longirostris	Sighting	Luksenburg, 2011
Stenella coeruleoalba	Stranding	This study
Tursiops truncatus	Sighting	This study
Delphinus capensis	Sighting	This study
Steno bredanensis	Sighting	This study
Pseudorca crassidens	Sighting	Luksenburg, 2011
Orcinus orca	Sighting	This study
Globicephala macrorhynchus	Stranding	Debrot *et al.*, 1998
Grampus griseus	Stranding	Agudo & Ponson, 1996; this study
*Kogia sima**	Stranding	Debrot *et al.*, 1998
*Ziphius cavirostris**	Stranding	Debrot & Barros, 1994
Megaptera novaeanglia	Sighting	This study
Physeter macrocephalus	Stranding	This study
Balaenoptera edeni/brydei	Stranding	This study

*, not documented in this study.

Species accounts

Atlantic spotted dolphin, the most numerous and frequently encountered species in this study, was observed in all months of the year, indicating it is common in Aruban waters. It also is one of the most commonly encountered marine mammals in nearshore habitats in Colombia (Pardo & Palacios, 2006; Fraija *et al.*, 2009) and Venezuela (Bolaños-Jiménez *et al.*, 2006, 2009a) but it has not yet been reported for Curaçao and Bonaire (Debrot *et al.*, 1998; Barros & Debrot, 2006). All adult individuals observed in Aruba were heavily spotted, consistent with coastal populations of this species in Central and South America (Perrin *et al.*, 1987).

Pantropical spotted dolphin was recorded only in relatively deep waters at distances greater than 15 km from shore. It may occur regularly in Aruban waters, given that the survey track rarely extended to waters deeper than 500 m. Pantropical spotted dolphins were never sighted in shallow waters (<490 m), whereas Atlantic spotted dolphins were never sighted in deeper waters (>250 m). Undoubtedly, ecological factors (habitat, prey, competitive exclusion) influence the local distributions of these species. Similar habitat use has been reported throughout the Caribbean (Mignucci-Giannoni *et al.*, 2003). Pantropical spotted dolphins have been documented off Curaçao (LeDuc *et al.*, 1997; Debrot *et al.*, 1998), Colombia (Pardo & Palacios, 2006; Pardo *et al.*, 2009a), and Venezuela (Bolaños-Jiménez *et al.*, 2006; Oviedo, 2007). The adults observed off Aruba had dark ventral spotting and light dorsal spotting, consistent with the offshore populations of this species worldwide (Jefferson *et al.*, 2008).

Spinner dolphin was observed in all seasons, indicating residence in Aruban waters. It is common off Curaçao, Bonaire and Venezuela (Debrot *et al.*, 1998; Romero *et al.*, 2001) but only one sighting has been reported for Colombia (Pardo *et al.*, 2009a).

Bottlenose dolphin was observed in all months of the year except June and December. No seasonal variation was apparent from the sighting data. Its common occurrence in shallow waters near the coast is consistent with observations of this species in Colombia (Pardo & Palacios, 2006; Fraija *et al.*, 2009) and Venezuela (Oviedo & Silva, 2005; Bolaños-Jiménez *et al.*, 2009a). Bottlenose dolphins are also common off both Curaçao and Bonaire (Debrot *et al.*, 1998; Barros & Debrot, 2006).

The sighting of long-beaked common dolphins represents the first record of this species in Aruban waters and one of the few records this far west. Scientists have recorded it once in the Gulf of Venezuela (Ramírez Carroz & González-Fernández, 2004; Jefferson *et al.*, 2009) and four times in the coastal waters off the Guajira Peninsula, northern Colombia (Palacios *et al.*, 2012). The single sighting in the current study during 20 months of fieldwork indicates long-beaked common dolphins are not a frequent visitor to Aruban waters. Because of the short geographical distance of Venezuela and Colombia to Aruba, the single sighting may have been of a wandering group from either the Venezuelan

https://doi.org/10.1017/S0025315413000337 Published online by Cambridge University Press

or the newly proposed Guajiran stock of the long-beaked common dolphin (Palacios *et al.*, 2012). The individuals photographed in Aruba appeared typical for *D. capensis*, but the taxonomic status of this population in the Caribbean is not clear (Esteves & Oviedo, 2007). For example, its external morphology has not been compared to other populations. However, the individuals in this study did not exhibit the mixture of features of *D. capensis* and *D. delphinus* observed in common dolphins in Angola (Weir & Coles, 2007).

The single record of humpback whales in February is consistent with the presence of this species in Curaçao, Bonaire, Colombia, and Venezuela during January through to April (Debrot & Barros, 1994; Debrot *et al.*, 1998; Silva *et al.*, 2008; Fraija *et al.*, 2009). Humpback whales are most likely observed in Aruba during January through to April during its winter breeding season in the eastern and southern Caribbean (Swartz *et al.*, 2003).

The small number of observations of rough-toothed dolphins, false killer whales, and killer whales indicates that these species are not resident in coastal Aruban waters. The 12 records of rough-toothed dolphins in a 13-year period may suggest that this species use coastal waters of Aruba occasionally, perhaps for specific purposes including birthing. Although there are a few records of killer whales in the waters off Curaçao, no published records exist for rough-toothed dolphins and false killer whales in those waters (Debrot *et al.*, 1998; Barros & Debrot, 2006). Records of these species in Colombia and Venezuela also are sparse (Álvarez-León 2002; Pardo *et al.*, 2009b; Romero *et al.*, 2001, Bolaños-Jiménez *et al.*, 2006, 2009b).

The occurrence of rorquals in Aruban waters remains unclear but only limited information is available for these species from the stranding records. Identification of whales of the Bryde's whale complex is difficult because the complex is thought to consist of three very similar species (Wada *et al.*, 2003; Sasaki *et al.*, 2006). Lateral ridges are prominent in *B. brydei*, and probably also in *B. edeni* (Wada *et al.*, 2003), and it is unclear if these two species can be separated in the field. That being the case, skull morphology (Wada *et al.*, 2003; Yamada *et al.*, 2006) and/or DNA analysis (e.g. Ross *et al.*, 2003) are essential for identifying stranded individuals. Attempts to do so are currently underway (J. Luksenburg & G. Sangster, in prepration). In the meantime, the single stranding in Aruba is best listed as *B. brydei/edeni*.

The seven species that are only known in Aruba from stranding records (Table 6) all prefer deeper waters (Ward *et al.*, 2001). All seven species have been reported from neighbouring countries (Colombia, Venezuela, Curaçao and Bonaire) (Vidal, 1990; Debrot *et al.*, 1998; Romero *et al.*, 2001; Bolaños-Jiménez *et al.*, 2006; Pardo & Palacios, 2006; Bermúdez-Villapol *et al.*, 2008a, b). Offshore surveys and surveys on the eastern side of the island are needed to assess the occurrence, distribution and seasonal trends of species that prefer deeper waters.

Previous records

Eight species were previously reported in Aruban waters (Agudo & Ponson, 1996; Debrot *et al.*, 1998; Barros & Debrot, 2006). The records include sightings and/or strandings of Atlantic spotted dolphins (November 1993, May 1995), bottlenose dolphins (August 1995), rough-toothed dolphins (possibly in 1998), Risso's dolphin (November 1993), short-finned pilot whale (April 1994), Cuvier's beaked whale (*Ziphius cavirostris*) (December 1991), dwarf sperm whale (*Kogia sima*) (May 1984), and Gervais' beaked whale (possibly in 1998, January 2004). Several of these records are either poorly documented or not documented at all.

The published records of Atlantic spotted dolphins, bottlenose dolphins, and rough-toothed dolphins (Agudo & Ponson, 1996; Barros & Debrot, 2006) did not include descriptive information about diagnostic features or photographic documentation needed to verify these records. Because these species can be confused easily with other species (e.g. Mignucci-Giannoni *et al.*, 2003), more evidence is necessary to verify these published records.

Three species, short-finned pilot whale, Cuvier's beaked whale, and dwarf sperm whale, have been documented by photographs or specimens (skulls) (Debrot & Barros, 1994; Debrot *et al.*, 1998). These records are here considered sufficient for verification. A record of a Risso's dolphin, which stranded in November 1993 (Agudo & Ponson, 1996) has been listed as 'unconfirmed' (Debrot *et al.*, 1998) or listed with a question mark (Barros & Debrot, 2006), perhaps because the initial publication lacked sufficient detail. However, examination of photographs and the field description by the original observer demonstrated that the animal was correctly identified (T.A. Jefferson, in litt.).

The record of a beaked whale (*Mesoplodon*) at Rincon in 2004 was previously reported as Gervais' beaked whale (Barros & Debrot, 2006) but the record is not sufficient to rule out the possibility that it was True's beaked whale (T.A. Jefferson, in litt.; J.G. Mead, in litt.). Females and juveniles of the two species may be distinguished on the basis of the relative length of the pectoral flippers, the degree of lateral rostral flattening and the shape of the beak and melon (Moore & Wood, 1957; Leatherwood *et al.*, 1976). Unfortunately, these features could not be measured reliably. Several records of Gervais' beaked whale are known for the Caribbean whereas no records of True's beaked whale have been documented from either the Gulf of Mexico or the Caribbean (Rosario-Delestre *et al.*, 1999; MacLeod *et al.*, 2006). Based on present knowledge, Gervais' beaked whale is the most likely of the two species to occur in Aruba. However, knowledge about beaked whales in the Caribbean is poor and it is not possible to distinguish between inadequate data and true absence (MacLeod *et al.*, 2006). Barros & Debrot (2006) reported a separate stranding of Gervais' beaked whale, possibly in 1998, but the supporting documentation was limited to a photograph in an unspecified newspaper. Thus, I conclude that Gervais' beaked whale has not yet been reliably documented in Aruban waters.

Conservation implications

This study documents the regular presence of several species and substantial numbers of cetaceans in Aruban waters. Assessing their conservation status and threats to them is important because of the intensity and increasing trend in human activities in Aruban waters, including tourism. This concern is underscored by: (1) the fact that all three stranding records of sperm whales in Aruba were caused by human activities (boat collision, entanglement in fishing gear); and (2) multiple observations of neonates of three species and feeding activity of seven species indicates that Aruban waters are breeding and feeding grounds for cetaceans.

https://doi.org/10.1017/S0025315413000337 Published online by Cambridge University Press

ACKNOWLEDGEMENTS

I am very grateful to Angiolina Henriquez of the Aruba Marine Mammal Foundation for sharing her unpublished data, her help with logistics and getting the project started. Her enthusiasm for this project led to many fruitful discussions. I am indebted to Leo Croes, captain of the 'Mahi Mahi', for his generosity and enthusiasm for this project, and for sharing his knowledge. This project would not have been possible without the many fishermen who allowed me to carry out my fieldwork on their boats, including E. Balentina, G. Carvalhal, P. Creutzberg, K. Creutzberg, L. Croes, M. Heyden, A. Ho, G. Maduro, E. Pinzon, R. Rijpma and R. Tramp. I am grateful to the Aruba Coast Guard for allowing access to the sperm whales that stranded in July 2010 and January 2011. I would like to thank the following people for providing information and documentation about cetaceans in Aruban waters: I. Agudo, B. Boekhoudt, R. Carmen, F. Croes, L. Croes, R. Derrix, F. Franken, A. Giel, F. Gulland, A. Henriquez, M. Heyden, A. Ho, J. Leacock, P. Meyer, M. Ponson, P. Sweetnam, N. Thijssen, J. Tromp, G. Werleman, E. van der Werf and R. van der Werf. I am grateful to T.A. Jefferson and J.G. Mead for their help with species identifications and to R.W. Baird for answering inquiries. I am especially thankful to Ida and Henry Does for their interest, generosity and hospitality throughout the study period. This paper was greatly improved by comments of P. Balint, E.C.M. Parsons, T.J. Ragen, L.L. Rockwood, G. Sangster, M. Scheidat and an anonymous referee.

FINANCIAL SUPPORT

T.G. Damian and P. Portier provided assistance with obtaining funding. Fieldwork was supported by Prins Bernhard Culture Fund, George Mason University, Cetacean Society International, Society for Marine Mammalogy, Lerner-Gray fund of the American Museum of Natural History, Humane Society International, Aruban Department of Agriculture, Husbandry and Fisheries, and K.M. Luksenburg-Bouwmeester.

REFERENCES

Agudo A.I. and Ponson Jr M.E. (1996) Primeiro registro de cetáceos na Ilha de Aruba. *Eubalaena* 9, 5–9.

Álvarez-León R. (2002) Capturas comerciales con palangre en la zona económica exclusiva frente a la Guajira, Caribe de Colombia. *Revista de Biología Tropical* 50, 227–231.

Baird R.W. (2002) Risso's dolphin. In Perrin W.F., Würsig B. and Thewissen J.G.M. (eds) *Encyclopedia of marine mammals*. San Diego, CA: Academic Press, pp. 1037–1039.

Barros N.B. and Debrot A.O. (2006) *Status of small cetaceans in the Leeward Dutch Antilles*. SC/58/SM14. Report presented to the Scientific Committee, 58th Annual Meeting of the International Whaling Commission, St Kitts & Nevis.

Baum J.K. and Worm B. (2009) Cascading top-down effects of changing oceanic predator abundances. *Journal of Animal Ecology* 78, 699–714.

Bermúdez-Villapol L.A., Sayegh A.J. and León T. (2008a) Notes on the confirmation of the dwarf sperm whale *Kogia sima* Owen, 1866 (Cetacea: Kogiidae) on Venezuelan coasts. *Revista Científica UDO Agrícola* 8, 154–162.

Bermúdez-Villapol L.A., Sayegh A.J., Rangel M.S., Rosso M.C. and Vera N.I. (2008b) Notes on the presence of Risso's Dolphin, *Grampus griseus* Cuvier 1812 (Cetacea: Delphinidae), in Venezuelan waters. *Revista Científica UDO Agrícola* 8, 163–170.

Bolaños-Jiménez J. and Villarroel-Marin A. (2003) Three new records of cetacean species for Venezuelan waters. *Caribbean Journal of Science* 39, 230–232.

Bolaños-Jiménez J., Bermúdez Villapol L., Sayegh A. and Solé G. (2006) *Current status of small cetaceans in Venezuela*. SC/58/SM9. Report presented to the Scientific Committee, 58th Annual Meeting of the International Whaling Commission, St Kitts & Nevis.

Bolaños-Jiménez J., Fertl D. and Iñíguez M. (2009a) A note on killer whale (*Orcinus orca*) occurrence in Venezuelan waters, 1982–2008. *Latin American Journal of Aquatic Mammals* 7, 75–79.

Bolaños-Jiménez J., Villarroel-Marín A.J. and Oviedo L. (2009b) *Preliminary assessment of the abundance of Atlantic spotted* (Stenella frontalis) *and common bottlenose* (Tursiops truncatus) *dolphins in the state of Aragua, Venezuela, on the basis of photo-ID techniques (winter 2009)*. SC/61/SM32. Report presented to the Scientific Committee, 61st Annual Meeting of the International Whaling Commission, Funchal, Madeira.

CIA World Factbook (2011) *Aruba*. https://www.cia.gov/library/publications/the-world-factbook/geos/aa.html

Cole S. and Razak V. (2009) How far, and how fast? Population, culture, and carrying capacity in Aruba. *Futures* 41, 414–425.

Davidson A.D., Boyer A.G., Kim H., Pompa-Mansilla S., Hamilton M.J., Costa D.P., Ceballos G. and Brown J.H. (2012) Drivers and hotspots of extinction risk in marine mammals. *PNAS* 109, 3395–3400.

Debrot A.O. (1998) New cetacean records for Curaçao, Netherlands Antilles. *Caribbean Journal of Science* 34, 168–170.

Debrot A.O. and Barros N.B. (1994) Additional cetacean records for the Leeward Dutch Antilles. *Marine Mammal Science* 10, 359–368.

Debrot A.O., De Meyer J. and Dezentjé P.J.E. (1998) Additional records and a review of the cetacean fauna of the Leeward Dutch Antilles. *Caribbean Journal of Science* 34, 204–210.

Debrot A.O., Witte R.H. and Scheidat M. (2011) *The marine mammals of the Dutch Caribbean: a comparison between EEZ sectors, contrasts and concerns*. SC/63/E9. Report presented to the Scientific Committee, 63rd Annual Meeting of the International Whaling Commission, Jersey, UK.

Degrati M., Dans S.L., Pedraza S.N., Crespo E.A. and Garaffo G.V. (2008) Diurnal behavior of dusky dolphins, *Lagenorhynchus obscurus*, in Golfo Nuevo, Argentina. *Journal of Mammalogy* 89, 1241–1247.

Dorenbosch M., Grol M.G.G., Nagelkerken I. and Van der Velde G. (2006) Seagrass beds and mangroves as potential nurseries for the threatened Indo-Pacific humphead wrasse, *Cheilinus undulatus* and Caribbean rainbow parrotfish, *Scarus guacamaia*. *Biological Conservation* 129, 277–282.

Dulau-Drouot V., Boucaud V. and Rota B. (2008) Cetacean diversity off La Réunion Island (France). *Journal of the Marine Biological Association of the United Kingdom* 88, 1263–1272.

Estes J.A., Williams T.M., Doak D., DeMaster D. and Brownell R.L. (eds) (2006) *Whales, whaling and ocean ecosystems*. Berkeley, CA: University of California Press.

Esteves M.A. and Oviedo L.E. (2007) A potential morphotype of common dolphin (*Delphinus* spp.) on the Northeast coast of Venezuela. *Aquatic Mammals* 33, 229–234.

Fraija N., Flórez-González L. and Jáuregui A. (2009) Cetacean occurrence in the Santa Marta region, Colombian Caribbean, February–May (2007) *Latin American Journal of Aquatic Mammals* 7, 69–73.

Gannier A. (2009) Comparison of odontocete populations of the Marquesas and Society Islands (French Polynesia). *Journal of the Marine Biological Association of the United Kingdom* 89, 931–941.

GEBCO. (2012) *General bathymetric chart of the oceans*. Available at http://www.gebco.net (accessed 15 March 2013).

Herzing D.L. (1997) The life history of free-ranging Atlantic spotted dolphins (*Stenella frontalis*): age classes, color phases and female reproduction. *Marine Mammal Science* 13, 576–595.

Heyning J.E. and Perrin W.F. (1994) Evidence for two species of common dolphins (genus *Delphinus*) from the eastern north Pacific. *Contributions in Science* 442, 1–35.

IUCN (2011) *IUCN Red list of threatened species*. Gland, Switzerland: International Union for Conservation of Nature and Natural Resources (IUCN).

Jefferson T.A. (2002) Rough-toothed dolphin: *Steno bredanensis*. In Perrin W.F., Würsig B. and Thewissen J.G.M. (eds) *Encyclopedia of marine mammals*. San Diego, CA: Academic Press, pp. 1055–1059.

Jefferson T.A. and Lynn S.K. (1994) Marine mammal sightings in the Caribbean Sea and Gulf of Mexico, summer 1991. *Caribbean Journal of Science* 30, 83–89.

Jefferson T.A., Fertl D., Bolaños-Jiménez J. and Zerbini A.N. (2009) Distribution of common dolphins (*Delphinus* spp.) in the western Atlantic Ocean: a critical re-examination. *Marine Biology* 156, 1109–1124.

Jefferson T.A., Webber M.A. and Pitman R.L. (2008) *Marine mammals of the world*. Amsterdam: Elsevier, 573 pp.

Karczmarski L., Würsig B., Gailey G., Larson K.W. and Vanderlip C. (2005) Spinner dolphins in a remote Hawaiian atoll: social grouping and population structure. *Behavioral Ecology* 16, 675–685.

Kizka J., Ersts P.J. and Ridoux V. (2010) Structure of a toothed cetacean community around a tropical island (Mayotte, Mozambique Channel). *African Journal of Marine Science* 32, 543–551.

Kohsiek L.H.M., Holsbergen C.H. and Terwindt J.H.J. (1987) Beach erosion along the west coast of Aruba, Netherlands Antilles. *Journal of Coastal Research* 3, 37–54.

Leatherwood S., Caldwell D.K. and Winn H.E. (1976) *Whales, dolphins, and porpoises of the Western North Atlantic, a guide to their identification*. NOAA Technical Report NMFS CIRC-396, 135–137.

LeDuc R.G., Perrin W.F., Debrot A.O., Barros N.B. and van Bree P.J.H. (1997) *Stenella attenuata* from Curaçao misidentified as *Stenella coeruleoalba*. *Marine Mammal Science* 13, 356–357.

Lewison R.L., Crowder L.B., Read A.J. and Freeman S.A. (2004) Understanding impacts of fisheries bycatch on marine megafauna. *Trends in Ecology and Evolution* 19, 598–604.

Luksenburg J.A. (2011) Three new records of cetacean species for Aruba, Leeward Antilles, southern Caribbean. *Marine Biodiversity Records* 4, e4. doi: http://dx.doi.org/10.1017/S1755267210001193.

MacLeod C., Perrin W.F., Pitman R., Barlow J., Balance L., D'Amico A., Gerrodette T, Joyce G., Mullin K.D., Palka D.L. and Waring G.T. (2006). Known and inferred distribution of beaked whale species (Cetacea: Ziphiidae). *Journal of Cetacean Research and Management* 7, 271–286.

Mignucci-Giannoni A.A., Swartz S.L., Martínez A, Burks C.M. and Watkins A.A. (2003) First records of the pantropical spotted dolphin (*Stenella attenuata*) for the Puerto Rican Bank, with a review of the species in the Caribbean. *Caribbean Journal of Science* 39, 381–392.

Miloslavich P., Díaz J.M., Klein E., Alvarado J.J., Díaz C., Gobin J., Escobar-Briones E., Cruz-Motta J.J., Weil E., Cortés J., Bastidas A.C., Robertson R., Zapata F., Martín A., Castillo J., Kazandjian A. and Ortiz M. (2010) Marine biodiversity in the Caribbean: regional estimates and distribution patterns. *PLoS ONE* 5, e11916.

Moore J.C. and Wood F.G. (1957) Differences between the beaked whales *Mesoplodon mirus* and *Mesoplodon gervaisi*. *American Museum Novitates* 1831, 1–25.

O'Hara T.M. and O'Shea T.J. (2005) Assessing impacts of environmental contaminants. In Reynolds III J.E., Perrin W.F., Reeves R.R., Montgomery S. and Ragen T.J. (eds) *Marine mammal research: conservation beyond crisis*. Baltimore, MD: Johns Hopkins University Press, pp. 63–83.

Oviedo L. (2007) Dolphin sympatric ecology in a tropical fjord: habitat partitioning by bathymetry and topography as a strategy to coexist. *Journal of the Marine Biological Association of the United Kingdom* 87, 1327–1335.

Oviedo L. and Silva N. (2005) Sighting frequency and relative abundance of bottlenose dolphins (*Tursiops truncatus*) along the northeast coast of Margarita Island and Los Frailes Archipiélago, Venezuela. *Revista de Biología Tropical* 53, 595–600.

Palacios D.M., Farías-Curtidor N., Jiménez-Pinedo C., Castellanos L., Gärtner A., Gómez-Salazar C., Caicedoherrera C. and Trujillo F. (2012) *Range extension for the long-beaked common dolphin* (Delphinus capensis) *to the Colombian Caribbean*. SC/64/SM20. Report presented to the Scientific Committee, 64st Annual Meeting of the International Whaling Commission, Panama City: Panama.

Pardo M.A. and Palacios D.M. (2006) Cetacean occurrence in the Santa Marta region, Colombian Caribbean, 2004–2005. *Latin American Journal of Aquatic Mammals* 5, 129–134.

Pardo M.A., Jiménez-Pinedo C. and Palacios D.M. (2009b) The false killer whale (*Pseudorca crassidens*) in the southwestern Caribbean: first stranding record in Colombian waters. *Latin American Journal of Aquatic Mammals* 7, 63–67.

Pardo M.A., Mejía-Fajardo A., Beltrán-Pedreros S., Trujillo F., Kerr I. and Palacios D.M. (2009a) Odontocete sightings collected during offshore cruises in the southwestern and western Caribbean Sea. *Latin American Journal of Aquatic Mammals* 7, 57–62.

Perrin W.F. (1998) *Stenella longirostris*. *Mammalian Species* 599, 1–7.

Perrin W.F., Mitchell E.D., Mead J.G., Caldwell D.K., Caldwell M.V., van Bree P.J.H. and Dawbin W.H. (1987) Revision of the spotted dolphins, *Stenella* spp. *Marine Mammal Science* 3, 99–170.

Plagányi E.E. and Butterworth D.S. (2005) Indirect fisheries interaction. In Reynolds III JE, Perrin WF, Reeves RR, Montgomery S & Ragen TJ (editors). *Marine mammal research: conservation beyond crisis*. Baltimore, MD: Johns Hopkins University Press, pp. 19–45.

Pyenson N.D. (2011) The high fidelity of the cetacean stranding record: insights into measuring diversity by integrating taphonomy and macroecology. *Proceedings of the Royal Society B* 278, 3608–3616.

Ramírez Carroz S. and González-Fernández M. (2004) Primer registro del delfín común (*Delphinus capensis*: Gray, 1828) en el golfo de Venezuela. *Boletin del Centro de Investigaciones Biologicas Universidad del Zulia* 38, 140–149.

Read A.J. (2005) Bycatch and depredation. In Reynolds III J.E., Perrin W.F., Reeves R.R., Montgomery S. & Ragen T.J. (eds) *Marine mammal research: conservation beyond crisis*. Baltimore, MD: Johns Hopkins University Press, pp. 5–17.

Read A.J. (2008) The looming crisis: interactions between marine mammals and fisheries. *Journal of Mammalogy* 89, 541–548.

Reeves R.R., Smith B.D., Crespo E.A. and Notarbartolo di Sciara G. (compilers) (2003) *Dolphins, whales and porpoises: 2002–2010 Conservation action plan for the world's cetaceans*. IUCN/SSC Cetacean Specialist Group. Gland (Switzerland) and Cambridge: International Union for Conservation of Nature and Natural Resources (IUCN), 139 pp.

Reynolds J.E. III, Perrin W.F., Reeves R.R., Montgomery S. and Ragen T.J. (eds) (2005) *Marine mammal research: conservation beyond crisis*. Baltimore, MD: Johns Hopkins University Press.

Ricklefs R.E. (2007) *The economy of nature*. 5th edition. New Yorkl: W.H. Freeman & Company.

Roman J. and McCarthy J.J. (2010) The whale pump: marine mammals enhance primary productivity in a coastal basin. *PLoS ONE* 5, e13255.

Romero A., Agudo A.I., Green S.M. and Notarbartolo-di-Sciara G. (2001) Cetaceans of Venezuela: their distribution and conservation status. *NOAA Technical Report NMFS* 151, 1–60.

Rosario-Delestre R.J., Rodríguez-López M.A., Mignucci-Giannoni A.A. and Mead J.G. (1999) New records of beaked whales (*Mesoplodon* spp.) for the Caribbean. *Caribbean Journal of Science* 35, 144–148.

Ross H.A., Lento G.M., Dalebout M.L., Goode M., Ewing G., McLaren P., Rodrigo A.G., Lavery S., and Baker C.S. (2003) DNA surveillance: web-based molecular identification of whales, dolphins, and porpoises. *Journal of Heredity* 94, 111–114.

Sasaki T., Nikaido M., Wada S., Yamada T.K., Cao Y., Hasegawa M. and Okada N. (2006) *Balaenoptera omurai* is a newly discovered baleen whale that represents an ancient evolutionary lineage. *Molecular Phylogenetics and Evolution* 41, 40–52.

Schipper J. (and 129 co-authors) (2008) The status of the world's land and marine mammals: diversity, threat, and knowledge. *Science* 322, 225–230.

Silva M.A., Prieto R., Magalhaes S., Seabra M.I., Santos R.S. and Hammond P.S. (2008) Ranging patterns of bottlenose dolphins living in oceanic waters: implications for population structure. *Marine Biology* 156, 179–192.

Smetacek V. and Nicol S. (2005) Polar ocean ecosystems in a changing world. *Nature* 437, 362–368.

Swartz S.W., Cole T., McDonald M.A, Hildebrand J.A., Oleson E.M., Burks C., Clapham P.J., Barlow J. and Martinez A. (2003) Visual and acoustic survey of humpback whales (*Megaptera novaeangliae*) in the eastern and southern Caribbean Sea. *Caribbean Journal of Science* 39, 195–208.

Tangley L. and Miller J.A. (1988) The Caribbean—an ecosystem in crisis. *Bioscience* 38, 319.

Van Vliet E. (2006) *Wereldwijzer Aruba*. Rijswijk: Elmar.

Vidal O. (1990) Lista de mamíferos acuáticos de Colombia. *Informe del Museo del Mar (Universidad Jorge Tadeo Lozano)* 37, 1–18.

Wada S., Oishi M. and Yamada T.K. (2003) A newly discovered species of living baleen whale. *Nature* 426, 278–281.

Ward N., Moscrop A. and Carlson C. (2001) Elements for the development of a marine mammal action plan for the ider Caribbean: a review of marine mammal distribution. UNEP(DEC)/CAR IG.20/INF.3. *First Meeting of the Contracting Parties (COP) to the Protocol Concerning Specially Protected Areas and Wildlife (SPAW) in the Wider Caribbean Region, Havana, Cuba, 24–25 September 2001*.

Weir C.R. and Coles P. (2007) Morphology of common dolphins (*Delphinus* spp.) photographed off Angola. *Abstracts of the 17th Biennial Conference of the Society for Marine Mammalogy, Cape Town, South Africa, 29 November–3 December, 2007*.

and

Yamada T.K., Chou L.-S., Chantrapornsyl S., Adulyanukosol K., Chakravarti S.K., Oishi M., Wada S., Yao C.-J., Kakuda T., Tajima Y., Arai K., Umetani A. and Kurihara N. (2006) Middle-sized balaenopterid whale specimens (Cetacea: Balaenopteridae) preserved at several institutions in Taiwan, Thailand, and India. *Memoirs of the National Science Museum, Tokyo* 44, 1–10.

Correspondence should be addressed to:
J.A. Luksenburg
Department of Environmental Science and Policy
George Mason University, 4400 University Drive
Fairfax VA 22030 4444, USA
email: j.luksenburg@yahoo.com.

https://doi.org/10.1017/S0025315413000337 Published online by Cambridge University Press