Cetaceans of Martinique Island (Lesser Antilles) : occurrence and distribution obtained from a small boat dedicated survey.

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Abstract

A dedicated survey of the cetacean population of Martinique Island (14°30'N and 61°W) took place from a 11m catamaran sailship between 14 march to 4 april 2003 and included systematic visual searching and acoustic sampling with a towed hydrophone. A total effective effort of 1315 km was logged in the territorial waters around the island during two consecutive periods. The boat moved on zig-zag tracks dictated by sea and wind conditions, cruising on engine most of the time, at a mean speed of 9 km/h. Sighting rate for *Delphinids* was obtained by processing visual datas obtained at ≤ Beaufort 3 sea conditions, using *Distance 2.2* software. A total of 33 on-effort sightings were made of 11 identified species including the pantropical spotted dolphin *Stenella attenuata* (5), bottlenose dolphin *Tursiops truncatus* (4), dwarf sperm whale *Kogia sima* (3), short-finned pilot whale *Globicephala macrorhynchus* (3), false killer whale *Pseudorca crassidens* (3), humpback whale *Megaptera novaeangliae* (3), Fraser's dolphin *Lagenodelphis hosei* (2), Risso's dolphin *Grampus griseus* (2), Sperm whale *Physeter macrocephalus* (2), and Cuvier's beaked whale *Ziphius cavirostris* (1). Four other taxa were identified as probable or possible : the Atlantic spotted dolphin *Stenella frontalis* (1), short-beaked spinner dolphin *Stenella clymene* (3), pygmy killer whale *Feresa attenuata* (1) and one *Mesoplodon sp.* (1). *S. attenuata* represented 14.3 % of the observed individuals while *T.truncatus* and *P.crassidens* represented 11.4 %. A sighting rate of $0.57.10^{-2}$ school/km (CV=36.2%) was estimated for the first period of the survey and $0.51.10^{-2}$ obs/km (CV= 40.4%) for the second. The sighting rate for individuals estimated for the delphinids was lower during the first period, 0.155 ind/km (CV=43.0%), than for the second, 0.381 ind/km (CV=56.4), during which the entrance of a different water mass was observed. This relative abundance index could be compared to those in the Greater Antilles, or Marquesas and Society Islands in the eastern tropical pacific.

Key words: boat survey, delphinids, humpback whale, sperm whale, Martinique Island, Caribbean.

Introduction

Martinique island lies between the Caribbean Sea and the western tropical Atlantic Ocean at a latitude of 14°30'N and a longitude of 61°W, between Dominica and Saint-Lucia islands (Fig.1). Its oceanography is characterized by oligo to mesotrophic waters, contrasting with more oligotrophic waters found further north (Muller-Karger et al., 1989; Bhattathiri et al., 1991; Sathyendranath et al.,1995; Agard & Gobin, 2000). The Caribbean Sea shelters over thirty cetaceans species that are subtropical, tropical or widely distributed in the Atlantic Ocean (Debrot et al., 1998; Mignucci-Giannoni, 1998). The local occurrence and distribution of cetaceans are poorly documented, except for the humpback whale (*Megaptera novaeangliae*) (Swartz et al., 2003), and to some extent, the sperm whale *Physeter macrocephalus* (Watkins et Moore, 1982; Watkins et al. 1985). By contrast, abundance surveys were conducted in the Gulf of Mexico and revealed a highly diversified cetacean community development, both in continental shelf and oceanic waters (Mullin & Hoggard, 2000). In the Lesser Antilles, sighting data indicated that 25 species can occur (Ward & Moscrop, 1999): the sei whale (*Balaenoptera borealis*), the minke whale (*Balaenoptera acutorostrata*), the Bryde's whale (*Balaenoptera edeni*), the humpback whale (*M. novaeangliae*), the sperm whale (P. *macrocephalus*), the pygmy sperm whale (*Kogia breviceps*), and for delphinids, the killer whale (*Orcinus orca*), the false killer whale (*P. crassidens*), the short-finned pilot whale (*G. macrorhynchus*), the melon-headed whale (*Peponocephala electra),* the rough-toothed dolphin (*Steno bredanensis*), the Fraser's dolphin (*Lagenodelphis hosei*), the bottlenose dolphin (*Tursiops truncatus*), the Atlantic spotted dolphin (*Stenella frontalis*), the pantropical spotted dolphin (*S. attenuata*), the spinner dolphin (*S. longirostris*), the Clymene's dolphin (*S. clymene*) and the Risso's dolphin (*Grampus griseus*). Complementary stranding data (Van Bree, 1975) indicated the occurrence of the dwarf sperm whale (*Kogia sima*), the striped dolphin (*S. coeruleoalba*), the Cuvier's beaked whale (*Ziphius cavirostris*) and the pygmy killer whale (*Feresa attenuata*). The Lesser Antilles area is also suspected to shelter other species such as the Gervais' beaked whale (*Mesoplodon europaeus*), the Blainville's beaked whale (*M. densirostris*) and the fin whale (*B. physalus*) (Ward & Moscrop, 1999).

We carried out a twenty-two days boat survey from 14 march to 4 april 2003, first to evaluate the nature of cetacean populations off La Martinique, and second to evaluate the local occurrence of migrating species well represented in Caribbean waters, such as the sperm and humpback whales.

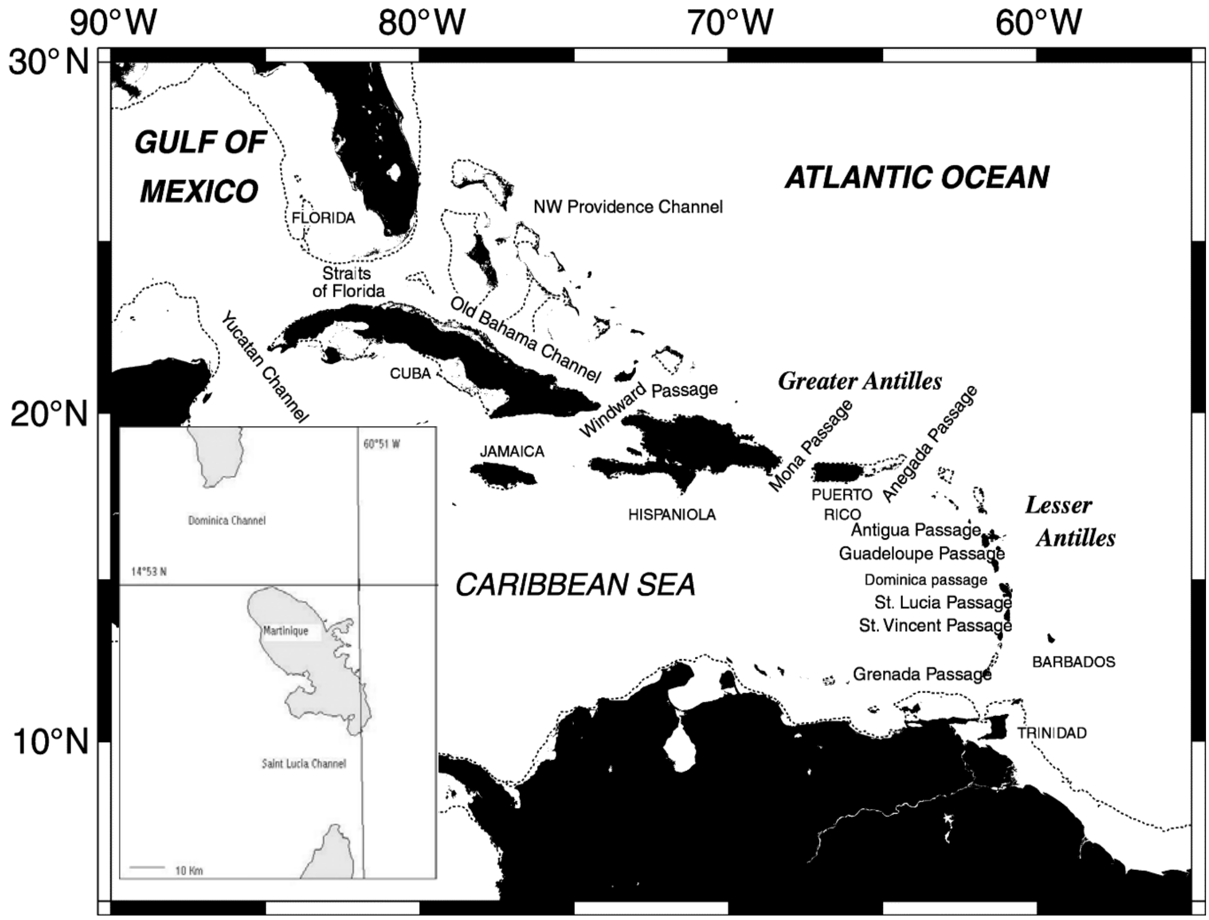

Figure 1. Location of Martinique Island in the Caribbean Archipelago (channels between islands are mentionned).

Materials and Methods

Study area

Our study area extends within 30 km from Martinique coastline. The island of volcanic origin lies in the middle of Lesser Antilles, and emerges from a 2500 m deep abyssal plain as a ridge rising-up to depths arround to 1200 m. It is surrounded by an asymetric shelf wich is short and step on the Caribbean, leeward, side and wider on the Atlantique, windward, side (De Miras, 1989). Depth over 1500 m are generally found within 6-10 km from leeward shoreline in contrast with the windward coast where they occur beyond 15 km. The continental slope varies widely inside territorial waters. Martinique features different coastline type and the leeward coast is indented by two large bays in the middle and south part of the island (Fig.2)

The local hydrobiology includes different phenomena at both large and medium scale: the primary production is variable and can be enhanced by mixing effect including the entrance of Amazon and Orenoco‘s panache waters (Müller-Karger, 1989). This temporal variability is increased by eddies, Caribbean Current and wind-driven mixing events that ensure nutriment supplies for phytoplanktonic biomass (Schiebel et al., 2001; Schmuker et Schiebel, 2002). An ‘island effect’ could also be caused by interactions between the island and currents and provide further enrichment of the water column, on a local scale (Heywood et al., 1990; Ramade, 1994). Upper watermasses (0-300 m) circulation presents seasonal variations where anticyclonic eddies coming from the Guianas’ shelf spreads west-north-west toward the Caribbean sea (Carton and Chao, 1998). The amplitude of eddies decreases with the Caribbean Current flowing out between Trinidad and Cuba (Pauluhn and Chao, 1999). In summary, Martinique island presents an attractive ecosystem to cetaceans species due to its geographical location in the Lesser Antilles, and botyn to hydrological features and seafloor physiography.

Survey platform, material and protocole

A 11 m catamaran sailboat with 80-hp diesel power was used for this survey, making possible an average cruising speed of 9 km/h during sampling. Even when motor-sailing, the particular shape of the front sail left the front sector unobscured. A GPS unit was used for navigation allowing a positionning with a 50-100 m accuracy. A single channel towed hydrophone with 60 m of cable (Magrec Ltd, U.K) was used systematically with a digital recording device (Sony TCD-8 DAT), the whole providing an useful bandwidth of 200 Hz-20 kHz. A standard crew of six people allowed four observer to be on duty. Three observers searched the 180° frontal sector with the naked eye 3.5 m above sea level : one stood in front of the mast, and two sat on the cabin top. One additional scientist performed the acoustic monitoring.

A combined visual and acoustic sampling protocol was performed during this survey: sampling was done either on diesel propulsion (76 % of the time) or motorsailing (24 % of the time). In the first case, a nominal speed of 9 km/h was maintained while in the second, speed ranged from 7.5 to 11 km/h. Sampling was carried out with sea state ≤ Beaufort 4. Whenever cetaceans were sighted, they were approached for species determination and school size estimation. Acoustic monitoring was carried out every 30 min (4.5 km sampling in average) by reducing boat speed to 3-5 km/h, for 1 min. The result of each monitoring session was logged, using a five-level scale for both signal and noise. Whenever good quality cetaceans emissions were heard, a recording was made. The initial sampling phase consisted in random zig-zag patterns within territorial waters, weather permitting, while in a subsequent complementary phase, the zig-zag contraint was relaxed and sampling was organized to optimize available survey time by accounting for local sea state conditions. Data were logged on two paper forms, one for sampling and acoustic parameters and the other for sighting information.

Data processing

Data were entered into a computer database. The geographical software package *Oedipe* (Massé et Cadiou, 1994) was used for mapping and effort calculations as well as for determining distance to shore for every sighting. Digitized isobaths were available for 200, 500, 1000, 1500 and 2000m depths. Sightings were plotted both on nautical chart and computer–based depth data. Two distinct habitat strata were defined for the data processing: the shallow water area (depth <1000 m) and the deep water area (depth >1000 m). Visual data processing was inspired from methods used by Gannier (2000; 2002) for dealing with small boat surveys in tropical archipelagos.

Delphinid diversity was determined with the Shannon-Weaver index (Frontier & Viale, 1995), by using all on-effort sightings:

$$\mathbf{H = - \Sigma\ (N_k/N_t)\ Log_2\ (N_k/N_t)}$$

where, $\mathbf{N_k}$ is the number of observed individuals belonging to species **k** and $\mathbf{N_t}$ is the total number of observed delphinids.

Sighting rates for individuals (SRI) were defined from the formulation of the density estimator in the line transect method (Buckland *et al.,* 1993), by assuming **esw** the effective search half-width to be constant across different strata. SRI was estimated separately for each period of the survey (the sampling phase and the complementary phases):

$$\mathbf{SRI = n \times S/L}$$

where, **n** is the number of on-effort sightings, **S** is the mean school size, **L** is the sampling effort. Because of the scarcity of sightings for most single species, we estimated the sighting rate and SRI for all delphinids species pooled. Sighting rates and SRI were estimated with *Distance 2.2* sofware (Laake *et al.,* 1994). Variance, SE and CV were obtained from empirical estimates of components with the delta-method (Buckland *et al.,* 1993). Confidence intervals were estimated at 95% CL on the basis of a log-normal distribution of SRI.

SRI may provide unbiased indications of the relative abundance in the temporal stratum if the effective search width is assumed to be constant in both periods. For a given survey protocol (i.e., same platform and number of observers), and a given species or group of species, the assumption of constant **esw** holds if sightings conditions are assumed to be constant on average in both strata. Because sighting conditions vary with wind speed, swell height, sun angle and cloud cover. Since wind in excess of Beaufort 4 have adverse effects on the detection of small cetaceans (Hiby & Hammond, 1989; Buckland *et al.,* 1993; Hammond *et al.,* 1995), we only used data obtained with a sea state ≤ Beaufort 3 to estimate sighting rates and SRI. Mixed-species schools were entered as single detections.

Acoustic data were used to estimate an acoustic presence index for humpback whales, sperm whales and delphinids:

$$\mathbf{ARI = [N_{as} / \Sigma\ N_a]_{10nm}}$$

where $\mathbf{N_{as}}$ is the number of positive acoustic sightings for a given or group of species, $\mathbf{N_a}$ the number of acoustic samples. This index was calculated for each sample of 10 nautical miles (18.5km) and then averaged for different strata and periods.

Results

Effort

Sampling effort amounted to 1315 km, from wich 500 km were obtained with Beaufort sea state 4, 450 km with Beaufort 3, and 350 km with Beaufort 0-2. The initial (zig-zag) period took place from 14 to 23 March 2003 where both windward and leeward sides were sampled, and the complementary phase, during which weather conditions only permitted to cover channels and leeward side, from 24 March to 4 April (Fig.2).

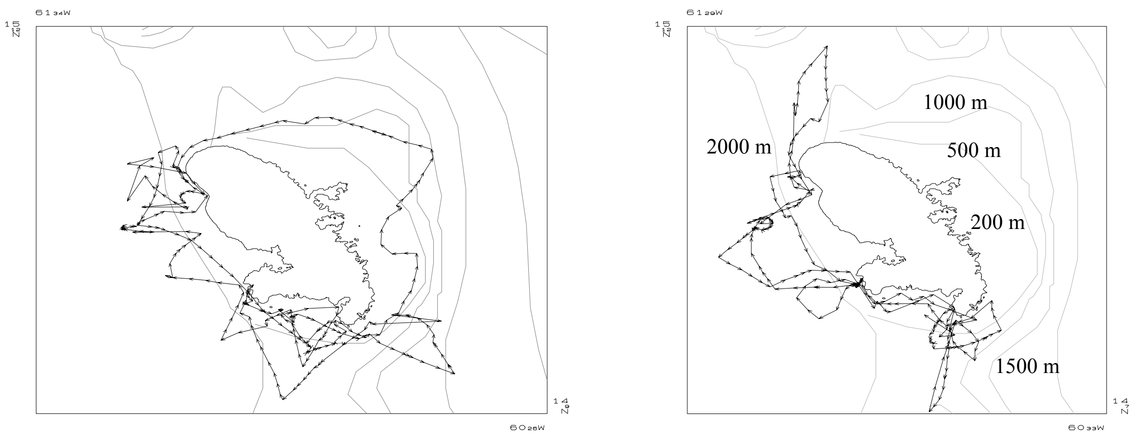

Figure 2. Sampling effort in Martinique : between 14 to 23 March (left) and 24 March to 4 April 2003 (right)

Sightings

A total of 33 on-effort sightings (Table 1) allowed to observe 39 groups of cetaceans, belonging to 11 different species identified with certitude: *Stenella attenuata, S. frontalis, Lagenodelphis hosei, Tursiops truncatus, Grampus griseus, Globicephala macrorhynchus, Pseudorca crassidens, Kogia sima, Ziphius cavirostris, Physeter macrocephalus*, and *Megaptera novaeangliae.* Three others species or genus where identified; we needed further obseervations to confirm their identification (*Stenella clymene, Feresa attenuata and Mesoplodon sp*.).

The pantropical spotted dolphin was the most common species in term of sighting frequency (F=14.3%) with five schools observed and a mean group of 102.8 individuals. This species was sighted mostly in the deep open sea waters strata (4 groups agains 1 in shallow waters) (Fig. 3) with a sighted average depth D=1398m; SD=892). The bottlenose dolphin ranked equally with the false-killer whale (F=11.4%), with a total of 4 schools observed for each. The mean school size was 5.2 individuals for *T.truncatus* and 21.2 individuals for *P.crassidens* (Table 1). The bottlenose dolphin was often seen in the open sea stratum (D=1021.7m; SD=180) as the false-killer whale (D=1072.5m; SD=168.5m). These two species were often observed in mixed school (n=3). Three others species ranked equally in terms of frequency (F=8.6%) with 3 sightings for each*: M. novaeangliae, Kogia* *sima,* and *G. macrorhynchus.* The humpback whale was observed three times, only in the shallow water stratum (D=475.7m; SD=63.3) (Fig.4). The dwarf sperm whale was sighted in school varying between one to three individuals over depth relatively shallow (D =573m; SD=129.3). Short finned pilot whales were sighted with an average size school of 25.3 individuals, in general close to the continental shelf brake (D=1052.7 m; SD=261.7) (Fig.3). The schools observed included a small proportion of young calves. Fraser's dolphin, Risso's dolphin, and sperm whale were both met on two occasions (F=5.7 %). *L. hosei* is a deep waters specie (D=1457m; SD=992) found usually in large schools of 65 individuals in average and was once observed in mixed group with *S. attenuata* and *G. macrorhynchus*.

The sperm whale was found in deep waters (D=1753 m; SD=574.2) in social school of 5.5 individuals in average, including calves, juvenils and one to two adults females (Fig.4). Risso's dolphin was sighted in small schools of 4 individuals over shelf break (D=1384m; SD=212) (Table 1). Cuvier's beaked whale, pygmy killer whale and the *Mesoplodon sp* were met once (F = 2.9%). A single *Z. cavirostris* was sighted in deep waters (D=1400m) while a small group of *Mesoplodon sp.* was sighted close to the shelf break. Mixed groups involving two or three species were found combining *P. crassidens, T. truncatus* and *F. attenuata* (possible) or *P. crassidens, T. truncatus* and *S. clymene* (possible).

Table 1. Sighting summary

Species	Total count *	Group size				Water depth (meters)		
		n	Mean	SE	Range	Mean	SE	Range
S. attenuata	514	5	102.8	89.3	87-130	1397.2	892.5	168-2159
P. crassidens	85	4	21.2	7.5	12-31	1072.5	168.5	822-1175
T. truncatus	21	4	5.2	0.5	3.5-7	1021.7	180	822-1215
M. novaeangliae	3	3	1	-	-	475.7	163.3	373-664
K. simus	4	3	1.3	0.6	1-4	573	129.3	462-542
G. macrorhynchus	76	3	25.3	5	20-30	1051.7	261.7	755-1250
L. hosei	130	2	65	7	50-70	1457	993	755-2159
P. macrocephalus	11	2	5.5	0.7	5-6	1753	574.2	1357-2159
G. griseus	2	2	4	1.4	3-5	1384	212.1	1234-1534
S. frontalis	60	1	60	-	-	642	-	-
Z. cavirostris	1	1	-	-	-	870	-	-
Mesoplodon sp	4	1	-	-	-	736	-	-

* : per number of individuals

For acoustic data, the dominant detection was the humpback whale (Fa=58.8%) with 218 listening stations, *P. macrocephalus* ranking third with 50 detections, mostly on the leeward side, and represented a frequency (Fa = 13.5 %). Delphinids were heard on 158 occasions (Fa = 42.7%) (Fig. 4).

A difference between populations structures was observed between the two survey periods. At the begining, delphinids were frequently sighted (74 %), and dwarf sperm whales (13%), but species like humpback whale (8.7%) and sperm whale (4.3%) where less common. During the second survey period, if delphinids still major species sighted (76.4%) and become more abundant at the end of the survey. Other species as *M.novaeangliae*, *P.macrocephalus*, *Z.cavirostris* and *mesoplodon sp*, occurred in equal proportions (5.9%). A Shannon-Weaver diversity index calculated for the global cetacean population (0.69) and for delphinids (0.62) indicated a relative low diversity.

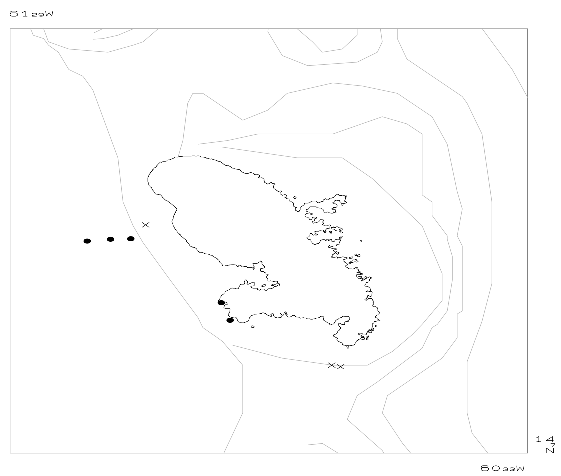

Figure 3. Sightings of Pantropical spotted dolphin (•) and short-finned pilot whale (x).

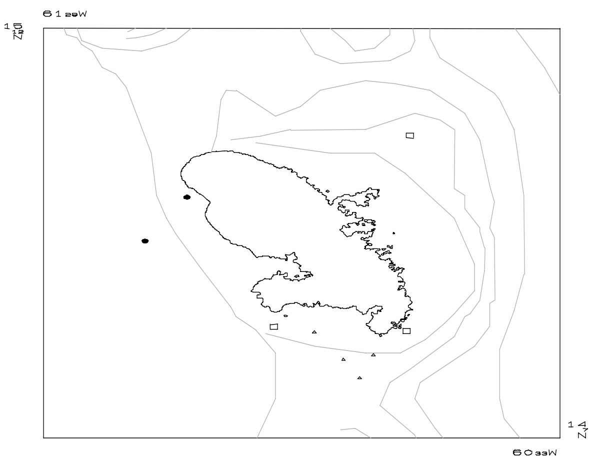

Figure 4. Sightings of false killer whale (Δ), sperm whale (•) and humpback whale (□).

Sighting rate for individuals

With 33 sightings in sea conditions ≤ Beaufort 3, a SRI of 0.155 delphinids/km (CV=43%) was obtained for the first phase of the survey and a SRI of 0.381 ind/km (CV=56.4%) for the second (Table 2). The 1:2.45 ratio between the two periods was due to a strong increase of mean shool size, from 27 to 74 individuals (T-test: T=-3.531, p~0.001), which was caused by a few sightings made during the complementary phase.

Table 2. Sightings frequency, average school size and relative abondance for Delphinids per periods of survey.
SD: standard deviation ; CV%: coefficient of variation; FDv: sightings frequency (sightings/km); S: mean school size (n individuals); SRI: relative abondance index (delphinids/km).

Index estimates	FDv (SD; CV%)	S (SD; CV%)	SRI (SD; CV%)
14 to 23 march	$0.57\ .10^{-2}$ (0.0015; 36.2)	27 (9.14; 33.7)	0.155 (0.668; 43.0)
24 march to 4 april	0.51.10-2 (0.0015; 40.4)	74 (35.55; 47.7)	0.381 (0.215; 56.4)

Acoustic rate index

ARI also showed a variation between the first and the second period of the survey (Table 3). When a Student t-test was performed, the values of ARI in both temporal strata were found to be significantly different ($p=0.04$; $P<0.05$). This difference is linked to the humpback whale acoustic activity which was higher during the initial phase (n=36, ARI=48.1%) compared to the second (n=24, ARI=17.1%). However, the difference in humpback whale acoustic detection rate is not significant (Mood's median test: $\chi^2=4.33$, $p=0.883$; $p>0.05$), and suggest that *M. novaeangliae* is still acoustically active late March off La Martinique.

Index estimates	ARI (SD)	ARI Mn (SD)	ARI D (SD)	ARI Pm (SD)
14 to 23 march	66.1 (29.4)	48.1 (40.0)	27.4 (28)	9.7 (20.0)
24 march to 4 april	43.6 (29.5)	17.1 (30.1)	25.7 (28.3)	6.2 (16.8)

Table 3. Acoustic relative abundance (ARI, %) per period and per species groups.
SD: standard deviation; Mn: *M.novaeangliae*; D: *Delphinids*; Pm: *P.macrocephalus*

Discussion

Delphinids and beaked whales occurrence in the Caribbean

All species observed during our survey were previously reported for the entire Caribbean and particularly in Lesser Antilles (Ward and Moscrop, 1999). Delphinids sightings in the eastern Caribbean included spinner, Risso's, bottlenose, pantropical and Atlantic spotted dolphins, melon-headed, pilot whale, Fraser's and Clymene dolphin, striped and rough-toothed dolphin, pigmy killer whale, killer and false killer whales. The pantropical spotted dolphin is a common species in the southwestern caribbean (Jefferson and Lynn, 1994) and by far the most abundant in the Gulf of Mexico (Mullin and Hoggard, 2000). According to Jefferson and Lynn (1994), Caribbean pantropical spotted dolphins are lighly spotted or sometimes not spotted at all even, if they are more robust and more spotted than animals observed in the Gulf of Mexico.

The Atlantic spotted dolphin seems to be currently observed in US waters of Greater Antilles at water depth deeper than 400 m (Roden and Mullin, 2000). Some time this species occurs near islands where it could be found at depth less than 183 m instead of off-shore (Mugnucci-Giannoni, 1998) as Puerto Rico. The bottlenose dolphin is the most frequently seen odontocete of the northern Caribbean (Erdmann et al., 1973; Mignucci-Giannoni, 1989) sighted primilarly over the shelf-edge and this species inhabit similar waters in the Gulf of Mexico (Hansen et al., 1996; Mullin and Hoggard, 2000). Records of the striped dolphin are not common in the Caribbean (Debrot et al., 1998) and this delphinid occurs in small groups between 1-30 individuals (Jefferson and Lynn, 1994). Roden and Mullin (2000) reported a sighting obtained in 1995 where a group of 140 animals was observed north of Puerto Rico. The short-finned pilot whale has a wide distribution in the Caribbean (e.g., van Bree, 1975; Watkins and Moore, 1982; Mattila and Clapham, 1989). This species were the second most common species sighted by Roden and Mullin (2000) in a wide range of water depths >500m. Tarusky and Winn (1976) stated that the most *G.macrorhynchus* sightings appeared over deep water and often near bank. They also found that this species were not common near islands during winter. Mignucci-Giannoni (1998) stated that they could be found in waters less than 183 m deep. Fraser's dolphin is only known from strandings (Mignucci-Giannoni et al., 1999), as pygmy killer whale (Rodriguez-Lopez and Mignucci-Giannoni, 1999).

Sightings and strandings of beaked whales particularly Cuvier's beaked (*Ziphius cavirostris*) have been reported from many locations in the Caribbean, leading researchers to conclude that this species may be common (Debros and Barros, 1994). In Martinique island, three strandings have been recorded between 1999 and 2003 (pers.comm. F. Martail, 2003).

Humpback whale

Our survey showed that humpback whale are often acoustically detected around La Martinique. Most humpback whales of the western North Atlantic stocks migrate in late autumn from high latitude feeding grounds to the Caribbean to breed and calve. About 7100 whales from the North Atlantic population of 9300-12 100 humpback whales are estimated to inhabit Caribbean breeding areas during winter (Smith et al., 1999). Low numbers found in winter around Cape Verde Islands are supposed to feed in the eastern North Atlantic (Reiner et al., 1996; Hazevoet and Wenzel, 2000). Research on humpback whales wintering in the western North Atlantic is usually focused on the Greater Antilles and the northern portion of Lesser Antilles (Swartz et al., 2003), areas which seems to be the greatest present-day concentration of this species. Well-studied areas include Silver Bank, Navidad Bank and Samana Bay off the northern coast of the Dominican Republic, Mona Passage off western Puerto Rico and Virgin and Anguilla Banks (Winn et al. 1975; Price 1985). However, it is known from research conducted 25 years ago (Winn et al., 1975; Levenson and Leapley, 1978) that *M. novaeangliae* winters from Guadeloupe to Venezuela. More recent reports (Swartz et al., 2001) and opportunistic sightings events (mentionned by fishermen) suggested that present-day abundance of whales is low in southeastern Caribbean. Our results suggested that several whales were located around La Martinique, but this presence need to be quantified more accurately during further research.

Sperm whales

Sperm whale are widely distributed in the tropical and temperate Atlantic ocean as well as in the gulf of Mexico (Jefferson and Lynn, 1994) and the Caribbean islands where they are usually observed in deep water channels and along continental slopes (e.g., Taruski and Winn, 1976; Watkins and Moore, 1982). They appear to be more abundant in the northern Antilles during fall and winter (Erdman et al., 1973; Mignucci-Giannoni, 1998). *P. macrocephalus* is routinely observed during whale-watching operations off Guadeloupe and Dominica islands, the latter being adjacent to our survey area in Martinique. Watkins et al. (2004) performed a number of passive acoustic and suction cup tagging experiments and observed that off leeward Dominica, Sperm whales were observed to feed actively during our survey, from acoustic data. The most interesting result was that nursery groups were observed during our survey in March, when Watkins et al. (2004) did mention mid-sized individuals. From these results, it would be necessary to assess the seasonal status of this species, including the occurrence of both females, calves and mature males during the winter season. Also, our study and previously published work provide evidence that sperm whale schools may use the entire Caribbean islands range as a regular feeding ground.

Comparison with some other tropical archipelagos

In spite of a modest survey effort in Martinique in comparison to results from other tropical islands worldwide, both diversity and individual sighting rate appear to be quite high, with a minimum of 11 different species sighted and delphinid/km. For example, the diversity is higher off Martinique than in two different archipelagos of French Polynesia (Gannier, 2000; 2002), but the relative abundance index seemed to be intermediate between estimates obtained in the Societies and Marquesas archipelagos. A lower diversity was found in the northern Caribbean (Roden and Mullin, 2000; Swartz et al., 2002): perhaps the variable physiography of the volcanic arc in the Lesser Caribbean favors higher abundance and diversity of delphinids (Swartz et al., 2001).

Table 4. Survey results in Caribbean and tropical Pacific region (French Polynesia)

Area	Total effort (km)	Sightings	Species (n)	SRI (Delphinids/km)
Martinique (overall)	1315	33	14	0.268
Greater Antilles (a)	4275	65	9	-
Lesser Antilles (b)	10 900	196	19	-
Greater Antilles (c)	6945	142	11	-
Marquesas (d)	2255	101	10	0.955
Societies (e)	6452	134	12	0.123

References: (a) Roden and Mullin, 2000; (b) Swartz et al., 2001; (c) Swartz et al., 2002; (d) Gannier, 2002; (e) Gannier, 2000.

The Martinique delphinid community also appeared to be linked to local oceanographic features: remote sensed imagery (Muller-Karger and Varela, 1989; Muller-Karger and al., 1995) as well as in situ measurement (Bhattathiri et al., 1991), show a great hydrologic variability in the Caribbean Sea, where surface currents, gyre and eddies located at distinctive areas trigger biological events (Schmuker and Schiebel, 2002). Martinique, among the Lesser Antilles lies at a frontier between oligotrophic waters in the north and mesotrophic waters in the southeastern Caribbean. The circulation of the Caribbean current plus wind driven mixing events produce local enrichment of the upper column (Schiebel et al., 2001). It is also well documented that a combination exists of turbulent mixing and advection of inputs coming from land river rainage (Orenoco and Amazon rivers). Small-scale events could be detectable during our survey through sharp changes in surface water colour, and possibly linked to the sighting of large dolphin schools during the second phase of our study.

Conclusion

Martinique waters shelter an abundant and diverse population of cetaceans. These preliminary results draw a trend of cetaceans occurrence and distribution during early spring in Lesser Antilles, although large Mysticetes and some Odontocetes species where not encountered, possibly due to the short survey period (22 days). Therefore, additionnal surveys are needed to provide an accurate knowledge of each species status promoting long term monitoring for the conservation of Martinique's populations. In the Martinique EEZ, different anthropic activities, running year-long, as vessels traffic and relative oil pollution threat, as noise could cause damage to populations.

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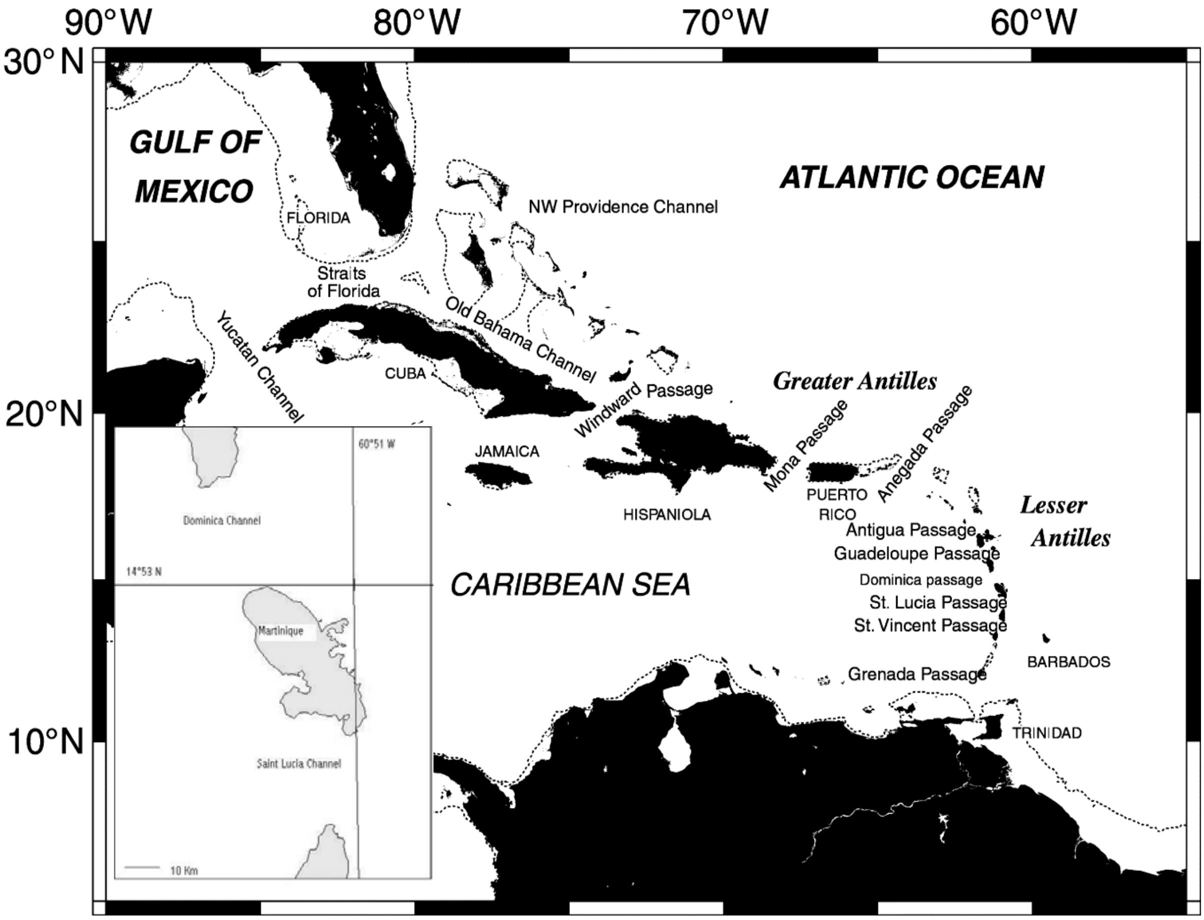

Figure 1. Location of Martinique Island in the Caribbean Archipelago (channels between islands are mentionned).

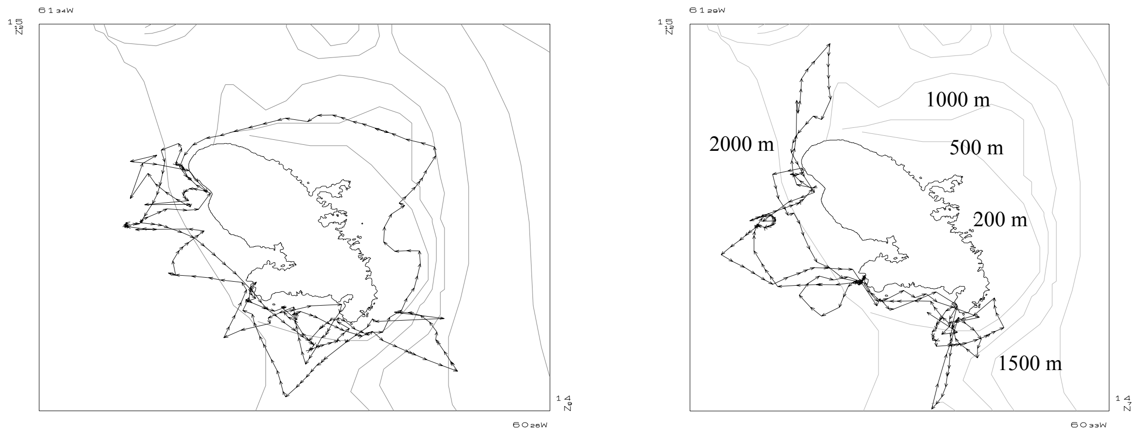

Figure 2. Sampling effort in Martinique : between 14 to 23 March (left) and 24 March to 4 April 2003 (right)

Figure 3. Sightings of Pantropical spotted dolphin (•) and short-finned pilot whale (x).

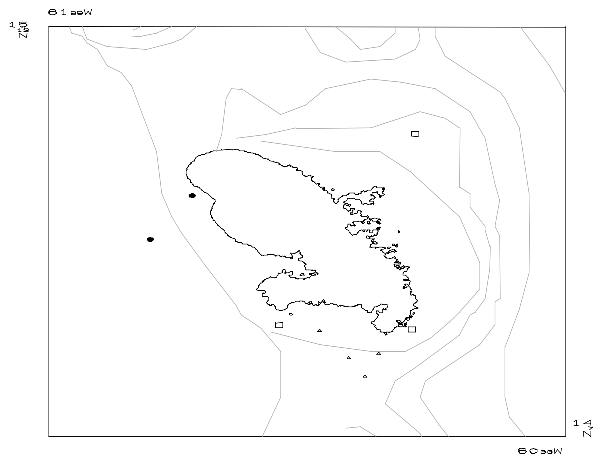

Figure 4. Sightings of false killer whale (Δ), sperm whale (•) and humpback whale (□).

Table 1. Sighting summary

Species	Total count *	Group size				Water depth (meters)		
		n	Mean	SE	Range	Mean	SE	Range
S. attenuata	514	5	102.8	89.3	87-130	1397.2	892.5	168-2159
P. crassidens	85	4	21.2	7.5	12-31	1072.5	168.5	822-1175
T. truncatus	21	4	5.2	0.5	3.5-7	1021.7	180	822-1215
M. novaeangliae	3	3	1	-	-	475.7	163.3	373-664
K. simus	4	3	1.3	0.6	1-4	573	129.3	462-542
G. macrorhynchus	76	3	25.3	5	20-30	1051.7	261.7	755-1250
L. hosei	130	2	65	7	50-70	1457	993	755-2159
P. macrocephalus	11	2	5.5	0.7	5-6	1753	574.2	1357-2159
G. griseus	2	2	4	1.4	3-5	1384	212.1	1234-1534
S. frontalis	60	1	60	-	-	642	-	-
Z. cavirostris	1	1	-	-	-	870	-	-
Mesoplodon sp	4	1	-	-	-	736	-	-

* : per number of individuals

Table 2. Sightings frequency, average school size and relative abondance for Delphinids per periods of survey.
SD: standard deviation ; CV%: coefficient of variation; FDv: sightings frequency (sightings/km); S: mean school size (n individuals); SRI: relative abondance index (delphinids/km).

Index estimates	FDv (SD; CV%)	S (SD; CV%)	SRI (SD; CV%)
14 to 23 march	$0.57 .10^{-2}$ (0.0015; 36.2)	27 (9.14; 33.7)	0.155 (0.668; 43.0)
24 march to 4 april	0.51.10-2 (0.0015; 40.4)	74 (35.55; 47.7)	0.381 (0.215; 56.4)

Table 3. Acoustic relative abundance (ARI, %) per period and per species groups.

Index estimates	ARI (SD)	ARI Mn (SD)	ARI D (SD)	ARI Pm (SD)
14 to 23 march	66.1 (29.4)	48.1 (40.0)	27.4 (28)	9.7 (20.0)
24 march to 4 april	43.6 (29.5)	17.1 (30.1)	25.7 (28.3)	6.2 (16.8)

SD: standard deviation; Mn: *M.novaeangliae*; D: *Delphinids*; Pm: *P.macrocephalus*

Table 4. Survey results in Caribbean and tropical Pacific region (French Polynesia)

Area	Total effort (km)	Sightings	Species (n)	SRI (Delphinids/km)
Martinique (overall)	1315	33	14	0.268
Greater Antilles (a)	4275	65	9	-
Lesser Antilles (b)	10 900	196	19	-
Greater Antilles (c)	6945	142	11	-
Marquesas (d)	2255	101	10	0.955
Societies (e)	6452	134	12	0.123

References: (a) Roden and Mullin, 2000; (b) Swartz et al., 2001; (c) Swartz et al., 2002; (d) Gannier, 2002; (e) Gannier, 2000.