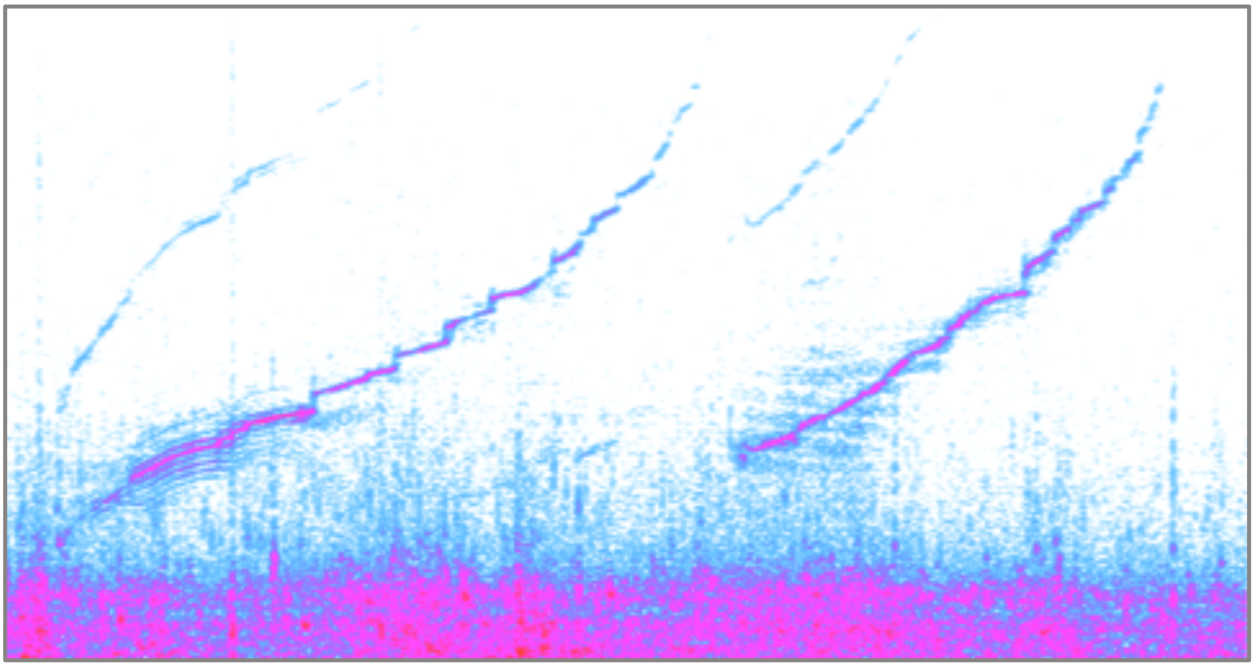
Acoustic characterization of cetacean populations offshore the Guyanese shelf

Mémoire de Master 1 Ecologie et Ethologie



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I- INTRODUCTION

French Guiana has a very important biodiversity both floristically and faunistically (Agence des aires marines protégées, DRE, 2009). Marine area, less studied, extends over an area of *ca*. 126 000 km² from the coast to the abyssal bottoms. Since 2015, several zones have been classified as ZNIEFF sea (Natural Zone of Faunistic and Floristic Interest) of type I and II (Geoguyane, GEPOG, DEAL, 2019). Marine mammals are an integral part of wildlife. For many species, this environment is the primary habitat for a range of key activities including feeding, breeding and calving (Ward *et al.,* 2001).

Studies have been conducted for some years on cetaceans, seabirds and large fish (Carpenter, FAO, Europäische Kommission, 2002 ; van Canneyt *et al*., 2009 ; RPS Energy, 2010 ; Bordin *et al*., 2012 ; Guillon *et al*., 2016). Indeed, these species which dominate the oceanic food chains, are subject to anthropic pressures (harvest, chemical and noise pollutions, climate change, *etc*.) and therefore act as indicators of the ecological state of the environment (Pusineri *et al.,* 2014, Mannocci *et al.,* 2014). Better knowledge of these species is essential to work on preservation of the marine ecosystem and the implementation of conservation actions (OSL, 2019). Oil exploration, which began in French Guiana within the 1960s, was developed from the beginning of the 2000s on the continental slope, with five seismic campaigns and five boreholes done in ten years (UICN, 2017). Several studies have been conducted to inventory the species and assess the sensitivity of these species to oil exploration (OSL,2019).

Research dedicated to cetaceans or dedicated to seismic prospecting on the continental shelf for oil exploitation has highlighted the wealth of French Guiana (Girondot & Ponge, 2006). Visual and acoustic observation campaigns were carried out between 2009 and 2016 during various prospection programs (REMMOA : van Canneyt *et al.,* 2009 ; GEPOG : Bordin *et al.,* 2012; Mannocci *et al.,* 2013) as well as campaigns of seismic explorations (RPS Energy, 2010 ; Schuler *et al*., 2012 ; Créocéan, 2013). These studies (Annex 1) have revealed a relatively large cetacean diversity in French Guiana, with 12 species assumed and 18 species identified. At international level, they are all included in Annex II of the Protocol on Specially Protected Areas and Wildlife (SPAW) of the Cartagena Convention and some species are included in the Appendices of the Bonn Convention (Conservation Convention migratory species belonging to wildlife). Through these conventions and the ministerial decree of 2011 France is committed to ensuring the long-term protection of all marine mammal species. Most of the species are also on the IUCN Red List at mondial and/or local level (Pusineri & Bordin, 2014 ; Créocéan *et al.,* 2018).

Work done further offshore in French Guiana highlights the particular importance of the slope, located between the depths of 100 m and 3000 m, where oil exploration is particularly concentrated. This slope has one of the greatest diversity and density of cetaceans in the entire marine territory of French Guiana

(Hardman, 2010).

From the coast to open sea, the nature of threats changes. Indeed, on the coast and on the continental shelf, it is above all the Guiana dolphins and the Bottlenose dolphins are likely to be affected by pollutions and accidental captures (Agence des aires marines protégées, DRE, 2009). On the continental slope and in the oceanic area, *Ziphiidae* are sensitive to noise pollution such as seismic activities carried out in the context of oil exploration (Créocéan *et al.,* 2018). Large cetaceans (fin whales and sperm whales) are most sensitive to collisions related to maritime traffic (Créocéan *et al*., 2018).

Since 2013, the association OSL *(Ocean Science & Logistics)* studies anthropogenic impacts of these cetacean populations, in 2017 OSL launched the project " Study of cetaceans of French Guiana by sea campaigns " Our project is a part of this large study, *Aquasearch* was in charge of visual and acoustic observations on more than 12 000 km of route off the coast of French Guiana, at the level of slope of the continental shelf. The main goal of this study (OSL, 2018) was to improve knowledge about cetaceans observed at the slope or at the continental shelf of French Guiana through acoustic and visual surveys at sea in order :

- to make recommendations for the conservation of species as part of the development of petroleum activities.
- at the Master's level, take advantage of this inventory to characterize the whistles of different species.

II- MATERIAL AND METHOD

2.1- Study area

The study was done on the whole of the Guyanese EEZ (Annex 2). The entire area is divided into three distinct but contiguous stratas, corresponding to the three main types of marine habitats (Girondot & Ponge, 2006) : the continental shelf, the continental and the ocean zone.

2.2- Data collection

The surveys were conducted from the Maxi Catamaran Guyavoile (59ft catamaran). Two data collection campaigns have been scheduled : One during the rainy season : two 10-day periods, from June 15 to 24, 2018, and from June 27 to July 4, 2018. One during the dry season : two periods of about 10 days, from September 19 to 26, 2018, and from October 02 to 11, 2018.

a) Observation data

Transects were predefined to sample the entire drop for the duration of the day. A traditional line-transect distance sampling protocol was realized. This method has a dual advantage, producing distribution and density data for cetaceans (OSL, 2018). For each group observed, the species, number, age classes, behavior, distance, viewing angle and GPS point are recorded. The presence of vessels, macro-rubbish, schools of fish and large Sargassum rafts were also noticed. In addition, the environmental parameters were noted : the speed and course of the ship, the height and direction of the swell, the speed and direction wind, Beaufort Sea conditions, visibility and cloudiness, glare and general conditions of observation. Visual observations were collected from sunrise to sunset, from about 6:30 to 18:30, by two observers. The rotation of observers took place every 2 hours.

b) Acoustic data

Acoustic recordings were made at various times to increase sampling diversity. Those made during the day lasted about 10 minutes, while the nighttime recordings were continuous throughout the night. Opportunistic records were also made during ideal weather conditions or during observation. For each record, the vessel was stopped and steered to limit its drift speed to no more than 2 knots, to limit unwanted noise that interferes with the acoustic detection of animals. The acoustic equipment consisted of a hydrophone (H2a-XLR, Aquarian Audio Products) connected to a recorder which is itself connected to an audio headset. The hydrophone was immersed at a depth of 10 m, avoiding contact with the hull of the boat to limit the noise. The files were saved in 24 bits in Wav format.

2.3- Whistle analysis

Records were cut in files of 1 minute with Audacity (2.3.1-alpha-Nov 11 2018). Analysis was done manually : the recordings files were analyzed with Audacity and Praat (6.0.43) in a visual and auditory way. The goal was to characterize the different types of whistles and to determine the species. Data analysis focused on day and opportunistic records. With this method different acoustic parameters were measured : time of start and end of the whistle, to provide its duration (ms), initial and end frequencies (Hz), minimum and maximum frequencies (Hz). Also, the shape of the whistle and the number of inflection points were determined (Bazúa-Durán & Au, 2004 ; Oswald *et al*., 2007 ; Díaz López, 2011).

2.4- Whistle description

Whistle characteristics were used to classify whistles within the different categories (Annex 3) "Rise" (whistle with progressively ascending frequencies and no inflection point). In Rise, there are two subtypes : a more concave ascendant (R1) and a more convex one (R2). "Fall" (whistle with gradually decreasing frequencies and without point of inflection). In Fall, there are two subtypes : a more concave descendant (D1) and a more convex one (D2), "Constant" (without point of inflection and having a constant frequency), "Wave" (whistle having two points of inflection and frequencies successively ascending and descending), "U" shaped (whistle with a point of inflection and frequencies gradually descending then ascending), finally "Multiple" (whistle with more than two points of inflection).

2.5- Statistical analysis

Datas were analyzed using Rstudio (version 1.1.4631) software. Mean and standard deviation of each variable was calculated. Normal distribution was verified using a Shapiro-Wilk test on the residuals. Homogeneity of variances were evaluated using a Bartlett test. Data were transformed log(x) to be normally distributed. Variances were homogenous. They were then compared using an ANOVA or a t-test, and a posthoc test (Tuckey).

Maps of the study area and species distribution were made using QGIS (version 2.18.0-Las Palmas) software. Data of the comparison part of *Stenella attenuata* whistles did not follow a normal distribution despite of suppression of the extreme values and transformations of the data. Given the limited data, it was decided to stay on trends and not on significant results. The analysis was therefore done graphically.

III-RESULTS

Almost 2986 km of transect were realized during both campaigns, of which 1740 km were devoted to visual observations and 923 km to acoustic recordings. The day transects allowed the observation of 13 different species (Annex 4), 2 species were observed only during the first season (June) : *Delphinus delphis* (Short-beaked common dolphin) and *Lagenodelphis hosei* (Fraser's dolphin) and 5 only during the second season (September) : *Balaenopteridae sp, Globicephala macrorhynchus* (Short-finned pilot whale), *Grampus griseus* (Risso's dolphin), *Kogia sima* (Dwarf sperm whale) and *Megaptera novaeangliae* (Humpack whale).

Acoustic transects allowed total sample records of 11 416 minutes. The record analysis identified several species (Annex 4) some of which had also been observed : *Tursiops truncatus* (Common bottlenose dolphin), *Stenella attenuata* (Pantropical spotted dolphin), *Sotalia guianensis* (Guiana dolphin), *Globicephala macrorhynchus* (Short-finned pilot whale), *Delphininae sp*. and *Balaenoptera borealis* (Sei whale). For *Tursiops truncatus*, 5 records with a total duration of 300 seconds were analyzed and 88 whistles were detected. Analysis of 6 different records, *i.e*. 360 seconds, detected 83 whistles of *Sotalia guianensis*. For *Stenella attenuate* 59 whistles were analyzed (8 recordings, 480 seconds). Regarding *Globicephala macrorhynchus*, the analysis of 120 seconds (2 recordings) detected 8 whistles. 19 recordings (1140 seconds) detected 55 whistles, often inaudible or isolated from *Delphininae sp*. Finally, vocalizations of *Balaenoptera borealis* were detected on 5 recordings (300 seconds).

Firstly, in order to get a global view of the data, a Principal Component Analysis (PCA) was performed using whistle characteristics for the different species (excluding *Balaenoptera borealis*). This analysis highlights a visual difference in the whistling of species according to their characteristic (Fig.1).

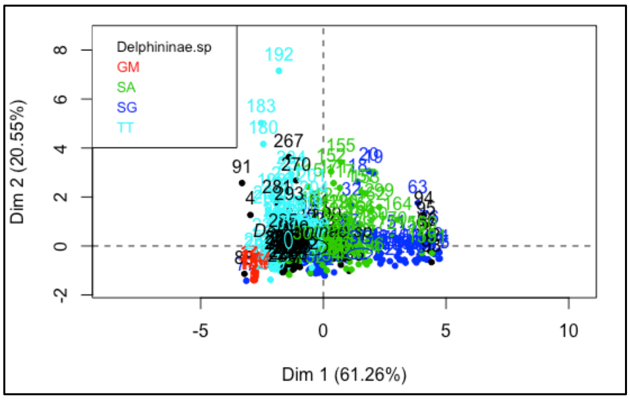
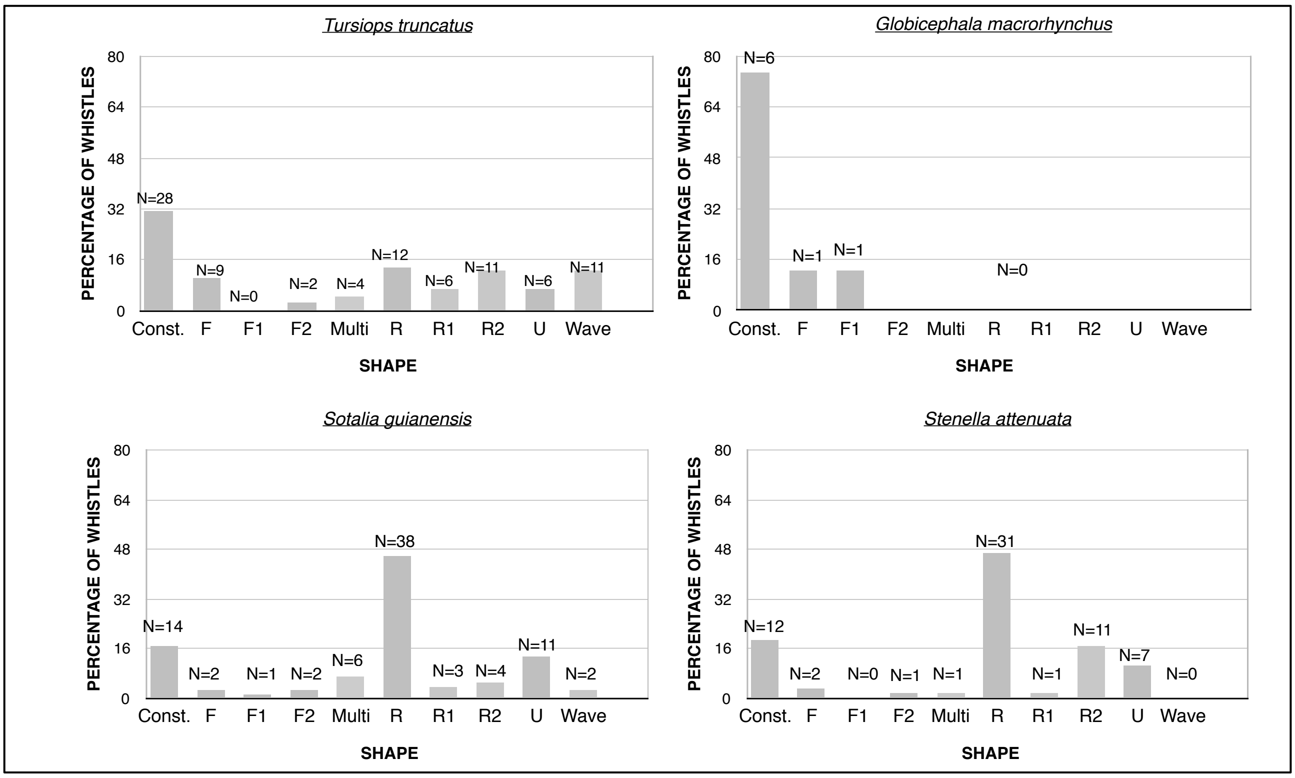


Figure 1 Representation of the factorial plan according to the axis 1 (61.26%) and the axis 2 (20.55%) obtained via an ACP of the species of cetaceans according to the characteristics of their whistles.

3.1- Type of whistles

Histograms for each species were carried out in order to highlight the types of majority and minority whistles by species (Fig.2).

Every whistle types of *Tursiops truncatus* were observed, excepted descending subclass Fall1 (Fig.2A). The most represented whistle was the constant type, representing 31%. Conversely, the whistles least present were the Fall 2 with 2%, the Multi with 4%. The other whistles were *ca*. 6%



(Rise 1 and U) and 12% (Rise, Rise 2 and Wave).

Two types of *Globicephala macrorhynchus* whistles were found. The most present observed whistle was the constant whistle with 75%. The least present being the whistling of type Fall and Fall 1 with 12%, all the other types of whistles being absent (Fig.2B).

A B

For *Stenella attenuata* every type of whistles were observed, excepted descending subclass Fall1 and wave (Fig.2C). The most represented whistle was the rise type, representing 47%. Conversely, the whistles least present were the rise1, the multi and the fall 2, with 1,5 %, the Fall with 3%. The other whistles were *ca*. 10% U, 16% Rise 2 and 18% Constant.

Every type of *Sotalia guianensis* whistles were observed. The most represented whistle was the rise type, representing C %. Conversely, the whistles least presen D ere the fall 1 (1.20 %), the wave, the fall and the fall 2 with 2.41 %. The other whistles were *ca*. 3.6 % (Rise 1), 4.8 % (Rise2), 7.3% (Multi), 13.25 % (U), 16.8 % (Constant ; Fig.2D).

3.2- Mean values of different whistle parameters

Mean values for each species were calculated, in order to highlight differences in frequency, duration or inflection point by species (Tab.1)

Figure 2 Type of Whistles for each species in percentage. The whistle percentage on the y-axis(y) and the whistle types on the abscissa (x). A : Tursiops truncates, B : Globicephala macrorhynchus, C : Stenella attenuate D; Sotalia guianenis, E : Delphininae sp. .

Parameters	*Tursiops truncatus*	*Globicephala macrorhynchus*	*Stenella attenuata*	*Sotalia guianensis*
Duration (ms)	321.4 ± 202	85.75± 52	291.92 ± 241	107.2± 92
Inflection point	0.516 ± 1.1	0	0.1818 ± 0.5	0.3976± 0.8
Min frequency (Hz)	5673 ± 1345	2790± 252	9795± 3085	12242± 4663
Max frequency (Hz)	7352 ± 1948	2959 ±108	13552± 4472	14018 ±4590
Mean frequency (Hz)	6512,5 ± 1646	2874 ± 180	11673.5± 3778	13130 ± 9254
Frequency range(Hz)	1679 ± 603	169± 144	3757 ± 1386	1770± 73

Table 1 Mean of different whistle parameters.

The mean duration of whistles was between 321 ± 202 ms (the longest : *Tursiops truncatus*) and 85.75 ± 52 (the shortest *Globicephala macrorhynchus*). The standard deviation showing the large distribution of the values. Whistles of *Tursiops truncatus* had the highest inflection point (0.5) followed by *Sotalia guianensis* and ranged from 0 to 6. Conversely, whistles of *Globicephla macrorhynchus* did not have inflection point.

The lowest mean frequencies were from *Globicephala macrorhynchus* (2874 Hz) and *Tursiops truncatus* (6512.5 Hz). The highest average frequencies were from *Stenella attenuata* (11673.5 Hz) and *Sotalia guianensis* (13130 Hz). The mean difference between the maximum and the minimum frequency (Frequency range) was bigger for *Stenella attenuata* than the other species with a whistle frequency between 9795 Hz and 13552 Hz (Freq. Range : 3757 Hz). For the other species the difference was smaller (Freq Range for *Tursiops truncatus* : 1679 Hz and 1770 Hz for *Sotalia guianensis*). The species with the lowest frequency range is *Golobicephala macrorhynchus* : 169 Hz.

3.3- Difference in whistle duration depending on the species

Boxplot for each species were carried out in order to highlight a difference in whistle duration or in variation frequency depending on the species (Fig.3).

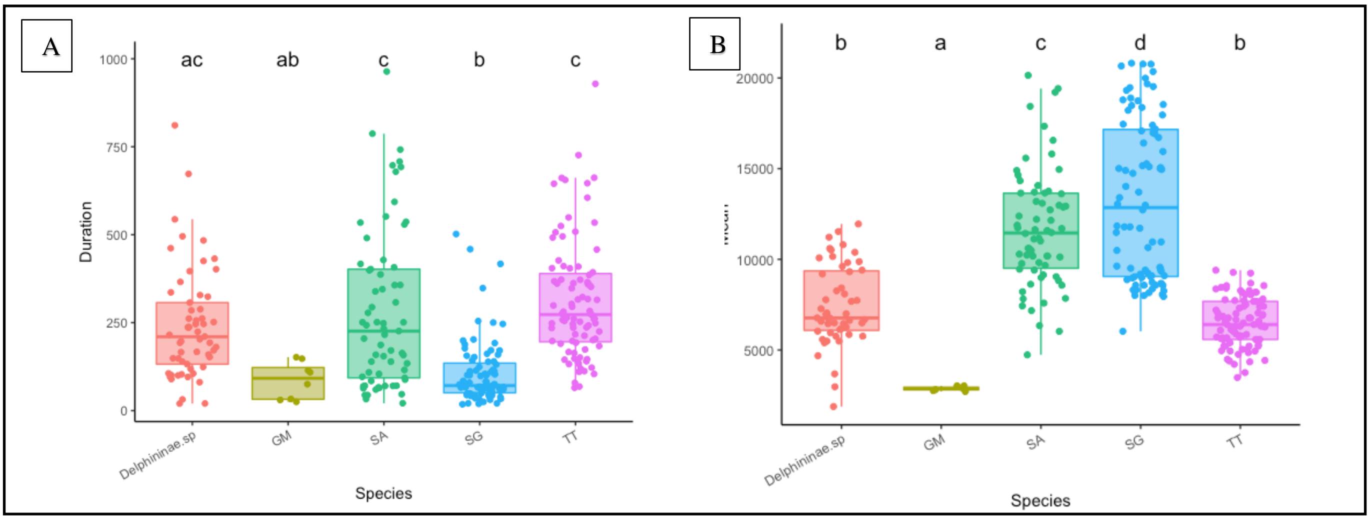


Figure 3 Species(x) versus whistling duration (y) are represented here as boxplot.

In Fig. 3A, whistles of *Globicephala macrorhynchus* (GM) are shorter than whistles of *Stenella attenuata* (SA ; p = 0.01199) and of *Tursiops truncatus* (TT ; p = 0.00153). Whistles of *Stenella attenuata* (p < 0.001) and *Tursiops truncatus* (p < 0.001) are longer than those of *Sotalia guianensis* (SG). The whistles of *Globicephala macrorhynchus* tend to be shorter than those of *Delphininae sp*. (p = 0.07711). Whistle duration of *Delphininae sp*. are longer than *Sotalia guianensis* (p < 0.001) but tend to be shorter than *Tursiops truncatus* (p = 0.06901).

In Fig. 3B, *Stenella attenuata* had whistles with large frequency variations between 10 000 and 13000 Hz. This species had significantly higher frequency variations than those of *Globicephala macrorhynchus* (p < 0.001), *Tursiops truncatus* (p < 0.001) and *Delphinidae sp* (p < 0.001). But *Sotalia guianenis* with large frequency variations between 10 000 and 17 000 Hz had significantly higher frequency variations than those of all the others species (p < 0.001).

3.3- Influence of the shape of the whistle on the duration

Then, Boxplot for each species were carried out in order to highlight the influence of the shape of the whistle on the duration (Fig. 4).

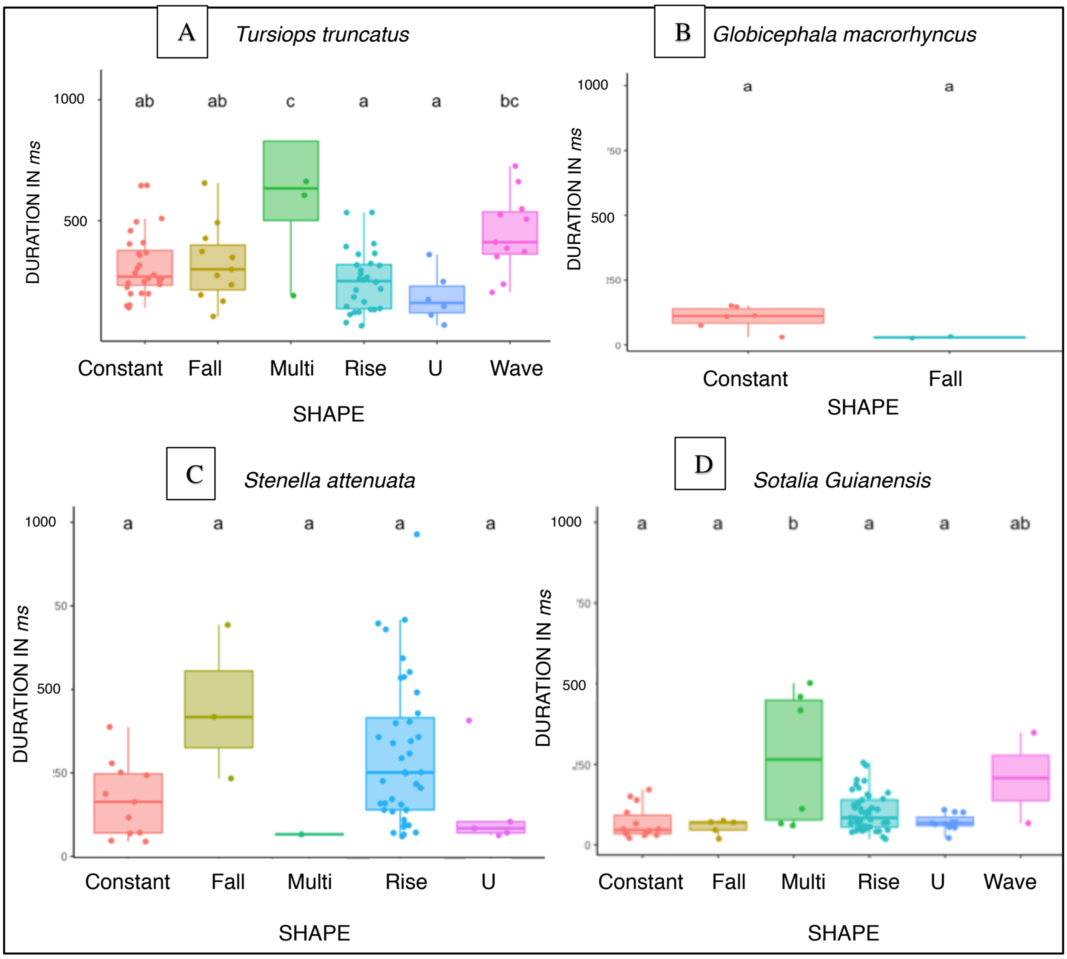


Figure 4 The types of whistling (x) versus time (y) are represented here as boxplot.

The longest whistle of *Tursiops truncatus* (Fig.4A) was 662 ms and it was a Multi, the shortest of 68ms was a U-type. The Multi whistles were longer than Constant, Rise, U ($p < 0.001$) and Fall ($p = 0.00224$). The Wave whistles were longer than Rise ($p=0.0104$) and U (0.0215). All other whistles were not significantly different from each other.

The longest whistle of *Globicephala macrorhynchus* (Fig.4B) was 152 ms and it was a Constant, the shortest of 25ms was Fall. The two whistles did not last significantly different from one another ($p = 0.07$).

For *Stenella attenuata* (Fig.4C), the longest whistle of 964 ms was a Rise, the shortest of 44ms was Constant. The duration of all whistles was not significantly different from each other. The longest whistle of *Sotalia guianenis* (Fig.4D) was a Multi of 502 ms, the shortest of 18ms was Rise. The Multi whistles were longer than Constant, Fall, Rise and U ($p < 0.001$).

Vocalise of the Rorqual Boreal

The Rorqual Boreal or Rudolphi (*Balaenoptera borealis*) was heard on 5 minutes of recordings from the September campaign. Its emission frequency is very low between 480 Hz and 216 Hz at fairly regular intervals of 1.91 seconds. The duration of a vocalize was 0.6 seconds. The vocalizations are all descending (Fig. 5).

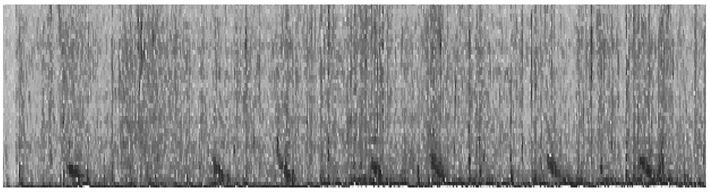


Figure 5 Spectrogram representation of the Balaenoptera borealis vocalizations.

3.4- Location of species according to the observation campaigns

A map, grouping the visual and acoustic observations makes it possible to highlight the zone and the period of presence of the species (Fig. 6).

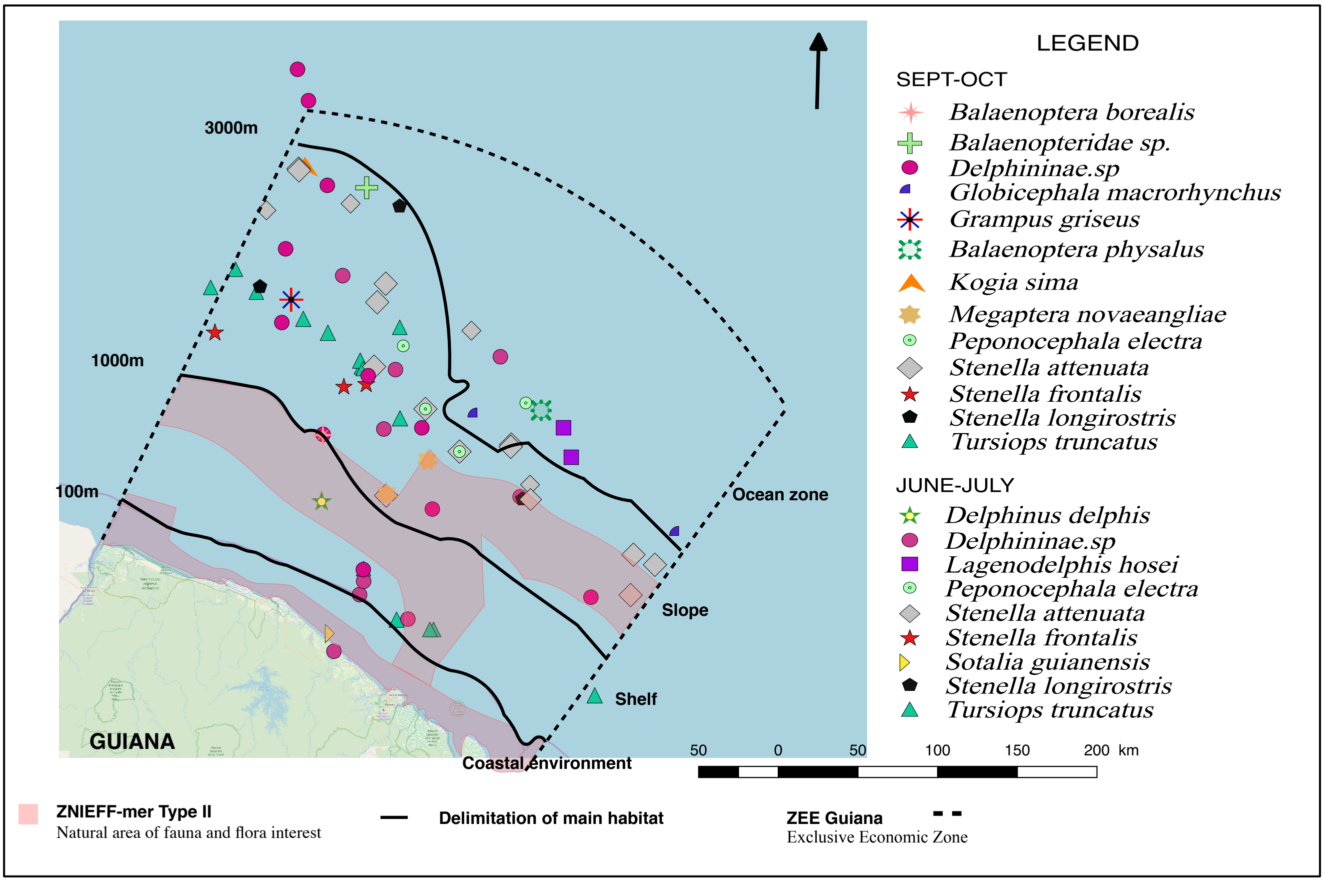


Figure 6 Location of the species present on the campaign of June and September.

In total, 9 species have been observed in June and July (Fig. 6). The most common species is *Tursiops truncatus*, followed by *Stenella attenuata*, and *delphininae sp*. *Sotalia guianensis* is present in the Coastal environment. *Delphinidae sp.*, were present within the four zones. *Delphinus delphis* has been observed only in the Shelf area. *Tursiops truncatus* has been observed in two areas : Shelf and Slope.

Stenella attenuata at the level of Slope and Ocean area. *Stenella frontalis, Peponocephala electra* and *Stenella longirostris* were present in the Slope zone. Finally, *Lagenodelphis hosei* was observed in Ocean zone.

During September mission, 5 species were observed already present in June : *Stenella attenuata, Tursiops truncatus, Stenella frontalis*, *Stenella longirostris* and *Peponocephala electra* (Fig. 6). In addition, these species were seen within the same area as the last campaign, the Slope area. It is also in this area that we find the majority of other species. *Stenella attenuata* is the most present, followed by *Tursiops truncatus* and *Delphinidae sp*. Large cetaceans were observed at the oceanic level (Minke whale : *Balaenoptera acutorostrata*) and Slope (*Megaptera novaeangliae, Balaeopteridae sp*., and *Balaenopteris borealis, Kogia sima*). *Globicephala macrorhynchus* has been observed on this campaign in the ocean zone.

3.5- Influence of the environment on the whistle of *Stenella attenuata*

A map of the studies area presents three analyzed acoustic points of *Stenella attenuata* (Annex 5). The objective was to notice if there were differences of whistle characteristics depending on the zones.

Firstly, a Principal Component Analysis (PCA) was performed using characteristics of the whistles. This analysis highlights a visual difference between the 3 zones but especially between zone 1 and 2

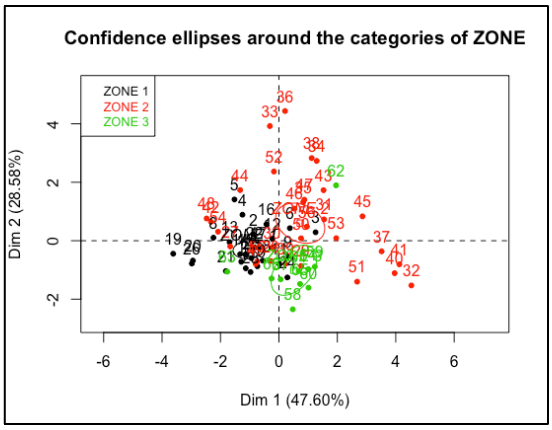


Figure 7 Representation of the factorial plan according to the axis 1 (61.26%) and the axis 2 (20.55%) obtained via an PCA of the species Stenella attenuata in three zones according to the characteristics of their whistles.

(Fig. 7).

In zone 1, only 4 types of whistles were not observed at all: Fall1, Fall2, Multi and Wave (Fig.8). The most observed whistles were Constant with 42.3%, followed by Rise2 (19.2%) and Rise (15.3%). The other whistles were *ca*. 11.5 % (U), 7.6 % (Fall), 3,8% (Rise 1). In zone 2, only 3 types of whistles were observed : Rise with 86.6%, Rise 2 with 10% and Fall2 (3.3%). The other whistles were absent. In zone 3, the largest whistles sound were U with 40% followed by Rise 2 with 30%. The whistles least present were Rise, Constant and Multi with 10%. The other whistles were absent.

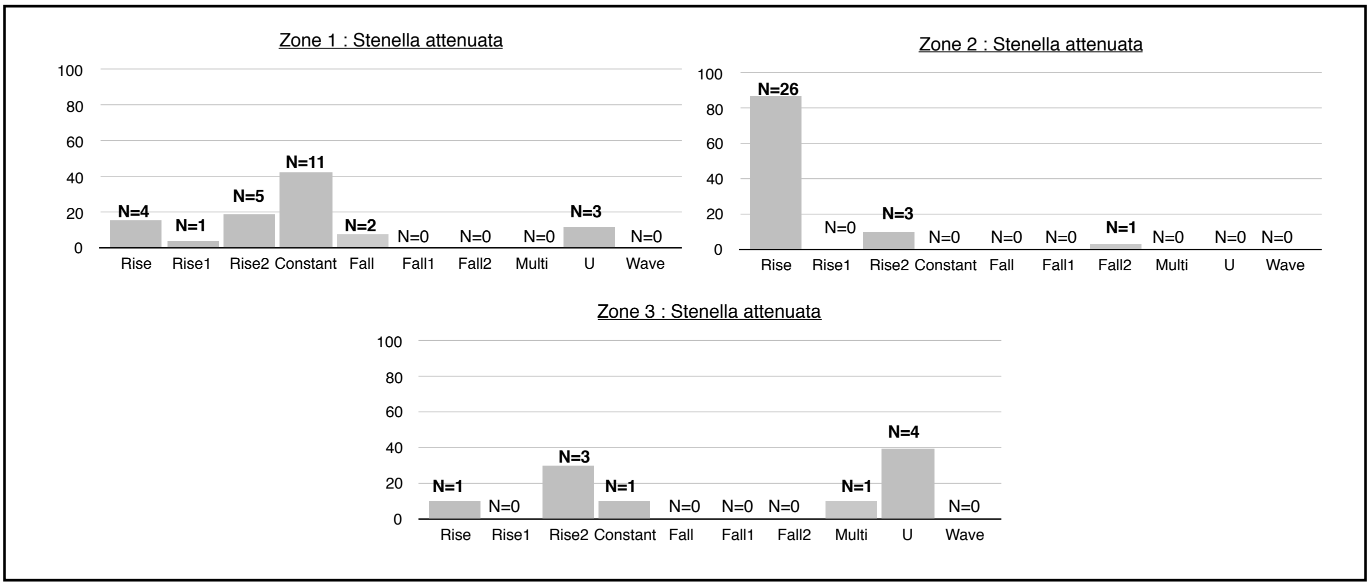


Figure 8 Type of Whistles for each zone in %. The whistle percentage on the y-axis(y) and the whistle types on the abscissa (x).

The duration of whistles tends to be longer in zone 1 and 2 than in zone 3 (Annex 6). The average duration of whistles in zone 2 is 0.37 seconds, those of zone 1 is 0.28 seconds while it is 0.11 in zone 3. The variation tends to be larger (between 933 Hz and 16087 Hz) for zone 2 than for the other zones. Zone 1 varying from 0 to 4357 Hz and zone 3 from 0 to 2920 Hz.

IV- DISCUSSION

In the present study, the most commonly encountered species in the coastal zone is the Guiana dolphin (*Sotalia guianensis*). This had also been observed within previous studies (Ward *et al*., 2001 ; Bouillet *et al*., 2002 ; Ponge & Girondot, 2006 ; van Canneyt *et al*. 2009 ; Bordin *et al.,* 2012). In our study, *Sotalia guianensis* was observed mainly in June, this may be due to low turbidity at that time, or as described by van Canneyt et *al*., (2009) and Bordin *et al.,(*2014), because Guiana dolphins are present all year on the coast, more or less close to the estuaries.

On the rest of the EEZ, studies *via* aerial observations have highlighted a procession of species largely dominated by the bottlenose dolphin (*Tursiops truncatus :* van Canneyt et *al*., 2009 ; Mannocci et *al*., 2013). In the present study, the most observed species changes according to the campaign. Indeed, during June campaign, *Tursiops truncatus* was the dominant species with six contact points (visual and acoustic) followed by *Stenella attenatua* (4 contact points). During the September campaign, it was the opposite, *Stenella attenuata* was dominant with eleven contact points against six contact points were noticed for *Tursiops truncatus*. In the two previously quoted studies, *Tursiops truncatus* was the most common species, but both were conducted in September. Only one other study with a similar methodology observed *Tursiops truncatus* and *Stenella attenuata* at least in May and June (Bordin et *al*., 2012).

Our inventory has highlighted the presence of the melon-head whale (*Peponocephala electra*) on the slope in September and the dwarf sperm whale (*Kogia sima*) between the slope and the ocean area (3000m). The other species observed were Common bottlenose dolphin (*Tursiops truncatus*), Fraser dolphin (*Lagenodelphis hosei),* Risso dolphin (*Gampus griseus*), Spinner dolphin (*Stenella longirostris*), Atlantic spotted dolphin (*Stenella frontalis*) and Pantropical spotted dolphin (*Stenella attenuata*). Similar results are presented in the study by Bordin et al., (2012) to allow that there is fidelity of these species to the slope area.

Large cetaceans were also observed on the slope (100 m to 3000 m depth) and in the oceanic environment (> 3000 m depth) : the Sei whale (*Balaenopteridae borealis*) was acoustically detected at the slope. This record makes it possible to provide additional data for this species, which is still said to be "presumed present" in the area with two recurring strandings (one in Suriname, Deboer,2013 ; one in Brazil, Costal *et al*., 2017). The fin whale (*Balaenoptera physalus*) and an undetermined *Balaenopteridae* were observed near or in the oceanic area. These observations reinforce the previous studies where *Balaenoptera physalus* was observed in the same zone (Ocean zone) and at the same time (September ; Ward *et al*., 2001 ; Carpenter,2002 ; van Canneyt et *al*., 2009). The humpback whale (*Megaptera novaeangliae*) was observed at the slope level. The slope must be an important habitat for this species because identical observations on the same period (September) have already been made (Ward et al.,2001 ; Créocan & Hardman, 2010).

These identifications are interesting because they allow to complete the list of species present at the level of the slope, which is an area very little studied because of its distance from the coast. All these studies quote above highlight the particular importance of the slope where densities are much higher : 149 ind./100km against 13 on the shelf and 38 in the ocean area (Bordin et *al*., 2012).

The acoustic approach has the advantage of being non-intrusive and operating independently of weather and lighting conditions (Samaran, 2008). Through acoustic observations, it is estimated that one to ten times more cetacean groups can be detected than by visual observations (Barlow & Taylor,2005 ; Rankin et *al*., 2007). In this study, more species were visually than acoustically determined, but only daytime acoustic data were analyzed. The result may be reversed after the analysis of all records.

A first analysis highlighted differences in whistle duration depending on the species. A previous study has shown that the acoustic frequency of sound signals emitted by cetaceans is inversely proportional to the length of the animal (Matthews et *al*., 1999). It was confirmed in our study, the largest species *Globicephala macrorhynchus* (5-7 meters Pusineri & Bordin, 2014) also has the lowest average frequency (<5000Hz), followed by *Tursiops truncatus* (3-4 meters Pusineri & Bordin,2014) with an average frequency of about 7000 Hz. Finally, the two smallest species : *Stenella attenuata* (1.6-2.6 meters, Pusineri & Bordin,2014) and *Sotalia guianensis* (2meters ; Pusineri & Bordin, 2014) produce higher frequencies between 10 000 and 17 000 Hz.

For *Tursiops truncatus,* the most observed whistles was Constant followed by Rise. The proportions of whistles types seem to vary from study to another. Indeed, it is the whistles Rise that was most present followed by Multi in the study of Díaz López (2011) in the Mediterranean Sea. While it was the whistles U and Fall most present in the study of Laurent (Personal communication) in Martinique. The least represented type was Fall1 or Multi, whereas in most studies it was the Constant type (Azevedo et *al*., 2007 ; Díaz López, 2011). The average frequency (6512.5 Hz) corresponds to the average frequency found in a similar study (6540 Hz, Akimaya & Mitsuaki, 2006). The average duration (321ms) was twice than the one found in Japan (125 ms, Akimaya & Mitsuaki, 2006) and was also much larger than the one found in Mexico (68ms May-collado, 2008) and Celtic Sea (64 ms, Ansmann, 2007). Regarding inflection points (0.5) a similar average was found in Celtic Sea (0.6, Ansmann, 2007).

In our study, for *Globicephala macrorhynchus*, two types of whistles were identified Constant and Fall. In the study of Laurent (2017), there were 3 types of whistles (Fall, Rise and Constant). Compared to other studies, the average frequency (2874 Hz) is much lower (5290 Hz in the Canary Islands Scheer, 2013 ; 5903 Hz Laurent,2017 in Martinique). The minimum and maximum average frequency (2790-2959 Hz) was also much lower (5430-9600 Hz, Rendell *et al*., 1999) but seems highly variable from one study to another since it varied between 6100 Hz and 9600 Hz (Oswald *et al*., 2003), 1660-8920 Hz (Scheer,2013) and 5447-6367 Hz (Laurent,2017). For the duration (85.75 ms), it was once again much shorter than in the other studies 560 ms (Rendell et al., 1999), 381 ms (Laurent,2017).

Only one previous study of *Stenella attenuata* was found concerning the proportion of each type of whistles (Papantoniou, 2014). In this study the Rise whistle was dominant, as in our study. However, the second majority whistle in the study of Papantoniou (2014) was the U whereas in our study, the U is less present than the constant whistles. The average frequency (11673 Hz) and the averages of the frequencies Min and Max (9795-13552 Hz) were included in the values found in the literature (8200-18700 Hz Oswald et *al*., 2003 ; 9100-2070 Hz Oswald, 2007). Number of inflection points (0.18) was lower than other studies (1.9 Oswald et al., 2003, 2007 and 0.35 Papantoniou, 2014). Regarding the duration it was shorter than in the studies of Oswald et al. (2003 ; 2007) (900 ms) but longer than the Papantoniou (2014) study (171 ms).

The dominant whistle type in *Sotalia guianensis* was the rise type, as in the study by Andrade *et al.* (2014). The minimum and maximum average frequencies (1224-14018 Hz) are slightly lower than those found in other studies 800-30 000 Hz (Lima & Pendu, 2014) and 7770 and 23680 Hz (Andrade et *al.*, 2014). Whistles duration is shorter than in previous studies and the number of inflection points is also lower (Lima & Pendu, 2014 ; Andrade *et al.*, 2014). As for *Tursiops truncatus*, duration varied with the form of whistle.

Duration varied with the form of whistle. The complex whistles (Wave and Multi) appeared significantly longer than the simple ones (Constant, Rise, Fall). As a result, the duration seemed to be related to the modulation of whistling. The same relationship was observed in May-Collado & Wartzok (2008) and Laurent (Personal communication). Our results suggest that whistles parameters examined in French Guiana for these 4 species differs from previous studies in other populations (Wang *et al.,* 1995 ; Oswald *et al.,* 2003, 2007 ; Papantoniou 2014). Several factors may explain differences in whistles characteristics. Each species is affected and evolves differently depending on the environmental influences (habitat, diet, etc.) and social influences (behavior, group formation, etc. : Wang et al., 1995 ; Berta *et al.,* 2006 ; May-Collado *et al.,* 2007). In addition, variations may also occur over time, Morisaka et *al*. (2005) identified differences in whistle parameters according to the years. Differences can also be induced by recording methods and soundtrack analysis (Oswald *et al.,* 2004).

In our study, the vocalizations of the Sei whale (*Balaenoptera borealis*) were averaged between 216 Hz and 480 Hz. The vocal repertoire of this species is still little known (Baumgartner *et al.,* 2008). But according to Samaran (2008), Sei whales emit acoustic signals of low frequencies (20-400 Hz) and short durations (<1.5 s). The duration here being on average of 0.6 seconds. *Balaenoptera* borealis use low frequencies with high intensity to facilitate the propagation of sound (Payne & Webb,1971 ; Cummings *et al*.,1971). In addition, signals are often emitted repeatedly over longer or shorter periods, punctuated by periods of silence, creating patterns of emissions that vary in duration (Watkins *et al.,* 1987 ; Mellinger & Clark, 2003). This vocal activity found in this recording, may suggest that Guyana would be a breeding place or area of movement for a male looking for a female (Tyack, 1999 ; 2000).

Results highlight a link between whistles and area. In general, animals produce signals adapted to their particular environment (Peters *et al.,* 2007). Intraspecific variations have been analyzed in several studies and can be explained by several factors (Rendell *et al.,* 1999 ; Jones & Sayigh 2002 ; Cook *et al*., 2004 ; Papale *et al*., 2013a,b). One of the first factors could be a different use of habitat (Bazua-Duran, 2004). Utilization of the different habitats of the Guianese waters is still under study. But it seems possible that these are important areas of feeding and reproduction, calving and rearing young (Pusineri,2016). The second factor could be the social structure and intraspecific variation in group fluidity (Jones & Sayigh,2002 ; Bazúa-Durán,2004), motivational state (Esch *et al*.,2009), and adaptation to environmental conditions (May-Collado & Wartzok,2008) as well as the possibility of learning, vocal exchange, and mimicry (Sayigh *et al*., 1990 ; Wang *et al*., 1995).

Zone 1 presented mostly Constant and Rise whistles. It has been shown that there is a general relationship between the activity of Bottlenose dolphin groups and their vocalization rate (Dos Santos *et al*., 2005). In a previous study (Papantoniou,2014), Rise was present in all types of behaviors. However, the U type, present in zone 3, was associated with travelling behaviors. The type Rise, Fall and U present randomly in zone 1 and 3 would be related to a behavior of socialization (Papantoniou,2014). Diversity of whistle type would be related to a displacement behavior ; we will find all types of whistles with in majority Constant whistles (as in zone 1) These whistles would be contact cry to maintain cohesion within the group during movement (Janik&Slater,1998). In the case of socialization just 3 types of simple whistling would have been determined (Papantoniou, 2014 ; Rise, Fall and U). In our study, the zone that comes closest to this is zone 3, although the fall type is very weak in all three zones.

According to Papantoniou (2014), duration of whistle sound seems to be depending on the behavior. In her study the short whistles (found in zone 3 in our study) would be related to a traveling behavior. The longer whistles in zone 1 and 2 would suggest hunting or socializing behavior. Azevedo et *al*. (2010) reported similar observation for Atlantic spotted dolphins but conversely, these findings contradict the observations of Petrella et *al*. (2012), who showed that feeding common dolphins *Delphinus sp*. displayed shorter whistle durations than groups engaged in traveling behavior only.

Frequencies variation could also depend on the behavior. In Papantoniou study (2014), high-frequency whistling was linked to hunting behaviors. In our study, we found precisely higher frequencies in zone 2 and lower frequencies related to displacements in zone 3. While hunting behavior, Acevedo-Gutiérrez and Stienessen (2004) reported that dolphins increase their rate of whistles during feeding events to recruit new individuals. A resting group produces fewer sounds compared to a feeding (Acevedo-Gutiérrez & Stienessen, 2004) or socially active group (Quick & Janik,2012).

It would be interesting to go further into this hypothesis of variations, depending on the use of habitat with more data, or with other species in truly distinct areas. This relationship may be difficult to assess with wild animals, which may be in large groups (Oswald et *al*., 2003), which can be divided into subgroups that emit different behaviors and therefore different whistling at the same time.

V-CONCLUSION

Study of marine mammals in their environment can be done through three complementary approaches: visual observations, telemetry and acoustic observations (Samaran, 2008). The oldest and most used approach today still visual observation (Costa,1993). Aerial overflights (REMMOA : van Canneyt et *al*., 2009) and boat surveys (GEPOG : Bordin et *al*., 2012) have shown a high cetacean diversity in the territory with 18 species already identified (Pusineri, 2016). Cetaceans are fairly evenly distributed throughout Guyana's exclusive economic zone (Agence des aires marines protégées,2009).
The study via acoustics has the advantage of being able to sample even if the conditions (visibility, distance of the individuals, night etc.) do not make it possible to do observations. This study initiates the beginning of the analysis of cetacean inventory data from French Guiana carried out in June and September 2018 via visual and acoustic observations. The objective is to better know the species that are present in Guyana, to know if they are resident and if not when and why species are there (breeding, calving, etc.).

As French Guiana is an important area for oil exploration, and the Whale-Whatching is in full expansion, it is essential to have good knowledge about the species, to better preserve through management measures. In this master-thesis, the collected data were used to go further in the qualitative and quantitative analysis of the whistles of 4 *Delphinidae* in order to compare them with other studies in other regions and to analyze the use of the habitat.

To date, 13 species have been determined. Whistles analysis revealed that whistle characteristics differ by species. The acoustic frequency of the sound signals emitted by the cetaceans being inversely proportional to the length of the animal. In addition, it has been shown that the longer the whistling sound, the more complex it may be in its shape and frequency variations.

Lastly, the whistles comparison of *Stenella attenuata* in three zones of the EEZ showed that whisles tend to be different depending on the area, which can be correlated with habitat use via the various behaviors of cetaceans (hunting, socialization, displacement).

Analysis of the nights records data can be used to complete this inventory but also to further or collect more data for research on whistles characterization and habitat use of these species.

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VII-ANNEXES

Annex 1- Previous studies and observed species.

Family	Scientific name	Common name	Presence	World	French Guiana	Area	Bibliographic reference
	Rorqual sp						de Boer, 2013, ; Créocéan, 2013
Balenopteridae	*Balaenoptera acutorostrata*	Petit rorqual	Likely	LC	Ukwn	Ocean Slope Shelf	Ward et al. 2001; Carpenter 2002
Balenopteridae	*Balaenoptera borealis*	Rorqual de Rudolphi	Likely	EN	Ukwn	Suriname	Carpenter 2002, de Boer, 2013
Balenopteridae	*Balaenoptera edeni*	Rorqual Bryde	Attested	DD	DD	Ocean Slope Shelf	Ward et al. 2001 Carpenter 2002, de Boer, 2013
Balenopteridae	*Balaenoptera musculus*	Rorqual bleu	Likely	EN	DD	Ocean Slope	Carpenter 2002
Balenopteridae	*Balaenoptera physalus*	Rorqual commun	Attested	EN	DD	Ocean Slope	Van Canneyt et al. 2009 Ward et al. 2001; Carpenter 2002; RPS Energy, Hardman 2010
Balenopteridae	*Megaptera novaengliae*	Rorqual à bosse	Attested	VU	DD	Ocean Slope	Ward et al. 2001 Carpenter 2002;RPS Energy, Hardman 2010
	Delphinus sp						Van Canneyt et al. 2009, Bordin et al. 2011-2012; de Boer, 2013 ;Créocéan, 2013 ; Guillon et Rinaldi, 2016 ; Guillon et al., MARGATS 2016
Delphinidae	*Delphinus capensis*	Dauphin communn à long bec	Likely	DD	Ukwn	Ocean Slope Shelf	Ward et al. 2001, Bordin et al. 2011-2012
Delphinidae	*Delphinus delphis*	Dauphin commun	Attested	LC	DD	Shelf	Ward et al. 2001 ; Carpenter 2002; de Boer, 2013
Delphinidae	*Feresa attenuata*	Orque pygmée	Likey	DD	Ukwn	Ocean Slope	Van Canneyt et al. 2009 ;Carpenter 2002
Delphinidae	*Globicephala macrorhynchus*	Globicéphale tropical	Attested	DD	DD	Ocean Slope Shelf	Van Canneyt et al. 2009 Carpenter 2002, Bordin et al. 2011-2012;RPS Energy, Hardman 2010; Shell,2012 ; Guillon et Rinaldi, 2016
Delphinidae	*Grampus griseus*	Dauphin de Risso	Attested	LC	DD	Ocean Slope	Van Canneyt et al. 2009 Carpenter 2002, Bordin et al. 2011-2012;RPS Energy, Hardman 2010 ; Shell,2012
Delphinidae	*Lagenodelphis hosei*	Dauphin de Fraser	Likely	DD	Ukwn		Carpenter 2002 ; Shell,2012; de Boer, 2013
Delphinidae	*Orcinus orca*	Orque	Attested	DD	DD	Ocean Slope	Ward et al. 2001, Ponge & Girondot, 2006 Carpenter 2002;RPS Energy, Hardman 2010 ; Créocéan, 2013

Family	*Scientific name*	Common name	Presence	World	French Guiana	Area	Bibliographic reference
	Rorqual sp						de Boer, 2013, ; Créocéan, 2013
Delphinidae	*Peponocephala electra*	Dauphin d'electre	Attested	LC	DD	Slope	Van Canneyt et al. 2009 Carpenter 2002, Bordin et al. 2011-2012;RPS Energy, Hardman 2010; de Boer, 2013
Delphinidae	*Pseudorca crassidens*	Faux orque	Attested	DD	DD	Ocean Slope Shelf Coastal area	Van Canneyt et al. 2009 Ward et al. 2001 Carpenter 2002; RPS Energy, Hardman 2010 ; Shell,2012 ; de Boer, 2013 ; Créocéan, 2013
Delphinidae	*Sotalia guianensis*	Sotalie	Attested	DD	EN	Coastal area	Van Canneyt et al. 2009 Bouillet et al. 2002 Catzeflis, 2008 Ward et al. 2001 ; Créocéan, 2013, Ponge & Girondot, 2006; Carpenter 2002, Hansen & Richard-Hansen 2007, Bordin et al. 2011-2012
	Stenella sp						Van Canneyt et al. 2009, Bordin et al. 2011-2012; RPS Energy, Hardman 2010; Shell,2012;de Boer, 2013
Delphinidae	*Stenella attenuata*	Dauphin tacheté pantropical	Attested	LC	LC	Ocean Slope	Carpenter 2002, Bordin et al. 2011-2012; RPS Energy, Hardman 2010 ; Shell,2012; de Boer, 2013 ; Créocéan, 2013 ; Guillon et Rinaldi, 2016 ; Guillon et al., MARGATS 2016
Delphinidae	*Stenella clymene*	Dauphin de Clymène	Likely	DD	Ukwn	Ocean Slope	Carpenter 2002 ; Shell,2012
Delphinidae	*Stenella coeruleoalba*	Dauphin bleu et blanc	Likely	DD	Ukwn	Ocean	Ward et al. 2001 Carpenter 2002;RPS Energy, Hardman 2010
Delphinidae	*Stenella frontalis*	Dauphin tacheté de l'atlantique	Attested	DD	DD	Slope Shelf	Ponge & Girondot, 2006 Carpenter 2002, Bordin et al. 2011-2012 ; Créocéan, 2013 ; Guillon et al., MARGATS 2016
Delphinidae	*Stenella longirostris*	Dauphin a long bec	Attested	DD	LC	Ocean Slope	Carpenter 2002, Bordin et al. 2011-2012;RPS Energy, Hardman 2010; Shell,2012; de Boer, 2013 ; Créocéan, 2013 ; Guillon et al., MARGATS 2016
Delphinidae	*Steno bradanensis*	Dauphin a bec étroit	Attested	LC	DD	Slope Shelf	Ward et al. 2001 Carpenter 2002 ; Bordin et al. 2011-2012 ; RPS Energy, Hardman 2010; Shell,2012; de Boer, 2013
Delphinidae	*Tursiops truncatus*	Grand dauphin	Attested	LC	LC	Slope Shelf Coastal area	Van Canneyt et al. 2009 Ward et al. 2001 Carpenter 2002, Bordin et al. 2011-2012; Shell,2012 ; Créocéan, 2013
	Mesoplodon sp.						Van Canneyt et al. 2009

Family	*Scientific name*	Common name	Presence	World	French Guiana	Area	Bibliographic reference
Ziphiidae	*Mesoplodon densirostris*	Baleine à bec de Blainville	Likely	DD	Ukwn	Ocean Slope	Carpenter 2002
Ziphiidae	*Mésoplodon europaeus*	Baleine à bec de Gervais	Likely	DD	Ukwn	Ocean Slope	
Ziphiidae	*Ziphiius cavirostris*	Baleine à bec de Cuvier	Attested	LC	DD	Ocean Slope	Van Canneyt et al. 2009 Carpenter 2002 ; RPS Energy, Hardman 2010
Physeteridae	*Physeter macrocephalus*	Cachalot	Attested	VU	VU	Ocean Slope	Van canneyt et al. 2009 Ward et al. 2001 ; Guillon et Rinaldi, 2016 ; Guillon et al., MARGATS 2016, Ponge & Girondot, 2006 Carpenter 2002, Bordin et al. 2011-2012; RPS Energy, Hardman 2010; de Boer, 2013
Kogiidae	*Kogia breviceps*	Cachalot pygmée	Likely	DD	Ukwn	Ocean Slope	Carpenter 2002
Kogiidae	*Kogia simus*	Cachalot nain	Likely	DD	Ukwn	Ocean Slope	Carpenter 2002 ; Guillon et al., MARGATS 2016

UICN Red List French Guiana 2017

DD : Data Defficient

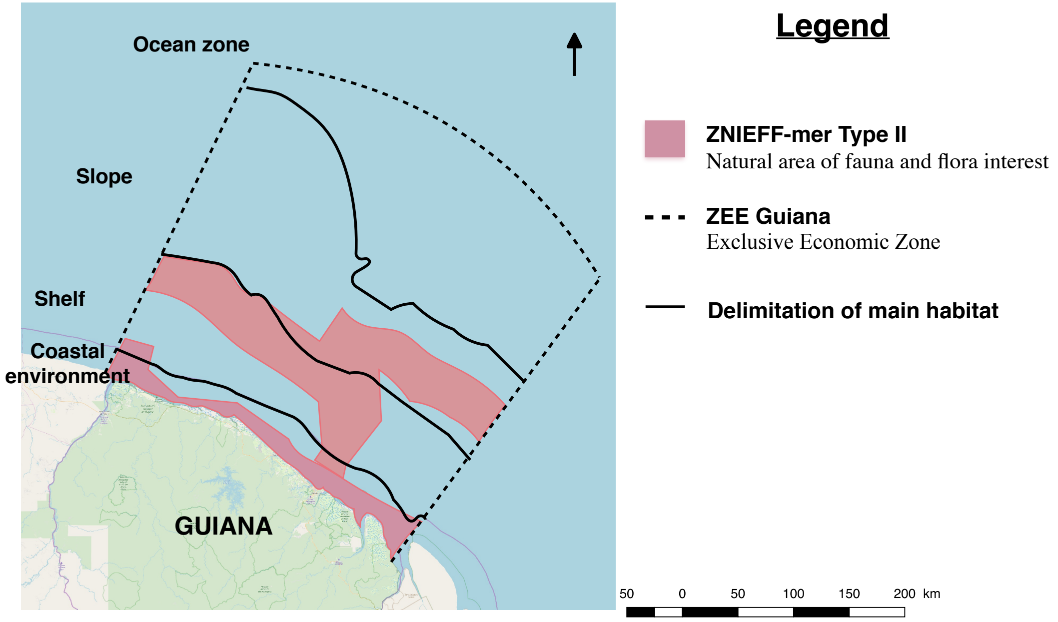
Vu : Vulnerable

LC : Least Concern

EN : Endangered

Ukwn : Unknow, no data found

Annex 2- Study area with protected site (pink) and the delimitation of main

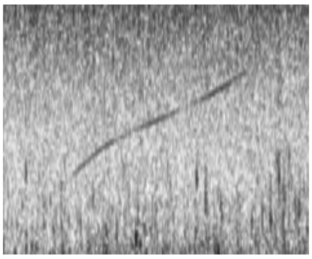
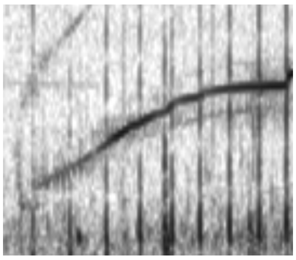
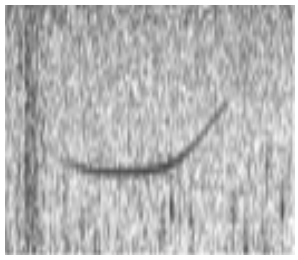
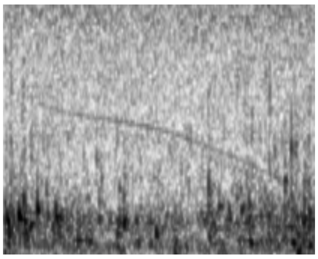
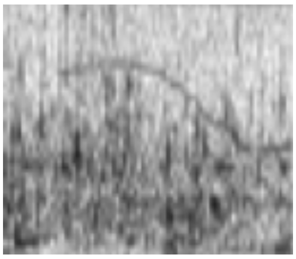
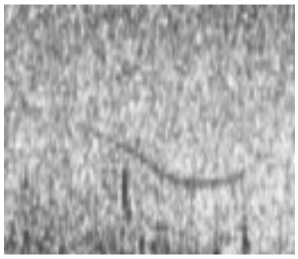
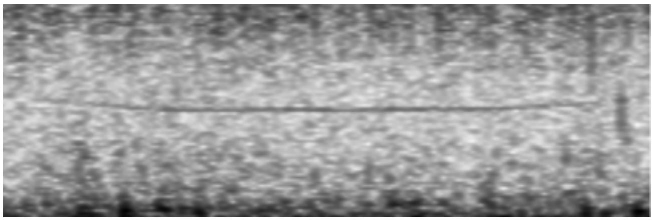
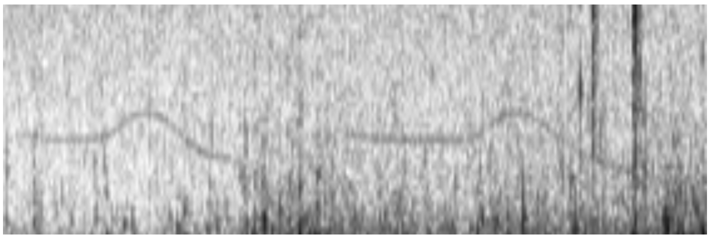
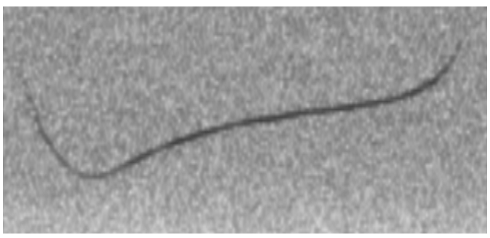
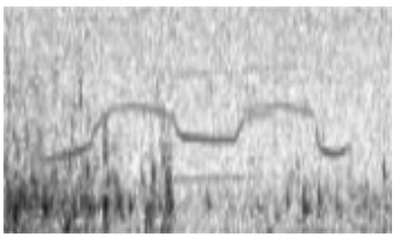


• The continental shelf, including a coastal strip that via the arrival of many riv
rich in alluvium there making turbid all year round.

• The continental slope begins with a steep slope in the eastern half of the EEZ a
the western half. The waters are generally clear, but in the eastern part are somet
turbid water masses, from the plume of the Amazon.

• The ocean zone (abyssal plains), with depths reaching 4500 m.

Annex 3 – Whistles categories.

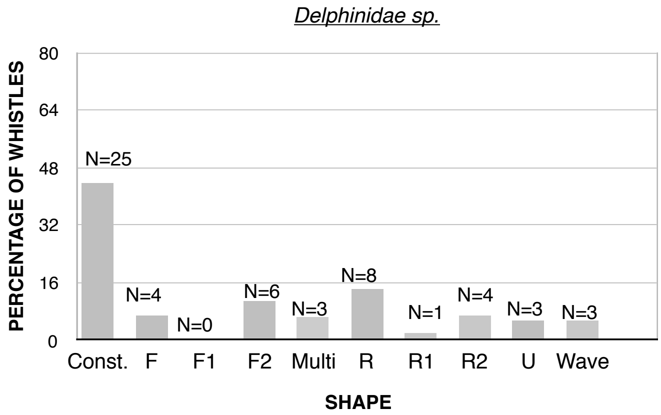
Rise	**R**	**R1**	**R2**
			
Fall	**F**	**F1**	**F2**
			
Constant			
Wave			
U			
Multiple			

Annex 4-Table of visual and acoustic observation on cetaceans during both campaigns.

Species	Number	Behavior	period	Detection
Balaenopteridae sp.	2	Movement	Sept/oct	Visual
Delphinus delphis	15	Movement	June/July	
Grampus griseus	2	Movement	Sept/oct	
Kogia sima	2	Stationary	Sept/oct	
Lagenodelphis hosei	80	Foraging	June/july	
Megaptera novaeangliae	5	Movement	Sept/oct	
Peponocephala electra	350	Foraging & Movement	200 June/July ; 150 Sept/oct	
Stenella longirostris	255	Foraging	200 June/July ; 55 Sept/oct	
Stenella frontalis	135	Attraction	95 June/July ; 40 Sept/oct	
Globicephala macrorhynchus	10	Movement	Sept/oct	Visual Acoustic
Stenella attenuata	442	Foraging & Movement & Attraction	185 June/July ; 257 Sept/oct	
Tursiops truncatus	149	Attraction & Movement	72 June/July ; 77 Sept/oct	
Sotalia guianensis	unknown	unknown	June/July	
Delphininae sp	64	Foraging & Movement & Attraction	4 June/July ; 60 Sept/oct	
Balaenoptera borealis	unknown	unknown	Sept/oct	Acoustic

Annex - Whistles analysis for Delphinidae sp.

Every type of whistles were observed, excepted descending subclass F1. The most represented whistle was the constant type, representing 44 %. Conversely, the whistles least present were the rise 1 with 1.75 %, the wave, the multi and the U with 5%. The other whistles were *ca*. 4 % (Fall and Rise2) and 8 %(Rise), 6 % (Fall2)

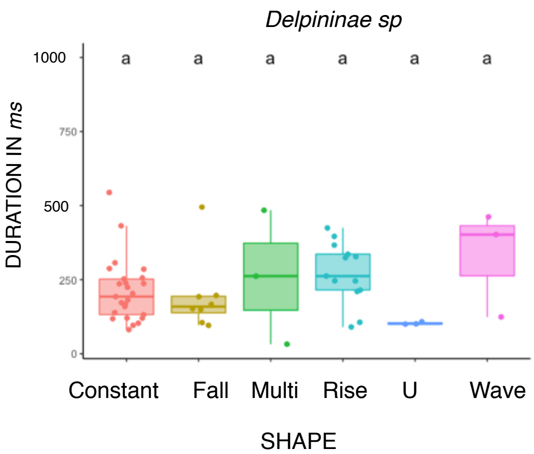


The mean duration of whistles was 241.8 ±157.22 ms, the standard deviation showing the large distribution of the values. The number of inflection point was on average 0.40 and ranged from 0 to 3. The mean maximum frequency was 9152 Hz and the minimum 8350 Hz. The Mean frequency was 8751 ms. The Frequency range was small: 802 Hz (Table 6).

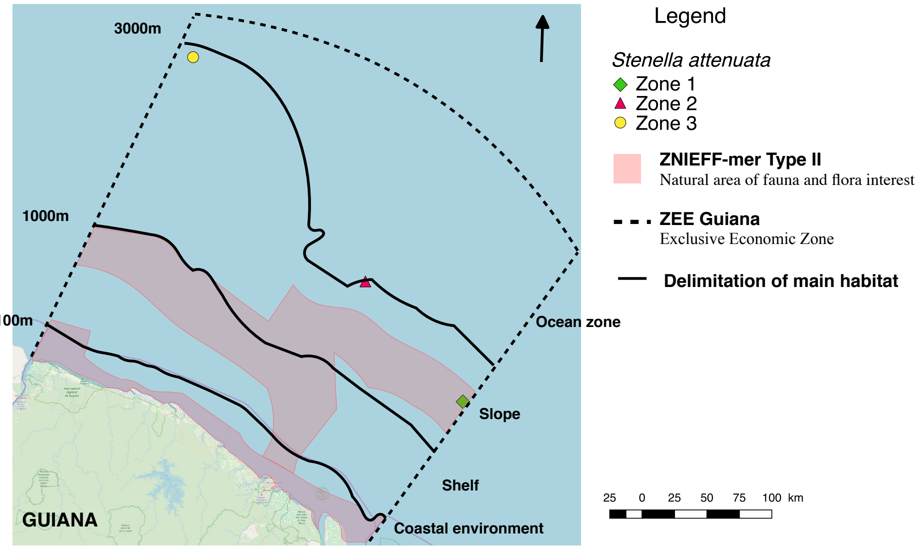
Table 2 Mean values of different whistle parameters for Delphininae sp.

Parameters	Mean value
Duration	241.8 ±157.22
Inflexion point	0.4035± 1.237215
Min frequency	8350 ±4470.581
Max frequency	9152 ±4438.658
Mean frequency	8751 ± 4454.6195
Frequency range	802

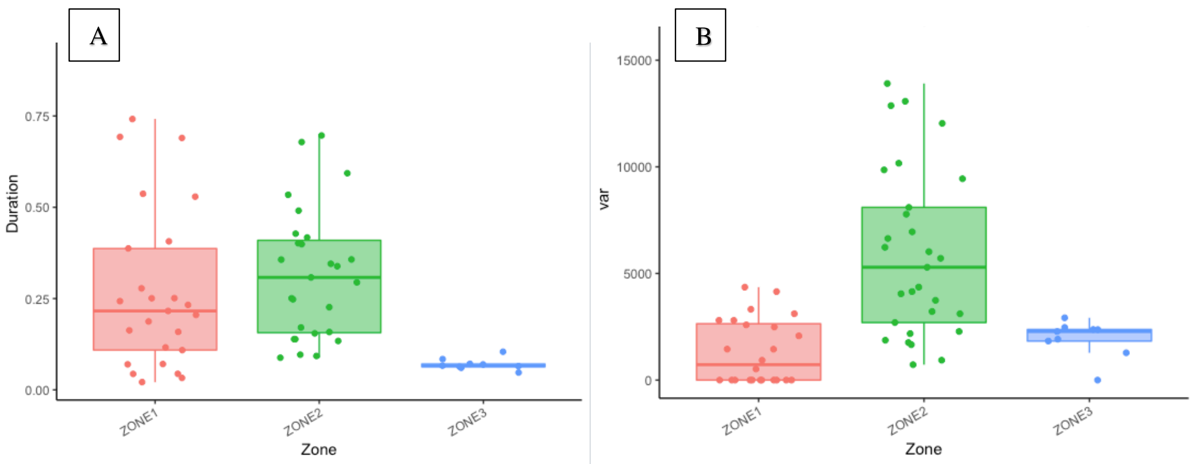
At last, for *Delphininae sp*. the longest whistle of 544 ms was a Constant and the shortest of 32 ms was Multi. The duration of all whistles was not significantly different from each other.



Annex 5 - Location of the three zone of *stenella attenuata* acoustic points.



Annex - The zone (x) versus time (duration) or frequency range (var) (y) are represented here as boxplot.



Annex - Présentation des espèces (Pusineri & Bordin, 2014 ; https://www.cetaces.org/fiches/, Jefferson et al.1993)

Tursiops truncatus, Grand dauphin ou Tursiops, Bottlenose dolphin

Reconnaissance : corps relativement massif, rostre court et large, coloration gris moyen à plus clair sur ventre. Tête pourvue d'un rostre assez court et épais, mais bien distinct du melon
Taille des groupes : quelques individus à quelques dizaines
Taille : 3-4 m environ
Habitat : plateau et talus et parfois milieu océanique
Fréquence des observations : ponctuelle

Globicephala macrorhynchus, Globicéphale tropical, Short-finned pilot whale

Reconnaissance : tête massive carrée dépourvue de rostre avec un melon volumineux en forme de globe, grand corps massif, coloration gris-foncée à noir sur tout le corps à l'exception de zones claires dans la région ventrale, aileron dorsal massif plus long que haut.
Taille des groupes : quelques dizaines d'individus en général
Taille : 5-7 m environ
Habitat : tombant et océanique
Fréquence des observations : ponctuelle

Stenella attenuata, Dauphin tacheté pantropical // Spotted dolphin

Reconnaissance : forme générale fuselée, à trois tons de gris délimités : foncé sur le dos, moyen sur les flancs, ventre crème, peau mouchetée à l'âge adulte, rostre long et fin et blanc au bout, ligne noire courant du rostre aux yeux. Tête pourvue d'un rostre long, assez fort et d'un melon assez effilé.
Taille des groupes : plusieurs dizaines à quelques centaines d'individus

Taille : 1,6 à 2,6 m

Habitat : essentiellement talus mais aussi milieu océanique

Fréquence des observations : fréquente

Sotalia guianensis, dauphin de Guyane, Guiana dolphin

Reconnaissance : corps assez trapu et de taille modeste, coloration bleu-grise sur le dos et rose à gris-claire sur la face ventrale, rostre relativement court et large, dorsale relativement massive et triangulaire.
Taille des groupes : quelques individus
Taille : 1,95 m environ
Habitat : très côtier
Fréquence des observations : fréquente

Résumé / Abstract

Des études précédentes ont mis en avant une large diversité de cétacés en Guyane Française avec 12 espèces dont la présence est probable et 18 espèces dont la présence est certaine. Ces études ont mis en avant la richesse du Talus, qui reste peu documenté. C'est pourquoi deux campagnes d'inventaires ont été réalisés avec *OSL* et *Aquasearch* : du 15 au 24 juin et du 27 au 04 juillet puis du 19 au 26 septembre et enfin du 02 au 11 octobre 2018. Ces campagnes de détections visuelles et acoustiques ont permis de déterminer 13 espèces avec certitude.
Cette étude est la première à présenter une analyse quantitative et qualitative des sifflements de 4 espèces de cétacés de Guyane. Au total ... minutes ont été analysés permettant d'extraire 88 sifflements pour *Tursiops truncatus*, 83 pour *Sotalia guianensis*, 59 pour *Stenella attenuata*, et 8 pour *Globicephala macrorhynchus*. Les résultats montrent des caractéristiques de sifflement diffèrent selon l'espèce, selon la durée (plus la durée est longue, plus les sifflements peuvent être complexes et avec de grandes variations de fréquence). Mais aussi d'après la littérature, selon le comportement, la formation du groupe et l'utilisation de l'habitat.

Previous studies have revealed a relatively large cetacean diversity in French Guiana, with 12 species assumed and 18 species identified with certainty. These studies have highlighted the specific richness of the Talus, for which there is still few data. This is why two inventory campaigns were conducted with OSL and *Aquasearch* : from June 15th to 24th and July 27th to July 4th, then from September 19th to 26th and from October 2nd to October 11th, 2018. These campaigns of visual and acoustic detections identified 13 species with certainty.
This study is the first to present quantitative and qualitative analyses of 4 species whistle characteristics in French Guiana. In total ... minutes were analyzed to extract 88 whistles for *Tursiops truncatus*, 83 for *Sotalia guianensis*, 59 for *Stenella attenuata*, and 8 for *Globicephala macrorhynchus*. The results show that whistles characteristics differ according to the species, and depending on the duration (the longer the duration is, the more the whistle can be complex and with large frequency variations). But also, according to the literature, depending on the behavior, the formation of the group and the use of the habitat.