First insights on the analysis of *Orcinus orca* individual dialects

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1. INTRODUCTION

1.1. Justification and objectives

In the present work bioacoustic aspects in *Orcinus orca* (Linnaeus, 1758), were studied specifically the individual dialects of the specie *O. orca* were considered. This paper intends to find differences in the individuals dialect of the animals in the study group.

1.2. Species

1.2.1. ***Orcinus orca*** (Linnaeus, 1758) (Fig. 1)

Figure 1: Killer Whales. In the top of picture has a female and in the underneath, has a male (modified from Ivaldi, 2012).

Taxonomy

Taxonomical arrangement followed the WoRMS Editorial Board (2016).

KINGDOM Animalia
SUBKINGDOM Bilateralia
INFRAKINGDOM Deuterostomia
PHYLUM Chordata
SUBPHYLUM Vertebrata
INFRAPHYLUM Gnathostomata
SUPERCLASS Tetrapoda
CLASS Mammalia Linnaeus, 1758
SUBCLASS Theria Parker and Haswell, 1897
INFRACLASS Eutheria Gill, 1872
ORDER Cetacea Brisson, 1762
SUBORDER Odontoceti Flower, 1867
FAMILY Delphinidae Gray, 1821
GENUS *Orcinus* Fitzinger, 1860
SPECIES *Orcinus orca* Linnaeus, 1758

Synonyms

The synonyms were arrangement according to ITIS report (2016).

Orca ater, Cope, 1869;
Orca capensis, Gray, 1846;
Delphinus gladiatorm, Bonnaterre, 1789;
Delphinus orca, Linnaeus, 1758;
Orcinus nanus, Mikhalev and Ivashin, 1981;
Orcinus glacialis, Berzin and Vladimirov, 1983

Common names

For this species, according to ITIS report (2016), the common names are Killer Whale and Orca.

Ecotypes or forms

Ten ecotypes of Killer Whales has been described (Fig. 2). They can be distinguished for having differences in: genetics, size, habitat, colour pattern, dorsal fin shape, vocalizations, diet and hunting strategies (Dahlheim et al., 2008; Ford, 2009; Foote et al., 2009). In the Northern Hemisphere are five ecotypes (Dahlheim et al., 2008; Ford, 2009; Foote et al., 2009) and in the Southern Hemisphere are other five ecotypes (Pitman and Ensor, 2003; Pitman et al, 2007; Pitman and Durban, 2010; Pitman and Durban, 2011; Pitman et al, 2011). In the wild exist dramatic differences between the ecotypes, specially in their feeding behaviour and prey specialisation (Pitman and Ensor, 2003; Pitman et al, 2007; Pitman and Durban, 2010; Pitman and Durban, 2011; Pitman et al, 2011).

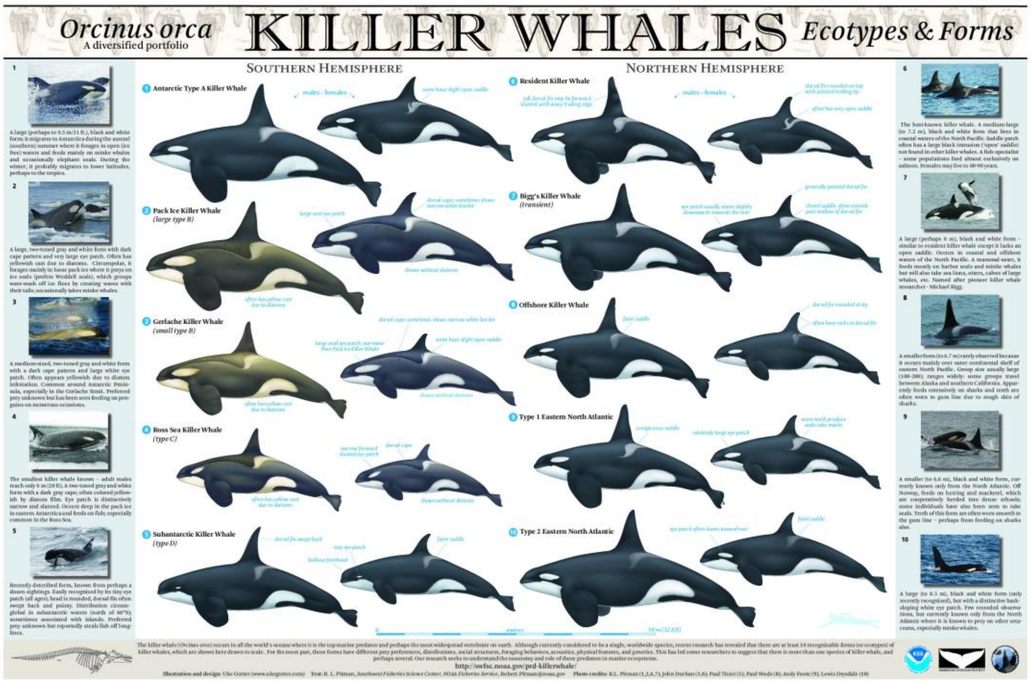


Figure 2: Ecotypes of Killer Whales. For each ecotype male and female are represented. The ecotypes of Northern Hemisphere are on the right column, while the ecotypes of Southern Hemisphere are on the left column (from NOAA, 2010).

Diagnosis

Killer Whales are easily distinguished among other cetaceans for its anatomy and behaviour. The adult size varies depending on the sex. Males from the North-pacific residents can reach a maximum length of 9 meters and a weight of 6,600 kg, while females 7.7 meters and 4,700 kg (Ford, 2009). For this same ecotype, length at birth about 2.4 meters and the weight its approximately 150 kg (Gots and Ronald, 2009).

In adult males, the dorsal fin is tall and triangular (can reach 2 meters of height), while in juveniles and in adult females it is curved backwards and smaller (can average be about 1 meter of height). Their pectoral fins are large and rounded (Gots and Ronald, 2009).

Swimming speed of these animals reaches 55 km/h, this velocity is the maximum that a marine mammal can attain (Gots and Ronald, 2009). Killer Whales have a continually and rapidly capacity to renews its skin, which helps them to improve their swimming efficiently by reducing drag (Heyning and Dahlheim, 1988; Hicks et al., 1985).

Killer Whales have a distinctive colour pattern, these mammals are with white and grey spots (Gots and Ronald, 2009). They have a white patch just above and behind the eyes (called eyepatch), the underside of the tail flukes is white, and the white belly extends forward to the end of the lower jaw (Gots and Ronald, 2009). Behind the dorsal fin there is a grey patch with a “shaddle” shape. The rest of the body is black (Gots and Ronald, 2009).

Diet

Killer Whales are in top-level of food chain (Wiles, 2004), despite enormous differences in diet between ecotypes exists. Different ecotypes specialize in distinct prey and hunting strategies, such as explained previously. In many parts of the world, Killer Whales feed mainly on either fish or marine mammals, but not both (Barrett-Lennard and Heise, 2006).

The teeth of Killer Whales are designed for grasping and tearing prey, not for chewing (Graham and Dow, 1990). These animals have 40-56 teeth (Heyning and Dahlheim, 1999). Calves teeth begin to erupt till 11 weeks of age, when take solid food from their mothers (Haenel, 1986; Asper et al., 1988; Heyning, 1988).

Habitat

The area where is more frequently to observe Killer Whales are the Arctic and the Antarctic oceans and areas of cold-water upwelling (Scheffer and Slipp, 1948; Tomilin, 1957). Despite these animals are found in the open ocean, but they seem to be most abundant in coastal waters (Scheffer and Slipp, 1948; Tomilin, 1957). On the other hand, they are able to enter shallow coastal or inter-tidal flats for hunting different preys (Scheffer and Slipp, 1948; Tomilin, 1957). Some pods have been observed in tropical waters and fresh water rivers, such as: The Rhine, The Thames and The Elbe (Scheffer and Slipp, 1948).

Geographic distribution

Killer Whales are worldwide distribution (Fig. 4), probably it is the most cosmopolitan of all cetaceans (Taylor et al., 2008). It is estimated that exist a minimum worldwide abundance of about 50,000 Killer Whales (Taylor et al., 2008). These animals are situated in all oceans and contiguous seas, from equatorial regions to the polar pack-ice zones, and may even ascend rivers. However, Killer Whales are most abundant in coastal waters and cold regions where productivity is high (Jefferson et al., 1993; Heining and Dahlheim, 1999).

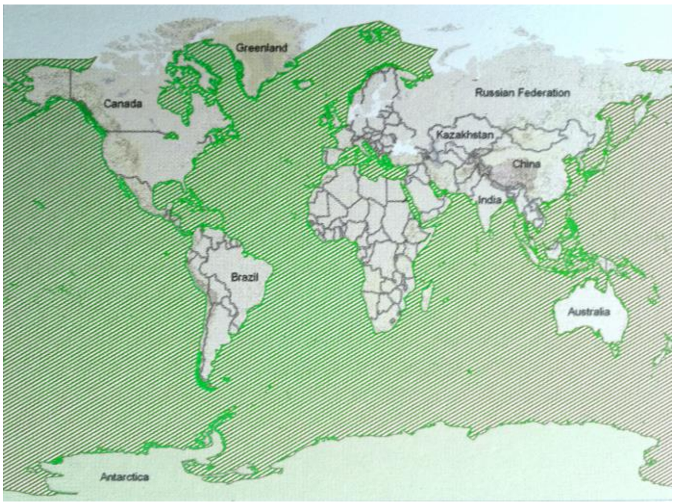


Figure 4: Killer Whales distribution (modified from Taylor et al., 2009).

Reproduction

In Killer Whales it is estimated that the age at first conception is 12.1 for northern and southern resident free-ranging populations and 9.8 for Killer Whales located at SeaWorld (Robeck et al., 2015). The estimated mean age at first observed calf is 14.2 for northern and southern resident free-ranging populations and 11.1 for Killer Whales located at SeaWorld (Robeck et al., 2015). Intervals between calves it is about 5 years (Ford, 2009). Mean and average life expectancy is 28.8 and 41.6 years for Killer Whales of SeaWorld (between 2000-2015), 20.1 and 29 years for southern resident and 29.3 and 42.3 years for northern resident, respectively (Robeck et al., 2015).

1.3. Loro Parque

Loro Parque was founded by Mr. Wolfgang Kiessling on December 17, 1972. It is located in the north of Tenerife (Canary Island, Spain). Initially, it was designed as a paradise for parrots, but today is zoological institution and genetic reserve.

Loro Parque Fundación

Loro Parque Fundación was established in 1994. This foundation is a non-profit organization that promotes species protection and awareness of the importance of environmental protection.

Orca Ocean

Orca Ocean is a Killer Whale facility that was inaugurated in 2006. This installation was designed to enhance scientific research, veterinary care and job husbandry. Loro Parque together with SeaWorld created an environmental awareness project for protecting the oceans. Loro Parque Fundación has invested a total of 17,000,000$ in biodiversity conservation since 1994, every year over 10% of its 1,000,000$ annual budget is addressed to marine mammal conservation actions.

Orca Ocean was designed thinking about animal welfare, it is considered the most innovative and modern in the world. Orca Ocean is composed of four pools that are in continual maintenance to ensure animal welfare. These pools are equipped with hydrophones located strategically (Fig. 5; Table 1).

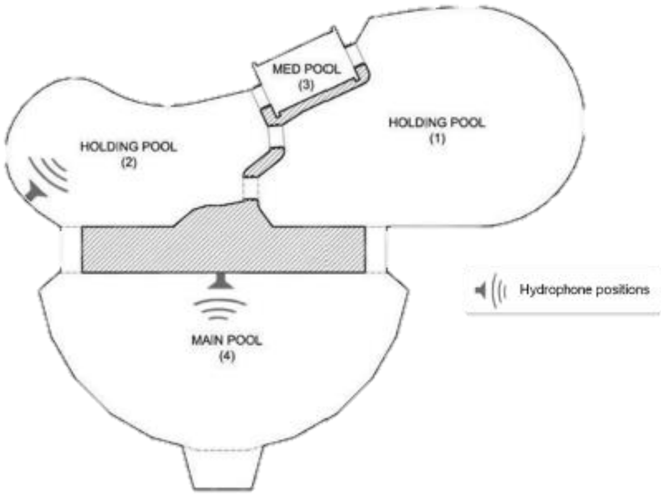


Figure 5: Orca Ocean facilities and hydrophone positions (modified from Kremers et al., 2012).

Table 1: Pool dimensions of Orca Ocean (modified from Kremers, 2012).

POOL	MAX. DEPTH (m)	MAX. WIDTH (m)	MAX. LENGTH (m)
(1) Holding pool	8.1	30.5	44.8
(2) Holding pool	8.1	20.5	36.5
(3) Med Pool	4.2	7.1	12.4
(4) Main Pool	24.5	24.5	50.5

Initially, Loro Parque housed 4 Killer Whales (Skyla, Kohana, Tekoa and Keto) that came from two SeaWorld parks. Later, in 2010, a calf was born –Adán. Finally, in 2011 a specimen that was rescued in Holland, Morgan, arrived to Loro Parque, (Fig. 6; Table 2). Morgan suffers from a hearing deficit, but it is integrate in the social group (Lucke et al., 2016). Orca Ocean guarantees care and survival of these animals.

Figure 6: Killer Whales of Loro Parque (1: Keto, 2: Tekoa, 3: Kohana, 4: Skyla, 5: Adán, 6: Morgan).

Table 2: Contain dates of births, the origin of Killer Whales, periods when subjects were in the same facility before came to Loro Parque, body lengths were measured on April 3, 2016 and body weights were measured on March, 2016 (modified from Kremers, 2012).

	Date of birth	**Blood**	**Previous contact**	**Total length (m)**	**Underarm to underarm length (m)**	**Weight (Kg)**
Keto (♂)	17 June 1995	75% Icelandic, 25% Canadian southern resident	With Tekoa: 22 months in SW Texas (from 9 to 11 years old)	6.04	3.22	3,712.65
Tekoa (♂)	8 November 2000	75% Icelandic, 25% Canadian transient	With Skyla: 2 months in SW Florida (when 3 years old); with Keto: 22 months in SW Texas (from 3 to 5 years old)	5.73	2.90	2,499.29
Kohana (♀)	3 May 2002	100% Icelandic	With Skyla: 22 months in SW Florida (from 2 to 4 years old)	5.20	2.98	2,095.6
Skyla (♀)	9 February 2004	75% Icelandic, 25% Canadian southern resident	With Tekoa: first 2 months of life in SW Florida; with Kohana: first 22 months of life in SW Florida	5.39	2.87	2,002.61
Adán (♂)	12 October 2010	87% Icelandic, 13% Canadian southern resident	With all members group in Loro Parque; Kohana is its mother	4.26	-	1,061.41
Morgan (♀)	Unknown, but it is estimated to be about 2 years	North Atlantic ecotype	With all members group since 2011 in Loro Parque	5.08	2.38	2,018.49

1.4. Sound production structure

Sound waves travel through water at a speed of about 1.5 km/sec, four and a half times faster than sounds travelling through the air (Ivaldi, 2012). The sounds production and reception in Killer Whales is necessary to navigate, communicate and hunt (Ivaldi, 2012).

These sounds are produced by a complex system that include the “phonic lips” and the melon, that is a rounded region forehead which consists of lipids (fats) (Ivaldi, 2012). Toothed whales produce some sounds by forcing the air through the nasal passage, that is situate below spiracle, and the phonic lips, making the surrounding a complex tissue called “dorsal bursa” vibrate, so that sound is produced (Fig. 7) (Ivaldi, 2012).

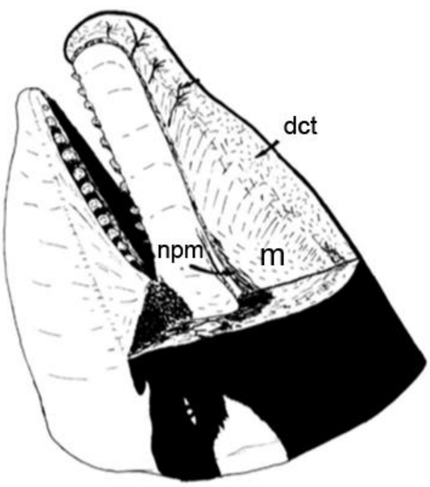


Figure 7: Killer Whale, sagittal section of rostral structures (dct: dermal connective tissue, m: melon, npm: nasal plug muscle) (modified from Mead, 1975).

The high-frequency sounds are generated in the nasal passages where pass through the melon that acts as an acoustical lens focussing these sound waves into a beam, which is projected forward into water in front of the animal (Ivaldi, 2012).

Releasing air from the blowhole isn’t required to produce sounds, but sometimes the two things are connected (Ivaldi, 2012).

1.5. Sounds types (calls, whistle and clicks)

Killer Whales producing three different types of sounds:

- Clicks: are brief sound pulses, emitted in series for echolocation, these have a frequency range between 20-108 kHz (Barrett-Lennard et al., 1996; Au et al., 2004; Simon et al., 2007).

- Calls: can be discrete calls, variable calls and aberrant calls. They are supossed to be a contact signal during cooperative foraging (Hoelzel and Osborne, 1986). According to SeaWorld the frequency range of calls is between 0.5-25 kHz, with peak energy at 1-6 kHz.

- Whistles: are tonal sounds used in socializing. They are also important for short-range communication (Deecke et al., 2005). According to SeaWorld the frequency range is between 0.5-40 kHz, with peak energy at 6-12 kHz.

Calls that sound the same time after time are called stereotyped calls, whistles can be stereotyped as well (Riesch et al., 2006).

Studies on northern resident Killer Whales showed that they produce more whistles when they are near to other individuals for communication and rarely emit them when they are dispersed over large areas to hunt (Culik, 2011).

In a pod is more dominant use the discrete calls because this type of sound has many functions, like promoting activities within the group or simply conveying messages between individuals (Ivaldi, 2012).

Some odontocetes have the ability of vocal learning, that means the influence of learning on different aspect of vocal communication (Janik and Slater, 1997; 2000).

Studies developed in SeaWorld proved that a calf learns its repertoire of calls selectively from its mother, even when other Killer Whales may be present and vocalize more frequently than the mother (Bowles, 1987). Calf can vocalize within a few days from its birth, but sound production is shaped with age (Bowles, 1987). When calf is about two months of age, they start to produce first pulsed calls with similarities to adult-type calls (Bowles, 1987).

As explained previously, clicks are use in series for echolocation. Produce directional broadband clicks in rapid succession, called a “train” (Barrett-Lennard et al., 1996; Au et al., 2004; Simon et al., 2007). Echolocation is a sophisticated system that it is present in odontocetes, and this adaptation is used to locate and discriminate objects by projecting high-frequency sound waves and listening for echoes, because in the environment the visibility is significantly reduced (Knudtson, 1996). When the sound beam hits an object, it is reflected back and channelled through the fluid, fat-filled lower jawbones to the sensory organs of the middle ear lying on either side of the skull (Fig. 8) (Knudtson, 1996). This tool permits to determinate the size, shape, speed, distance, direction, and even some of the internal structure of objects in the water; it is useful for hunt or to get orientation (Knudtson, 1996).

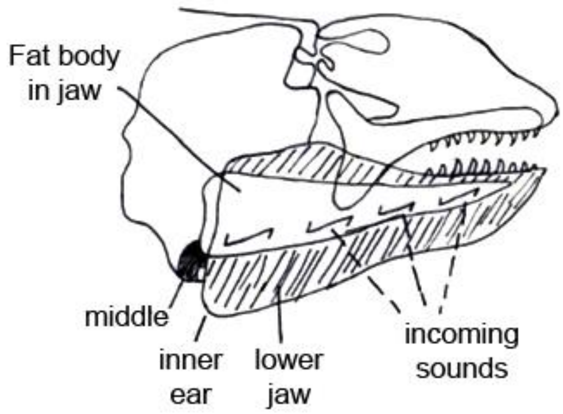


Figure 8: Sound receiving system of Killer Whales (modified from Ivaldi, 2012).

1.6. Hypothesis

This study is developed to demonstrate if individual dialects exist in a group of captive Killer Whales, as nobody has demonstrated yet if every individual uses the whole group dialect or the group dialect is in fact the sum of several heterogeneous individual dialects.

2. MATERIAL AND METHODS

This study has been developed thanks to Loro Parque Fundación, which is studying Killer Whale communication since 10 years. As a result a group dialect has been described (Annex).

Orca Ocean is equipped with 12 built-in hydrophones, all the pools except the medical have 3 hydrophones and main pool has 3 extra ones (Rosa et al., 2005). Three hydrophones are arranged in a digital network using digitalization nodes (Figure 9) that send time tagged digital signals to a central server (Rosa et al., 2005). The central server detects the sound arriving to each hydrophone and establishes the initial time of each event. The detection is performed with an algorithm that calculates the dimensional distance to the mean background noise, hence every sound is tagged with this dimensional distance, that measures the quality of the sound similarly to the noise to signal ratio. A low dimensional distance implies a bad quality sound (noisy) whereas a high dimensional distance describes low noise sounds. These sounds are stored in a central database that was consulted using the program Classifier (Figure 10). Every call was classified by two persons using the dialect described for Loro Parque and the hydrophone were the call was recorded was identified and tagged automatically by the system.

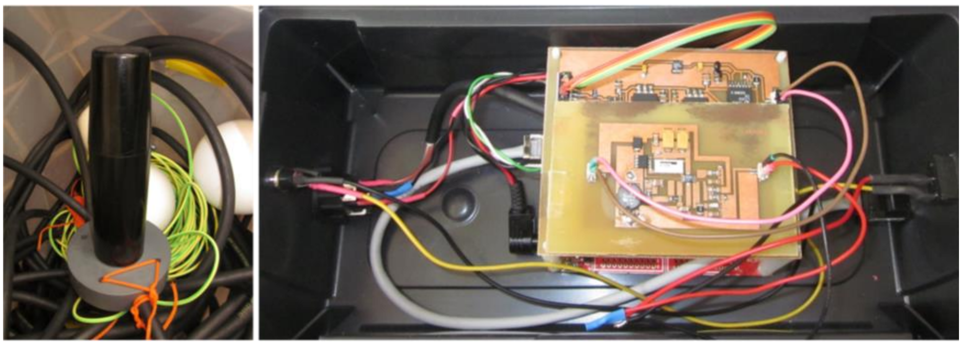


Figure 9: Smart hydrophone. Hydrophone on the right and node on the left.

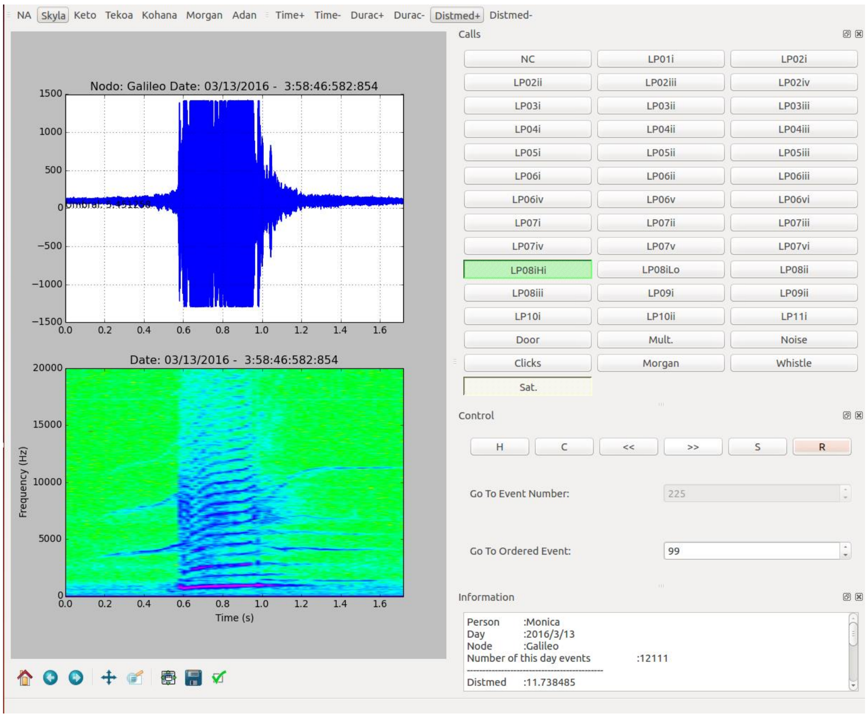


Figure 10: Program used for classify.

In order to identify the animal making the calls an experiment was designed to isolate one single animal in main pool during all the night. The experiment was developed with five out of six animals in the group, excluding Morgan for its hearing deficit because presumably her dialect is not related with the group’s dialect. The recording time was set up from 18:00 to 8:00 the following day (Table 3), when trainers were absent from the facility, in order to avoid any behavioural. The recordings were performed with three hydrophones, one on each pool, in order to detect the first hydrophone to be reached by the sound, hence identifying the pool where the sound was emitted.

Table 3: Sleep configuration in the nigth that developed the recordings. * At the night where Tekoa was alone the others pools were connected.

	SLEEP CONFIGURATION		
	Main pool	**Holding pool (1)**	**Holding pool (2)**
18:00 4/02/2016 - 8:00 5/02/2016	Adán	Keto, Tekoa, Morgan	Kohana, Skyla
18:00 26/02/2016 - 8:00 27/02/2016	Tekoa	Keto, Kohana, Skyla, Morgan, Adán*	
18:00 3/03/2016 - 8:00 4/03/2016	Keto	Tekoa, Morgan, Adán	Kohana, Skyla
18:00 12/03/2016 - 8:00 13/03/2016	Skyla	Keto, Tekoa, Adán	Kohana, Morgan
18:00 17/03/2016 - 8:00 18/03/2016	Kohana	Keto, Tekoa, Adán	Skyla, Morgan

When the call classification was completed, data were exported to an Excel spreadsheet and a computer script (R Core Team, 2015) was prepared to perform statistical analysis. R was used to plot frequency histograms and perform chi-square tests, in order to compare the individual dialects.

During the recording sessions one of the three hydrophones was not detecting properly because some electrical noise in the network. The digitalization node of other hydrophone failed after two recording sessions, leaving just the hydrophone in main pool to collect the data during the rest of the experimental sessions. As the time of the sound reaching the hydrophone was not available for all the experimental sessions an alternative method to identify the sounds produced in main pool must be used. In order to do so, all the available sounds recorded produced in holding pool and recorded in main pool were selected and the frequency distribution of their dimensional distances analyzed. The dimensional distances distribution followed a standard normal distribution with mean 5.29 and SD 1.08. Using the properties of the standard normal distribution it was calculated that 95% of the sounds produced in holding pool had dimensional distances (noise to signal ratio) lower that 7.088814, hence all sounds with dimensional distance over 7.1 were attributed to main pool with a 5% error.

$$Z = \frac{X - \mu}{\sigma}$$

$$P(Z<C) = 0.95$$

$$P(Z<1.65) = 0.9505$$

$$1.65 = \frac{X - \mu}{\sigma}$$

$$X = 1.65\ \sigma + \mu$$

Where σ: standard deviation; μ: mean

$$X = 1.65 * 1.089699 + 5.290811 = 7.088814 \rightarrow \text{Cut point}$$

As the animal in main pool every experimental session was known, all the sounds attributed to main pool were attributed to the respective individual in order to analyse the individual dialects.

3. RESULTS

In this study, a total of 5 individuals of *Orcinus orca*, 3 males (2 adults and 1 juvenil) and 2 females were observed. The sound production is irregular, as some animals were more vocal (produce more sounds than others), and some animals use a bigger number of different calls, whilst others use only a few (Table 4). In the graphic that represents emission calls frequency for animal (Fig. 11), Tekoa is the animal which makes more vocalisations (made a total of 747), after Keto (reached 494 calls) and Skyla (a total of 318). However, Adán and Kohana produced few vocalizations in all the night (only emited 8 and 31, respectively).

From the results, it seems that males produce more vocalizations than females and juveniles. Also, exist differences between the number call types produced by every individual were detected (Tekoa: 13, Keto: 9, Skyla:7, Kohana: 8 and Adán: 4). As there is a clear relation with the number of calls and the number of types, the diversity of calls used by each individual could be an artefact.

Table 4: Summary of calls types produced for five individuals of *Orcinus orca* during the experiment. The differents calls are compiled in the document "Loro Parque Dialect". Differents LP0 indicate the different call types.

	Adán (♂)	Keto (♂)	Tekoa (♂)	Skyla (♀)	Kohana (♀)
LP01i	0	11	5	0	2
LP02i	0	8	3	0	2
LP02ii	0	0	2	0	0
LP06i	4	11	62	1	5
LP06ii	0	0	12	1	0
LP06iv	0	11	5	3	1
LP06/LP02	0	2	2	0	0
LP07ii	2	262	46	264	13
LP07iii	0	84	0	5	1
LP07iv	0	0	1	2	0
LP08i	0	103	82	42	5
LP08ii	0	0	451	0	0
LP08iii	0	0	75	0	0
LP10i	1	2	0	0	0
LP10ii	1	0	1	0	2

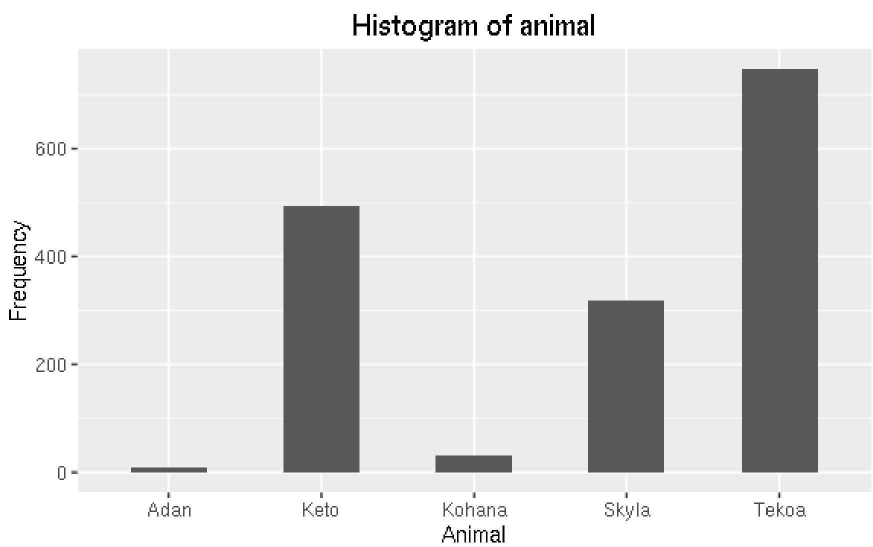


Figure 11: Frequency of emission calls produced for five individuals of *Orcinus orca* during the experiment.

In addition, it is important to remark that not all calls are shared by the individuals. This can be the effect of the high frequency of use in the case of LP07ii (the most frequent call in all the study), but this does not apply to LP06i which is only the 5th most used call in the study. Three call types were found to be individual-specific (LP02ii, LP08ii and LP08iii), nevertheless all of them were used only by a single animal, Tekoa, who presented the highest call rate of the experiment. Keto and Skyla shared one preferred call (LP07ii). Keto produced with a high frequency LP08i. The individual distribution of the calls can be easily seen in Figures 12 and 13.

Figure 12: Frequency of call types for all members of group.

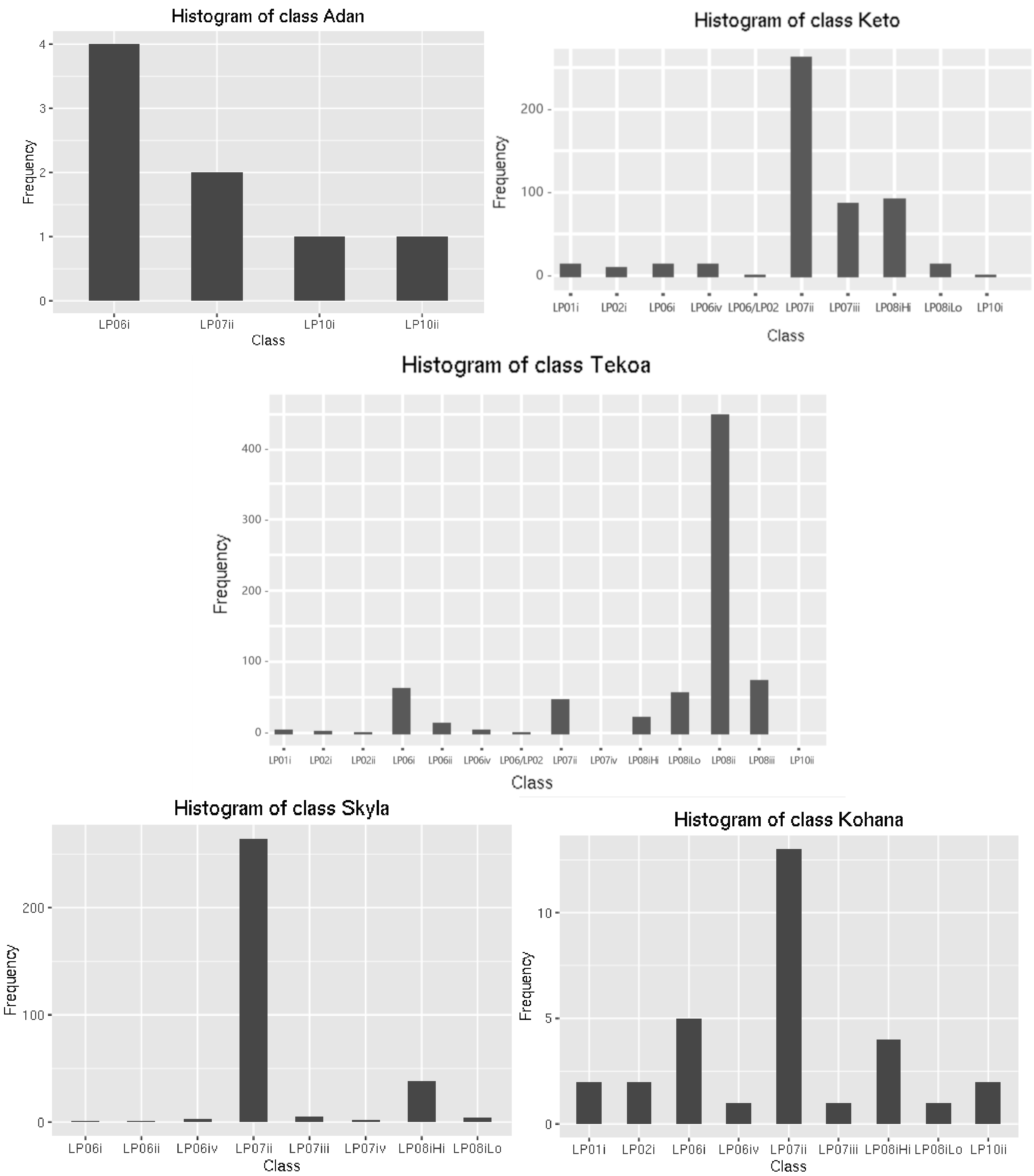


Figure 13: Frequency of call types for each animal.

To check if differences in individual dialects were statistically significative a chi-square test was used, with the *p*-value calculated with Montecarlo method as a result of the high number of zeros recorded. The result of the test X^2-test = 1503.8 and the *p*-value = 0.0004998, indicates the existence of significant differences. Hence, the results probe even though the low number of cases, that Killer Whales use different individual dialects.

4. DISCUSSION

The results of this study show differences between the compositions of the individual dialects of the Killer Whales in the group of Loro Parque. Nevertheless, the fact that the group dialect (Fig. 12) build with the sum of individually identified calls recorded during the experiment does not match with previous group dialects determined for the same animals, suggests that the behavioural situation during the experiment did not allow the animals to use the whole call types.

During the experiment, the animals were not in a social context, they were isolated, in this conditions the animals produce predominantly cohesion calls for keep the social structure and communicate. They reduce their social interaction for the distribution in the pools and rest in the nights. In a previous study supposed that LP07i and LP08i were cohesion calls because these increased in the night when any animals were isolated. In the present project the data show that LP07ii is the most frequent call and it was used for all members of group, maybe because the sounds of subtype LP07 have a similar structure. Also, LP08i is the 3th most used call and this was used for all the animals except for Adán, but it only has a few vocalizations. Besides, in the past were observed that the rest of the dialect could be relation with social interaction, the most important were LP01i and LP02i, in this case these call types are uncommon, therefore it is very probable that these sounds are used for interact with other members of group.

Similarly to the signature whistle hypothesis probed in dolphins (Sayigh et al., 2007) it can be inferred that Killer Whales could have a similar mechanism of group cohesion using *signature calls*. If such a calls would exist, every individual should have use a preferred call during the temporal isolation experiment, not shared with any other member of the group. That would be the case of LP08iii class, which was used only by Tekoa. But in this case Tekoa does not have a single *signature call*, but three which are not used by the rest of the group (LP02ii, LP08ii and LP08iii). Unfortunately, not other member of the group showed a distinctive *signature calls*, hence the hypothesis can not be considered. On the contrary, Keto and Skyla share LP07ii, this call is predominant in both. As these animals have a similar genetic origin (75% Icelandic, 25% Canadian Southern resident) this could be indicating that LP07ii has probably Icelandic origin. But the general knowledge on Killer Whale dialects supports that the dialect similarity is related with the social proximity (Crance, 2008), which is not the case of Keto and Skyla, who came from different social groups. The general use of LP06i and LP07ii is also contradictory with the *signature calls* hypothesis, as it would support the existence of common cohesion calls. It is specially interesting the common use of LP06i, as this is only the 5th more frequent call found in the experiment, but again a contradictory finding, as it does not seem reasonable that a cohesion call is used with such a low frequency in isolation, except that they can maintain visual contact through the doors.

As a consequence, the individual dialects that resulted from this experiment cannot be considered complete, but just portray the individual cohesion dialects or the cohesion calls used by every individual.

5. CONCLUSIONS

1. The conditions of the experiment did not allow the animals to use the whole dialect.

2. The sounds of subtype LP07 and LP08i maybe are cohesion calls.

3. It is probable that LP01i and LP02i are used for social interaction.

4. Tekoa presented three calls which are not used by the rest of the group, but another animal produced a distinctive *signature calls*, so the hypothesis of *signature calls* it is not supported by the results of this experiment.

5. LP06i and LP07ii support the existence of common cohesion calls, but it is rarely present a high frequency of these types of calls when they are isolated.

6. This is the beginning of the study of individual dialects in *Orcinus orca* and it would be necessary to do this experiment in more occasions for confirm the results and observe if have any variable. However, the sounds that are used frequently should be clear from the start of the study.

6. BIBLIOGRAPHY

Asper, E.D; Young, G.W. and Walsh, M.T. (1988) Observations on the birth and development of a captive-born killer whale. International Zoo Yearbook. 27: 295-304.

Au, W.W.L; Ford, J.K.B; Horne, J.K. and Allman, K.A.N. (2004) Echolocation signals of free-ranging killer whales (*Orcinus orca*) and modelling of foraging for chinook salmon (*Oncorhyncus tswawytscha*). Acoustical Society of America. 115: 901-909.

Barrett-Lennard, L.G. and Heise, K.A. (2006) The natural history and ecology of killer whales: Foraging specialization in a generalist predator. In: Whales, whaling and ocean ecosystems. University of California Press, USA.

Barrett-Lennard, L. G; Ford, J.K.B. and Heise, K.A. (1996) The mixed blessing of echolocation: differences in sonar use by fish-eating and mammal-eating killer whales. Animal Behaviour, 51 (3): 553-565.

Bowles, A.E; Young, W.G. and Asper, E.D. (1987) Ontogeny of stereotyped calling of a Kiler Whales calf, *Orcinus orca*, during her first year. Rit Fiskideildar, 11: 251-27.

Crance, J.L. (2008) Changes in killer whale, *Orcinus orca*, stereotyped call repertoires as a function of time and social association (Unpub lished master's thesis). Department of Marine Science, University of San Diego, San Diego, USA.

Culik, B.M. (2011) Odontocetes: the toothed whales. CMS Technical series, 24: 147-152.

Dahlheim, M.E; Schulman-Janiger, A; Black, N; Ternullo, R; Ellifrit, D. and Balcomb III, K.C. (2008) Eastern temperate North Pacific offshore killer whales (*Orcinus orca*): Occurrence, movements, and insights into feeding ecology. Marine Mammal Science, 24 (3): 719-729.

Deecke, V. B; Ford, J.K.B. and Slater, P.J.B. (2005) The vocal behaviour of mammal-eating killer whales: communication with costly calls. Animal Behaviour 69: 395-405.

Foote, A.D; Newton, J; Piertney, S.B; Willerslev, E. and Gilbert, M.T.P. (2009) Ecological, morphological and genetic divergence of sympatric North Atlantic killer whale populations. Molecular Ecology. 18 (24): 5207-5217.

Ford J.K.B. (1989) Acoustic behaviour in resident killer whales (*Orcinus* orca) off Vancoucer Island, British Columbia. Canadian Journal of Zoology 67: 727-745.

Ford, J.K.B. (2009) Killer whale *Orcinus orca*. In: Encyclopedia of Marine Mammals, 2nd edn, San Diego, CA: Academic Press, USA.

Gots, B.A. and Ronald, K. (2009) Orca or killer whale, *Orcinus orca* (Linnaeus 1758). In: Marine Mammal Management Distance education course. Oceanographic Center, Nova Southeastern University, Canada.

Graham, M.S. and Dow, P.R. (1990) Dental care for a Captive killer whale, *Orcinus orca*. Zoo Biology Vol. 9 (4): 325-330.

Haenel, N.J. (1986) General notes on the behavioral ontogeny of puget sound killer whales and the occurrence of allomaternal behavior. In: Behavioral biology of Killer Whales. Kirkevold, B.C. and Lockard, J.S., USA.

Heyning, J.E. (1988) Presence of solid food in a young killer calf whale (*Orcinus orca*). Marine Mammal Science 4: 68-71.

Heyning, J.E. and Dahlheim, M.E. (1988) *Orcinus orca.* Mammalian Species No. 304. American Society of Mammalogists: 1-9.

Heyning, J.E. and Dahlheim, M.E. (1999). Killer whale - *Orcinus orca*. Handbook of Marine Mammals, Vol. 6, 11: 281-322.

Hicks, B.D; St. Aubin, D.J; Geraci, J.R. and Brown, W.R. (1985) Epidermal growth in the bottlenose dolphin, *Tursiops truncatus*. The Journal of Investigative Dermatology 85: 60-63.

Hoelzel, A.R. and Osborne, R.W. (1986) Killer whale call characteristics: implications for cooperative foraging strategies. In: Behavioral biology of Killer Whales. Kirkevold, B.C. and Lockard, J.S., USA.

ITIS report (2016) <https://www.itis.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=180469#null> (accessed 14.4.2016).

Ivaldi, C. (2012) Research on the volcal culture of *Orcinus orca* in the Loro Parque, Tenerife: a pilot study. [Laurea magistrale], Università di Bologna, Corso di Studio in Biologia marina [LM-DM270] - Ravenna

Janik, V.M. and Slater, P.J.B. (1997) Vocal learning in mammals. Advances in the Study of Behaviour, 26: 59-99.

Janik, V.M. and Slater, P.J.B. (2000) The different roles of social learning in vocal communication. Animals Behaviour, 60: 1-11.

Jefferson, T.A; Leatherwood, S. and Webber, M.A. (1993) FAO species identification guide. Marine mammals of the world. UNEP/FAO, Italy.

Knudtson, P. (1996) Orca: visions of the killer whale. Greystone Books, Vancouver, BC, 110 pp.

Kremes, D; Lemasson, A; Almunia, J. and Wanker, R. (2012) Vocal sharing and individual acoustic distinctiveness withing a gropu of captive orcas (*Orcinus orca*). Journal of Comparative Phychology, 126 (4): 433-445.

Lucke, K; Finneran, J.J; Almunia, J. and Houser, D.S. (2016) Variability in Click-Evoked Potentials in Killer Whales (*Orcinus orca*) and determination of a hearing impairment in a Rehabilitated Killer Whale. Aquatic Mammals, 42 (2): 184-192.

Mead, J.G. (1975) Anatomy of the external nasal passages and facial complex in the Delphinidae (Mammalia: Cetacea). Smithsoman Institution Press, USA.

National Oceanic and Atmospheric Administration (2010) Killer Whale ecotypes and froms poster. Available from: <https://swfsc.noaa.gov/uploadedImages/Divisions/PRD/Programs/Ecology/Killer%20Whale%20Poster%20-%20final.jpg?n=1491> (accessed 18.11.2016).

Pitman, R.L. and Ensor, P. (2003) Three forms of killer whales (*Orcinus orca*) in Antarctic waters. Journal of Cetacean Research and Management. 5 (2): 131-139.

Pitman, R.L. and. Durban, J.W. (2010) Killer whale predation on penguins in Antarctica. Polar Biology. 33: 1589-1594.

Pitman, R.L. and Durban, J.W. (2011) Cooperative hunting behavior, prey selectivity and prey handling by pack ice killer whales (*Orcinus orca*), Type B, in Antarctic Peninsula Waters. Marine Mammal Science. Advance copy.

Pitman, R.L; Perryman, D.L. and Eilers, E. (2007). A dwarf form of killer whale in Antarctica. Journal of Mammalogy. 88 (1): 43-48.

Pitman, R.L; Durban, J.W; Greenfelder, M; Guinet, C; Jorgensen, M; Olson, P.A; Plana, J; Tixier P. and Towers, J.R. (2011) Observations of a distinct morphotype of killer whale (*Orcinus orca*), Type D, from Subantarctic Waters. Polar Biology. 34: 303-306.

R Core Team (2015). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. < https://www.R-project.org/>

Riesch, R; Ford, J.K.B. and Thomsen, F. (2006) Stability and group specifity of stereotyped whistles in resident killer whales, *Orcinus orca*, off British Columbia. Animal Behaviour 71: 79-91.

Robeck, T.R.; Willis, K; Scarpuzzi, M.R. and O´Brien, J.K. (2015) Comparisons of life-history parameters between free-ranging and captive Killer Whale (*Orcinua orca*) populations for application toward species management. Journal of Mammalogy XX (X): 1-16, 2015.

Rosa, F; Sanluis, J.C; Lüke, J.L. and Almunia, J. (2015) Loojimg for number of degrees of freedom at *Orcinus Orca* calls for the design of a classifier. IBAC. La Laguna University and Loro Parque Foundation, Spain.

Sayigh, L.S; Esch, C; Wells, R.S. and Janik, V.M. (2007) Facts about signature whistle of bottlenose dolphins, *Tursiops truncatus*. Animal Behaviour 74: 1631-1642.

Scheffer, V.B. and Slipp, J.W. (1948) The whales and dolphins of Washington State with a key to the cetaceans of the West Coast of North America. American Midland Naturalist 39: 257-337.

SeaWorld reported (2016) <https://seaworld.org/en/animal-info/animal-infobooks/killer-whale/communication-and-echolocation>(accessed 24.11.16).

Simon, M.; McGregor, P.K. and Ugarte, F. (2007) The relationship between the acoustic behaviour and surface activity of killer whales (*Orcinus orca*) that feed on herring (*Clupea harengus*). Acta ethologica Springer-Verlag and ISPA 10 (2): 47-53.

Taylor, B.L; Baird, R; Barlow, J; Dawson, S.M; Ford, J; Mead, J.G; Notarbartolo Di Sciara, G; Wade, P and Pitman, R.L. (2008) *Orcinus Orca*. In: IUCN 2009. IUCN Red List of Threatened Species. Version 2009.2.

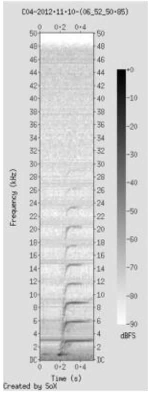
Thomsen, F; Franck, D. and Ford, J.K.B. (2001) Characteristics of whistles from the acoustic repertoire of resident killer whales (*Orcinus orca*) off Vancouver Island, British Columbia. Journal of the Acoustical Society of America, 109: 1240–1246.

Tomilin, A.G. (1957) Mammals of the U.S.S.R. and Adjacent Countries. Vol. IX. Cetacea. Moscow, Soviet Union [Translated in 1967 by Israel Program for Scientific Translations, Jerusalem].

Wiles, G.J. (2004) Washington State status report for the killer whale. Washington Department Fish and Wildlife, Olympia: 106.

WoRMS Editorial Board (2016) World Register of Marine Species. Available from: <http://www.marinespecies.org>at VLIZ. (accessed 19.09.16).

7. Annex – Loro Parque Dialect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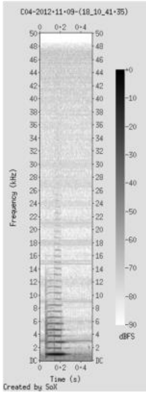
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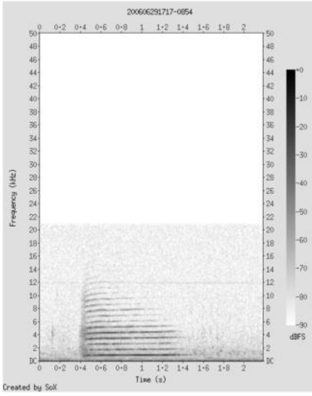
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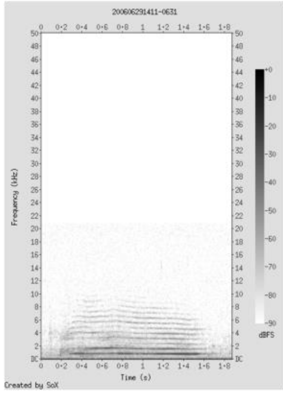
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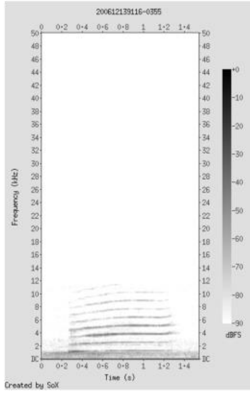
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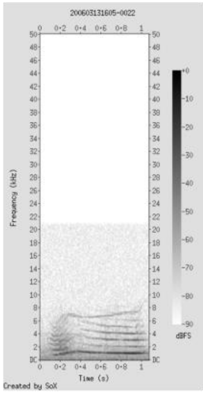
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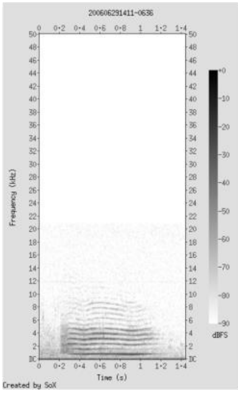
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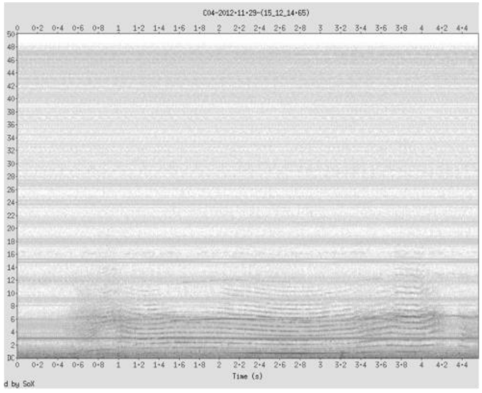
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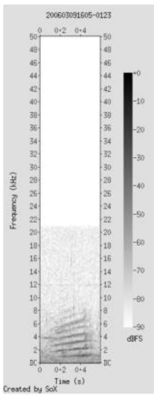
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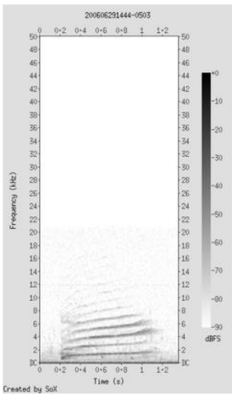
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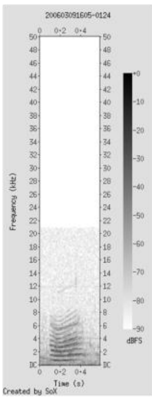
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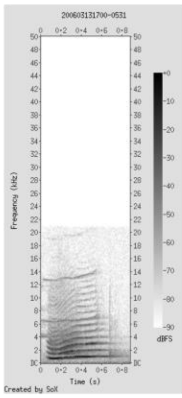
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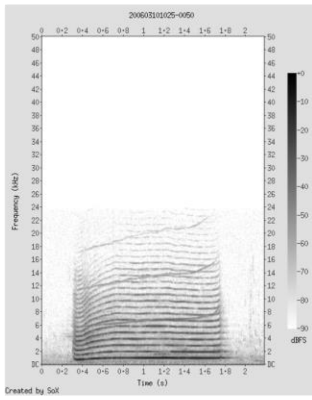
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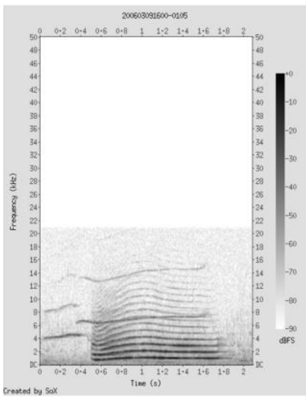
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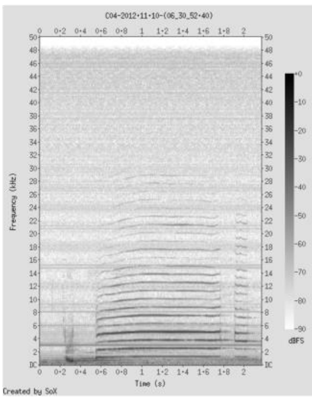
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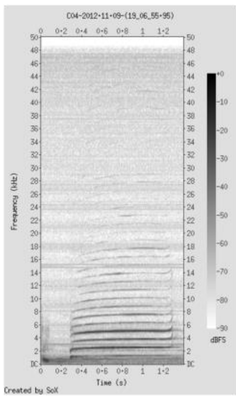
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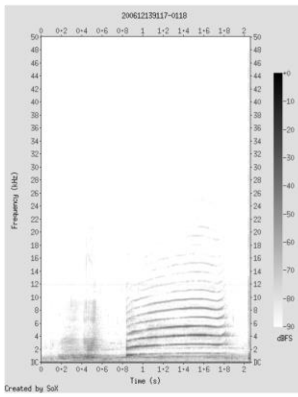
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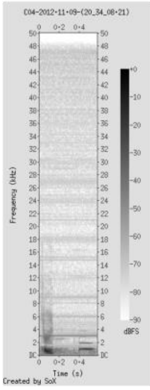

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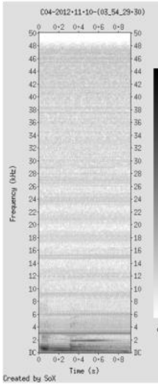

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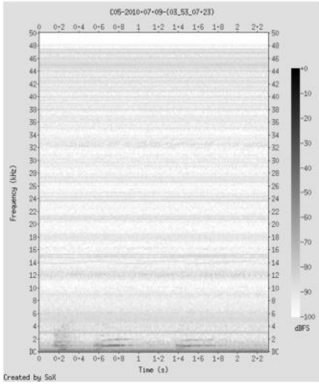

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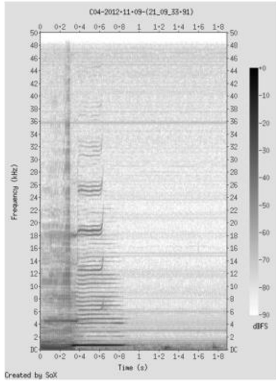

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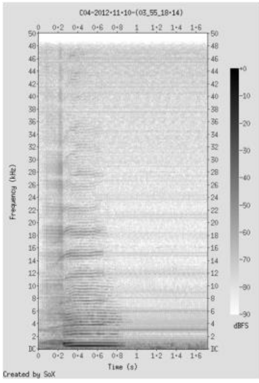

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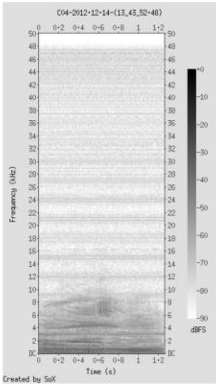

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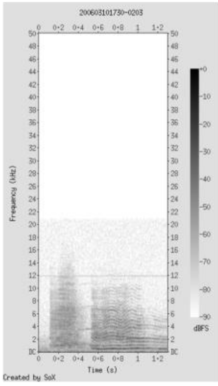

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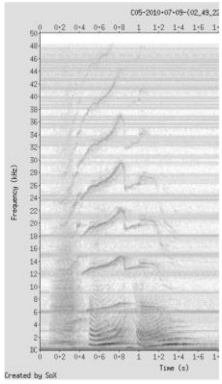

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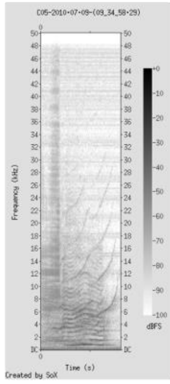

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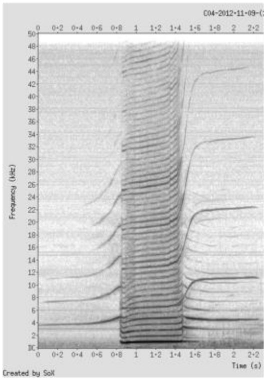

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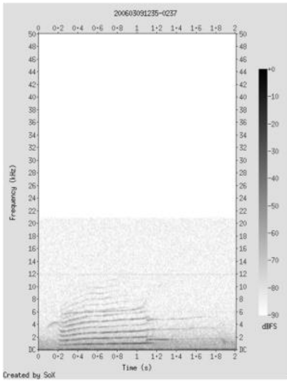

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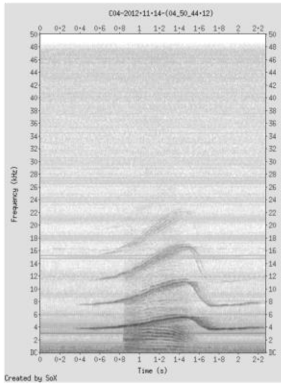

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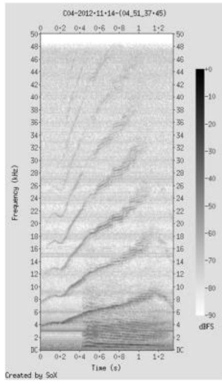

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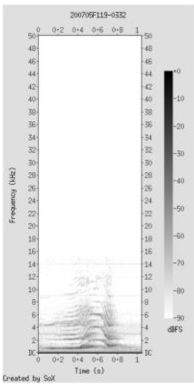

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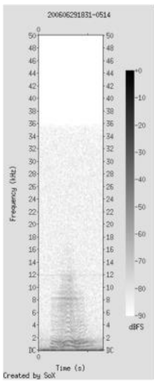

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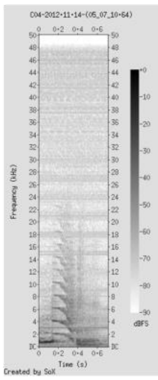

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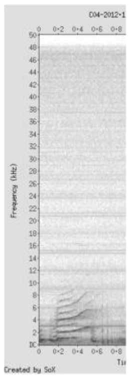

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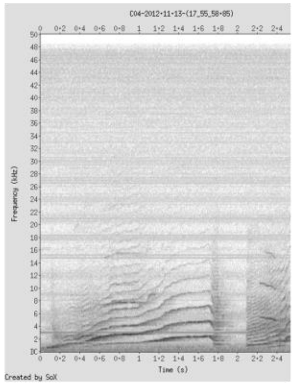

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8. ACTIVITIES DEVELOP DURING REALIZATION OF TFT

I can developed this study based on Loro Parque Fundación where stay between March and May. There Javier Almunia explained in detail the purpose of the project. The Foundation and The University of La Laguna work together for obtain an smart hydrophone which can classify automatically calls in real time for localize, identify and count individuals for aiding management and conservation, the system could work in open sea. After that, he taught me the most important concepts of bioacoustics. Also, he showed me the functioning of the hydrophones, and later Fernando Rosa and José Carlos Sanluis discovered me in more detail the recording system. Knowing all this I performed a simulation of classification. Then, when I understood the method of classify sounds, I could start the analysis of the recording. When I finished the classification we made a comparation with the results of my colleague. Beside this we had to discriminate that sounds produced in other pools. So, we preparated the scripts in R and the data for statistic analysis for corroborate hypothesis. Finally, I could develop my hypothesis that it was include in this paper.

	TIMING (Weeks)															
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
Initial meeting for explain the project																
Bioacoustic formation																
Know functioning of the hydrophones																
Learn to classify the vocalization of orcas with a simulation																
Classify the recordings for the experiment																
Compare the results of my classification with my colleague																
Discriminate the sounds that produce in other pools																
Prepare the scripts in R and the data																
Statistic analysis																
Develop the paper																

9. EDUCATION RECEIVED

During the practices I received the necessary formation for developed my project, this include: in first time, the knowledge about bioacoustic and the method of classify the vocalizations of orcas for identify the different call types; in second time, to know the operation of the system of recording; in the end, I improve my use of the statistic program called R, that we use for process the data.

On the other hand, with this project I could know the ethology of the orcas, and I could observe these animals and any medical training close up.

10. LEVEL OF INTEGRATION AND IMPLICATION IN THE DEPARTAMENT AND RELATION WITH STAFF

I developed my practice and my project in Loro Parque Fundación. I collaborated in the education department and I have had a very good relation with all members. For my work I have needed to have relation with others sections like marine mammals who the coaches facilitate to me all information about Killer Whales. The staff was really good with me at the first time and help me for everything. I want emphasize the present and the support of my tutor, Javier Almunia. He allowed me know my best point and my worst, for improve.

The project permitted me collaborate with a big study that Loro Parque Fundación and The University of La Laguna have developed since 10 years. This project can be may possible classify these sounds automatically with smart hydrophones.

11. POSITIVE AND NEGATIVE ASPECT OF DEVELOP OF TFT

The develop of this study is very interesting and important, it is innovative. Also, I have learned a lot of things like the necessity and the phonic structure of the orcas. These are the more positive aspects of this work.

However, this project has had any complication, such as: the sleep configuration in the pools, because always it is not possible separate them; and the record system sometimes has technical problems too. These negative aspects slow down it.

12. PERSONAL EVALUATION OF LEARNING ACHIEVED ALONG DEVELOP OF TFT

With this project I have learned and I have had a big evolution in my student life. Thus, I have never collaborated in something similar, this experience was very important and enriching for myself. Also, the practice showed me that I would like work in this world in the future.