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Small Vessel Impact on the Whistle Parameters of Two Ecotypes of Common Bottlenose Dolphin (*Tursiops truncatus*) in La Paz Bay, Mexico

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Abstract: Vessel traffic is one of the major sources of underwater anthropogenic noise. Dolphins can modify their vocal repertoire, especially whistles, in presence of vessels to facilitate their communication. Acoustic data were collected (sampling rate 96 kHz) in La Paz Bay, Gulf of California, Mexico. Whistle rate and parameters of the coastal and oceanic ecotypes of common bottlenose dolphins (*Tursiops truncatus*) were measured in absence of vessels and in presence of moving small vessels (size 5–10 m). The peak noise difference was calculated between the two frequency bands dominated by the whistles (2000–20,000 Hz) and the small vessel (500–2000 Hz). In presence of vessels the oceanic ecotype decreased whistle frequencies while the coastal ecotype increased them. Both ecotypes raised whistle frequencies with the decreasing of the peak noise difference. The differences in habitat and group structure could have driven the two ecotypes to react in a different way to the vessel presence.

Keywords: anthropogenic noise; cetaceans; vocalizations; disturbance; Gulf of California; marine conservation

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1. Introduction

Underwater noise pollution is an increasing threat for the marine environment [1] and is recognized as a pollutant at a global scale [2]. Commercial shipping, oil and gas activities, naval operations, fishing, construction, icebreaking or recreational boating are some of the anthropogenic noise sources in the ocean [3]. Vessel traffic, especially, is one of the main sources of anthropogenic underwater noise [1,3–5]. Vessels produce noise by the cavitation created by the propeller and the rotating machinery of the engine [6]. Noise level is related to size, power, load and vessel speed [3].

Dolphins use a wide variety of sounds to communicate, navigate and feed [7]. The fast sound propagation in the water and the central role of acoustics in the dolphin ecology, make them potentially vulnerable to damage or disturbance by underwater anthropogenic noise [7]. Common bottlenose dolphins (*Tursiops truncatus*) produce whistles during intra-specific social interactions, such as mother–calf interactions, group cohesion and coordinated foraging [8–10]. Whistles are narrow-band, frequency-modulated signals, with durations up to a few seconds and frequencies typically between 1 and 35 kHz [11–13]. Vessel effects on dolphins have generally been investigated in coastal environments, where the main source of anthropogenic noise consists of small vessels [1]. Dolphins have been previously found to respond to vessel noise modifying duration, emission rate, amplitude and frequencies of whistles to facilitate the transmission of their signals and to avoid acoustic masking [10,11,14–17]. In dolphins, vessel noise may also induce behavioral changes [18], reduced foraging [19,20], displacement [14] and stress [21].

Coastal and oceanic ecotypes of common bottlenose dolphin have been recorded in many regions, including the Gulf of California [22]. In some regions of the world it has been recognized that the two ecotypes differ in habitat distribution, social structure, behavior [23,24], phenotype [25], diet [26], genotype [22,27] and whistle repertoire [28]. In the Gulf of California, the coastal ecotype individuals are larger, with lighter pigmentation, shorter rostrum and flippers compared to the oceanic ones [22,26,29]. The ecotypes also differ in group structure. The oceanic ecotype lives in groups of up to 300 dolphins while the coastal type is found in groups with an average of less than 20 individuals [29].

Because of living in two distinct habitats, the ecotypes are exposed to a different variety of threats [30], and thus they could show different reactions to these. In coastal environments, due to the high vessel traffic, the anthropogenic noise level could be higher compared to the oceanic habitat [31,32]. The coastal ecotype could be exposed to a high and repeated vessel traffic that could cause long-term effects on its survival and reproduction rate [33,34]. Another possibility is that dolphins, facing a constant exposure to vessel traffic, could become tolerant to it [35,36].

The present study focuses on the coastal and oceanic ecotypes of common bottlenose dolphins encountered in La Paz Bay, Gulf of California. The research compares the whistle parameters and rates of the two ecotypes in absence of vessels and in presence of a single small vessel. The hypothesis is that the anthropogenic noise produced by a small vessel causes a change in the whistle parameters and rates of the dolphins. Furthermore, the two ecotypes could have developed different ways to adjust their whistle parameters and rates in response to an increase of the anthropogenic noise level.

2. Materials and Methods

The study area was La Paz Bay, located in the Baja California peninsula, Mexico, in the south-western Gulf of California (Figure 1). Surveys were conducted with a 7.3 m research vessel (fiberglass skiff with Honda 75 HP engine), between October 2020 and September 2021, only under favorable weather conditions (Beaufort scale ≤ 2). Observations were performed using a continuous scanning method by naked eye and with binoculars [37].

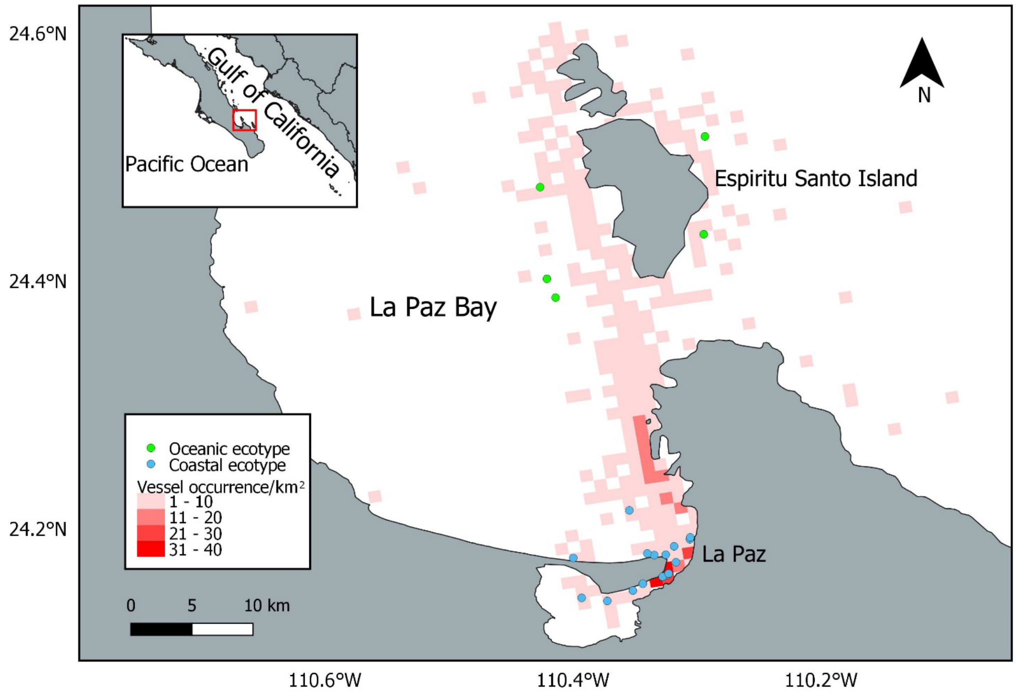

Figure 1. Location of the common bottlenose dolphin groups recorded (coastal groups, $n = 16$; oceanic groups, $n = 5$) and vessel occurrence. Basemap shapefile provided by Comisión Nacional para el Conocimiento y Uso de la Biodiversidad (CONABIO).

To describe the general vessel traffic, the type and location of any vessel not docked or anchored was recorded, either in movement or not (Table 1). Location was calculated using the recorded distance (meters from the research vessel estimated by naked eye) and magnetic bearing (measured with a compass), taken as soon as vessels were visible. The same trained researcher collected the observational data throughout the study for consistency purposes, including the estimation of distances to vessels and dolphin groups. Hence, any bias was consistent throughout fieldwork.

Table 1. Vessel types considered in the study.

Vessel Type	Definition	Length (m)
Fishing panga	Panga * vessel used for fishing activities.	5–10
Touristic panga	Panga vessel used for touristic activities.	5–10
Passenger panga	Panga vessel used for carrying passengers from the shore to other vessels or vice versa.	5–10
Ferry	Large-sized vessel used for carrying people and goods as a regular service from one port to another.	150–200
Yacht	Vessel used for recreational activities.	10–30
Sailing boat	Any vessel propelled entirely or partly by sails.	5–30
Cargo	Merchant vessel carrying goods and materials from one port to another.	150–200
Jet ski	Personal watercraft used for recreational activities	2–4

* A panga is a type of small-sized (between 5 and 10 m long) fiberglass vessel, equipped with 75–150 HP outboard engine, common in the study area.

When a sighting occurred, the research vessel tracked parallel to the course of moving dolphins, approaching slightly to the rear of the group in a slow and continuous maneuver. At this point, the engine was turned off, remaining so during all the recording duration, and the hydrophone carefully deployed (4 m cable length). When the sea depth was less than 4 m, a length of the cable equal to the half of the sea depth was deployed. Sea depth was measured at the beginning of each recording session using a digital depth gauge HONDEX (PS-7). In case the dolphins were not visible or audible with the hydrophone, the engine was turned on and the group was carefully followed to attempt another recording session (for a maximum of 3 attempts). Acoustic data were collected using a Reson TC4013.1 hydrophone (sensitivity -211 $dB_{RMS} \pm 3$ dB re 1 V/μPa, frequency response 1 Hz to 170 kHz, omnidirectional) connected through a Reson VP2000 Voltage Preamplifier EC6081 (50 dB gain, 500 Hz high-pass filter, 50 kHz low-pass filter) to a Marantz PMD661 recorder (sampling rate 96 kHz, 24 bits resolution).

For each recording session the ecotype and number of dolphins were noted. Due to the difficulty of determining which individuals were being recorded, all visible dolphins were counted and considered as one 'acoustic' group. Common bottlenose dolphin ecotypes were determined by naked eye observations, according to the specific morphological characteristics previously reported in the study area [22,26,29]. No mixed groups were encountered. Recordings were conducted as long as dolphins were visible. During the observation time, on occasion, vessels approached the group of dolphins, so separate recordings with and without vessels were obtained for the same group. Data were analyzed assuming that both events were independent and dolphins would have modified whistle parameters only in presence of vessels. A minimum of 5 min was taken between two acoustic recordings (with the exception of two consecutive recording without vessels) to assure independence between the acoustic recordings of the same dolphin group.

Acoustic recordings were divided into two categories: absence of vessels (no other vessels audible both above by ear or below the surface with the hydrophone, or visible by naked eye during the recording session) and presence of a moving small vessel (a single small vessel audible and visible by naked eye during the recording session). The visibility by naked eye, considering the good weather conditions during the study (cloud cover < 20%) was estimated at around 3.5 km. The small vessels considered were touristic, fishing and passenger pangas. Acoustic recordings were first inspected in the spectrogram view of Raven Pro (version 1.5 Cornell University, Laboratory of Ornithology, New York) in the time-frequency domain (512 points fast Fourier transformed [FFT], Hann window, 50% overlap). Non-overlapping whistles with the complete sound clearly visible in the spectrogram were identified and selected for analysis with Luscinia (version 2.16.10.29.01) [38]. In Luscinia the spectrogram was set at 10 ms frame length, 5 ms time step, 48 kHz maximum frequency, 1024 spectrograph point and Hann window with a 50% overlap. For each whistle, the fundamental frequency contour was manually traced with the cursor, and the standard parameters duration, starting frequency, ending frequency, minimum frequency, maximum frequency, frequency range and peak frequency were automatically extracted in Luscinia [11,17]. To avoid the pseudo-replication of stereotyped whistles, signals with identical time-frequency contours, visually matched by two trained observers, were considered only once. Whistle rate was calculated as the number of whistles/number of dolphins/recording duration [39].

For the acoustic recordings in presence of a small vessel, every whistle was sorted according to its initial time (time associated to its starting frequency reading). Each recording was divided into three time intervals, adapted from Buckstaff [40]: *during approach* (1 min before and 1 min after the moment the small vessel was closest to the dolphin group); *before approach* (over 1 min before the moment the small vessel was closest to the dolphin group); *after approach* (over 1 min after the moment the small vessel was closest to the dolphin group). For the *during approach* interval, at the moment the small vessel was closest to the dolphin group, the distance between them (hereafter referred to as distance) was calculated trigonometrically knowing their respective locations (calculated as previously explained). Additionally, the level of vessel noise perceived by dolphins was calculated from the recording amplitudes. For every recording session the relative power spectral density (PSD) was extracted using the function PAMGuide [41] in MATLAB (version R2015a, Mathworks) (see Figure S1 for PSD examples). The highest peak of the root-mean-square (RMS) level was considered on each of the two frequency bands representing the small vessel and the whistles. The band between 500 and 2000 Hz is the frequency range of most of the maximum amplitudes of small vessels, according to previous studies [42–45]. On the other hand, the band 2000–20,000 Hz is the range where most of the whistle energy is concentrated [12,46–48]. An index of vessel noise perceived by dolphins was estimated from the difference of the two bands peaks (peak noise in the whistles band minus peak noise in the vessel band). Negative peak noise difference values mean that vessel noise was more intense than whistles and vice versa. The frequency with the highest peak in the band 500–2000 Hz was found at 984 $\pm$ 552 Hz (mean $\pm$ SD), while in the band 2000–20,000 Hz it was found at 4288 $\pm$ 4678 (mean $\pm$ SD).

As the hydrophone was located in the research vessel, it was needed to correct PSD peak of the small vessel to represent the actual noise level received by dolphins. First it was solved trigonometrically, for every recording session, the distance between the small vessel and dolphins. Then, the difference of this distance, to the one between the small vessel and the hydrophone, was used to adjust the peak level of the vessel band, using formulas for sound absorption and spreading (assumed spherical) [49]. A similar approach was used to adjust the peak level in the whistles band, in order to standardize for constant distance between dolphins and the hydrophone for all recording sessions. The standardized arbitrary distance was 282 m, calculated from the average distance between dolphins and the research vessel in *during the approach* intervals.

The normality and homoscedasticity of the data were checked by significance tests (Shapiro–Wilk and Levene's test, respectively). As the assumption of normality was not valid for all the data, non-parametric tests were used. Mann–Whitney U-tests were applied to compare whistle parameters and rates of the two ecotypes between presence and absence of vessels. Kruskal–Wallis non-parametric test, followed by Dunn post hoc test, were performed to compare the whistle parameters and rates between the three time intervals. Non-parametric Kendall's tau test was used to evaluate the correlation between whistle parameters and the peak noise difference. Statistical analyses were performed in

R software (version 4.0.5, The R Foundation for Statistical Computing, Vienna, Austria, http://www.rproject.org) with the RStudio interface (version 1.4.1106), using "stats", "car" [50] and "dunn.test" [51] packages.

3. Results

A total of 25 surveys were conducted in an effort of 179 h and 12 min, during which 820 other moving vessels were encountered (Figure 1). The most common type of vessel was the touristic panga (n = 441; 54%), followed by the yacht (n = 161; 20%), the sailing boat (n = 96; 12%), the fishing panga (n = 57; 7%), the ferry (n = 34; 4%), the passenger panga (n = 15; 1%), the jet ski (n = 9; 1%) and the cargo (n = 7; 1%).

A total of 375 whistles (oceanic, n = 190; coastal, n = 185) in the absence of vessels and 183 whistles (oceanic, n = 105; coastal, n = 78) in the presence of a single small vessel were analyzed (Table 2 and Table S1). Descriptive statistics (mean, standard deviation, median) of the whistle parameters and rates were calculated (Tables 3 and 4).

Table 2. Data collection recap table.

	Absence of Vessels	Presence of a Single Small Vessel	Total
Oceanic ecotype			
N° groups recorded	5	4	5
N° recordings	17	5	22
Recording duration (min)	167	55	222
N° whistles	190	105	295
Coastal ecotype			
N° groups recorded	13	10	16
N° recordings	35	11	46
Recording duration (min)	252	83	335
N° whistles	185	78	263

Table 3. Descriptive statistics of the whistle parameters and rates of the two bottlenose dolphin ecotypes in absence of vessels and in presence of a single small vessel.

Oceanic Ecotype	**Absence of Vessels (n = 190)**			**Presence of a Single Small Vessel (n = 105)**		
	Mean	**sd**	**Median**	**Mean**	**sd**	**Median**
Duration (s)	1.13	0.60	1.08	1.07	0.56	0.92
Starting frequency (kHz)	12.10	5.76	9.95	10.75	4.40	9.46
Ending frequency (kHz)	8.97	3.72	7.82	9.31	4.55	8.29
Minimum frequency (kHz)	7.32	2.14	7.01	7.07	1.96	6.71
Maximum frequency (kHz) *	18.57	4.37	18.53	17.01	3.52	16.96
Frequency range (kHz) *	11.26	4.33	11.12	9.93	3.07	9.79
Peak frequency (kHz)	11.76	3.58	11.13	11.11	2.69	10.80
Whistle rate	0.02	0.01	0.02	0.04	0.04	0.03
Coastal Ecotype	**Absence of Vessels (n = 185)**			**Presence of a Single Small Vessel (n = 78)**		
	Mean	**sd**	**Median**	**Mean**	**sd**	**Median**
Duration (s)	1.08	0.70	0.99	1.23	0.80	1.12
Starting frequency (kHz)	10.69	4.60	10.18	11.62	3.85	11.00
Ending frequency (kHz) *	9.11	3.31	8.66	10.02	2.97	9.88
Minimum frequency (kHz) *	6.95	2.03	6.65	7.89	2.00	7.95
Maximum frequency (kHz)	15.28	3.90	14.95	16.07	3.32	15.46
Frequency range (kHz)	8.33	3.82	7.86	8.17	3.06	8.17
Peak frequency (kHz) *	10.00	2.75	9.68	10.82	2.63	9.95
Whistle rate	0.05	0.08	0.03	0.04	0.05	0.02

* Significantly different parameters between absence of vessels and presence of a single small vessel (Mann–Whitney U-tests, $p < 0.05$).

Table 4. Descriptive statistics of the whistle parameters and rates of the two bottlenose dolphin ecotypes *before approach, during approach* and *after approach* of a single small vessel.

Oceanic Ecotype	***Before Approach* (*n* = 45)**			***During Approach* (*n* = 16)**			***After Approach* (*n* = 44)**		
	Mean	**sd**	**Median**	**Mean**	**sd**	**Median**	**Mean**	**sd**	**Median**
Duration (s)	1.06	0.62	0.81	1.22	0.65	1.05	1.03	0.44	0.96
Starting frequency (kHz)	10.83	4.51	9.74	11.24	3.19	10.39	10.49	4.72	9.05
Ending frequency (kHz) *	10.80	5.73	9.10	9.81	4.28	8.61	7.60	2.17	7.00
Minimum frequency (kHz) *	7.31	2.08	7.11	8.22	1.90	7.97	6.42	1.62	6.29
Maximum frequency (kHz)	16.90	4.29	16.81	18.00	3.33	17.06	16.76	2.61	16.91
Frequency range (kHz)	9.59	3.37	8.69	9.79	3.66	9.68	10.34	2.51	10.71
Peak frequency (kHz)	11.63	2.74	11.34	11.86	2.99	12.11	10.32	2.34	10.27
Whistle rate	0.04	0.04	0.02	0.03	0.04	0.02	0.06	0.08	0.03
Coastal Ecotype	***Before Approach* (*n* = 23)**			***During Approach* (*n* = 17)**			***After Approach* (*n* = 38)**		
	Mean	**sd**	**Median**	**Mean**	**sd**	**Median**	**Mean**	**sd**	**Median**
Duration (s)	1.07	0.75	0.91	1.51	1.04	1.26	1.20	0.69	1.17
Starting frequency (kHz)	11.17	4.71	10.18	11.90	2.74	11.89	11.76	3.77	10.86
Ending frequency (kHz)	9.99	3.69	10.98	9.93	2.58	9.68	10.08	2.71	9.88
Minimum frequency (kHz)	7.38	2.93	7.01	7.74	1.06	7.90	8.00	1.64	8.27
Maximum frequency (kHz)	16.24	3.85	15.58	15.88	3.03	15.53	16.04	3.17	15.06
Frequency range (kHz)	8.41	3.17	7.91	8.14	3.15	8.92	8.04	3.03	8.17
Peak frequency (kHz)	11.48	3.05	10.69	10.16	2.21	9.40	10.71	2.50	10.35
Whistle rate	0.03	0.04	0.01	0.05	0.05	0.04	0.04	0.05	0.03

* Significantly different parameters between before, during and after approach (Kruskal–Wallis test, $p < 0.05$).

The whistles of the oceanic ecotype showed lower maximum frequency (W = 12,545, $p < 0.05$) and narrower frequency range (W = 11,884, $p < 0.05$) in presence of a single small vessel compared to the whistles in absence of vessels. On the contrary, the whistles of the coastal ecotype showed in presence of a single small vessel higher ending frequency (W = 5747, $p < 0.05$), minimum frequency (W = 4947, $p < 0.05$) and peak frequency (W = 6029, $p < 0.05$) (Table 3).

The whistles produced by the oceanic ecotype *after approach* showed lower ending frequency compared to the whistles *before approach* and *during approach* (χ^2 = 13.201, df = 2, $p < 0.05$). Furthermore, minimum frequency of the whistles emitted *after approach* was lower compared to the whistles *during approach* (χ^2 = 10.218, df = 2, $p < 0.05$) (Table 4) (Figure 2). Whistles emitted by coastal ecotype dolphins showed no significant differences between *before approach*, *during approach* and *after approach* (Table 4).

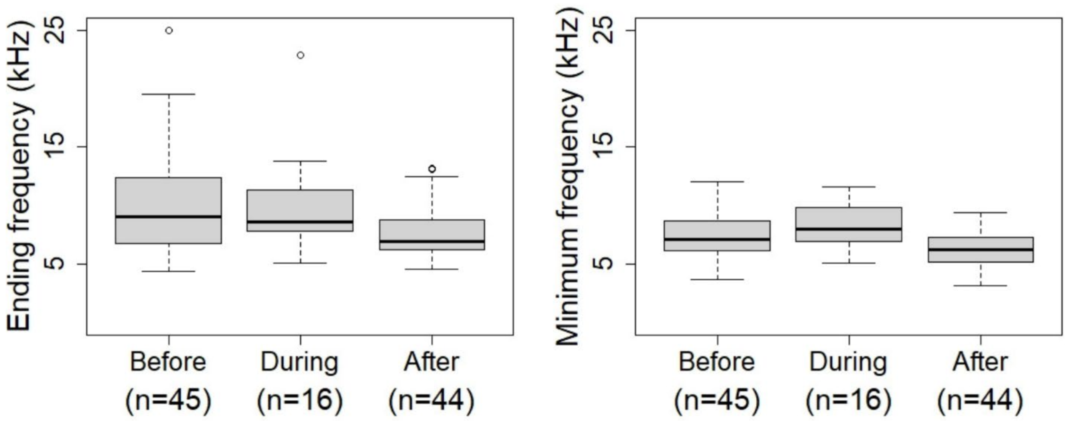

Figure 2. Whistle parameters of the oceanic ecotype significantly different between *before approach*, *during approach* and *after approach*. The ending frequency *after approach* resulted lower compared to the one *before approach* and *during approach*. The minimum frequency *after approach* was lower compared to the one *during approach*.

The starting frequency of the whistles of the coastal ecotype showed significantly negative correlation with the peak noise difference ($\tau = -0.3633924$, $z = -1.9703$, $p < 0.05$) (Figure 3). Duration and frequency range of the whistles of the oceanic ecotype showed significantly positive correlation with the peak noise difference (respectively: $\tau = 0.4426352$, $z = 2.2287$, $p < 0.05$; $\tau = 0.4233902$, $z = 2.1318$, $p < 0.05$) . On the contrary minimum and starting frequency were negatively correlated with the peak noise difference (respectively: $\tau = -0.4831425$, $z = -2.4246$, $p < 0.05$; $\tau = -0.579771$, $z = -2.9096$, $p < 0.05$) (Figure 4).

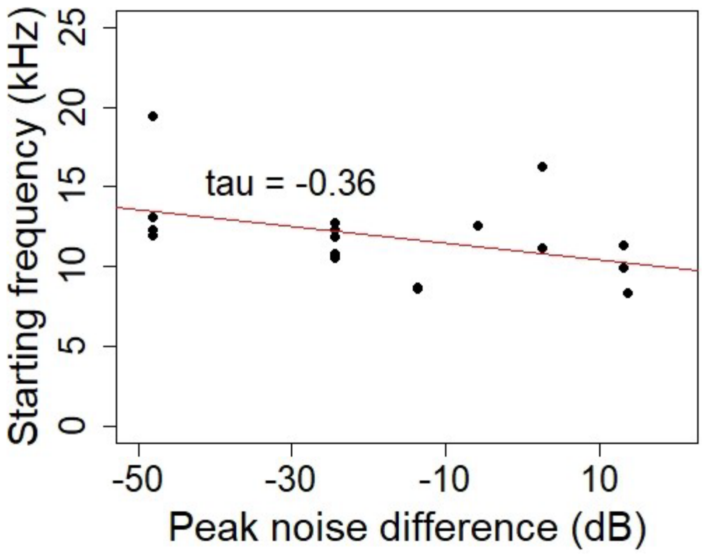

Figure 3. Scatter plots and linear best-fit lines of the starting frequency of the whistles of the coastal ecotype in function of the peak noise difference.

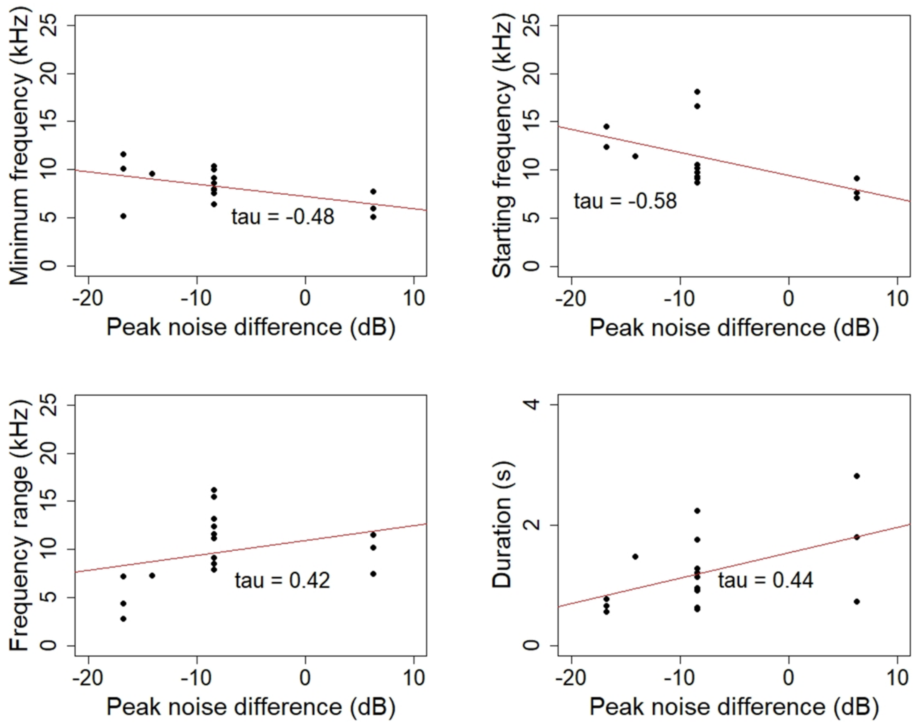

Figure 4. Scatter plots and linear best-fit lines of the whistle parameters of the oceanic ecotype in function of the peak noise difference. Minimum frequency and starting frequency of the whistles were negative correlated with the peak noise difference. On the contrary, frequency range and duration frequency were positive correlated with the peak noise difference.

4. Discussion

This study finds that the common bottlenose dolphins encountered in La Paz Bay changed the whistle parameters in presence of vessels. The oceanic ecotype produced whistles at lower frequencies in presence of a small vessel while the coastal one increased the frequency of its whistles. Bottlenose dolphins have been found to both increase [10,11,52] and decrease [28,47,53] whistle frequencies in noisy environments, avoiding acoustic masking and improving signal transmission. The whistle rate of both ecotypes seemed to not be affected by the presence of vessels and showed no changes during the different time intervals. However, other studies found a whistle rate increase in the presence of a vessel [54] and at the beginning of its approach [40]. Regarding the time interval analyses, in the oceanic ecotype the whistles showed the lowest frequencies *after approach*. This result could be due to the time dolphins needed to adjust their frequency whistles in response to the vessel noise.

The different reactions displayed by the two ecotypes in presence of vessels could be due to the different habitats they occupy. In the oceanic environment transmission loss is predominantly spherical, while in the coastal area it tends to be cylindrical, resulting in a noisier environment in the shallow waters of the coastal zone [55]. Furthermore, the underwater ambient noise in the coastal habitat could be higher compared to the oceanic one, due to the presence of the snapping shrimps that produce sounds in the 5–10 kHz frequency band along the coastal waters [56]. These sounds could even overlap with the frequency range of the whistles, causing acoustic masking. Combining these elements with the higher occurrence of vessels along the coastline, communication between dolphins may be less effective in this area [40]. The coastal ecotype could thus increase whistle frequencies, prioritizing the communication with the closest individuals. On the other hand, the oceanic ecotype, living in big groups [22], may have produced lower-frequency whistles in presence of vessels to cover longer distances and communicate with the outermost individuals of the group.

In the *during the approach* intervals both ecotypes seemed to react in a similar way to the peak noise difference. Whistles showed negative correlations between starting frequency and peak noise difference, meaning that when the vessel noise was more intense compared to the whistle signal, dolphins raised whistle starting frequencies. Moreover, the oceanic ecotype produced whistles with higher minimum frequency and shorter duration with the increasing of vessel noise. The correlation between minimum frequency and the peak noise difference, while maximum frequency remained constant, explains the positive correlation with the frequency range. The greater number of whistle parameters correlated with the peak noise difference expressed by the oceanic ecotype resulted in a more drastic shift of the whistle contour, suggesting a higher impact. On the other hand, the coastal ecotype was encountered in an area with a higher abundance of vessels compared to the offshore habitat (Figure 1), and it could hence be more habituated to vessel noise. For both ecotypes, the limited number of whistles considered to establish the correlations hinders reaching clear conclusions. More data is needed to validate this finding.

During the monitoring the touristic panga was the most encountered vessel, confirming that touristic activities regularly take place in La Paz Bay. Such activities mainly occur along the coast of La Paz and on the western side of the Espiritu Santo Island (Figure 1). Although sea lions, whale sharks and large whales are the main attractions at La Paz Bay, in case of a sighting, vessels may follow dolphins as well. While counting all the vessel types helped to understand their occurrence in the study area, the anthropogenic noise impact on the dolphins was tested only for pangas. Pangas are the most common vessel in La Paz Bay and they are the ones commonly used to approach dolphins. Moreover, focusing on vessels with similar engine powers minimized the variation. However, the duration of the acoustic impact, the speed of the vessel, could have influenced in different manners each encountered group [1].

Dolphins could continue to frequent the same localities, even if they are affected by the vessel presence, because they depend on those areas to maintain their activities [57–59].

When the cost of benefits of remaining in the favorite habitat exceeds the cost of disturbance, animals show tolerance instead of site avoidance [60]. The presence of the coastal ecotype in an area with high occurrence of vessels may indicate the ecological importance of that area for the dolphins, probably due to high prey availability, and outlines a possible tolerance to high levels of noise and disturbance. It is possible that the coastal dolphins of La Paz Bay tolerate high levels of anthropogenic noise rather than avoiding the area. Nevertheless, the effects of such repeated exposure to noise are unknown. A more focused study on the common bottlenose dolphin distribution is needed to assess the presence of biologically important areas (e.g., for resting, nursing and feeding), regarding where to propose noise mitigation measures.

The vocal plasticity of dolphins is still far from understood. Changes in whistle parameters may be metabolically expensive [61] and may not be sufficient to compensate for long-term noise impact [62]. Anthropogenic noise levels and vessel traffic are expected to rise in the future and it is necessary to increase the mitigation measures to address underwater noise pollution [1]. Reducing the number and speed of vessels, avoiding sudden gear-shifts and increasing the distance from the animals may help to reduce the noise impact during sightings [63].

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/d14090712/s1, Table S1: Data collected in presence of a single small vessel; Figure S1: Relative power spectral density in coastal and oceanic habitats.

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References

1. Erbe, C.; Marley, S.A.; Schoeman, R.P.; Smith, J.N.; Trigg, L.E.; Embling, C.B. The effects of ship noise on marine mammals—A review. *Front. Mar. Sci.* **2019**, *6*, 606. [CrossRef]
2. Van der Graaf, A.; Ainslie, M.; André, M.; Brensing, K.; Dalen, J.; Dekeling, R.; Robinson, S.; Tasker, M.; Thomsen, F.; Werner, S. *European Marine Strategy Framework Directive-Good Environmental Status (msfd ges): Report of the Technical Subgroup on Underwater Noise and Other Forms of Energy*; TSG Noise & Milieu Ltd: Brussels, Belgium, 2012.
3. Hildebrand, J.A. Anthropogenic and natural sources of ambient noise in the ocean. *Mar. Ecol. Prog. Ser.* **2009**, *395*, 5–20. [CrossRef]
4. Andrew, R.K.; Howe, B.M.; Mercer, J.A.; Dzieciuch, M.A. Ocean ambient sound: Comparing the 1960s with the 1990s for a receiver off the California coast. *Acoust. Res. Lett. Online* **2002**, *3*, 65–70. [CrossRef]
5. Hermannsen, L.; Mikkelsen, L.; Tougaard, J.; Beedholm, K.; Johnson, M.; Madsen, P.T. Recreational vessels without Automatic Identification System (AIS) dominate anthropogenic noise contributions to a shallow water soundscape. *Sci. Rep.* **2019**, *9*, 15477. [CrossRef] [PubMed]
6. Erbe, C. Underwater noise of whale-watching boats and potential effects on killer whales (*Orcinus orca*), based on an acoustic impact model. *Mar. Mammal Sci.* **2002**, *18*, 394–418. [CrossRef]
7. Gordon, J.; Tyack, P.L. Sound and cetaceans. In *Marine Mammals*; Springer: Berlin/Heidelberg, Germany, 2002; pp. 139–196.
8. Janik, V.M.; Sayigh, L.S. Communication in bottlenose dolphins: 50 years of signature whistle research. *J. Comp. Physiol. A* **2013**, *199*, 479–489. [CrossRef]
9. King, S.L.; Janik, V.M. Bottlenose dolphins can use learned vocal labels to address each other. *Proc. Natl. Acad. Sci. USA* **2013**, *110*, 13216–13221. [CrossRef]
10. Heiler, J.; Elwen, S.H.; Kriesell, H.; Gridley, T. Changes in bottlenose dolphin whistle parameters related to vessel presence, surface behaviour and group composition. *Anim. Behav.* **2016**, *117*, 167–177. [CrossRef]
11. May-Collado, L.J.; Wartzok, D. A comparison of bottlenose dolphin whistles in the Atlantic Ocean: Factors promoting whistle variation. *J. Mammal.* **2008**, *89*, 1229–1240. [CrossRef]
12. Richardson, W.J.; Greene, C.R., Jr.; Malme, C.I.; Thomson, D.H. *Marine Mammals and Noise*; Academic Press: Cambridge, MA, USA, 2013.
13. Oswald, J.N.; Rankin, S.; Barlow, J. To whistle or not to whistle? Geographic variation in the whistling behavior of small odontocetes. *Aquat. Mamm.* **2008**, *34*, 288–302. [CrossRef]
14. Rako, N.; Fortuna, C.M.; Holcer, D.; Mackelworth, P.; Nimak-Wood, M.; Pleslić, G.; Sebastianutto, L.; Vilibić, I.; Wiemann, A.; Picciulin, M. Leisure boating noise as a trigger for the displacement of the bottlenose dolphins of the Cres–Lošinj archipelago (northern Adriatic Sea, Croatia). *Mar. Pollut. Bull.* **2013**, *68*, 77–84. [CrossRef] [PubMed]
15. Fouda, L.; Wingfield, J.E.; Fandel, A.D.; Garrod, A.; Hodge, K.B.; Rice, A.N.; Bailey, H. Dolphins simplify their vocal calls in response to increased ambient noise. *Biol. Lett.* **2018**, *14*, 20180484. [CrossRef] [PubMed]
16. Kragh, I.M.; McHugh, K.; Wells, R.S.; Sayigh, L.S.; Janik, V.M.; Tyack, P.L.; Jensen, F.H. Signal-specific amplitude adjustment to noise in common bottlenose dolphins (*Tursiops truncatus*). *J. Exp. Biol.* **2019**, *222*, jeb216606. [CrossRef] [PubMed]
17. Perez-Ortega, B.; Daw, R.; Paradee, B.; Gimbrere, E.; May-Collado, L.J. Dolphin-Watching Boats Affect Whistle Frequency Modulation in Bottlenose Dolphins. *Front. Mar. Sci.* **2021**, *8*, 102. [CrossRef]
18. Williams, R.; Lusseau, D.; Hammond, P.S. Estimating relative energetic costs of human disturbance to killer whales (*Orcinus orca*). *Biol. Conserv.* **2006**, *133*, 301–311. [CrossRef]
19. Aguilar Soto, N.; Johnson, M.; Madsen, P.T.; Tyack, P.L.; Bocconcelli, A.; Fabrizio Borsani, J. Does intense ship noise disrupt foraging in deep-diving Cuvier's beaked whales (*Ziphius cavirostris*)? *Mar. Mammal Sci.* **2006**, *22*, 690–699. [CrossRef]
20. Wisniewska, D.M.; Johnson, M.; Teilmann, J.; Siebert, U.; Galatius, A.; Dietz, R.; Madsen, P.T. High rates of vessel noise disrupt foraging in wild harbour porpoises (*Phocoena phocoena*). *Proc. R. Soc. B Biol. Sci.* **2018**, *285*, 20172314. [CrossRef]
21. Wright, A.J.; Soto, N.A.; Baldwin, A.L.; Bateson, M.; Beale, C.M.; Clark, C.; Deak, T.; Edwards, E.F.; Fernández, A.; Godinho, A. Do marine mammals experience stress related to anthropogenic noise? *Int. J. Comp. Psychol.* **2007**, *20*, 274–316.
22. Segura, I.; Rocha-Olivares, A.; Flores-Ramírez, S.; Rojas-Bracho, L. Conservation implications of the genetic and ecological distinction of Tursiops truncatus ecotypes in the Gulf of California. *Biol. Conserv.* **2006**, *133*, 336–346. [CrossRef]
23. Bearzi, M.; Saylan, C.A.; Hwang, A. Ecology and comparison of coastal and offshore bottlenose dolphins (*Tursiops truncatus*) in California. *Mar. Freshw. Res.* **2009**, *60*, 584–593. [CrossRef]
24. Viloria-Gómora, L.; Medrano-González, L. Population ecological traits of Tursiops truncatus putative morphotypes in the transitional region of the Mexican Pacific Ocean. *Therya* **2015**, *6*, 351–369. [CrossRef]
25. Gao, A.; Zhou, K.; Wang, Y. Geographical variation in morphology of bottlenosed dolphins (*Tursiops* sp.) in Chinese waters. *Aquat. Mamm.* **1995**, *21*, 121.
26. Díaz-Gamboa, R. Diferenciación Entre Tursiones Tursiops Truncatus Costeros y Oceánicos en el Golfo de California por Medio de Análisis de Isótopos Estables de Carbono Y Nitrógeno. Master's Thesis, Centro Interdisciplinario de Ciencias Marinas, La Paz, Mexico, 2003.
27. Lowther-Thieleking, J.L.; Archer, F.I.; Lang, A.R.; Weller, D.W. Genetic differentiation among coastal and offshore common bottlenose dolphins, *Tursiops truncatus*, in the eastern North Pacific Ocean. *Mar. Mammal Sci.* **2015**, *31*, 1–20. [CrossRef]
28. Peters, C.H. Context-Specific Signal Plasticity of Two Common Bottlenose Dolphin Ecotypes (*Tursiops truncatus*) in Far North Waters. Ph.D. Thesis, Massey University, Albany, New Zealand, 2018.

29. Salinas Zacarías, M.A. *Ecología de los Tursiones, Tursiops truncatus, en la Bahía de La Paz, BCS*; Instituto Politécnico Nacional, Centro Interdisciplinario de Ciencias Marinas: La Paz, Mexico, 2005.
30. Wells, R.; Natoli, A.; Braulik, G. Tursiops truncatus (Errata Version Published in 2019). The IUCN Red List of Threatened Species: E. *T22563A156932432*. 2019. Available online: https://www.iucnredlist.org/species/22563/156932432 (accessed on 10 August 2022).
31. Bittencourt, L.; Barbosa, M.; Santos-Neto, E.B.; Bisi, T.L.; Lailson-Brito, J.; Azevedo, A.F. Whistles of Atlantic spotted dolphin from a coastal area in the southwestern Atlantic Ocean. *J. Acoust. Soc. Am.* **2020**, *148*, EL420–EL426. [CrossRef]
32. Kelly, C.; Glegg, G.; Speedie, C. Management of marine wildlife disturbance. *Ocean. Coast. Manag.* **2004**, *47*, 1–19. [CrossRef]
33. Nowacek, S.M.; Wells, R.S.; Solow, A.R. Short-term effects of boat traffic on bottlenose dolphins, Tursiops truncatus, in Sarasota Bay, Florida. *Mar. Mammal Sci.* **2001**, *17*, 673–688. [CrossRef]
34. Marley, S.A.; Kent, C.P.S.; Erbe, C.; Parnum, I.M. Effects of vessel traffic and underwater noise on the movement, behaviour and vocalisations of bottlenose dolphins in an urbanised estuary. *Sci. Rep.* **2017**, *7*, 13437. [CrossRef]
35. Acevedo, A. Interactions between boats and bottlenose dolphins, *Tursiops truneatus*, in the entrance to Ensenada De La Paz, Mexico. *Aquat. Mamm.* **1991**, *17*, 120–124.
36. Gregory, P.R.; Rowden, A.A. Behaviour patterns of bottlenose dolphins (*Tursiops truncatus*) relative to tidal state, time-of-day, and boat traffic in Cardigan Bay, West Wales. *Aquat. Mamm.* **2001**, *27*, 105–113.
37. Mann, J. Behavioral sampling methods for cetaceans: A review and critique. *Mar. Mammal Sci.* **1999**, *15*, 102–122. [CrossRef]
38. Lachlan, R.F. Luscinia: A bioacoustics Analysis Computer Program. Version 1.0 [Computer Program]. Available online: www.lusciniasound.org (accessed on 30 June 2007).
39. Quick, N.J.; Janik, V.M. Whistle rates of wild bottlenose dolphins (Tursiops truncatus): Influences of group size and behavior. *J. Comp. Psychol.* **2008**, *122*, 305. [CrossRef] [PubMed]
40. Buckstaff, K.C. Effects of watercraft noise on the acoustic behavior of bottlenose dolphins, Tursiops truncatus, in Sarasota Bay, Florida. *Mar. Mammal Sci.* **2004**, *20*, 709–725. [CrossRef]
41. Merchant, N.D.; Fristrup, K.M.; Johnson, M.P.; Tyack, P.L.; Witt, M.J.; Blondel, P.; Parks, S.E. Measuring acoustic habitats. *Methods Ecol. Evol.* **2015**, *6*, 257–265. [CrossRef] [PubMed]
42. Barlett, M.L.; Wilson, G.R. Characteristics of small boat signatures. *J. Acoust. Soc. Am.* **2002**, *112*, 2221. [CrossRef]
43. Amoser, S.; Wysocki, L.E.; Ladich, F. Noise emission during the first powerboat race in an Alpine lake and potential impact on fish communities. *J. Acoust. Soc. Am.* **2004**, *116*, 3789–3797. [CrossRef]
44. Picciulin, M.; Sebastianutto, L.; Codarin, A.; Farina, A.; Ferrero, E.A. In situ behavioural responses to boat noise exposure of Gobius cruentatus (Gmelin, 1789; fam. Gobiidae) and Chromis chromis (Linnaeus, 1758; fam. Pomacentridae) living in a Marine Protected Area. *J. Exp. Mar. Biol. Ecol.* **2010**, *386*, 125–132. [CrossRef]
45. Mensinger, A.F.; Putland, R.L.; Radford, C.A. The effect of motorboat sound on Australian snapper Pagrus auratus inside and outside a marine reserve. *Ecol. Evol.* **2018**, *8*, 6438–6448. [CrossRef]
46. Herzing, D.L. Vocalizations and associated underwater behavior of free-ranging Atlantic spotted dolphins, Stenella frontalis and bottlenose dolphins, Tursiops truncatus. *Aquat. Mamm.* **1996**, *22*, 61–80.
47. Gospić, N.R.; Picciulin, M. Changes in whistle structure of resident bottlenose dolphins in relation to underwater noise and boat traffic. *Mar. Pollut. Bull.* **2016**, *105*, 193–198. [CrossRef]
48. Van Ginkel, C.; Becker, D.M.; Gowans, S.; Simard, P. Whistling in a noisy ocean: Bottlenose dolphins adjust whistle frequencies in response to real-time ambient noise levels. *Bioacoustics* **2018**, *27*, 391–405. [CrossRef]
49. Kinsler, L.E.; Frey, A.R.; Coppens, A.B.; Sanders, J.V. *Fundamentals of Acoustics*; John Wiley & Sons: Hoboken, NJ, USA, 2000.
50. Fox, J.; Weisberg, S. *An {R} Companion to Applied Regression*, 3rd ed.; Sage: Thousand Oaks, CA, USA, 2019.
51. Dinno, A. dunn. test: Dunn's test of multiple comparisons using rank sums. *R package version* **2017**, *1*, 1.
52. La Manna, G.; Manghi, M.; Pavan, G.; Lo Mascolo, F.; Sarà, G. Behavioural strategy of common bottlenose dolphins (*Tursiops truncatus*) in response to different kinds of boats in the waters of Lampedusa Island (Italy). *Aquat. Conserv. Mar. Freshw. Ecosyst.* **2013**, *23*, 745–757. [CrossRef]
53. Morisaka, T.; Shinohara, M.; Nakahara, F.; Akamatsu, T. Effects of ambient noise on the whistles of Indo-Pacific bottlenose dolphin populations. *J. Mammal.* **2005**, *86*, 541–546. [CrossRef]
54. Scarpaci, C.; Bigger, S.W.; Corkeron, P.J.; Nugegoda, D. Bottlenose dolphins (*Tursiops truncatus*) increase whistling in the presence ofswim-with-dolphin'tour operations. *J. Cetacean Res. Manag.* **2000**, *2*, 183–185.
55. Urick, R.J. *Principles of Underwater Sound*, 2nd ed.; McGraw-Hill Book Company: New York, NY, USA, 1975.
56. Leon-Lopez, B.; Romero-Vivas, E.; Viloria-Gomora, L. Reduction of roadway noise in a coastal city underwater soundscape during COVID-19 confinement. *J. Acoust. Soc. Am.* **2021**, *149*, 652–659. [CrossRef] [PubMed]
57. Richardson, W.J.; Würsig, B. Influences of man-made noise and other human actions on cetacean behaviour. *Mar. Freshw. Behav. Phy.* **1997**, *29*, 183–209. [CrossRef]
58. Lusseau, D. The hidden cost of tourism: Detecting long-term effects of tourism using behavioral information. *Ecol. Soc.* **2004**, *9*. [CrossRef]
59. Sini, M.; Canning, S.J.; Stockin, K.; Pierce, G.J. Bottlenose dolphins around Aberdeen harbour, north-east Scotland: A short study of habitat utilization and the potential effects of boat traffic. *J. Mar. Biol. Assoc. United Kingd.* **2005**, *85*, 1547–1554. [CrossRef]

60. Buckingham, C.A.; Lefebvre, L.W.; Schaefer, J.M.; Kochman, H.I. Manatee response to boating activity in a thermal refuge. *Wildl. Soc. Bull.* **1999**, *27*, 514–522.
61. Holt, M.M.; Noren, D.P.; Dunkin, R.C.; Williams, T.M. Vocal performance affects metabolic rate in dolphins: Implications for animals communicating in noisy environments. *J. Exp. Biol.* **2015**, *218*, 1647–1654. [CrossRef]
62. Wartzok, D.; Poppper, A.; Gordon, J.; Merrill, J. Factors affecting the responses of marine mammals to acoustic disturbance. *Mar. Technol. Soc. J.* **2004**, *37*, 6–15. [CrossRef]
63. Jensen, F.H.; Bejder, L.; Wahlberg, M.; Soto, N.A.; Johnson, M.; Madsen, P.T. Vessel noise effects on delphinid communication. *Mar. Ecol. Prog. Ser.* **2009**, *395*, 161–175. [CrossRef]