LONG-FINNED PILOT WHALE (*GLOBICEPHALA MELAS*) RESPONSE TO WHALE-WATCHING VESSELS IN THE STRAIT OF GIBRALTAR

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ABSTRACT

Four species of resident cetaceans coexist in the Strait of Gibraltar, of which the long-finned pilot whale (*Globicephala melas*) is the most frequently observed. Our study was carried out between May and September during the past 4 years. Data was collected on the response of the target species towards whale-watching vessels (initial and general), and was categorised in 3 groups: approximation, indifference, and evasion. These 3 categories were statistically confronted against different collected variables (e.g. wind scale, wind direction, sea state, sighting duration, association with other vessels, etc.) using a table of contingencies. The response - be it initial or general - was statistically significant (p-value < 0,05) when confronted to some of the analysed variables. One of the main results of the study shows that the largest part of long-finned pilot whales sightings were represented by approximation or indifferent initial and general behavior towards the whale-watching vessels. Most of the evasive behavior was observed in the seasons of 2004 and 2005, coinciding with an increase in discoordination among whale-watching operators. We conclude that the evasive behavior of pilot whales in the Strait of Gibraltar is directly related to the cooperation between whale-watching vessels which is directed at limiting the activity's impact. In view of the results, it seems necessary to establish a carrying capacity for the number of whale-watching opreators in the Strait of Gibraltar and increase the collaboration between operators, as well as to adjust the whale-watching codes of conduct with Morocco, as the main part of sightings take place in Moroccan waters. This code of conduct should be enforced by a bilateral control body from Spain and Morocco.

INTRODUCTION

Whale watching can be defined as an ecotouristic activity, which is a nature tourism in addition to a series of contributions to conservation of species or habitats involved (Goodwin, 1996). In addition to the economic benefit, local employment (IFAW, 1999) as well as occasinally platforms for scientific research are created (Robbins & Mattila, 2000). Whale watching is defined by the IWC (International Whaling Commission) as any comercial activity which provides the public with the opportunity to observe these animals in their natural habitat. The beginnings of whalewatching date back to 1995 on the south coast of California (Hoyt, 1992), and since 1990 it has continually grown from 31 countries to 87 in 1998 (Hoyt, 2001). In the Strait of Gibraltar the number of whale-watching visitors per year increased from 400 in 1998 to 20000 in 2003 (Carbó *et al*., 2007) and up to 37000 in 2007 (E. Andreu, personal comunication).

There are also many studies showing changes in normal behavior and natural use of habitat as results to exposure to whale-watching activity (Bejder & Samuels, 2004; Orams, 2004). Slight behavioral changes have been reported on the short term (Corkeron, 2004). On one occasion, a long term study on the impact of commercial whale watching on a resident species, showed that there was a negative effects on the reproductive rate and distribution by increasing the number of whale-watching vessels by just one vessel (Bejder *et al.,* 2006). These negative effects are determining vital factors. Up to four resident species of cetaceans can be observed in the Strait of Gibraltar: common dolphin (*Delphinus delphis*), striped dolphin (*Stenella coeruleoalba*), bottlenose dolphin (*Tursiops truncatus*) and the long-finned pilot whale (*Globicephala melas*).

The pilot whale is the target species for the whale-watching activities, representing the most frequently sighted species together with the bottlenose dolphin, and thus potentially the most susceptible species to suffer from the impact of this activity. For the area of the Strait of Gibraltar, a total of approximately 270 pilot whales have been estimated (Verborgh *et al.,* 2006). The purpose of this study is to determine whether the cetaceans' behavioral response varies significantly according to the different variables collected during the study period, and if there is any relationship between this variation and certain factors intrinsic to this activity. The ultimate goal is to determine the level of impact of the whale-watching activity on the long-finned pilot whale population in the Strait of Gibraltar, and to establish the best modus operandi for the operators, in order to avoid the overexploitation of the resource.

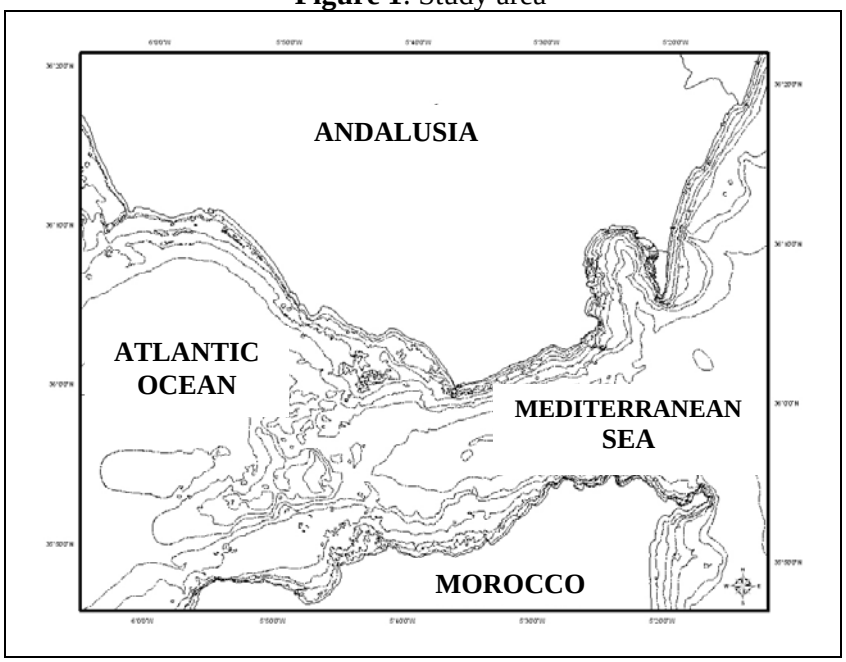
On the 21st of December 2007, the Royal Decree 1727/2007 was accepted in which protection measures for cetaceans are defined and which aim at regulating determined human activities dedicated to whale watching, be it for touristic, scientific or recreative purposes. This Royal Decree formulates a series of criteria and rules in order to keep this activity within a sustainable framework and to lower the disturbance and negative effects which can arise from whale-watching activities.

MATERIAL AND METHODS

STUDY AREA

The Strait of Gibraltar is the only communication channel between the Mediterranean Sea and the Atlantic Ocean (cf. Figure 1). The création of the Strait is linked to the tectonic processes between the eurasian and african tectonic plates. The Strait is 60 km long between the imaginary lines which unite Cape Trafalgar in Andalusia with Cape Spartel in Morocco, and Almina Point in Ceuta with Europa Point in Gibraltar. The channel has a maximum width of 44 km between Cape Trafalgar and Cape Spartel, and a minimal width between Tarifa and Punta Cires (cf. Figure 1 in the Annex).

Figure 1: Study area



Given the tectonic processes mentionned above, the bottom of the channel posesses a very chaotic bathymetry which goes from minimal depths in the central area of the occidental side of about 100m (Bajo de Camarinal), up to depths of approximately 900 m in the oriental side between Carnero Point and Punta Cires. Predominant winds in our study area are composed by the western Poniente and the eastern Levante. These are quite strong winds due to the acceleration generated by the geography of the area which is composed of mountains on both shores. The local oceanography is characterised by the exchange of water masses between the Atlantic and the Mediterranean. The strong evaporation in the Mediterranean Sea (Tchernia, 1978) and the exit of mediterranean water through the Strait of Gibraltar generates a deficit which is not compensated by the freshwater input of rivers and precipitations, leading to a negative equilibrium. All this added to the thermo-haline differences of the mediterranean and atlantic waters, favors relevantly the exchange of water masses at depth (Lacombe & Richez, 1982). The stratification of both water masses in the Strait of Gibraltar is due to the difference in density between both masses. Between the 2 water masses an interface is created, which is located in the column related to the internal tide.

DATA COLLECTION

Data collection was carried out during the months of April to October the years 2003 to 2007. In 2003, data was collected btween June 1st and October 13th; in 2004 between the 8th of May and the 15th of September; in 2005 between the 23rd of April and the 18th of September; in 2006 between the 22nd of May and the 30th of September; and in 2007 between the 1st of May and the 30th of September.

Data was collected from 2 commercial whale-watching vessels which operate in the Strait of Gibraltar: the Jackelin (see Figure 2) of 26 m length and a total capacity of 180 passengers, and the Dolphin Safari (see Figure 3) of 20 m length and a total capacity of 60 passengers. Data analysed during the 2003 trhough 2006 seasons were collected from the Jackelin, whereas data analysed for the following year were collected from the Dolphin Safari.

Figure 2: The larger vessel "Jackelin"

Figure 3: The smaller vessel "Dolphin Safari"

Data collected corresponds to the protocols established by the SEC (Spanish Cetacean Society) (S.E.C., 1999). Each sighting was divided in 3 sections: first sighting, contact and end of sighting. For each section, GPS coordinates as well as meteorological and oceanografic data were recorded. Activity was also recorded for each section. Speed of approximation of the cetaceans was collected in the first section, as well as the distance from which the dolphins were detected and the behavior at detection. Data on social structure (cohesion, group size, calf presence, interactions…) and to the general behavior (association with birds, boats, orientation…). The animals' response towards the vessel was collected for both contact and end of sighting, and was grouped as approach, indifference or evasion. Approximation was accpeted when the dolphins came towards the vessel once it was in the restricted permanence area, approximately at 60 m. Indifference was considered as a neutral attitude towards our vessel without approaching or leaving. Evasive behavior was considered when the dolphins swam away from the vessel. In addition, data on effort was collected.

DATA TREATMENT

The statistical analysis carried out is a contingnecy table in which the 3 initial and general responses (approximation, indifference and evasive behavior) were confronted with all the other collected variables. Initial response was collectd in the contat section of the data collection form and corresponds with the event of our approximation towards the pilot whales. General behavior was collected in the general behavior section and represents the animals'behavior towards the presence of our vessel during the sightings.

RESULTS AND DISCUSSION

The result were 774 sightings of long-finned pilot whales, of which 5 events were discarded because of incomplete data, from a total of 859 sighting trips. A total of 31150 km were covered, which corresponds to 1874 hours. The maximum sigthing rate was found in 2004, being similar in the rest of the years (cf. Table 1).

Table 1. Summary of the sampling effort

	ESFUERZO				
YEARS	*NUMBER OF SIGHTINGS*	*SIGHTING RATE (SIGHT/TRIP)*	*DISTANCE COVERED (Km)*	*SAMPLING DURATION (hours)*	*NUMBER OF SIGHTING TRIPS*
2003	181	0,78	7270	429	185
2004	176	1,07	6063	363	165
2005	169	0,78	6989	461	216
2006	111	0,83	5283	287	134
2007	137	0,86	5545	334	159
TOTAL	774		31150	1874	859

All hypothesis were tested via contingency tables, in order to analise the relation between different qualitative variables. The contingency table shows acquired absolute frequencies, i.e. totals of each variable. To know if these are randomly distributed or on the other hand they are interdependant, a Chi-square test was carried out.

This test is:

- H0: Both populations are homogenous (n(i,j) = n(i',j') for any (i,j,i'j')
- H1: Both populations are heterogeneous (variables are interdependent)

The value of the Chi-square test measures the difference between values n(i,j) from the table and the theoretical values which should correspond under the null hypothesis.

If its p-value is inferior to 0,05, this indicates a significant difference and thus rejects the null hypothesis. In this case, a contrast of verosimilitude is carried out to ensure the results are correct. If there is dependence between both variables, it is quantified with the following association means: C (contingency coefficient), Cramer's V and Phi (see Tables 4 and 5)

The contrasts between initial and general responses during the different seasons were statistically significant. Simply put, one can deduct from the study that long-finned pilot wahles react to vessels with indifferent or approximation behavior. Although evasive data are relatively small in comparison with the previously mentioned behaviors, it can be clearly seen that this behavior is concentrated in the years 2004 and 2005 (see Figure 1). These years were characterised by uncoordinised whale-watching activity amongst the different operators, and by the chaos in the modus operandi of the whale-watching vessels. The increase in vessels may well be seen as a potential problem towards the animals, although this one has showed to be negligible.

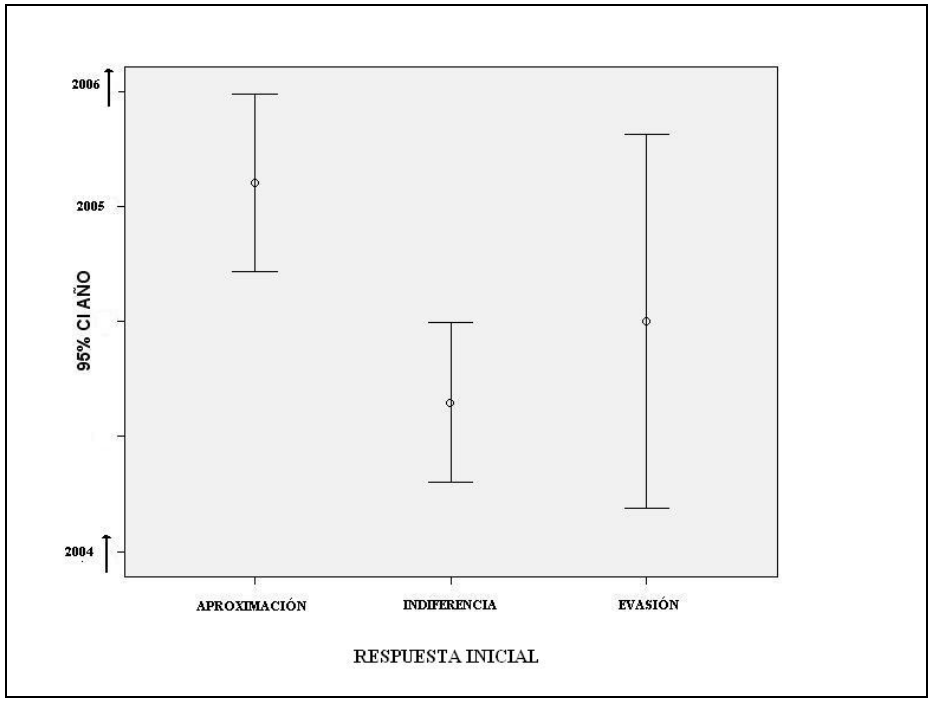
Table 4. Initial response/year contingency table

CONTINGENCY TABLE	YEAR					*TOTAL*
	2003	*2004*	*2005*	*2006*	*2007*	
APROXIMATION	52	49	70	71	47	289
INDIFFERENCE	112	107	82	34	78	413
EVASIVE BEHAVIOR	0	7	10	3	0	20
TOTAL	164	163	162	108	125	722

Tabla 5. General response/year contingency table

CONTINGENCY TABLE	YEAR					*TOTAL*
	2003	*2004*	*2005*	*2006*	*2007*	
APROXIMATION	80	54	93	74	70	371
INDIFFERENCE	77	94	60	32	57	320
EVASIVE BEHAVIOR	3	15	12	2	1	33
TOTAL	160	163	165	108	128	724

Figure 1. Boxplot representing *initialresponse against to the variable year*



Initial and general responses were also statistically significant in relation to the presence/absence of calves and neonates. This could mean that although there is a significant dependence relationship, there is no proof that the presence of calves or neonates leads to an evasive response in long-finned pilot whales. In fact, approximation occurs in presence of calves, as can be seen in Figure 2, where the initial approximation behavior is concentrated closely to calf presence. This is possibly due to the curious nature of calves towards the vessels.

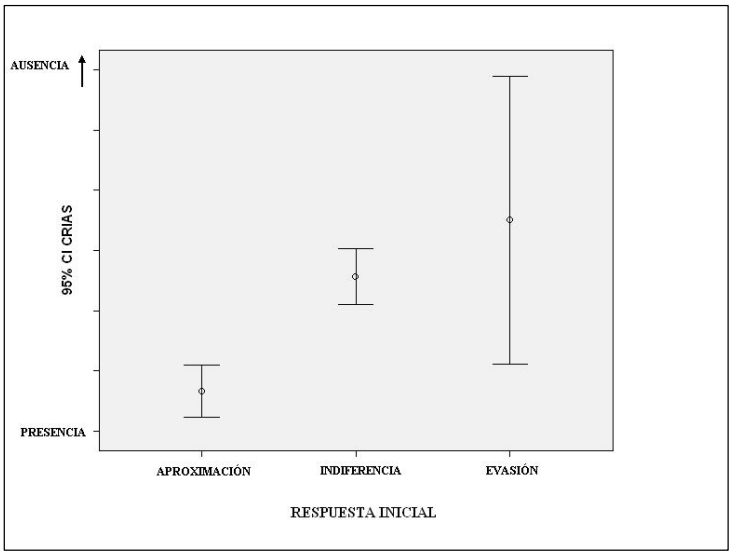
Table 6. Initial response/calf absence/presence contingency table

CONTINGENCY TABLE	*CALF PRESENCE/ABSENCE*		*TOTAL*
	PRESENCE	*ABSENCE*	
APROXIMATION	241	48	289
INDIFFERENCE	266	147	413
EVASIVE BEHAVIOR	11	9	20
TOTAL	518	204	722

Table 7. General response/calf absence/presence contingency table

CONTINGENCY TABLE	*CALF PRESENCE/ABSENCE*		*TOTAL*
	PRESENCE	*PRESENCE*	
APROXIMATION	312	59	371
INDIFFERENCE	196	124	320
EVASIVE BEHAVIOR	16	17	33
TOTAL	524	200	724

Figure 2. Boxplot representing *initial response against the variable presence/absence of calves*



The contrast between initial response and the previous association of the ilot whales to whale-watching vessels is also significant. The amount of sightings in which the study vessel approaches pilot whales when these are already associated to another whale-watching vessel is lower than the number of occasions in which we have exclusive contact with these animals. Nevertheless, not a single evasive behavior is observed when pilot whales which are already in contact with a previous vessel is approached by our vessel. This could be interprated as a habituation behavior of the pilot whales to the presence of vessels.

Tabla 8. Initial response/association with vessels contingency table

CONTINGENCY TABLE	*ASOCIATION WITH VESSELS*		*TOTAL*
	NO	YES	
APROXIMATION	266	22	288
INDIFERENCE	393	14	407
EVASIVE BEHAVIOR	20	0	20
TOTAL	679	36	715

The contrast between initial and general response in relation to group size is also significant. The amount of sightings in which evasive behavior was the initial response is reduced to zero when group size increases. In Figure 3 it can be observed how evasive behavior is related to the minimum group size encountered. This may be due to a sensation of security and thus greater tolerance towards the presence of vessels when group size is high.

CHI SQUARE TEST	*INITIAL RESP. -YEAR*		*INITIAL RESP.- PRES/ABS. CALF*		*INITIAL RESP.-ASOC. VESSEL*		*INITIAL RESP.-GROUP SIZE*	
	VALUE	*P-VALUE SIG*	*VALUE*	*P-VALUE SIG*	*VALUE*	*P-VALUE SIG*	*VALUE*	*P-VALUE SIG*
CHI-SQUARE TEST								
PEARSON'S CHI-SQUARE	61,325	0,000	33,073	0,000	7,310	0,026	29,343	0,000
VEROSIMILITUDE	67,222	0,000	34,504	0,000	8,042	0,018	29,930	0,000
LINEAR TO LINEAR ASSOCIATION	10,581	0,001	32,312	0,000	7,281	0,007	29,056	0,000
ASSOCIATION MEASURES								
PHI	0,291	0,000	0,214	0,000	0,101	0,026	0,208	0,000
CRAMER'S V	0,206	0,000	0,214	0,000	0,101	0,026	0,147	0,000
CONTINGENCY COEFFICIENT	0,280	0,000	0,209	0,000	0,101	0,026	0,204	0,000

Table 2. Statistical results for each contrast between initial response and variables.

CHI SQUARE TEST	*GENERAL RESP.-YEAR*		*GENERAL RESP.-PRES/ABS. CALF*		*GENERAL RESP.-GROUP SIZE*		*GENERAL RESP.-BEHAVIOR*		*GENERAL RESP.-SIGHTING DURATION*	
	VALUE	*P-VALUE SIG*	*VALUE*	*P-VALUE SIG*	*VALUE*	*P-VALUE SIG*	*VALUE*	*P-VALUE SIG*	*VALUE*	*P-VALUE SIG*
CHI-SQUARE TEST										
PEARSON'S CHI-SQUARE	51,297	0,000	54,727	0,000	47,179	0,000	76,491	0,000	11,491	0,003
VEROSIMILITUDE	53,575	0,000	55,377	0,000	52,283	0,000	81,854	0,000	12,130	0,002
LINEAR TO LINEAR ASSOCIATION	11,015	0,001	53,535	0,000	45,887	0,000	3,631	0,057	11,439	0,001
ASSOCIATION MEASURES										
PHI	0,266	0,000	0,275	0,000	0,263	0,000	0,331	0,000	0,128	0,003
CRAMER'S V	0,188	0,000	0,275	0,000	0,186	0,000	0,234	0,000	0,128	0,003
CONTINGENCY COEFFICIENT	0,257	0,000	0,265	0,000	0,254	0,000	0,314	0,000	0,127	0,003

Table 3. Statistical results for each contrast between general response and the variables.

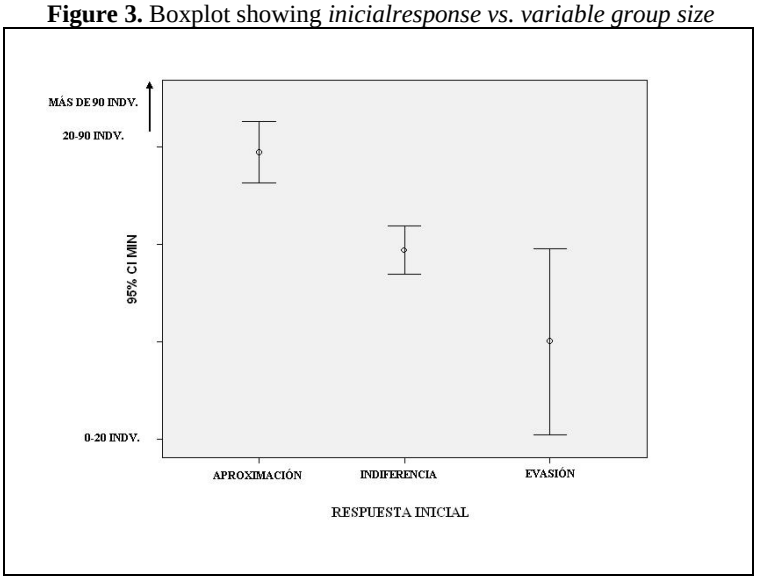
Table 9. Initial response/group size contingency table

CONTINGENCY TABLE	*MINIMAL GROUP SIZE (INDIVIDUALS)*			*TOTAL*
	0-20	20-90	> 90	
APROXIMATION	118	149	6	273
INDIFFERENCE	237	145	2	384
EVASIVE BEHAVIOR	16	4	0	20
TOTAL	371	298	8	677

Table 10. General response/group size contingency table

CONTINGENCY TABLE	*MINIMAL GROUP SIZE (INDIVIDUALS)*			*TOTAL*
	0-20	20-90	> 90	
APROXIMATION	154	189	8	351
INDIFFERENCE	195	106	0	301
EVASIVE BEHAVIOR	28	4	0	32
TOTAL	377	299	8	684

Figure 3. Boxplot showing *inicialresponse vs. variable group size*



General activity which was the most commonly observed during the sighting, was also contrasted against the animals' general response. The result was a statistically strongly significant relationship between both. Travelling and resting behavior represent a large part of the pilot whales' general response. Nevertheless, a noticeable increase is observed in milling and socialising as general behavior in comparison to initial behavior in which the strong majority was composed of travelling and resting behavior.

Table 11. General response/ general behavior contingency table

CONTINGENCY TABLE	*GENERAL ACTIVITY*							*TOTAL*
	INDETERMINED	*FEEDING*	*RESTING*	*MILLING*	*SOCIALISATIÓN*	*TRAVELLING*	*ON BOW*	
APROXIMATION	4	5	98	72	17	159	8	363
INDIFFERENCE	10	4	54	22	2	210	0	302
EVASIVE BEHAVIOR	2	0	14	2	0	14	0	32
TOTAL	16	9	166	96	19	383	8	697

CONCLUSIONS

The initial response of long-finned pilot whales to whale-watching vessels in the Strait of Gibraltar is mostly of approximation or indifference, the evasive response being much less frequent.

Uncoordinated whale watching in the Strait of Gibraltar usually leads to an evasive initial and general response of long-finned pilot whales, because of the chaotic situation.

The presence/absence of young animals and neonates is not a determinig factor considering the long-finned pilot whale evasive response, be it initial or general. Nevertheless, the presence of calves favors the approximation of the whale-watching vessels, possibly because of the curiosity of these young animals which start their independenct expolration.

The larger the size of the group of animals, the less frequent the initial and general evasive response towards the research vessel, which could indicate that a larger group provides more security.

RECOMMENDATIONS

As the association of cetaceans to a previous whale-watching vessel, decrease the evasive behavior response to an additional arrival of a vessel, whereas the discoordination of whale-watching operators tends to increase the same response, it is recommended to coordinate the different operators in order to reduce as much as possible the possible impact on the long-finned pilot whales..

Increase the effort to find larger groups of long-finned pilot whales during trips, as these are less evasive and possibly less disturbed by the presence of vessels.

Try to define a ww-vessel carrying capacity in the Strait of Gibraltar and stimulate the use of the resource through non-disturbing activities, as for example with land-based observations during scenic tours through the Natural Park of the Strait of Gibraltar.

To collaborate as far as possible with whale-watching operators in order to collect behavioral data, emphasising on the response towards vessels, in order to achieve larger scale studies, as recommende by the IWC WW subcommittee.

Standardise data collection among all the whale watching companies in order to improve the compatibility comparative studies.

It is recommended to continue this study in order to assess the impact on the long-finned pilot whale population in the Strait of Gibraltar, as well as to try to include the other cetacean species present in the area.

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