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The short-term impact of dolphin-watching on the behaviour of bottlenose dolphins (Tursiops truncatus) in western Australia.

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Abstract
This paper presents the research findings of interactions between bottlenose dolphins (*Tursiops truncatus*) and a dolphin-watching Tour Boat in Bunbury (Western Australia). Sixty-four hours of surface behaviour observations were collected with "focal group sampling" assessed over three minute intervals. The study compared behaviour patterns both with and without the presence of the Tour Boat. The results show that the presence of the Tour Boat can influence the duration (time spent) and frequency (number of occurrences) of behavioural states and also the structure of the population. The time spent resting ($P<0.05$) and feeding ($P<0.01$) decreased, whereas travelling ($P<0.01$) increased. The frequency of all the behavioural states increased, in particular travelling, resting ($P<0.01$) and feeding ($P<0.05$). The group structure was also influenced ($\chi^2 = 11.44$; $P<0.01$), as dolphins tend to spread in more groups of fewer animals in the presence of the Tour Boat. The behaviour analysis of the direct reaction of animals in close contact by the Tour Boat showed that dolphins displayed attraction in 20% of cases and were deterred in 28% of cases; for the rest, the response was neutral. The short-term changes in behaviour pattern can be used as an early indicator of potential halt to animal vulnerability in order to assess and recommend appropriate management and conservation strategies especially in regions, such as the Mediterranean Sea, where, for the combination of many disturbance factors, cetacean populations are vulnerable. [JMATE. 2009;2(1):3-9]

Keywords: Behavioural state, bottlenose, dolphin-watching, indicator, MPA management, *Tursiops*.

Introduction

Dolphin and whale watching has become a popular eco-tourism activity, more than ever during the past 10 years. In some areas, such as the Mediterranean Sea, where dolphin-fishery trophic competition is common (15, 19), it has been even suggested to convert in part the fishing industry into dolphin-watching in order to transform existing competition into a more sustainable activity, especially in Marine Protected Areas. However, the impact of such activity on marine mammals is still not well known and there is growing concern over the effects of this industry on dolphin behaviour and conservation.

In order to prevent negative impacts on the animals by cetacean watching, relevant conservation authorities have already published reports (9, 24) and observation guidelines (4, 1). More studies are however needed to better understand and verify the effects of this interaction.

Dolphins deal with anthropogenic activities at sea and animal behaviour changes in response to these interactions. Changes in behavioural pattern can be used as an early indicator of the impact of human activities and can help wildlife management to adopt appropriate conservation measures to reduce the consequences of disturbance and population vulnerability.

Studies on small cetaceans in the presence of tour vessels have documented short-term changes in animal activity including: breathing rates in *Tursiops truncatus* (*T.t.*) (25, 34); swimming directions in *Stenella* spp., *Orcinus orca* and *Tursiops aduncus* (7, 45, 27) and speed in *Orcinus orca* and *T.t.* (26; 34); diving times in *T.t.* and *Sousa chinensis* (20; 33); phonation rates in *T.t.* (39, 14); specific behavioural states such as travelling (27) and feeding (2), behavioural state patterns (28, 17) and synchrony (23), in *T.t.*. Furthermore, Bejder *et al*. (12) evaluated changes in relative abundance due to long-term disturbance in bottlenose dolphin (*Tursiops* sp.). Other studies have focused on the interactions between dolphins (*T.t.*) and "swim-with" activities (38).

However, due to the massive growth of this new anthropogenic activity, more information is needed to better understand the impact of these interactions on wildlife and to be able to properly manage the industry and improve the protection guidelines that safeguard the watched populations.

In the Mediterranean Sea, for example, bottlenose dolphin populations (*T.t.*) are scattered (5, 31) and animals are declining in number (36). As a consequence, the impact of a human activities such as dolphin-watching can have a harmful effect on conservation of local populations. On the other hand, sightings are considered more an event then a state and it is very difficult to have enough records of surface behaviour, both with and without the presence of a Tour Boat, to be able to statistically compare differences.

In Australia and New Zealand, by contrast, where marine mammals are far more abundant and cetacean tourist activity is at present more common, data on dolphin behaviour patterns are easier to collect and statistically meaningful conclusions can be drawn. For these reasons a study was undertaken on the interactions between bottlenose dolphins (*T.t.*) and a dolphin-watching Tour Boat in Bunbury (Western Australia).

The study analyses the short-term impact on all the surface behavioural states (40) and, due to specific conditions that excluded any uncertainty from other 'treatments' (37, 11), the trial was divided into a 'control' ('without' the Tour Boat and only the presence of the investigator boat) and an 'exposed' (only 'with' the Tour Boat and the investigator boat present).

The aim of the research was to compare the behaviour of bottlenose dolphins in the absence ('without') and presence ('with') of a Tour Boat, in order to better understand what kinds of dolphin behaviour were more subject to changes and,

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knowing the biology of the species, to suggest appropriate strategies for approaching the animals and/or reducing, where necessary, interaction with the wildlife.

Materials and Methods

The area

Bunbury is located approx. 200km south of Perth (Western Australia). Within Koombana Bay the study site is located at the right side of the "Cut" of the Leschenault estuary (33°18.07'S 115°40.20'E) north of the city of Bunbury (Fig. 1). The study area was chosen because the protected and shallow waters are home to an already established and structured dolphin population. Furthermore many dolphins were already photo-identified by the Bunbury Dolphin Discovery Centre, which also assisted the research with trained volunteers. Good weather conditions during the summer season allowed for excellent and lasting viewing conditions. The dolphins usually spend their time in the area around the "Cut". Their behaviour patterns are of relatively long duration with prolonged sequences of activities. This allowed for long time sampling with the motor of the investigator inflatable often being turned off. Two or three times a day a Tour Boat interacted with the animals for dolphin watching activity.

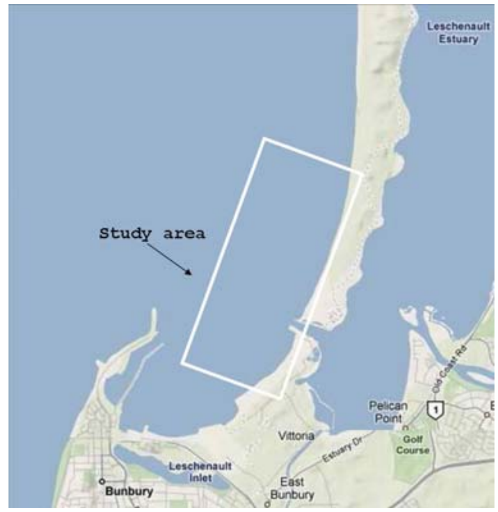

Figure 1: Map of the study area.

Data collection

A total of 64 hours of sampling of surface behaviours with and without the 'dolphin watching' Tour Boat were recorded by the same investigator.

Behaviour was recorded by scan sampling of the focal school with the recording of the predominant group activity, subsequent to a scan on the individuals within the school, and assessed over a 3 minutes sampling interval (3, 30).

A school was defined as individuals in apparent association, moving in the same direction, engaged in the same activity (40) and within 10m of one another (43).

The investigator recorded the number of schools visible from the investigator boat, the number of dolphins and the surface behaviour in the nearest school. When more than one school was present, or if two merged or one split, only the behaviour of the closest school was recorded together with the number of animals. Data were only collected in good weather and sea conditions (Beaufort 2 or less).

The observation area was considered approximately 350m in each direction from the investigator boat, which was manoeuvred as far as possible to minimise effects on the school of dolphins. Most of the time the engine was turned off and, if the school needed to be followed, the boat moved at approximately 50m distance, in parallel to the animal's directions and matching the same speed of the school.

To minimise the effect of the investigator boat as a disturbance factor, the investigator boat always maintained the same procedure with or without the presence of the Tour Boat. The study was undertaken in weekdays and there were rarely other boats, however, when another boat came within 350m of the animals, data were not recorded.

The predominant group activity, or behavioural state, was deduced at the end of the three minute sampling and on the basis of various objective and discrete factors such as: group type and dimension, association, distance, direction, breathing rates, speed, progress, prey, acoustic and superficial behaviour. The behavioural states were divided into six categories, reciprocally exclusive, such as:

Travelling	(T)	Straight movement (>2 mph), breathing rates less than 30 sec., sometimes with few changes of direction (travelling around), dorsal fin as superficial behaviour.
Socialising	(S)	Physical contact, rubbing, bowing, arching, bonding, sometime with tail slapping of some individuals. Many clicks and whistles. This includes playing, which involves chasing or displays of calve or surf on waves.
Resting	(R)	Slow travel, (<2mph), frequent floating at surface, frequent direction changes.
Milling	(M)	No consistent movement (<2mph).
Feeding	(F)	Long dive with rapid surfacing, frequent direction changes, fast swim, fish chase, with or without bird diving, many clicks and echo-location sounds.
Diving	(D)	Dive longer than 3 min.

Furthermore, conduct of direct reaction of animals in 'close contact' by the Tour Boat was recorded in three different categories:

Attracted	Bow riding, approaching or following the boat, begging.
Neutral	Swimming around and underneath the boat.
Deterred	Escaping from boat, tail slapping close to the boat, blowing, long dive (>3 minutes).

The 'without' behaviour was recorded in the absence of any other vessel, except for the investigator boat, within a distance of approximately 350m. The 'with' behaviour started from when the Tour Boat was approximately less than 150m from the dolphins. Data records of when the Tour Boat was within the 350 and 150m zone, were not used in the analysis. Sequences ended when the focal school was lost (usually during travelling) or when observation was not possible (bad weather condition or day end).

Uncertain behaviours were uncommon and so have not been considered in the analysis, together with the first three sample intervals taken after the arrival of the investigator.

The statistical sample unit was the sequence of the 3 min. sampling interval of the focal school scan sampling. Only sequences longer than 36 min. (12 sampling intervals) were used to assess differences in behavioural state. Each sequence was separated by the following by a minimum of 45 minutes.

'Close contact' data records (n=36) were analysed separately and were not used to evaluate the 'without' versus the 'with' behavioural state differences.

Data analysis

This study compared the states 'without' versus 'with' the 'dolphin watching' Tour Boat for the following parameters:

a) numbers of school detectable from the investigator boat;

b) number of dolphins in the school of which the superficial behaviour was recorded;

c) duration, expressed as relative percentage of time spent performing a behavioural state (32);

d) frequency, measured as the number of occurrences of a behavioural state per unit of time-30 minutes (32).

Figures are expressed as mean ± standard error.

Sequences used in the analysis lasted from 36 to 210 minutes (mean 63 ± 9 minutes).

A total of 28 sequences taken without and 18 sequences taken with the Tour Boat (for a total of 51.4 hours) were unpaired compared with the Mann-Whitney U-Test to assess differences in the duration and frequency of behavioural states.

The Chi-square Test was used to test the association between two treatments and the frequency of:

a) numbers of detected schools;

b) number of 3 minute sampling intervals spent performing a behavioural state (duration);

The null hypothesis was that the proportion of number of detected schools/sampling interval in each of the categories of number/behavioural states, was the same without and with the presence of the Tour Boat.

Data were gathered in the summer of 2000 and the deductions are particularly relevant as, with the rising popularity of Bunbury as a location for dolphin watching activities, there is increased concern for an appropriate management of this industry. The results of this study will be useful also to test long-term responses to the behaviour pattern due to this specific disturbance factor.

Results

Of the 1278 3 minute behavioural sample intervals collected, 1028 were used in the analysis: of these 781 were recorded without any type of boat present except that of the investigator, while 247 were also recorded with the commercial Tour Boat present.

For the 'without treatment' the average sequence length was 69 ± 19.6 minutes; the dolphins tended to associate in schools of a mean group size of 6.93 ± CI 0.65 (St. Dev. 1.74) and a median of 6. A mean of 1.25 ± CI 0.19 (St. Dev. 0.52) schools were detected (Table 1) and in more than 75% of the records only one school was sighted (Fig. 2).

For the "with treatment", the average length of the sequence was 46.8 ± 4.5 minutes, the mean group size was 6.11 ± CI 0.64 (St. Dev. 1.53) and the median was 6. A mean of 1.59 ± CI 0.36 (St. Dev. 0.85) schools of dolphins were detected (Table 1) and in 40% of the records more than one school was sighted (Fig. 2).

The duration in the presence of the Tour Boat of travelling, milling and diving increased, while resting, socialising and feeding decreased. Significant difference in the duration of behaviour was shown for travelling (P<0.01), feeding (P<0.01) and resting (P<0.05) (Table 1) (Fig. 3).

The frequency in the presence of the Tour Boat showed an increase in all behaviours (Fig. 4) with a statistically significant difference for travelling (P<0.01), resting (P<0.01) and feeding (P<0.05) (Table 1). In most of the cases, dolphins changed their behaviour pattern between the first and the third sample interval after the arrival (<150 m from the dolphins) of the Tour Boat.

The group structure was also influenced (Table 1, Fig. 2), as dolphins in the presence of the Tour Boat tended to spread out into more groups with fewer animals. In presence of the Tour Boat, in fact, the mean number of detected schools increased by 27% while mean group size decreased by 12%; the

	Duration %						Frequency						Mean number of dolphins per school	Median	Mean number of detected school	Close contact %
Behavioral state	T	S	R	M	F	D	T	S	R	M	F	D				
Without	27.4	16.0	30.6	3.2	20.0	2.9	0.8	0.4	0.4	0.1	0.3	0.1	6.93	6	1.25	
With	46.1	12.8	20.1	6.0	7.6	7.5	1.8	0.6	0.8	0.3	0.5	0.4	6.11	6	1.59	
Mann-Whitney U-Test	**		*		**		**				*					
Chi-Square	***														**	
Attracted																20
Neutral																52
Deterred																28

Table 1: Comparison of states without and with the Tour Boat. Percentage of conduct of close contact by the Tour Boat. Mann-Whitney U test to assess differences in the duration and frequency of behavioural states. Chi Square to test respectively the association between number of sampling interval in each category of behavioural states and the quantity of detected school in each of the numerical categories, both without and with the Tour Boat. P<0.05=*; P<0.01=**; P<0.001=***. T=Travelling; S=Socializing; R=Resting; M=Milling; F=Feeding; D=Diving.

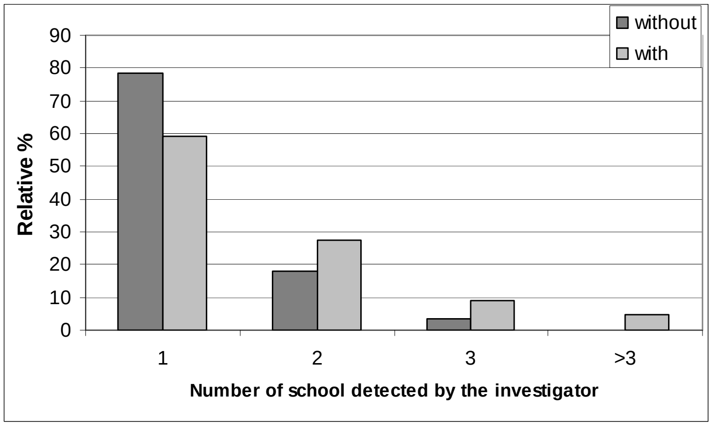

Figure 2: Relative percentage of number of schools of dolphins detected by the investigator boat, without and with the Tour Boat.

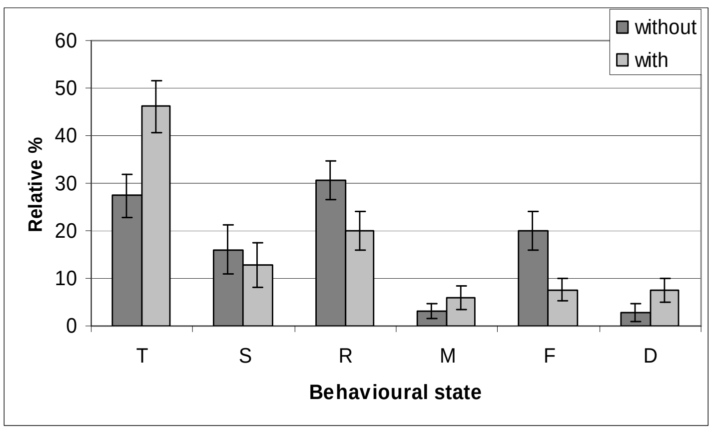

Figure 3: Mean duration of the different behaviours, expressed as percentage of time spent performing a behavioural states ± Standard Error, without and with the Tour Boat. T=Travelling; S=Socialising; R=Resting; M=Milling; F=Feeding; D=Diving.

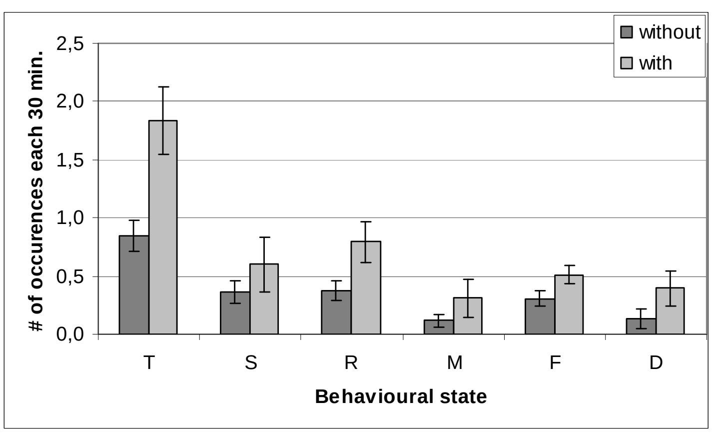

Fig. 4 Mean frequency of the different behaviours, measured as number of occurrences of the behavioural states per unit of time ± Standard Error, without and with the Tour Boat. T=Travelling; S=Socialising; R=Resting; M=Milling; F=Feeding; D=Diving.

Mann-Whitney test, however, showed no significant difference between group size for the two 'treatments'.

The Chi-square test showed that the presence of the Tour Boat had some association with the number of schools recorded ($\chi2 = 11.44$; $P<0.01$; DF=3) as well as the duration of the behavioural states ($\chi2 = 16.186$; $P<0.001$; DF=5).

'Close contact' of the animals by the Tour Boat was recorded 36 times. Dolphins were attracted in 20% of cases and deterred in 28% of cases; for the rest, the conduct was neutral (Table 1).

Discussion

The results show that the presence of the Tour Boat affects the frequency and the duration of the main behaviours and can change the structure of the groups.

Travelling, resting and feeding were the behavioural states more affected by the presence of the Tour Boat.

Changes in travelling, resting and feeding due to the presence of the tourist vessel have already been shown in other studies.

However, the impact on the resident population may differ according to the changed behavioural state. Changes in travelling duration and frequency, for example, could not have an impact on dolphin population vulnerability, as it is not such a crucial activity as socialising, resting or feeding.

In Lemon *et al*. (27) it was shown experimentally that with the Tour Boats approaching, Indian Ocean bottlenose dolphins (*Tursiops aduncus*) changed their behaviour from travelling to milling nine times out of twelve. However, most of the time after departure from the area of the Tour Boats, the animals returned to their original behavioural state. In Doubtful Sound, in New Zealand, in the presence of Tour Boats, changing from socializing, milling and resting to travelling almost doubled in *T.t.* (28).

In Bunbury, in the presence of the Tour Boat, the duration of resting was reduced by one-third and frequency increased by more than 100%. Lusseau (28), in Doubtful Sound, observed that in the presence of Tour Boats the probability of bottlenose dolphins (*T.t.*) to stay in a resting state decreased. A similar response to the presence of Tour Boats was observed by Constantine *et al*. (17), still in New Zealand, with resting being the most affected behavioural state. This may have a great impact particularly on dolphins that rest in shallow waters to recover energy. Spinner dolphins (*Stenella longirostris*), for example, visit near-shore waters during the day for resting purposes after feeding offshore and can be negatively effected by an intense dolphin watching, as in the Mauritius Islands (MMCS pers. comm.), or in Hawaii where Delfour (18) demonstrated the vulnerability of this species to coastal human activities in resting areas. Similarly for Risso's dolphins (*Grampus griseus*) that were sighted resting in near-shore waters in Sardinia (6) and in California (42).

In our study, in the presence of the Tour Boat, the feeding behavioural state significantly changed in duration and frequency. Most of the time feeding was manifested in "pushing the fish towards the shoreline shallow water". In Florida, for Allen and Read (2), the density of boat traffic influenced in different ways feeding behaviour and, according to Nowacek *et al*. (34), the approaches of boats to dolphins (*T.t.*) in shallow water increased the possibility of change in behaviour.

For group feeding, school cohesion is important and disturbance, due to boat presence or noise, can affect vulnerability, especially in areas with reduced food availability; low group cohesion can diminish feeding success, while increasing energy requirements (44).

As observed in other studies for bottlenose dolphin (*T.t.*) and humpbacked dolphins (*Sousa chinensis*) (20,34,33) diving times changed in the presence of Tour Boats. In our study both duration and frequency of diving increased though, compared to the control, the difference was not statistically significant.

In our study, when the Tour Boat was in close contact, the animals displayed neutral conduct in 56% of cases. In the Bahamas, Ransom (35) found that bottlenose dolphins (*T.t.*) changed their behaviour in 59% of approaches, with negative responses predominating (i.e. dolphins typically avoided the boat). Interestingly, in the same study, striped dolphins (*Stenella coeruleoalba*) were also reported to change their behaviour 68% of the time when a boat approached, but positive responses predominated (i.e. dolphins often approached the boat). In Wales, Gregory and Rowden (22) observed that most of the bottlenose dolphins (*T.t.*) displayed neutral conduct around boats and were deterred by kayaks; however dolphins displayed attraction to dolphin-watching boats. None of these changes can be deduced from the tourist boat and, furthermore, speculation, or misjudging, could be made on the conduct of the dolphins towards the Tour Boat by not properly trained tourist operators.

In Bunbury, at the time of the arrival of the Tour Boat, the animals tended to reduce significantly the activities that were not compatible with the vessel's presence, such as feeding and resting; and by contrast increasing their travelling and tendency to spread out into more schools with fewer animals in each school.

Many studies confirm that the impact of vessels on dolphin is directly related to the number of boats approaching the animals (17, 12), probably linked to the increase in noise (10) and the possibility for the animals "to easily and comfortably escape" a possible threat scenario (46) through increased dive duration or changing swimming speed and direction (27). Goodwin *et al.* (21), however, associated the aversive behaviour more to the classes of boat in motion (i.e. speed boat and jet skis) than to the number of boats *per se*.

Moreover, stress for the animals can vary in relation to the biological conditions and can result in an increased risk for people approaching the wild animals. In Bunbury, where there was a low intensity of disturbance, as only one Tour Boat approached the dolphins twice a day, dolphins could have easily avoid the interaction. Nevertheless, during our research, adult males displaying breeding activities upon the arrival of the boat, showed aggressive behaviour (i.e. tail slap) toward the Tour Boat, demonstrating that, even in controlled situation, a low risk of aggression still remains and it must always be remembered that approaching wild cetacean or, even worst, swimming with them, can be potentially dangerous (41, 16).

Although short-term impact on behaviour does not necessary affect the survival of the resident populations and behavioural changes due to eco-tourism are not necessarily bad for bottlenose dolphins (*T.t.*) (29) or animals under observation (13), the results of this study highlight the importance of quantitative and qualitative monitoring on any potential impact of this human activity. In Shark Bay (Australia), Bejder *et al.* (12) found that vessels activities, when more than one tour vessel is operating, lead to a "decline in relative abundance of bottlenose dolphins exposed to the long-term disturbance" and that a similar decline "would be devastating for small, closed, resident, or endangered cetacean populations". In the Mediterranean Sea the impact on the marine ecosystem due to human population is high in terms of overexploitation, pollution, ferry and boat traffic and impact of recreational activities. The result of these circumstances is that populations of bottlenose dolphins are generally smaller and scattered also in the open sea (still within the continental shelf) and, for this reason, the potential impact of dolphin-watching must be even more carefully considered, especially on particular and susceptible behavioural states. Outcomes of this study in Western Australia could be, consequently, useful to properly manage this activity which is rapidly increasing in many regions including the Mediterranean.

Management of Tour Boat activities must take into account several aspects from a small to large scale such as: the status of the local cetacean population, the number of vessels and tours per area, the specific response of the species in a particular behaviour state (i.e. resting or feeding), the seasonal behaviour (i.e. breeding season), the type of group approached, etc. Proper adaptive management must include a strict assessment of the initial and ongoing situation in order to control the number of licences issued and the maximum number of tours per vessel per day under specific circumstances. Experts should always be on board to assess if the type of performed behaviour is compatible with the boat approach. Independent periodic reports should also be issued to monitor over time the impact of the eco-tourist activity on the observed cetacean population

Even if not directly correlated to a decline in population, the study of behavioural changes in the presence of the tourist activity could be a good indicator to detect 'early signs of stress' that could result in a later decline of the local population and could help in the proper management of the activities of dolphin watching or swimming with dolphins, especially if promoted as a sustainable alternative to fishing.

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