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Article

Are Land Based Surveys a Useful Tool for Managing Marine Species of Coastal Protected Areas?

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Abstract: One goal of the LIFE project "Del.Ta." (NAT/IT/000163) was the preparation of an Action Plan to protect the bottlenose dolphin community in the Pelagie Archipelago (Sicily, Italy). It stressed the importance of regular monitoring of the spatial and temporal distribution of dolphins in order to evaluate the impact of local activities. This study assesses whether land-based surveys could be an effective alternative to vessel-based surveys. During the summer of 2006, both surveys' methodologies were used at Lampedusa, with 35 sightings recorded from land and 31 from a boat. Comparison was based on the assessment of the type of information they provided in relation to the presence of the animals and their behavior. Both methodologies were applicable, but there were differences in their requirements, potential information generated, costs, and sensitivity to weather conditions. Vessel-based surveys require well trained observers and enable photo-identification and observation of social interaction and morphology. Animal movements, interactions with anthropogenic elements and group dynamics are better collected from land but spatial data can be documented up to 1 nautical mile from the coast. Weather conditions have a significant platform specific effect on sighting frequencies. The high sighting frequency during land surveys provides support for the development of zero-impact land-based dolphins watching activity.

Keywords: *Tursiops truncatus*; shore-based survey; vessel survey; distribution

1. Introduction

Information about spatial and temporal variation in cetacean abundance is essential in establishing the best management actions, and the effectiveness of any conservation actions taken [1]. For European waters, the "Habitat Regulation" provides for the regular surveying of endangered species, which must be implemented and maintained over the long term. Cetacean presence can be recorded directly or indirectly through different techniques of which applicability varies according to the target species and its characteristics [1]. These methods can include visual and acoustic surveys along line transects or from fixed points. Surveys can be conducted from different platforms (sea, air or land) and using different sampling methods. Distance sampling or capture-mark-recapture by photo-identification is used to enable assessment of population size.

Analysis of a number of variables related to the aims of the survey is essential to choosing the best monitoring methodology. Budget, available time, and logistical support are limiting factors for the research that must be carried out [2]. Equally important are the spatial scale and the morphology of the area. In seeking the most appropriate methodology a compromise must be made between the aims of the research and resource availability [2].

The bottlenose dolphin (*Tursiops truncatus*, Montagu 1821) is one of the most widespread cetacean species in the North East Atlantic and the Mediterranean Sea [3]. Classified by IUCN specialists as "Vulnerable", the Mediterranean bottlenose dolphin [4,5], like all the other coastal cetaceans, is exposed to human activities and threatened by pollution [6], direct wounding and killing, overfishing [7], habitat loss [8], interaction with professional fishing activities [7], physical and acoustic disturbance, and increasing boat traffic [9]. The species is listed in Annexes II (Animal and botanic species of community interest whose conservation requires special conservation zones) and IV Animal and botanic species of community interest in need of strict protection of the EU Habitat directive 92/43, which stresses that the conservation of rare or endangered species must be linked to their habitat preservation. Marine mammals, including the bottlenose dolphin, are protected by Italian Law 157 of 11 February, 1992.

In Lampedusa waters, the bottlenose dolphin is the most sighted species [3] and the population has been studied since 1996 [10,11]. Interaction between dolphins and human activities is particularly intense, especially with fishing [12] and vessel traffic [13,14]. In the Lampedusa archipelago, the Marine Protected Area of the Pelagie Islands was set up in October 2002 (Italian Official Gazette no. 14, 18 January 2003) with the main goal of developing effective means of management in order to achieve the long-term conservation of biodiversity of the Pelagie Islands and implement related cultural values.

One of the main goals of the LIFE project "Del.Ta." (NAT/IT/000163) was the preparation of an Action Plan to manage the bottlenose dolphin community in the Pelagie Archipelago (Sicily, Italy). The Action Plan stressed the importance of continuous surveying of the spatial and temporal distribution, and occurrence of animals to help maintain the current population, to improve its health status, to ensure increasing availability of trophic resources and the improvement of habitat conditions, to mitigate risks linked to human and anthropic activities, and to develop scientific knowledge about the species [15].

Based on the conservation aims of the Lampedusa survey, concerning the mitigation of threats and the monitoring of the status of the dolphin population, we identified two methodologies as the most useful for the area: land and vessel-based surveys. These methodologies are normally employed independently; however, to integrate data on presence, distribution, abundance and behavior, they can also be run simultaneously [16–18]. Land-based surveys from fixed points are particularly useful to avoid interference of research boats with animal behavior [19].

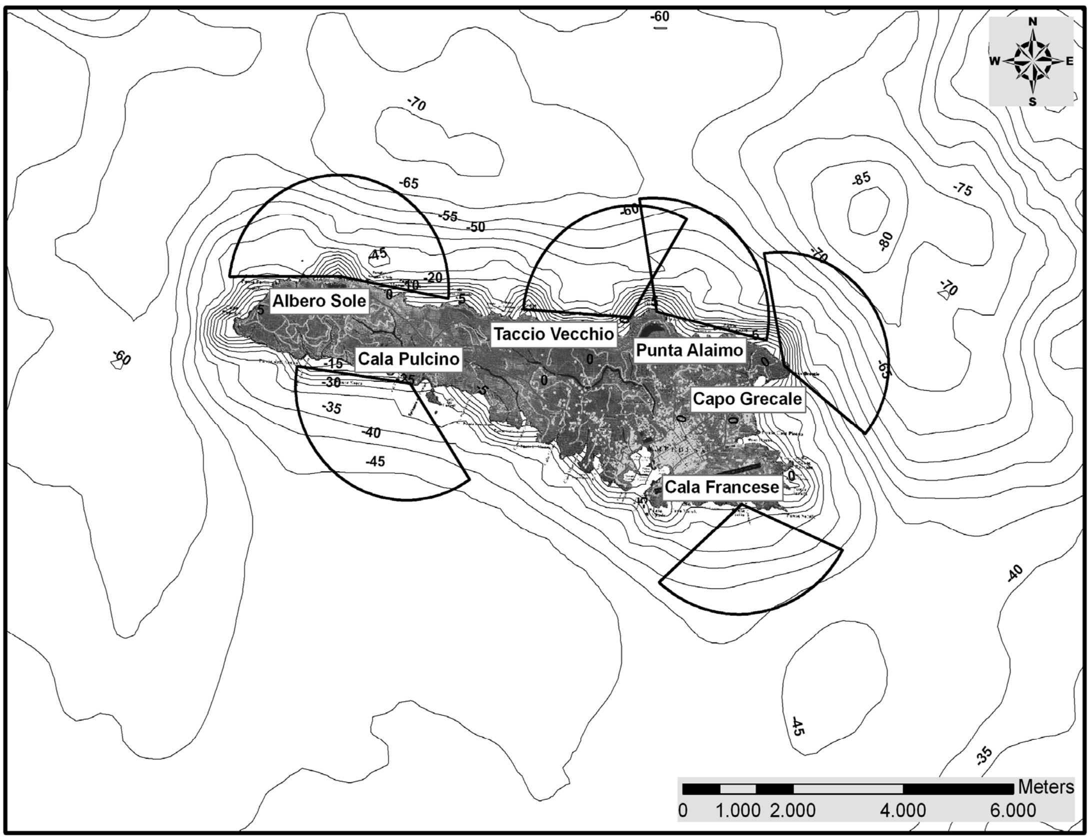
In this study we compare results obtained from land and sea-based monitoring of cetaceans and their behavior in Lampedusa waters, and we assess their applicability.

2. Materials and Methods

2.1. Study Area

This study was conducted in the waters around Lampedusa Island (Figure 1). The island is part of the Pelagie Archipelago (Strait of Sicily, Southern Italy), together with Linosa and Lampione, and is located between 35°29'28" and 35°21'39" N and 12°30'54" and 12°37'55" E. Lampedusa is 361 km away from the Sicilian coast and only 115 km from Tunisia. Coastal and seabed morphology is very different between the north and south of the island. In the north, the entire coast is made up of cliffs with no beaches and the seabed slopes down to a depth of 70 m at 1 nm offshore. In the south, sandy beaches alternate between gullies and the seabed reaches a depth of 45 m at 1 nm offshore.

Figure 1. Lampedusa Island and land-based survey positions with their open view sea sectors.



2.2. Data Collection

Data were collected from 1 July until 30 September 2006.

Two methodologies were used to conduct the surveys: data collection from fixed land positions and vessel-based surveys. Weather conditions (sea state, wind force and direction, and visibility) were factors limiting the number of days and hours of both land and sea-based surveys. Monitoring was conducted only if wind intensity was lower than Beaufort 3, sea state lower than Douglas 3, and when visibility was greater than 1nm. Surveys should generally not be performed in sea states above Beaufort 3 due to the reduction in the detectability of surfacing cetaceans [1].

2.2.1. Vessel-Based Survey

Vessel-based surveys were conducted within 6 nautical miles from the coast only during daylight hours in four different time slots from sunrise to sunset (sunrise–10.00; 10.00–14.00; 14.00–18.00; 18.00–sunset). Since the unique port is located on the southern side, the northern waters of the island could not be reached when the conditions in the southern side were too bad. This resulted in a 65% of days of survey not conducted due to bad weather conditions.

During the vessel-based surveys, data were collected through pre-determined transects around the island aboard an inflatable boat with a constant speed of approximately 8 knots. At least 3 observers constantly monitored the sea at a position of 1m over the sea surface. Research boat position, environmental variables, weather conditions and the presence of fishing or pleasure boats were recorded every hour. Once geographic position had been recorded, photos for identification were taken.

2.2.2. Land-Based Survey

During the land-based surveys, animals were observed in a 1-mile strip. The distance was determined with binoculars with reticules and confirmed by a laser telemeter (8 × 30). Six fixed points ranging from 9 to 133 m above sea level were used: Cala Francese (SE 9m, 70° sea sector open view), Cala Pulcino (SW 66 m, 140° open view), Albero Sole (NW133m, 240° open view), Punta Taccio Vecchio (NW 71m 150° open view), Punta Alaimo (NE 50m, 130° open view) and Capo Grecale (NE 52 m, 170° open view) (Figure 1). The fixed positions were selected in order to collect data from locations covering both the north and south coast.

Surveys were scheduled daily, 7 days a week, at set hours during the morning (8–11:00) and before sunset (17:00–20:00). The calendar based on the random rotation of the six locations was modified when weather conditions prevented monitoring. The percentage of surveys that could not be conducted due to bad weather conditions was 50%.

Observations were carried out both with the naked eye and binoculars (7 × 50) using the continuous horizon "scanning" method [20]. At least two observers were involved in simultaneous monitoring the sea surface. No synchronized surveys at different locations were conducted. During the surveys, weather conditions and boat presence within a distance of 1 nautical mile from the coast were collected every 15 minutes. Boats were divided into 3 categories: fishing, sailing (with auxiliary engine not operating), and motor boats.

2.3. Data Analysis

Sighting positions were located using ArcGis 9.0 software.

Weather categories were labeled according to the prevailing Douglas scale values recorded during each survey session. Conditions 0 and 1 were considered optimal survey conditions.

Monitoring data were analyzed as sighting frequencies (number of sightings per observation hour in every survey session) and duration of each sighting.

Inter-observer agreement was assessed comparing data collected independently by the 2 land observers who contributed the most to the data collection. The Mann Whitney test was used to evaluate similarity between the sighting frequency means.

Data obtained through the two sampling methods were compared using the Mann Whitney test. The influence of location and weather conditions on information obtained through both methods of data collection were tested using the Kruskal-Wallis Test. Statistical analyses were performed using SPSS 15.0 software.

3. Results

We collected data during 65 land surveys, corresponding to 150.77 monitored hours and resulting in 33 sightings, and during 33 sea surveys corresponding to 91.43 monitored hours with 31 sightings (Table 1).

Table 1. This table reports the survey effort carried out using vessel and land based methodologies during 2006, and the mean duration and sighting frequency recorded.

Survey Effort		
	Land-based	Vessel-based
Number of surveys	65	33
Hours of Observation	150.77	91.43
Number of Sightings	33	31
Mean duration of sightings (hours)	0.59 (SD = 0.48)	0.37 (SD = 0.28)
Mean sighting frequency of surveys	0.29 (SD = 0.57)	0.47 (SD = 0.52)

The mean sea sighting frequency of sea surveys (0.47, SD = 0.52) was significantly higher than for land-based surveys (0.29, SD = 0.57) (Mann-Whitney Test: N = 98; Z = −2.36; p = 0.01). Mean sighting durations were not comparable (Table 1).

3.1. Observation Agreement

There were no differences in sighting frequencies between the land observers: observer 1 and observer 2 (Mann-Whitney test N = 65, Z = −0.482 p = 0.63) also taking into consideration different weather conditions (N = 29, Z = −0.225 p = 0.866 in condition 1; N = 25, Z = −1.011 p = 0.475 in condition 2, N = 9, Z = −0.354 p = 0.889 in condition 3).

These results confirm inter-observer agreement in data recorded by observers 1 and 2, which were pooled and used for further analyses (Table 2).

Table 2. This table reports the comparison of data collected from land among the two monitoring observers.

	Land-based	
	Observer 1	*Observer 2*
Number of survey as principal investigator	19	46
%	29.2%	70.8%
Number of sightings	7	26
% Surveys with sightings	37%	57%
% Days with sightings	40%	50%
Number of surveys in condition 1	7	22
Number of sightings in condition 1	5	18
Number of surveys in condition 2	8	17
Number of sightings in condition 2	2	4
Number of surveys in condition 3	4	5
Number of sightings in condition 3	0	2

3.2. Weather Condition Influence

Table 3 shows that sighting frequencies collected from land were significantly lower when collected during the worst weather conditions (Kruskall-Wallis Test N = 65; X^2 = 14.95, Df = 3; p = 0.00). However, there were no significant differences in sea sighting frequencies in relation to the 4 categories of standard weather conditions (Test Kruskall-Wallis N = 33; X^2 = 3.22; Df = 3; p = 0.36).

Table 3. This table reports the comparison between the mean sighting frequencies in different weather conditions on land- and vessel-based data.

	Land	**Sea**
Mean frequency in condition 0	2.32 (SD = 1.44)	0.75 (SD = 0.67)
Mean frequency in condition 1	0.37 (SD = 0.51)	0.53 (SD = 0.53)
Mean frequency in condition 2	0.13 (SD = 0.25)	0.40 (SD = 0.49)
Mean frequency in condition 3	0.04 (SD = 0.12)	0.12 (SD = 0.17)

3.3. Distribution of the Animals

Figure 2 and 3 show the number of sightings/effort hours distributed in the areas covered by land-based observers and in a spatial grid of 1nm^2 for the vessel based survey. Moving from the smaller scale (1 nm) of the terrestrial survey (Figure 2) to the larger scale (6 nm) of the vessel survey (Figure 3), it is evident that the animals show peaks of density in offshore waters, even if they are present also in the coastal area, more visited by vessels, where their density is lower.

Figure 2. Sighting frequency, boat presence and open view sea sectors using land-based survey. The spatial grid used in the figure is composed by cells of 1 nm^2.

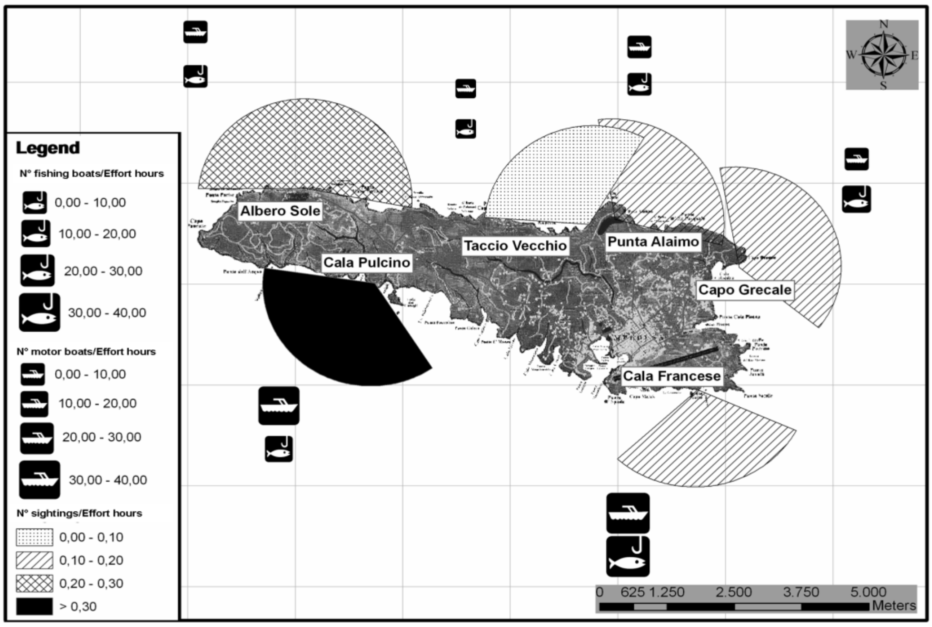
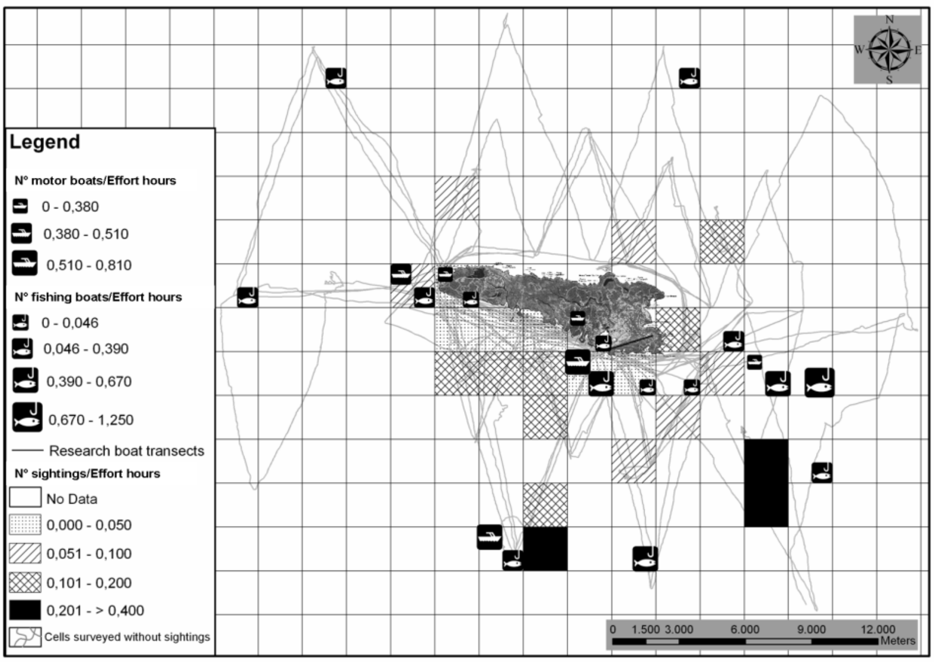


Figure 3. Sighting frequency, boat presence and research boat transects using vessel-based survey the spatial grid used in the figure is composed by cells of 1 nm^2.



Land-based survey data did not show any statistical differences between localities (Test Kruskall-Wallis: N = 65; X^2 = 10.24; Df = 5; p = 0.07) even when only data collected under optimal conditions was considered (0, 1 categories) (Test Kruskall-Wallis N = 31; X^2 = 5.98; Df = 5; p = 0.31). Also, sighting durations recorded from land did not show differences between localities (Test Kruskall-Wallis: N = 33; X^2 = 8.646; Df = 5; p = 0.12) (Table 4).

Table 4. This table reports the total number of sightings, mean sighting durations (SD), and survey effort obtained by land for each locality.

Locality	No. sightings	Mean sighting duration (min)	SD	Survey effort
Cala Francese	4	7.20	0.06	15
Capo Grecale	4	31.80	0.50	13
Punta Alaimo	4	37.80	0.30	7
Punta Taccio Vecchio	1	31.80	0.00	7
Albero Sole	7	43.20	0.81	10
Cala Pulcino	13	41.40	0.30	13

4. Discussions

Cetacean regular monitoring is demanding in terms of resource availability, time, and skills. It is therefore fundamental to keep in mind that different methods have different requirements and generate different types of information (Table 5).

Table 5. This table summarizes the cost-benefit comparison between land and vessel-based studies using, as parameters, requirements (*Researcher skills, Equipment*, *Useful observation time for sighting animals),* potential information generated (*Mean monitored area for every 3h of surveying*, *Potentially monitorable areas, Easily observed elements, Observed elements with high skills and attention, Generally unrecordable elements),* costs (*Equipment and equipment management costs)* and sensitivity to weather conditions.

	Land-based study	Vessel-based study
Researcher skills	Medium skill level (high if the aim is to collect data about group composition or behavior)	High skill level in camera use (and possibly video camera), GPS, echo sounder, nautical license
Equipment	Low costs: Binoculars, Telemeter or theodolite, Collecting form, Chronometer	High costs: Rubber dinghy use, Fuel, GPS, Binoculars, Collecting form, Chronometer, Camera with lens, Video camera
Equipment management costs	Low	High
Mean monitored area for every 3h of surveying	3.16 nm^2	12 nm^2
Potentially monitorable areas	Max 1 nm from the coast	In this study, rubber dinghy up to 6 nm from the coast (generally up to 12 nm)
Useful observation time for sighting animals	high	limited
Weather conditions	0-1	0-3
Easily observed elements	Presence, movements and interactions with anthropic elements such as boat presence and approach	Presence, precise georeferentiation

Table 5. *Cont.*

	Land-based study	Vessel-based study
Observed elements with high skills and attention	Behavior and group dynamics, georeferentiation	Behavior, social interaction, age classes, sex, morphology and animal body condition, photo-id.
Generally unrecordable elements	Classes, sex, age, morphology and animal condition, individual identification	Interaction with anthropic elements caused by research vessel disturbance

The use of land-based surveys allows researchers to analyze sighting frequencies, seasonal variations, and produce estimates of density and spatial distribution along the coastal area, but the support of another method is needed to provide a complete picture, essential for developing an effective management plan. Land-based surveys are cheaper and training is easier in terms of time.

Another important aspect is assessing the influence of weather conditions on the data collected within the standard values of 3 on the Douglas and Beaufort scales. Sea and wind state of more than 0 results in a reduction in sighting frequencies for both vessel and land-based surveys, although it is only significant for data collected from land. This result supports the assumption that the relationship between presence data and weather conditions is likely to be platform specific [1]. Consequently, care should be taken in comparing data across locations or over periods if the influence of weather conditions has not been considered.

The land-based surveys enabled the collection of behavioral data on cetacean reaction when boats (ferries, tourist vessels, and fishing boats) crossed the coastal area where anthropogenic interactions are more frequent [14].

In the south-western waters, the land-based surveys revealed a high presence of dolphins and boats (Figure 2). However, vessel records showed that the maximum bottlenose dolphin density was offshore (Figure 3) where the number of boats decreases, supporting the notion that bottlenose dolphins tend to move away from areas more frequented by pleasure motor boats, even in the sections with the highest coastal sighting frequency.

In the eastern coast, both methods counted a medium-high sighting frequency, but the very low mean sighting duration at *Cala Francese* leads us to assume that animals may be disturbed by fast boat routes [14]. The presence of these boats, which can disrupt animal behavior, could be the cause of the recorded decrease in sighting duration in *Cala Francese* waters, near the harbor area. Higher sighting frequencies in the south-eastern offshore waters also support the assumption that animals remain less in coastal waters with higher traffic.

5. Conclusions

Behavioral data can contribute substantially to understanding spatial distribution; however, the two different platforms enable the collection of different categories of data on behavior. Only the vessel-based method allows individual reconnaissance by photo analysis and is consequently fundamental for estimating group composition, permanence in the area, and loss of weight over time, whereas only land-based surveys allow recording of sighting duration and reaction to anthropogenic elements such as approaching boats, without influencing the behavior of the animals in any way (Table 5).

Furthermore, weather conditions have a significant platform specific effect on sighting frequencies. The comparison presented in this paper shows that the use of combined methodologies, in our case land and vessel-based surveys, can enable a better understanding of spatial distribution, habitat use and animal behavior, also in relation to the presence of anthropogenic factors and disturbance. If supplemented by regular, but less frequent vessel-based survey data, monitoring can be carried out mainly from land. Observation from a land platform provides the possibility of increasing the number of surveys and saving on the money needed for boat trips. Furthermore, the high sighting frequency during the land surveys opens up the possibility of developing land-based dolphin watching as an activity. Land-based dolphin watching has no impact on the animals and can be as appealing as boat dolphin watching.

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