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Impact of whale-watching on the short-term behavior of Southern right whales (*Eubalaena australis*) in Patagonia, Argentina☆

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ABSTRACT

In the last 30 years, whale watching tours in Patagonia, which are primarily based on viewing pods of Southern right whale, have become increasingly popular. The aim of this study was to evaluate the impact of whale watching boat trips on the behavior of whales. Data were analyzed by means of a Generalized Linear Model using a log-link function for categorical data. The model that best fitted the data had four selected first-order interactions among factors. Whales showed short-term reactions to boats, changing their behavior in response to the approaching boats. If the boat approached appropriately (i.e. with the engines off), whales reacted positively by approaching the boat and seeking contact, whereas if the boat approached inappropriately (i.e. with the engines on), whales reacted negatively by moving away from the boat and avoiding contact. The results of this study may have significant implications for whale watching regulations and their enforcement.

1. Introduction

Whale watching is one of the most rapidly growing and economically attractive tourist activities worldwide (Cisneros-Montemayor, Sumaila, Kaschner, & Pauly, 2010; Hoyt, 2001; Hoyt & Hvenegaard, 2002; Orams, 2002), valued at over US$ 2 billion a year (Bailey, 2012; Chen, 2011; O'Connor, Campbell, Cortez, & Knowles, 2009). The global industry of whale watching attracts over 13 million people annually in over 119 countries and whale watching operations around the world now include 3330 operators and employ an estimated 13,200 people (O'Connor et al., 2009). This activity not only provides employment and economic benefits for many local communities around the world, but also is an incentive for the conservation of whales as it is a non-lethal activity that provides important information of cetaceans and their environment (IFAW, 1995) and encourages people to appreciate and protect whales (Wearing, Cunningham, Schweinsberg, & Jobberns, 2014). Over the last 20 years, there has been an awakening interest and a general fascination in observing marine wildlife in their natural environment (Bertellotti, D' Amico, & Cejuela, 2013; Corkeron, 2004; Curtin, 2003; Muloin, 1998; Neil & Breeze, 1998; Orams, 2000; Schofield, Scott, Katselidis, Mazaris, & Hays, 2015; Seminiuk, Bourgeon, Smith, & Rothley, 2009; Topelko & Dearden, 2005; Villanueva, Walker, & Bertellotti, 2014), which may benefit conservation through changing attitudes towards wild animals and natural habitats (Duffus & Deaden, 1993) and creating a need within people to help protect them (Lien, 2001). In this sense, whale watching can act as a platform from which commercial tour operators can educate tourists about long-term sustainable benefits of whale watching (Wearing et al., 2014). Species that live in coastal environments are the most used as a tourist attraction because of their easy access (Christiansen & Lusseau, 2014; Coscarella, Dans, Crespo, & Pedraza, 2003; Lusseau, 2004; Schofield et al., 2015). Great whale species approach coastal waters during part of their life cycle activities (i.e. reproduction, nursing, feeding), making them more susceptible to human disturbance (Orams, 1997). If conducted properly, whale watching is relatively benign (Blewitt, 2008; Jensen et al., 2009; Lusseau, Bain, Williams, & Smith, 2009; Noren, Johnson, Rehder, & Larson, 2009). However, uncontrolled whale watching may disturb whales, causing changes in their natural behavior, which could in turn modify their distribution, reproduction and survival (Berrow & Holmes, 1999; Constantine & Baker, 1997; Heckel, Reilly, & Sumich, 2001; IFAW, 1995; Lusseau, Lusseau, Bejder, & Williams, 2006; Williams, Bain, Ford, & Trites, 2002). Governments and NGOs have attempted to reduce the impact of this activity worldwide by developing Guidelines and Codes of Conduct that aim both to reduce the negative effects of this activity and to give an educational opportunity to visitors (Cole, 2007; Garrod & Fennell, 2004; Orams, 1997). When educational objectives are met, contrary to what can be expected, close-range observation of whales does not influence the satisfaction level of tourists (Orams, 2000).

In Argentina, whale watching has developed on the observation of Southern right whales (*Eubalaena australis*) around Península Valdés, Chubut Province, and this has promoted a growing ecotourism industry for more than 30 years (Coscarella et al., 2003; Rivarola, Campagna, &

☆ In memory of Mariano Van Gelderen: "The king of the whales".

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Tagliorette, 2001). This activity, which generated total revenues of over US$ 42.6 million in 2006 (US$ 2.1 million in direct expenditure and US$ 40.5 million in indirect expenditure) (Hoyt & Iñíguez, 2008), is currently one of the fastest growing sources of income and employment for the province after oil exploitation and fisheries (Argüelles & Bertellotti, 2008).

Southern right whales come to Península Valdés coast in mid-May to mate and give birth to their calves, remaining in the area until mid-December. Península Valdés is internationally known as one of the most important breeding areas for this species in the southwestern Atlantic Ocean (Bastida, Rodríguez, Secchi, & Da Silva, 2007). In addition, it is considered one of the best places in the world to watch Southern right whales, due to the large number of animals as well as to their predictability and proximity to the coast (Fazio et al., 2015, in press). The annual population growth rate is around 4–6% (Crespo et al., 2014) and the breeding population of Península Valdés is estimated in around 4000 whales (Cooke, 2012). The number of whales peaks in September, with up to 1000 individuals (Crespo et al., 2015).

The whale watching season in Península Valdés extends from June to December and, like other wildlife tourism destinations, this touristic place has also experienced a rapid growth (Secretaría de Turismo y Áreas Protegidas, 2015). The number of tourists that visit Península Valdés to see whales at close range from boats has increased from 70,462 in 2002 to more than 120,000 in 2015 (Ruiz Diaz & Ganduglia, 2013; Secretaría de Turismo y Áreas Protegidas, 2015). During each season, the number of tourists peaks in October (Ruiz Diaz & Ganduglia, 2013), coinciding with the peak of whale abundance (Crespo et al., 2014). Whale watching in Península Valdés started in the 1970's but it was not until 1983 that it was commercially established (Rivarola et al., 2001). The activity began in Puerto Pirámides with only two small companies working with three boats. Since the early 1990's, six companies operate one boat at a time, but under exceptional circumstances up to 12 boats can be simultaneously operated (Tagliorette et al., 2008). Whale watching was first regulated in 1984 by Provincial Law N° 2381, which was made taking into account the laws of other countries. In 2008, the Government Tourism Office of Chubut Province implemented a new whale-watching Law N° 5714, and Decree 167, including the "Patagonian whale-watching technique", which is a set of rules, codes of conduct and maneuvers developed throughout the years to interact correctly with Southern right whales. Although this technique was developed mainly by experienced whale-watchers, a few studies have also referred to the boat's approach (Argüelles, 2008; Carribero, Berrier, & Lindner, 2006; Fazio, Marino, & Bertellotti, 2006; Rivarola et al., 2001) and to the short-term effects of this approach on the behavior of whales (Alvarez Colombo, Arias, & Garciarena, 1990; Argüelles, 2008; Arias, Alvarez Colombo, & Garciarena, 1992; Garciarena, 1988; Rivarola et al., 2001). Although these studies have provided recommendations to improve whale-watching management, it is unknown how the sound of the engines and maneuvers made by the vessel operators at Península Valdés affect whale behavior. The question on the convenience of keeping engines turned on or off during the sighting has been a controversial theme within the community of whale watchers and the government for at least two decades.

The main objective of this study was to evaluate the impact of whale watching through observable reactions of Southern right whales to this activity in Península Valdés, and thus obtain new impact indicators that may be relevant for the design of future research protocols and management.

Fig. 1. Geographical location of the whale-watching area in Península Valdés, Chubut, Argentina.

2. Methods

2.1. Study area, survey procedure and data collection

This study was carried out during the breeding season of Southern right whales, between August and December 2006. The area surveyed corresponded to the surroundings of Puerto Pirámides (42°.56 S, 64°.28 W), between Punta Piaggio (42°.32 S, 64°.28 W) and Punta Alt (42°.41 S, 64°.16 W) (Fig. 1). This area is the only licensed by the government for whale watching operations.

A total of 611 whale watching commercial trips were undertaken to observe whales, obtaining 186 h of direct observation. Between one and four trips were made each day depending on the weather conditions. Patagonia is a windy region and therefore navigation during days with strong wind is restricted. With south winds of more than 35 $km \cdot h^{-1}$ intensity, coast guard authorities close the port and prohibit all navigation (Fazio et al., 2015, in press). All observations were carried out with Beaufort sea level below four (Beaufort scale is an empirical measure that relates wind speed to observed conditions at sea and ranges from 0 to 12, increasing in a non-linear manner). Trips were made with three of the six whale watching companies currently operating in Puerto Pirámides, on different types of boats, including one catamaran, four rigid-hull boats and one zodiac. All boats sailed from Puerto Pirámides and the number of passengers ranged from 19 to 70, depending on the size of the boat. Large boats usually have more than one outboard engine, while small boats have only one, and these engines had between 150 and 300 hp each. For every trip, the date, trip duration and weather conditions were recorded. During each trip, a "sighting" was considered when the boat stopped and stayed for at least 1 min observing one or more whales. Several sightings could be performed during the same trip. On each sighting, the following variables were recorded: the onset and finishing time, the weather condition, the number of whales observed, the group type and the behavior.

Whale groups were classified according to their composition as: mother with calf (a mother and a calf born in the current season - MC), solitary individual (a young or lonely adult — SI) and mating groups (one female and up to six males — MG). In a given sighting, more than one group could be seen. However, if a MC was seen interacting with a SI, the group was classified as MC. For analysis purposes, group types were grouped as MC/J (mother and calves plus juveniles or solitary individuals) as opposed to MG. The behavior of

whales in response to the approach of boats during whale watching were classified into three mutually exclusive categories (Fig. 2): "approach behavior" when the whale's initial behavior changed to approach the craft, "neutral behavior" when the whale was indifferent to the boat, continuing its activity, and "avoidance behavior" when the whale's initial behavior changed to actively moving away from the boat. The whale's initial behavior was measured at a distance >150 m from the boat. The boat maneuvers to approach the whales during each sighting as well as the whale's behavior before and during each sighting were recorded. The boat maneuvers to approach and interact with whales during a sighting were classified as "appropriate" or "inappropriate" regarding the law that regulates whale watching in Chubut Province (Fig. 3). The most appropriate way of approaching a whale (Fig. 3 above) was doing so from behind and remaining parallel to the animal and placing the boat at one side so as avoid interfering with the whale's movements. Finally, either the whale or the boat approached the other slowly. Following that described by Rivarola et al. (2001), maneuvers considered inappropriate were (Fig. 3 below): direct approach (the boat moved from some point at the sea in a straight line (directly) towards a whale, changing speed and direction), chasing (the boat moved behind the whale or parallel to it, increasing its speed and chasing the whale when the distance between both increased), encircling (the boat moved around the whale describing a semicircle or a whole circle), and drifting towards the whale (the boat moved windward, considering the position of the observed whale). We also recorded if the engines of the boat were on or off during the sightings and the distance between whales and boats to compare whales' behavior in response to appropriate and inappropriate boat approaching. The distance between whales and boats was measured with a digital telemeter (Bushnell, mod. Yardage Pro Legend Scout Laser Rangefinder, range: 15–930 yards, 6 × 23 mm).

2.2. Data analysis

Data were analyzed by means of a General Linear Model using a log-link function for categorical data, also known as log-linear model, constructing multi-way frequency tables. The null model was constructed considering the independence between the behavioral reaction of the whales (approaching, neutral and avoidance behaviors) and the type of group (mother with calf or mating group), maneuvers (appropriate and inappropriate), and engines (on and off) as factors. Models were tested using the GLM package of the R software for the Poisson family, and a plot of deviation from the independence model was created using the loglm package (R Core Team, 2008). Models incorporate factors sequentially, starting with first-order interactions (factors are considered in pairs), and then second-order interactions (trios of factors are included sequentially into the models and so on). The best model fit was evaluated using differences in Akaike information criterion (ΔAIC) and the weight of the model (Burnham & Anderson, 2002). The best fit model is the model that minimizes the number of parameters while increasing the ability to predict the observed frequencies. The r^2 for the best fit model was calculated as 1- (residual deviance/null deviance).

3. Results

The models were sequentially tested including all interactions among variables. The interactions between the engines (E) and type of group (TG) and between maneuver (M) and type of group (TG) were the only ones that were not significant.

Models including all significant factors were selected using ΔAIC (Table 1). The first-order interaction (product term of the main effects variables) present in the first six models (B TG), indicates that the behavior observed is conditioned by the type of group. The presence of this term in most models points out that the reaction is very different between MC/J and MG. None of the models considering two first-order interactions was able to improve the preceding model, unless it included the interaction between behavior and type of group. Among these, the model including the conditional dependence of the maneuver on the engines was the one with the best fit (EM BTG). The models considering three of the selected first-order interactions again showed the influence of the type of group on the behavior and the conditional dependence of the maneuvers on the position of the engine, but added one important feature: the dependence of the observed behavior on the engine (BE EM BTG). Lastly, the model that held the four selected first-order interactions among factors was the best fit model, taking into consideration the dependence of the behavior on the engine, maneuver and type of group and also the dependence of the maneuver on the engine (BE EM BTG BM).

Deviations of the observed frequencies from the independence model showed a positive trend in the number of whales performing "approaching" behaviors during an appropriate approach when engines were off, and a negative trend when the engines were on (Fig. 4). During an inappropriate approach, whales tended to perform more "avoidance" behaviors when the engines were on and fewer "avoidance" behaviors when the engines were off (Fig. 4). Also, whales tended to display neutral behaviors more often than expected by chance when the approach was inappropriate and the engines were on and to display less neutral behaviors when the approach was inappropriate and the engines were off (Fig. 4). The deviations described were recorded only in the category mother with calf, as there was no significant elicited response to the factors considered for the mating groups.

When maneuvers were inappropriate (n = 209, Fig. 5 above), distance decreased slightly, being practically constant during the sighting. In contrast, when maneuvers were appropriate (n = 138, Fig. 5 below), the distance decreased, reaching a close approach between whales and boats.

4. Discussion

Wild animals react in response to human activities in three different ways: positively, negatively or neutrally (Whittaker & Knight, 1998). As it has been observed in many species of whales (Watkins, 1986), Southern right whales change their behavior in response to the approach of whale-watching boats, reacting negatively (moving away from the boat and avoiding contact), positively (approaching the boat and seeking contact) or neutrally (being indifferent).

Fig. 2. Whales' behavior in response to the approach of boats during whale watching: approach (right), neutral (middle) and avoidance (left).

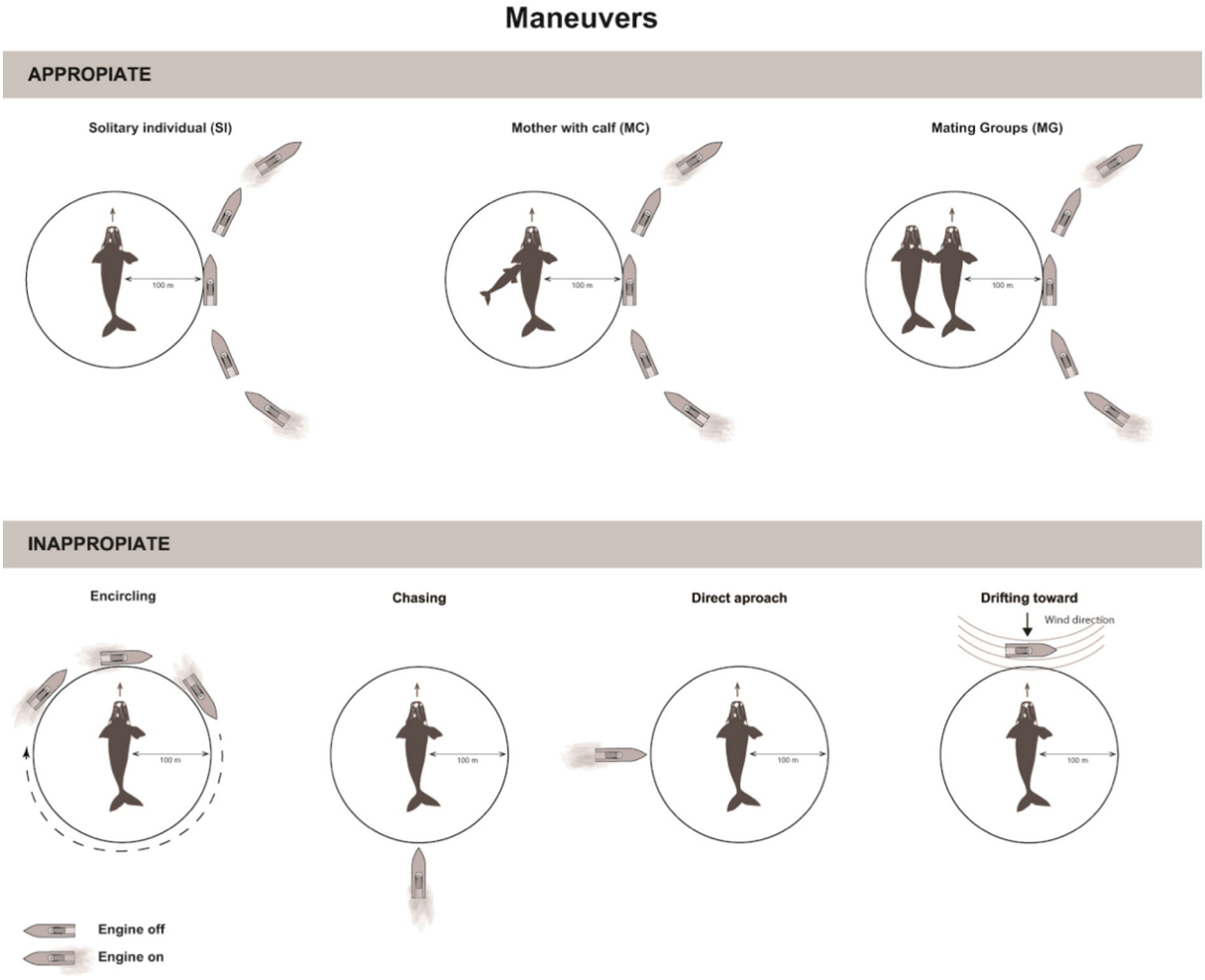

Fig. 3. Boat maneuvers to approach the whales during a sighting. Appropriate maneuvers above and inappropriate maneuvers below.

This is the first work carried out in Southern right whales in Península Valdés in which several factors affecting the behavior of whales during a whale-watching operation are considered simultaneously and from onboard the boats that perform the sighting trips. This work corroborates that the behavior of whales is differentially affected depending on the type of group that is being sighted. Most importantly, it also demonstrates not only that an inappropriate approach has a negative impact on the response of whales but also that whether the boat engine is on or off affects their behavior. The mating groups, which are composed of a female and several (up to six) males, present high activity level of surface behaviors. These whales focus on reproductive activities, and therefore the presence of boats usually does not affect them. Although during this work we witnessed the dissolution of mating groups in two opportunities due to the approach of vessels, the observed frequency of behaviors for this kind of groups did not differ from the expected one. On the other hand, the whale watching area is used mainly by mother with calves/juveniles groups, and so, the number of occasions when the boat operator decided to approach a mating group was small in relation to the total number of interactions. Most observations were performed on mother with calf groups. These groups were the ones most affected by the factors considered. They tended to come closer to the boat during sightings when the approach was appropriate and tended to perform more "avoidance" behaviors when the approach was inappropriate. In addition, when the maneuver was inappropriate and the engines remained on, whales displayed fewer "approaching" behaviors, were more neutral and displayed much more "avoidance" behaviors. Instead, when the engines were turned off, whales displayed more "approaching" behaviors. This also reflects the fact that boat operators are more prone to perform wrong maneuvers when they have the engines on. A growing number of studies have investigated the impact of the vessel noise on cetaceans (Jensen et al., 2009; Lusseau et al., 2009; Noren et al., 2009;Sousa-Lima & Clark, 2008; Weinrich & Corbelli, 2009). Stamation, Croft, Shaughnessy, Waples, and Briggs (2010) found that the humpback whale mother with calf was the most sensitive group to vessel noise.

Regulations for Southern right whales of Península Valdés were developed during a 5-year period in which all stakeholders, including the government, NGOs, academia, tour operators and most importantly,

Table 1
Summary of the ten best AIC-ranked log-linear models fitted to evaluate the influence of selected variables on the response behavior of Southern right whales. B = Behavior. E = Engine, TG = Type of Group. M = Maneuver. AIC = Akaike Information Criterion. ΔAIC = Differences in AICc. wi = Akaike weight.

MODEL	AIC	ΔAIC	Wi
BE EM BTG BM	96.32	0.00	0.81
BE EM BTG	99.26	2.94	0.18
EM BTG	117.73	21.41	1.8E−05
BE BM BTG	151.47	55.15	8.5E−13
BTG BM	197.55	101.23	8.4E−23
BTG	455.03	358.71	1.04E−78
BE BM EM	709.04	612.72	7.23E−134
BE EM	711.92	615.60	1.75E−134
BE BTG	711.92	615.60	1.71E−134
BE BM	746.14	649.82	6.36E−142
EM BM	764.14	667.82	7.85E−146

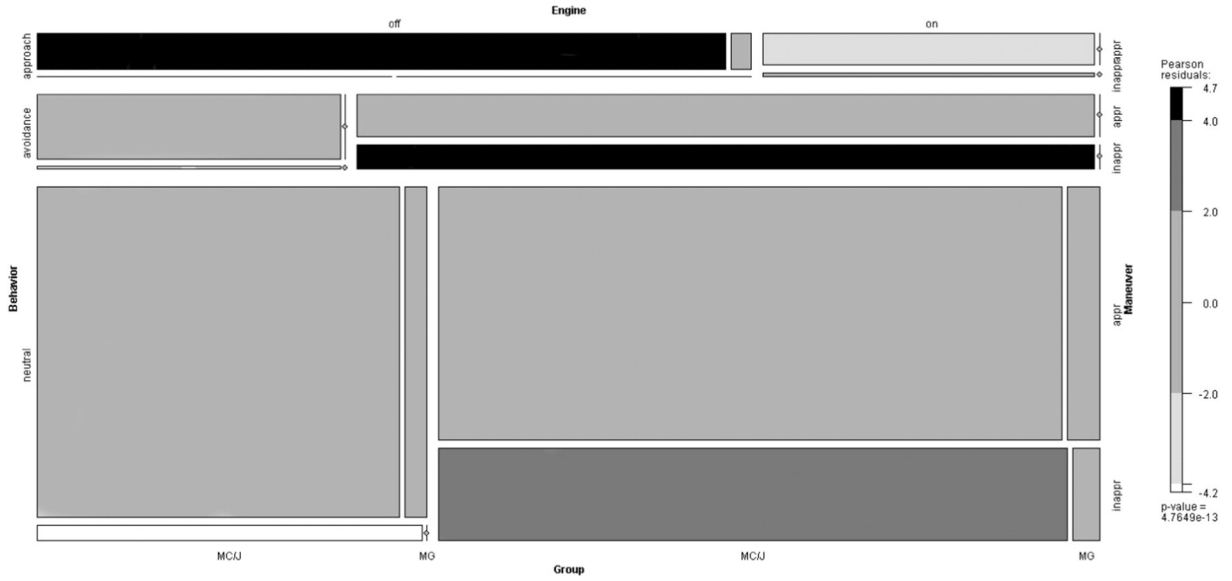

Fig. 4. Mosaic display showing the Pearson's residuals between the independence model and the observed frequencies. The levels of the variables are: Behavior (avoid, neutral, approach); Engine (on, off); Maneuver (appropriate — appr, inappropriate — inappr); Type of Group (MC/J, MG). The black panels indicate a positive deviation from that expected if the variables were independent. The white panels indicate a negative deviation from independence. The gray panels indicate no significant differences from that expected.

whale watchers, participated. These regulations encouraged the Whale Watching Sustainable Tourism Workshop carried out in Puerto Pirámides in 2004 and the International Workshop on Management and Non-Lethal Use of Cetaceans conducted in Puerto Pirámides in 2005 (Fazio et al., 2015, in press). The results of the present study indicate that regulations have worked well, and that when the sightings are made following these regulations, whales are not disturbed. In fact, the interaction between Southern right whales and whale-watching boats at the breeding area of Península Valdés could be relatively positive since whales tend to approach to the boat by themselves when approximations are done properly. This is supported by the distance records, which showed that when the boat approached whales doing inappropriate maneuvers, whales maintained a constant distance, and that when the maneuvers were appropriate and the engines were off, whales approached the boats by themselves. This is particularly important considering that most sightings are made with animals in the main stages of their life cycles (mother with calf and mating groups).

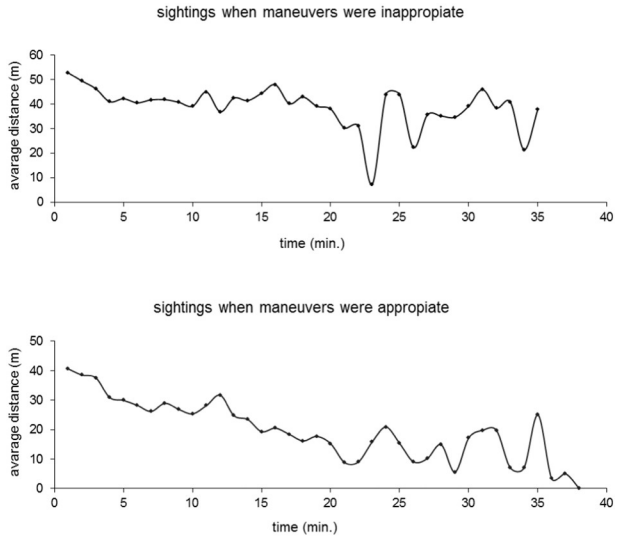

Fig. 5. Average initial distance between whales and boats during a sighting when maneuvers were inappropriate (above) and appropriate (below).

It seems that if whale watching is developed with environmental responsibility, it could be a sustainable activity that supports local economies and can promote the generation of awareness on environment and species conservation. The whale watching industry has grown at an average rate of 3.7% per year (O'Connor et al., 2009). However, it may not be possible to ensure that all stakeholders operate within the parameters of sustainable practice (Wearing et al., 2014). In South America, the average annual growth has exceeded tourism growth rates in 10% per year (O'Connor et al., 2009). In Argentina, whale watching has increased since its origin but since 2005, the activity in Puerto Pirámides seems to have reached its carrying capacity (Fazio et al. 2015, in press). In recent years, whale watching has spread to a nearby area, in the neighboring province of Río Negro. Although there is a regulation for the activity, the tour operators in Río Negro do not have the same experience as those of Península Valdés regarding the way they need to approach the whales. Chubut Province is in the forefront of protection of its wildlife resources, counting on specific legislation and application authorities that have inference on the development of the activity (Coscarella, 2005). Besides, most whale watchers in Puerto Pirámides have 30 years of experience with the species, and have developed a conduct code that includes their day-to-day experiences. It has been previously suggested that, in the last 30 years, there has been a positive evolution in the way whale watching is performed; particularly due to the expertise whale watchers have gained on how to approach the whales (Argüelles, 2008).

On the other hand, although whale watching is part of the global tourism trade, it is really a community level industry that offers communities a sense of identity and cultural pride (Wearing et al., 2014). Whale watching also is viewed positively by tourists who are likely to visit countries with a strong commitment to whale and dolphin conservation (Parsons & Draheim, 2009; Wearing et al., 2014). However, human and ecological dimension of whale watching must be understood and balanced at all stages of management (Duffus & Deaden, 1993). This is the case of Southern right whales at Península Valdés where whales not only represent one of the most profitable touristic resources for Chubut Province but also are a historical and cultural reference in the region. The community involved in whale watching is also a great promoter of solving local problems with the animals they live and work with (Fazio et al., 2015, in press). The people of Puerto Pirámides have taken part in many meetings to start some actions against kelp gulls, which peck skin and blubber from the backs of Southern right whales,

causing them serious injuries (Fazio, Bertellotti, & Villanueva, 2012; Fazio et al., 2015). This is a problem that occurs only in Península Valdés and is the consequence of poor waste management, which has led to an overpopulation of kelp gulls (Fazio et al., 2012, 2015). After many meetings, the government of Chubut Province has implemented a management action plan to reduce kelp gull attacks to Southern right whales. Stefanski and Villasante (2014) interviewed tourists to find out about their willingness to pay to manage gulls versus to pay to manage waste; the results showed that tourists preferred to pay to manage waste.

Puerto Pirámides has been recently considered by National Geographic as the best place in the world to perform whale watching. Whale watching in Puerto Pirámides is a good example to be taken into account by other countries. The experience gathered in the last years by whale watchers, the implementation of a Code of Conduct and a Patagonian whale watching technique, the constant revision of the law that regulates the activity, and the commitment of both the local community and tourists are all signs that whale watching in Puerto Pirámides is carried out with environmental responsibility.

4.1. Management implications

The results obtained may have immediate application to the whale watching regulations. The safety of the tourists is a key aspect to be taken into account during these trips and the maneuverability of the boat should be maintained at all times. The area where the whale watching activities are carried out is a closed bay, inside a gulf (Fig. 1), and the sightings are performed close to the shore, which, depending on the weather conditions, allows turning the engine off and experiencing the silence of the Patagonian sea and hear nothing but the breaching whales. When these conditions are met, whales are more prone to come closer to the boat, and even swim under it. Regulations should encourage whale-watching boat operators to turn off the engine whenever possible to improve the quality of the tourists' experience.

This work illustrate that if whale watching is carried out with environmental responsibility, it could be sustainable along the time. It demonstrates that an inappropriate approach has a negative impact on the behavior of whales and corroborates that when the sightings are made following regulations, whales are not disturbed. The regulations were in part proposed by the whale-watchers themselves, and thus the guidelines were created including first-hand experience. Even though, regulations for Southern right whales of Península Valdés works fine, part of the regulations are in need on “tough” information as the evaluation done in this work on the engine affecting whale's behavior. So, future studies should evaluate the possibility of implement other kinds of engines that reduce noise and hence the impact on the whales. Additionally, there is a need to understand the energetic costs for the breeding whales of whale watching and to evaluate the socio-economic impacts of the activity on the region.

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