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deck of the semi-submersible
whale-watching vessel Yellow Submarine
at Peninsula Valdes, Argentina as a
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INTERNATIONAL
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Assessment of the underwater viewing deck of the semi-submersible whale-watching vessel “Yellow Submarine” at Península Valdés, Argentina as a platform of opportunity for scientific research with the southern right whale, *Eubalaena australis*

Mariano Sironi^{1,2}, Lucía Alzugaray¹, Agustina Saez¹, Florencia Vilches¹, Alejandro Fernández Ajó¹ and Paula Faiferman¹

¹Instituto de Conservación de Ballenas, Buenos Aires and Puerto Madryn, Argentina. www.icb.org.ar

²Facultad de Ciencias Exactas, Físicas y Naturales, Universidad Nacional de Córdoba, Argentina.

ABSTRACT

Whale-watching vessels can be used as platforms to collect scientific data on the natural history of cetaceans. Vessels with underwater viewing decks are exceptional and offer a unique view of the whales. We assessed the underwater viewing platform of the semi-submersible vessel Yellow Submarine that operates off Puerto Pirámides, Península Valdés, Argentina as a platform of opportunity for southern right whale (*Eubalaena australis*) research. The variables considered during observations included, among others, the age class and sex of the animals observed, behavioral patterns, opportunities for individual photo-identification, distance and duration of the underwater observations and how weather conditions affected data collection. The Yellow Submarine offers a unique platform to make underwater observations of southern right whales in this calving ground. The main limitations are the relatively short duration of the observations and reduced visibility in spring. Recommendations are given to counter some of these limitations.

INTRODUCTION

Whale-watching vessels have been used as platforms of opportunity to conduct a variety of scientific studies on cetaceans in different locations around the world (*e.g.*, Argüelles *et al.*, 2016; Bejder, 2005; Christiansen *et al.*, 2014; Coscarella *et al.*, 2003; Peters *et al.* 2013; Robbins, 2000; Robbins and Mattila, 2000; Williams, 2003). The vast majority of the studies rely on observations from the top deck of vessels while cetaceans are at the surface, while underwater visual data can only be collected by using underwater cameras. Whale-watching vessels that offer direct underwater viewing of large whales are exceptional.

The company Yellow Submarine (YS) from Argentina developed a semi-submersible vessel especially designed for underwater watching of whales and sea lions. The vessel is managed by the whale watch company Southern Spirit in Puerto Pirámides, Península Valdés, Argentina and operates during the southern right whale (*Eubalaena australis*) calving season (June thru December). The *Instituto de Conservación de Ballenas* (ICB, Whale Conservation Institute) is an Argentine non-profit organization dedicated to the conservation of whales and their environment through research and education.

As part of a cooperation agreement between YS and ICB, volunteer naturalists from ICB went on whale watch trips on board the YS during the 2014 and 2015 whale-watching seasons for the purpose of complementing the information provided by the captain and whale watch guides to the tourists, sharing information about the whale research and conservation projects conducted by ICB and collecting basic scientific data to evaluate the YS underwater deck as a platform of opportunity for whale research.

General objective. To assess the underwater viewing platform of the semi-submersible vessel Yellow Submarine that operates off Puerto Pirámides, Península Valdés, Argentina as a platform of opportunity for southern right whale research.

Specific objectives. To determine:

- The percentage of whale watch trips during which the whales were observed underwater
- The age class composition of the animals observed
- Behavioral budgets by quantifying the percentage of time different age and sex classes spent in different behavioral patterns
- The percentage of calves and / or solitary animals that could be sexed
- Whether it was possible to photo-identify the whales underwater
- The average distance to the whales and length of time whales were observed
- The frequency of observations made from the port and starboard sides of the vessel
- Whether unusual observations were made from this underwater platform
- Whether plankton was / was not visible
- The average weather conditions (visibility, cloud cover, sea state, water temperature) during the trips

MATERIALS AND METHODS

Data were collected by one observer at a time in the underwater viewing deck of the YS. All observers were biologists, biology students or naturalists from *Instituto de Conservación de Ballenas*. Observations were recorded on spreadsheets and included the following variables:

1. Underwater observation of whales during the trip: yes/no
2. Age class: MC=Mother-Calf; C=Calf; A=Adult; J=Juvenile; I=Indeterminate age
3. Behavioral patterns:
 - a. swimming parallel to the boat
 - b. ↑ swimming away from the boat
 - c. ↓ swimming toward the boat
 - d. nursing
 - e. whale passes under the boat
 - f. mating
 - g. surface activity (rolling at the surface, flipper slapping, breaching)
 - h. resting at the surface
 - i. resting underwater
 - j. not determined
4. Sex of calves and/or of solitary individuals
5. Good conditions for photo identification: yes/no
6. Distance between the whales and the boat: 1=0-5m; 2=5.1-10m; 3=>10m
7. Duration of the observations in sec: 1=1 to 5"; 2=6 to 10"; 3=>10"
8. Boat side of the first approach to the whales: P=Port side; S=Starboard side
9. Visibility (subjective scale): 1=Good; 2=Medium; 3=Bad
10. Percentage cloud cover: 1=0-25%; 2=26-50%; 3=51-75%; 4=76-100%
11. Sea state: 1=flat calm; 2=ripples with some white water; 3=0.6-1m waves with white caps; 4=1.5-2m waves with white caps
12. Plankton: visible / not visible
13. Water temperature (Celsius)

The observer took photographs and recorded unusual observations, including significant lesions, physical contact between the whales and the boat, etc. All photographs and observations were made during regular whale watch tourist trips and no changes in the boat's maneuvers or in the duration of the trips were requested by the observer to improve the quality or increase the number of the data collected.

The Yellow Submarine. The following vessel description and specifications were downloaded from www.yellowsubmarinearg.com (on 10 May, 2016). The vessel was designed and built by the shipbuilder Federico Contessi in Mar del Plata, Argentina and then transported by land to Puerto Pirámides, Argentina.

Passengers can watch whales from the outdoor upper deck as a conventional tour and from the lower deck with underwater viewing. This level has 40 viewing windows and seats (Fig. 1).



Figure 1: the Yellow Submarine in Puerto Pirámides and its underwater viewing deck (left photo credit: Yellow Submarine S.A.).

Technical specifications:

- Dimensions: length overall 17.2 m - beam overall 4 m – draft 2.1 m.
- Total weight: 47 tons
- Hull material: Marine stainless steel
- Seats: 50 passengers (including crew)
- Visual range on upper deck: 360°
- Visual range on submersed lower deck: 40 windows (20 on each side)
- Engine specification: 2 x Mercury Verado 275 HP (550 Hp)
- Cruising speed: 6 knots
- Technology applied to watching cetaceans: state-of-the-art hydrophones to listen to whales' sounds.
- Safety on board: The semi- submersible is equipped with life rafts, individual life jackets, VHF radio, chart-plotter, GPS, echo sounding and firefighting equipment.
- Water closet: Yes

Crew on board:

- 1 captain (professional skipper – whale-watching guide)
- 1 mariner (whale-watching guide)
- 1 bilingual guide (Spanish and English)

RESULTS

General results. Data were recorded during 33 trips between 3 Oct and 20 Nov, 2014 and 38 trips between 30 Aug and 30 Oct, 2015, totalling 71 trips. Whales were observed underwater in 96% (n=68) of the trips (see photographs in Annex 1). In 343 encounters with the whales in both years, the first approach occurred from the starboard side on 54% (n=185) and from the port side on 46% (n=158) of the occasions. This difference was greater in 2014, when the first approach occurred from the starboard side on 61% (n=94) and from the port side on 39% (n=60) of the occasions (N=154). Conditions to take identification photographs during observations of each age class were good in 3% of observations of mothers (6 of 214), 5% of calves (13/262), 5% of adults (5/102) and 0% of juveniles (0/5) (Table 1).

Table 1: Percentages of: trips with / without underwater observations; boat side of first approach, and trips when good identification photographs of mothers (M), calves (C), adults (A) and juveniles (J) could be taken.

Underwater observations			
YES		NO	
96%		4%	
Starboard		Port side	
54%		46%	
Photo ID			
M	C	A	J
3%	5%	5%	0%

Age and sex. From a total of 370 groups observed, 58% (n=214) were mother-calf pairs, 28% (n=102) were adults, 13% (n=48) were calves, 1% (n=5) were juveniles and 1 was an individual of indeterminate age. Sex could be determined in only 2% (n=4) of 262 calves observed in both years and in 19% (n=15) of 81 adults observed in 2015.

Behavioral patterns. To help evaluate the vessel as a platform for right whale behavioral observations, we include a variety of behavioral budgets. In 2014, six behavioral patterns were recorded for mother-calf pairs during 154 observations. The most frequent patterns were (1) swimming parallel to the boat, (2) swimming away from the boat and (3) passing under the boat, which totaled 87% and 90% of the patterns observed for mothers and calves, respectively. The remaining patterns included swimming toward the boat and resting (Fig. 2).

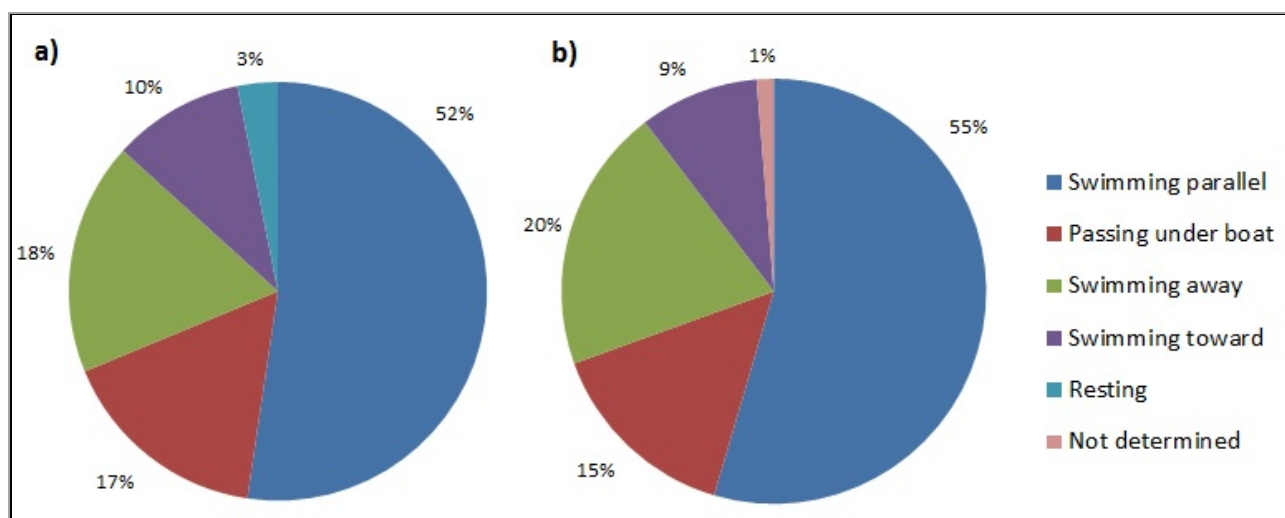


Figure 2. Behavioral budgets for mothers (a) and calves (b) in 2014.

In 2015, seven behavioral patterns were recorded for all age classes. During a total of 216 observations, the most common patterns were (1) swimming parallel to the boat, (2) passing under the boat and (3) swimming away from the boat, which totalled 79% of the patterns observed. The remaining patterns included swimming toward the boat, resting, mating and surface activity (Fig. 3).

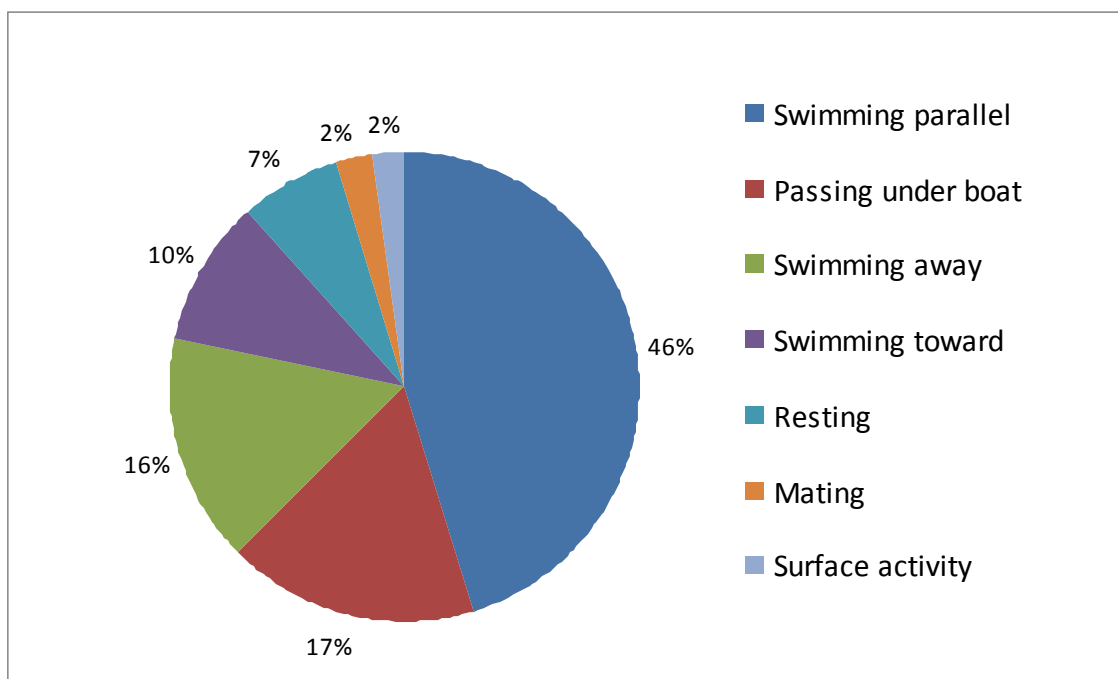


Figure 3. Behavioral budget for all age classes combined in 2015.

Distance and duration. The distance between the whales and the boat during the observations was estimated for a total of N=236 encounters. The most frequent distance range was 5.1-10m (n=123; 52%) followed by 0-5m (n=90; 38%) and more than 10.1m (n=23; 10%), *i.e.*, 90% of observations were made at less than 10m (Fig. 4a). The duration of the underwater observations was recorded for a total of N=342 encounters. Most encounters (n=188; 55%) lasted between 1 and 5sec, followed by encounters that lasted more than 10sec (n=93; 27%) and those that lasted between 6 and 10sec (n=61; 18%) (Fig. 4b).

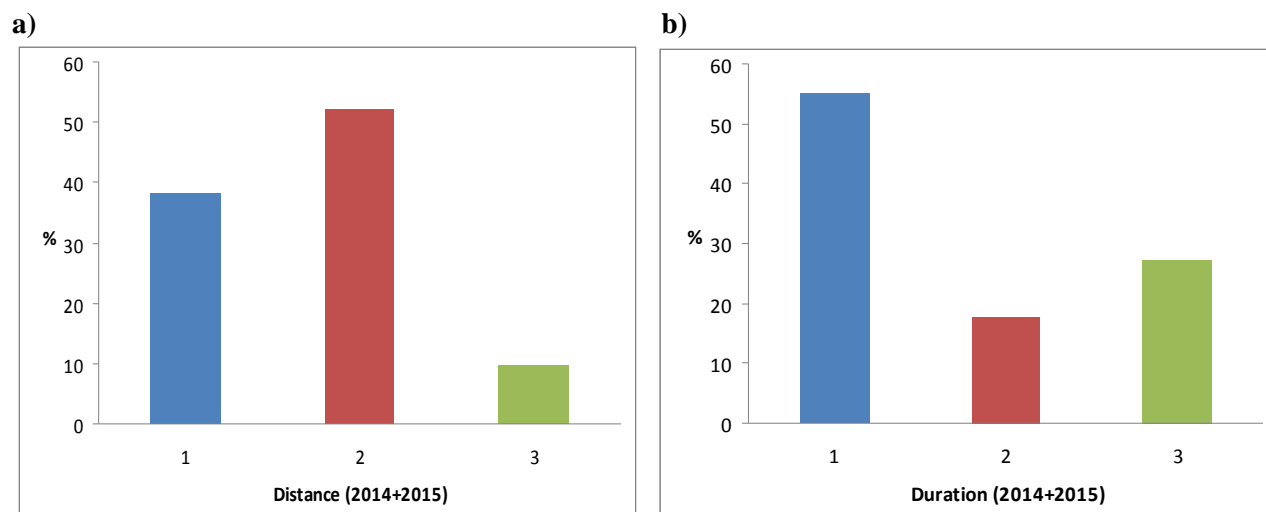


Figure 4. a) Distance between the whales and the boat: 1=0-5m; 2=5.1-10m; 3=10.1m or more. b) Duration of underwater observations: 1=1-5sec; 2=6-10sec; 3=more than 10sec.

Weather conditions. Underwater visibility (recorded on a subjective scale: 1=Good; 2=Medium; 3=Bad), percentage of cloud cover (1=0-25%; 2=26-50%; 3=51-75%; 4=76-100%) and sea state (on a scale from 1 to 4 where 1=flat calm; 2=ripples with some white water; 3=0.6-1m waves with white caps; 4=1.5-2m waves with white caps) were recorded in 33 trips in 2014 and 38 trips in 2015 totaling 71 trips. Visibility was

considered to be medium in 45% (n=32), bad in 41% (n=29) and good in 14% (n=10) of the trips. Weather conditions were good in most trips. Skies were clear (1) or partly cloudy (2) in most trips (65%; n=46). Sea state was flat calm (1) or calm (2) in most trips (94%; n=67). The mean water temperature was 11.2°C in Sept and 12.1°C in Oct, 2015. We recorded whether plankton was visible in 27 trips in 2015. Plankton was visible in 70% of the trips.

Other observations. In this section we include other observations that can help to evaluate the underwater viewing deck of the Yellow Submarine as a platform to study the behavior and assess the health of the southern right whale in this calving ground.

2014.

- A young calf was photographed with a small rope in its mouth on Oct 28.
- An adult female with a propeller scar on her left flank was observed on Oct 17.
- Whale skin was seen in the water on several occasions.
- There was physical contact between a calf and the boat on one occasion when the calf rubbed its body against the boat.

2015.

- A male was observed copulating with an adult female accompanied by a calf on Sep 8.
- A very active calf hit the boat on Sep 14 and continued to move toward the stern of the boat.
- Abundant plankton was observed on several trips. Plankton reduced visibility and made data recording more difficult.

DISCUSSION

This study aimed at assessing the underwater viewing deck of the whale-watching vessel Yellow Submarine in Puerto Pirámides, Península Valdés, Argentina as a platform of opportunity to conduct scientific research with southern right whales in this nursing ground. The assessment did not aim at evaluating the quality of the observations from a tourist perspective and is totally unrelated to the customer satisfaction on board.

The proportion of trips when whales could be observed from the underwater deck was very high (0.96). However, this does not imply that good quality data could be collected on every trip. The mean duration of the observations was 10sec or less and visibility was considered to be good in only 14% of the trips. Distance estimates indicate that most observations were made at 10m or less, limited by visibility. In 2015 plankton was visible in 70% of the trips and it reduced visibility too. The combination of these factors curtailed the chances to obtain high quality photographs of the callosity patterns for individual identification (Payne *et al.*, 1983), *e.g.*, only 3% of mothers and 5% of calves could potentially be photo-identified. This could hinder certain research studies that are based on photo-identification. It is important to note that most observations were made in Sep - Nov (southern spring) when plankton begins to bloom and whales are sometimes seen feeding (Sironi, 2004; Hoffmeyer *et al.*, 2010). Therefore, considering that the whale-watching season goes from Jun thru Dec, it is likely that better and longer observations could be made during the winter months (Jun-Aug) when visibility is better.

Although a slight difference in the most frequent behavioral patterns is observed between the 2014 and 2015 seasons, no test of significance is presented here because the overall objective was to evaluate the vessel as a platform for right whale behavioral observations and research. The differences might be a consequence of the relatively small sample size.

In 2014, the first approach to the whales occurred from the starboard side on 61% and from the port side on 39% of the occasions. This could be due to the captain's preference when approaching the animals, the relative low number of trips analyzed (33) or other unknown factors. This bias was less evident in 2015. Overall, the first approach occurred from the starboard side on 54% of the occasions during the study period.

The vast majority of the whales observed in both years were mothers and calves, which is consistent with the age class composition of southern right whales in their nursing grounds in spring (Sep - Nov) (Payne, 1986; Best, 1994). The proportion of adults observed in 2014 (14%) was much lower than in 2015 (38%). All data in 2014 were collected in Oct - Nov whereas most data in 2015 were collected in Sep - Oct. Adults leave the area earlier than mother-calf pairs, thus the proportion of adult whales to mother-calf pairs tends to decrease throughout the season (Payne, 1986; Sironi, 2004). The small proportion of calves that could be sexed (0.02) is likely the result of the direction of sunlight that can interfere with some underwater observations.

The most frequent behavioral pattern observed was swimming parallel to the boat. This is probably a consequence of the type of approach preferred by the boat captain to give the tourists on board a better view of the whales. This perspective, when the whales' full body is visible underwater, can allow to make good visual assessments of skin lesions and scars, but it reduces the chances to obtain photographs of the full callosity pattern for individual identification. On the other hand, the second most common pattern observed, *i.e.*, the whales passing under the boat, offers a very good perspective for photo-identification. However, priority to observe the whales during the trips is given to the tourists on board and therefore the chances to obtain good identification photographs can be reduced.

Among other observations made in the course of this study, some were particularly interesting and/or relevant to assess right whale health and human impacts. The case of the young calf photographed with a small rope in its mouth on Oct 28, 2014 was reported to the wildlife authorities and to the Coastal Wildlife Rescue Network of Chubut Province. An adult female with a propeller scar on her left flank was observed on Oct 17, 2014. Other observations were useful for promoting people's interest in whale conservation. A male was observed copulating with an adult female accompanied by a calf on Sep 8, 2015. Although this behavior is not rare, the case was recorded on video and photographed underwater. The images received much media attention, which helped to promote right whale conservation by increasing awareness in the general public. See, for instance, the press article http://www.clarin.com/sociedad/Logran-ballenas-copulando-Puerto-Piramide_0_1427857442.html

As a general conclusion, the whale-watching vessel Yellow Submarine offers a unique platform to make observations of southern right whales at Península Valdés, Argentina from an underwater perspective. The main limitations are the relatively short duration of the observations and reduced visibility in spring. To counter some of these limitations, we recommend to:

- use the lower deck for overall visual health assessments including skin lesions, scars, human-induced wounds, etc.
- concentrate research effort during the earlier months of the whale-watching season (Jun-Aug) to improve visual conditions
- combine lower deck and upper deck photographs for individual identification
- when possible, use primarily the starboard side and front areas of the boat.

ACKNOWLEDGMENTS

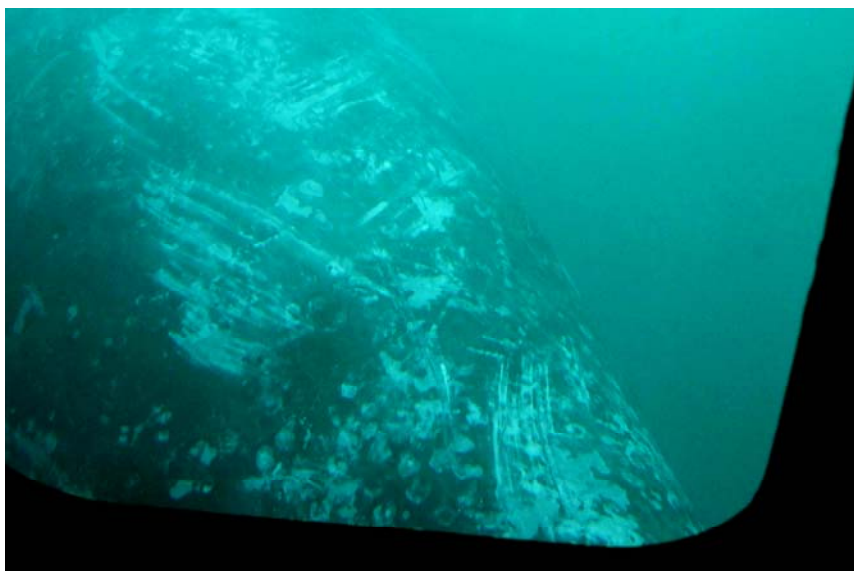
We especially thank Julitte Decré and Tiño Resnik of Yellow Submarine S.A. for providing a seat in the boat for a naturalist on board to conduct this assessment. We thank the captains Juan Pablo Martorell Juárez, José Anibal Cepeda and Oscar Alberto Alcántara; the guides Claudio Nicolini, Federico Arribere and Sanda Stojakovic; the photographers Luis Pettite and Luis Burgueño, and all the staff at Southern Spirit (Lula Lopez, Gaby Chara, Carla de Zan, Juan Pablo Benitez and Romina Ocaranza) for their help during the whale-watching trips and with the educational activities on land. We thank Rafael Benegas, Sofía Benegas, Ernesto Ricci, Marcela Uhart, Diego Moreno, Chiquito Díaz, Miguel Botazzi, Luis Burgueño, Mónica Torres and Argentina Visión for their help with transportation between Puerto Madryn and Puerto Pirámides. Special thanks to Roxana Schteinbarg, Diego Taboada, Marcos Ricciardi, Carina Marón, José Carracedo, Ximena Taboada and Joaquín Iñurrátegui at *Instituto de Conservación de Ballenas* for their collaboration in different aspects of this research. We thank the *Dirección de Fauna y Flora Silvestres* and the *Subsecretaría de*

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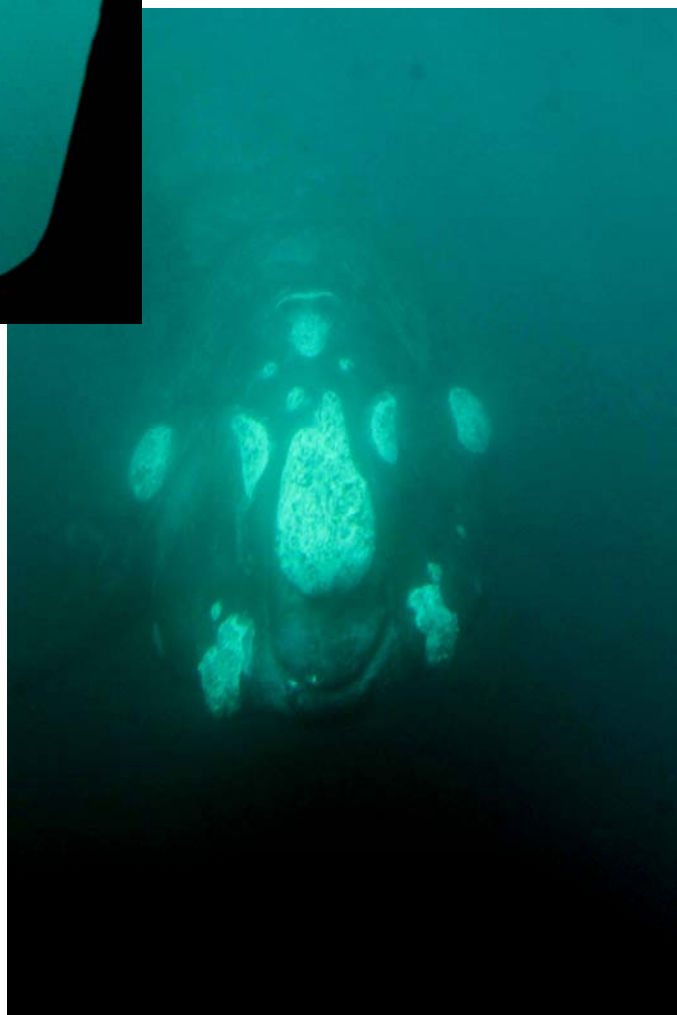
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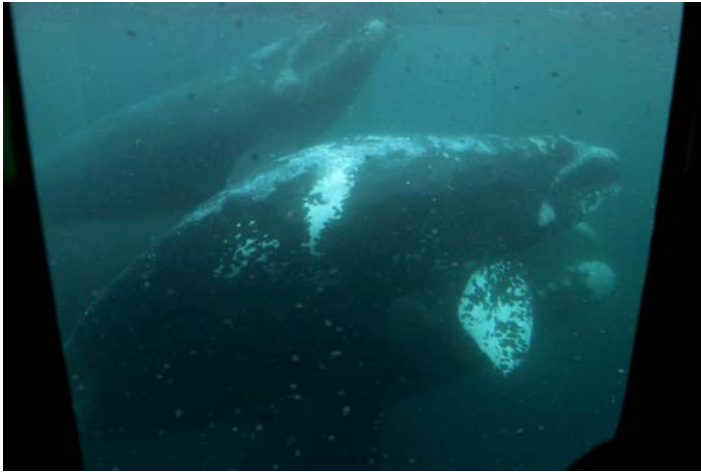
ANNEX 1: photographs of southern right whales taken from the underwater deck of the whale watching vessel Yellow Submarine in Puerto Pirámides, Chubut, Argentina.

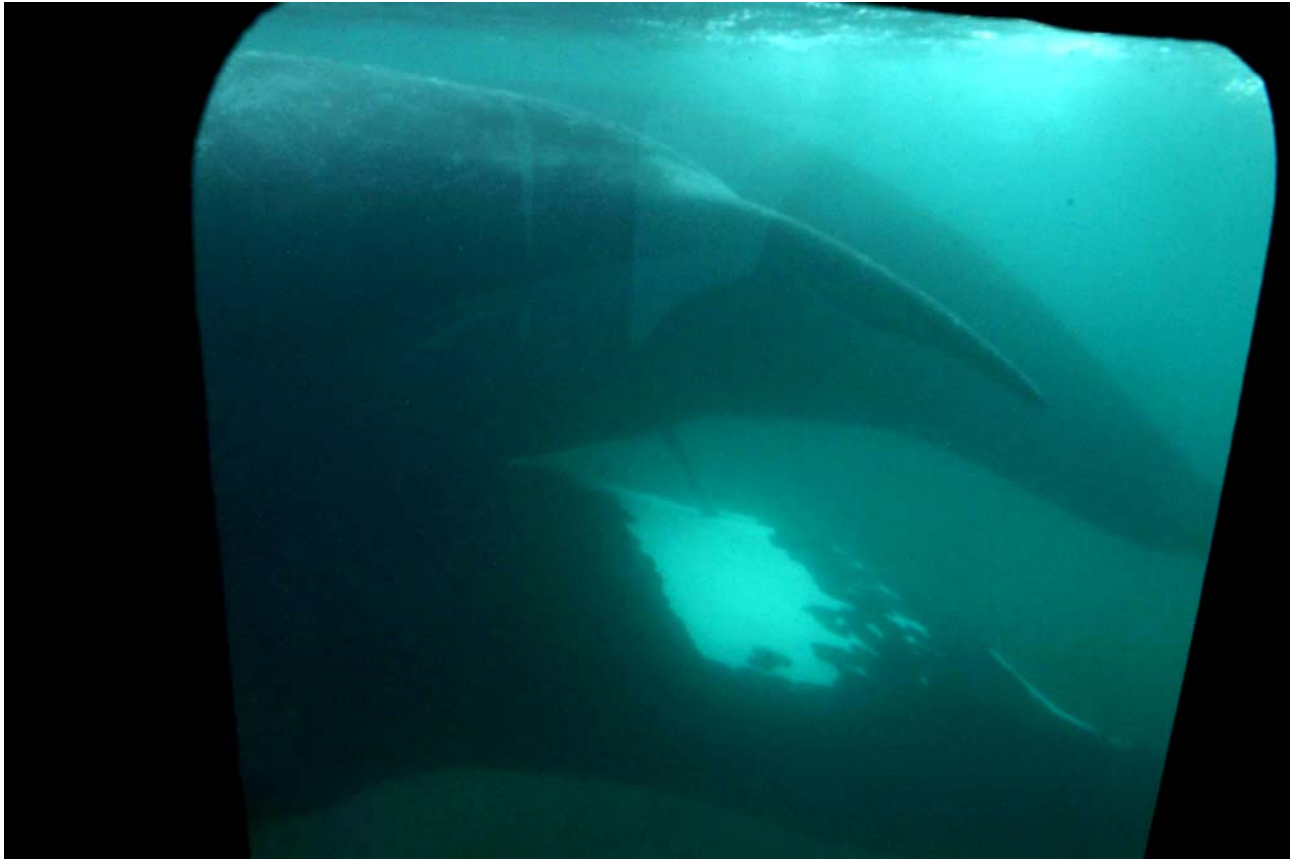


Skin lesions, marks, scars and callosity pattern.



Behavioral patterns observed: swimming parallel to the boat, resting underwater, passing under the boat and swimming toward the boat.





A male copulating with a female accompanied by her calf.