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Short Note

Diving Behavior of Southern Right Whales (*Eubalaena australis*) in a Maritime Traffic Area in Patagonia, Argentina

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Southern right whales (*Eubalaena australis*) come to the Península Valdés coast in early June 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 et al., 2007). While recovering from its near extinction, the southern right whale population at Península Valdés is growing at an annual rate of 6.9% (Crespo et al., 2011; Cooke, 2012). The whales surprisingly have left areas with minimum human disturbance and moved to areas with high levels of human activities close to Puerto Madryn city. They are currently concentrated around harbors and areas for water sports, vessel traffic, whale-watching activities, and recreational use.

Together with the increasing population of southern right whales in Golfo Nuevo and increased commercial activities in the port, there also have been increases in the risk of collisions between whales and boats. In 2008, an accident near one of the piers of Puerto Madryn harbor ended up with the death of a juvenile southern right whale during the maneuver of an Argentine navy ship (International Whaling Commission [IWC], 2010), dangerously leaving the ship adrift.

Southern right whales use calm and shallow coastal waters to give birth to their young, and, by the end of the whale season (October onwards), they move away from the coast to deeper waters where they perform long dives in an apparent feeding behavior. In recent years, many swarms of lobster krill (*Munida gregaria*) have been observed in Golfo Nuevo, and some boaters have reported whales feeding on these swarms. In 1932, Mathews had already reported that three right whales hunted in the 1927-1928 and 1928-1929 whaling seasons had been feeding on post-larvae of *M. gregaria* in the Patagonian Shelf (Werner et al., 2011). Recently, G. Trobbiani & A. Irigoyen (unpub. data) have video-recorded swarms of *M. gregaria* at 50 m depths in the same area used by southern right whales in Golfo Nuevo. If southern right whales are feeding on these lobster krill aggregations, we expect to record dives in these deep waters. Deep diving (> 120 m) has been reported for the northern right whale (Baumgartner & Mate, 2003), which feeds in the Great South Channel between Cape Cod and Georges Bank (Wishner et al., 1995; Beardsley et al., 1996; Baumgartner & Mate, 2003). High vessel traffic in this area has caused many vessel-related injuries and deaths (Marine Mammal Commission [MMC], 1999). Nowadays, this species is one of the most endangered large whales; and, despite international protection from whaling and the intensive management efforts undertaken by the governments of the U.S. and Canada to protect them, only around 300 individuals remain (Knowlton et al., 1994; IWC, 2001; Kraus et al., 2001). Like northern right whales, southern right whales could be feeding in an area with vessel traffic. The deep waters of Golfo Nuevo are used by ships and vessels as a route to enter the port. If this area is also used as a feeding area for whales, it may increase the risk of collision between southern right whales and ships. These kinds of accidents have been increasingly recorded in other species worldwide (Laist et al., 2001; Nowacek et al., 2003; Carrillo & Ritter, 2010; Ritter, 2012).

Due to the increase in the number of southern right whales, the use of areas near the cities, and the reports of whales diving in relatively deep waters in the areas used by ships, an increase in

the probability of collisions is expected. These collisions could be even more plausible depending on the time whales spend at the surface. If whales were visible at the surface at all times, ships could implement measures to avoid them; whereas if whales spent much time diving and emerged near the ships, no measures could be undertaken. The aim of this study was to assess the diving behavior of southern right whales in Golfo Nuevo. To our knowledge, this is the first record of depth diving of southern right whales in the world. This is a matter of interest since whales are diving into deeper waters in ship traffic areas to and from the Puerto Madryn port.

The study area was located at approximately 12 km (42° 698611 S, 64° 993889 W) from Puerto Madryn city (Figure 1) in an area with depths between 80 and 120 m. This study was carried out in November 2013, towards the end of the whale breeding season. In order to record the depth and diving time of whales, we used a time-depth recorder (TDR), the Sensus ULTRA Reefnet, attached to a suction-cup device (SCD) designed by us (Figure 2). The device was a floating capsule of closed cell material attached to a carbon fiber base with two silicone suction cups of 5-cm diameter each.

This was the first time that a SCD was used to tag southern right whales. Darts with satellite

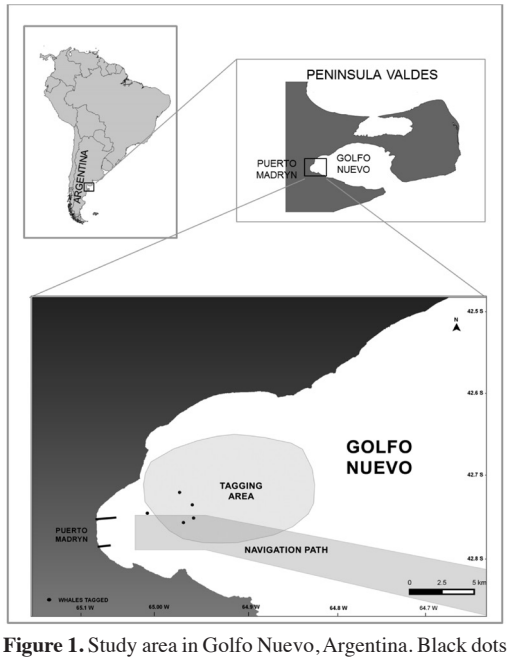

Figure 1. Study area in Golfo Nuevo, Argentina. Black dots represent the five tagged southern right whales (*Eubalaena australis*) at deep waters in Golfo Nuevo. Ports of Puerto Madryn city (black solid lines) and the route used by ships to enter to Puerto Madryn port are also shown.

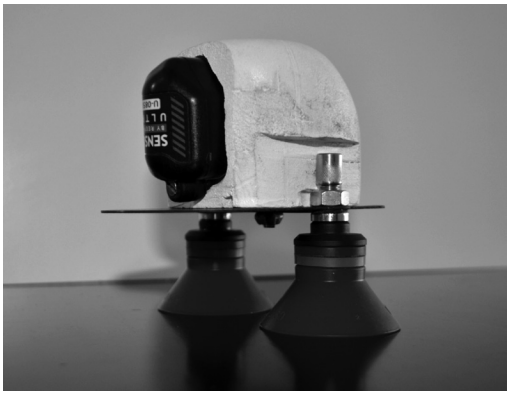

Figure 2. Suction cup device (SCD)

transmitters and VHF antennas were previously used in South Africa (Oosthuizen, 2004; Mate et al., 2006). The SCD was deployed from a semi-rigid haul boat of 5.6 m powered by a 90-HP outboard engine. The device was placed at the end of a 4.5-m-long pole of carbon fiber. The end of the pole had a system that released the SCD, allowing the attachment of the tag on the whale by applying pressure. The device-placement maneuver included the selection of the target whale, the approach to the whale at a constant speed of up to 3 or 4 m from it, and the positioning of the SCD on the whale's back (Figure 3). Once the tag was attached to the whale, the boat moved slowly away from the tagged individual and remained with the engine off until the tag was released and recovered by direct visualization. The device release mechanism was specifically designed by the authors for this study and was created by using sodium bicarbonate powder covering the center hole of the SCD. After approximately 30 min, sea water came into contact with the powder, which became diluted, therefore releasing the device.

A total of 11 tag-placement attempts were undertaken, but only five were successful. Whales dived for periods of about 10 min and then abruptly returned to the surface to breathe. Once on the surface, they breathed around four times and dived again. Between breaths, they swam at a fast speed, so those breaths were the only opportunities to tag the whales, limiting the number of opportunities to attach the device. Two calves, one adult female (with a calf), a solitary adult, and a juvenile (which was interacting with another juvenile) were tagged. All tagging attempts were recorded using photography and video. A total of 1:11:50 h of dive duration data were recorded from the TDR. Dive duration, average and maximum depth, and ascent rate were recorded for all the tagged whales. Maximum depth of the place where the whales were tagged was also recorded

Figure 3. Placement of the SCD: Above, sequence of the SCD placement; below left, SCD attached to the whale; and below right, whales starting deep immersion.

with a boat echosounder (Furuno LS-610). All dives recorded exceeded 50 m depth, except for that of one of the calves, which descended only 6.39 m (Table 1). The diving profiles of the tagged whales are shown in Figure 4. Individuals 1, 2, and 3 were tagged on 22 November, whereas Individuals 4 and 5 were tagged on 30 November.

Individual 1 was an adult that was being disturbed by dusky dolphins at the time of tagging. The profile shows that it dived to a depth of 56.98 m and returned to the surface at 2.27 m s^{-1} in about 2 min. Individual 2 was a calf that was at surface, waiting for its mother, which was diving. Individual 3 was a juvenile interacting with another juvenile. In fact, both juveniles did the same cycles of deep immersion. As the TDR remains inactive at depths less than 1 m, two diving profiles were obtained for Individual 3. In both cycles, depths were close to 70 m, which was similar to the depth recorded by the echosounder. Individual 4 was a mother with a calf. In this case, the maximum depth recorded (68.02 m) was also similar to the depth recorded by the echosounder. Two completed diving cycles were recorded, and we assumed that in the third cycle this individual lost the tag. The fact that two cycles were recorded uninterruptedly in the latter case could be because the tag was placed just above the right lateral midline of the whale, so the TDR remained active since it was 1 m below the surface all the time. All other whales were tagged on the back. Individual 5 was a calf that was more than 1 y old. The profile shows that it dived to a depth of 54.46 m and returned to the surface at 1.04 m s^{-1}, with an ascent rate similar to the one obtained for the juvenile.

To our knowledge, these data are the first record concerning the diving profiles for southern right whales worldwide. In the study area, the fact that

Table 1. Total recording time, maximum depth, and ascent rate of each tagged individual whale

ID	Category	Time (min s)	Maximum depth (m)	Ascent rate (m s^{-1})	Echosounder depth (m)
1	Adult	8'30"	56.98	2.27	80
2	Calf	4'00"	6.39	0.55	70
3	Juvenile	11'30"	74.66	1.08	83
		8'20"	70.55	1.11	70
4	Mother	33'00"	68.02	1.67	77
5	Calf	6'30"	54.46	1.04	64

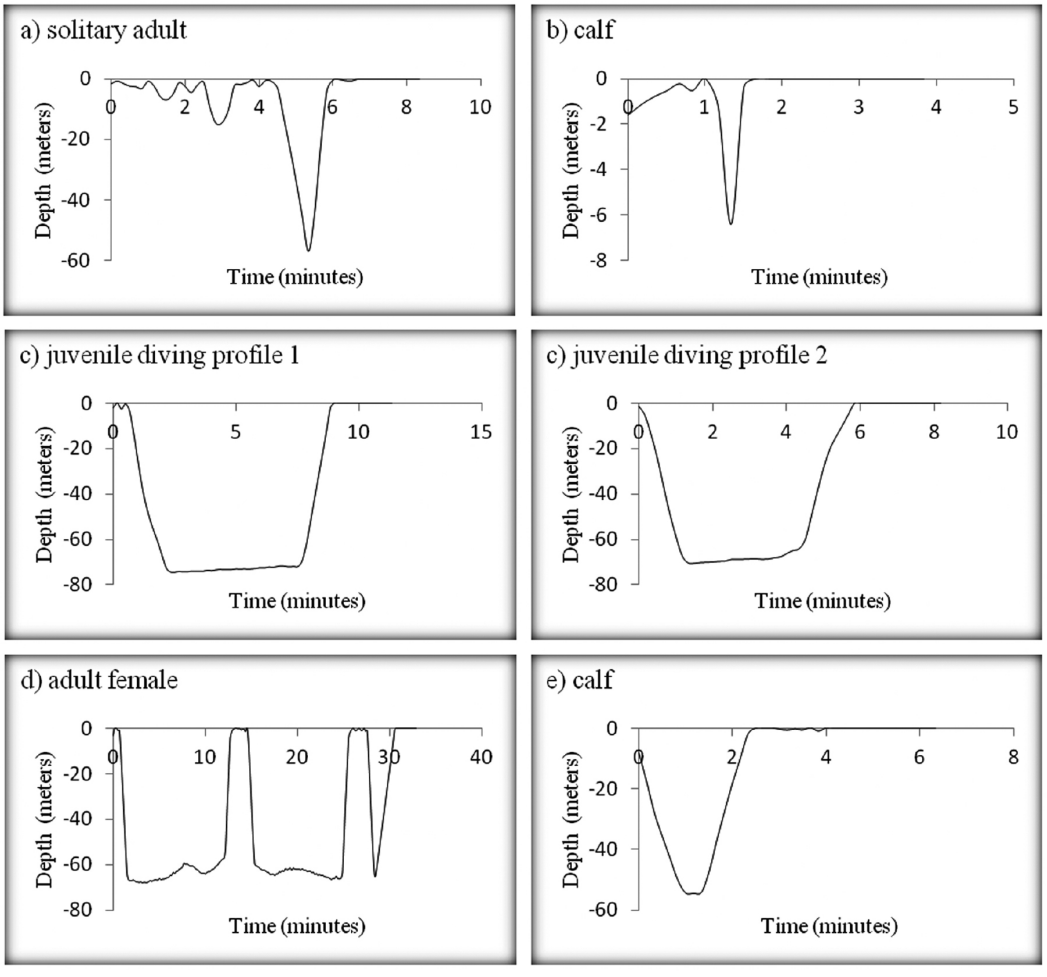

Figure 4. Diving profiles of the tagged whales: (a) solitary adult, (b) calf, (c) juvenile, (d) adult female, and (e) calf

whales dive for long periods and abruptly return to the surface to breath reinforces the need to gather scientific data to address potential problems related to the use of space involving whales and ships near Puerto Madryn city in commercial maritime trade and port areas. An understanding of whale diving behaviors and the evaluation of risks of collision and management of the resource are crucial to ensure whale protection. Furthermore, this information is critical for calculating detection probabilities, through precise estimates of the proportion of time whales are visible at the surface (Würsig et al., 1984; Dorsey et al., 1989). In Argentina, southern right whales not only represent a potential alternative for ecological and sustainable tourism but also are a historical and cultural reference. Puerto Madryn city provides most of the support services related to tourism, especially whale watching and cruise tourism. Whale watching is one of the most profitable tourism resources for the region, and the conservation of whales and responsible management of activities involving interactions with them is of main concern. The collisions are not only a threat to whales, but they also can pose a risk to humans who sail in small vessels and kayaks around the harbors. Understanding their area usage and diving patterns, and planning spatially explicit strategies should be the next steps to avoid conflicts.

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Montanelli, dfyfschubut@gmail.com). Special permissions were approved by Subsecretaría de Conservación y Áreas Protegidas, Secretaría de Turismo by Order No. 047–SsCyAP–13 (Contact information: Dr. Víctor Fratto, proyectos conservacion@gmail.com) due to the fact that the tagging area included the Doradillo Protected Area (42° 37' 16" S, 64° 51' 32" W). During the writing of this manuscript, MBA had a doctoral fellowship from CONICET and SCTeIP Chubut. This work was supported by Centro Nacional Patagónico–CONICET, Secretaría de Ciencia, Tecnología e Innovación Productiva of Chubut Province, and Fundación Vida Silvestre Argentina, and was also supported by Conservation, Research and Education Opportunities (http://creoi.org/effects-of-anthropogenic-activities-on-the-distribution-abundance-and-behavior-of-southern-right-whales-in-golfo-nuevo-chubut). Special thanks to Walter Etchaide for his nautical assistance and to Rafael Benegas, Martín Chaparro, Gabriela Palacios, Daniel Góngora, Eliana Carabajal, and Verónica D'Amico for their collaboration.

Literature Cited

Bastida, R., Rodriguez, D., Secchi, E., & Da Silva, V. (2007). *Mamíferos acuáticos de Sudamérica y Antártida* [Aquatic mammals of South America] (1st ed.). Buenos Aires, Argentina: Vazquez Mazzini Editores.

Baumgartner, M., & Mate, B. (2003). Summertime foraging ecology of North Atlantic right whales. *Marine Ecology Progress Series*, *264*, 123-135. http://dx.doi.org/10.3354/meps264123

Beardsley, R. C., Epstein, A. W., Chen, C., Wishner, K. F., Macaulay, M. C., & Kenney, R. C. (1996). Spatial variability in zooplankton abundance near feeding right whales in the Great South Channel. *Deep-Sea Research II*, *43*, 1601-1625. http://dx.doi.org/10.1016/S0967-0645(96)00050-1

Carrillo, M., & Ritter, F. (2010). Increasing numbers of ship strikes in the Canary Islands: Proposals for immediate action to reduce risk of vessel–whale collisions. *The Journal of Cetacean Research and Management*, *11*(2), 131-138.

Cooke, J. (2012). *Southwest Atlantic right whales: Updated population assessment from photo-id collected at Península Valdés, Argentina* (IWC/64/Rep 1 Annex F).

Crespo, E. A., Pedraza, S. N., Dans, S. L., Coscarella, M. A., Svendsen, G. M., & Degrati, M. (2011). *Number of southern right whales* Eubalaena australis *and population trend in the neighbourhood of Península Valdés during the period 1999-2011 by means of aerial and boat surveys*. Southern Right Whale Assessment Workshop**,** Buenos Aires, Argentina. 15 pp.

Dorsey, E. M., Richardson, W. J., & Würsig, B. (1989). Factors affecting surfacing, respiration, and dive behaviour of bowhead whales, *Balaena mysticetus*, summering in the Beaufort Sea. *Canadian Journal of Zoology*, *67*, 1801-1815. http://dx.doi.org/10.1139/z89-257

International Whaling Commission (IWC). (2001). Report of the workshop on status and trends of western North Atlantic right whales. *The Journal of Cetacean Research and Management* (Special Issue 2), 61-87.

IWC. (2010). *The global ship strikes database*. Retrieved from http://iwc.int/index.php?cID=872&cType=document

Knowlton, A. R., Kraus, S. D., & Kenney, R. D. (1994). Reproduction in North Atlantic right whales (*Eubalaena glacialis*). *Canadian Journal of Zoology*, *72*, 1297-1305. http://dx.doi.org/10.1139/z94-173

Kraus, S. D., Hamilton, P. K., Kenney, R. D., Knowlton, A. R., & Slay, C. K. (2001). Reproductive parameters of the North Atlantic right whale. *The Journal of Cetacean Research and Management* (Special Issue 2), 231-326.

Laist, D. W., Knowlton, A. R., Mead, J. G., Collet, A. S., & Podesta, M. (2001). Collisions between ships and whales. *Marine Mammal Science*, *17*, 35-75. http://dx.doi.org/10.1111/j.1748-7692.2001.tb00980.x

Marine Mammal Commission (MMC). (1999). *Marine Mammal Commission annual report: 1998*. Bethesda, MD: MMC. 239 pp.

Mate, B., Mesecar, R., & Lagerquist, B. (2006). The evolution of satellite-monitored radio tags for large whales: One laboratory's experience. *Deep-Sea Research II*, *54*, 224-247. http://dx.doi.org/10.1016/j.dsr2.2006.11.021

Nowacek, D., Johnson, M., & Tyack, P. (2003). North Atlantic right whales (*Eubalaena glacialis*) ignore ships but respond to alerting stimuli. *Proceedings of the Royal Society B: Biological Sciences*, *271*, 227-231. http://dx.doi.org/10.1098/rspb.2003.2570

Oosthuizen, W. H. (2004). *South African progress report on cetacean research*. Roggebaai, South Africa: Marine and Coastal Management, Department of Environmental Affairs and Tourism.

Ritter, F. (2012). Collisions of sailing vessels with cetaceans worldwide: First insights into a seemingly growing problem. *The Journal of Cetacean Research and Management*, *12*(1), 119-127.

Werner, R., Forcada, J., Bertellotti, M., Crespo, E. A., Dans, S., Degrati, Y., . . . Acevedo-Whitehouse, K. (2011). Report of the Southern Right Whale Die-Off Workshop (Conference Paper). *The Journal of Cetacean Research and Management*, *12(*Supp.), 367-398.

Wishner, K. F., Schoenherr, J. R., Beardsley, R., & Chen, C. (1995). Abundance, distribution and population structure of the copepod *Calanus finmarchicus* in a springtime right whale feeding area in the southwestern Gulf of Maine. *Continental Shelf Research*, *15*, 475-507. http://dx.doi.org/10.1016/0278-4343(94)00057-T

Würsig, B., Dorsey, E. M., Fraker, M. A., Payne, R. S., Richardson, W. J., & Wells, R. S. (1984). Behavior of bowhead whales, *Balaena mysticetus*, summering in the Beaufort Sea: Surfacing, respiration, and dive characteristics. *Canadian Journal of Zoology*, *62*, 1910-1921. http://dx.doi.org/10.1139/z84-281