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Ocean to ocean: First documented migration of a Southern right whale from the southwest Atlantic to the southeast Pacific

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INTERNATIONAL
WHALING COMMISSION

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ABSTRACT

Southern right whales (*Eubalaena australis*) exhibit a circumpolar distribution in the Southern Hemisphere. In South America, this species occupies breeding and nursing grounds during the austral winter along both the Pacific (the Chile-Peru population) and Atlantic coasts (the west South Atlantic population). Available information on historical and contemporary feeding areas of the critically endangered Chile-Peru population is limited. A recent study has reported the presence of individuals near Isla Chiloé, Chile, almost year-round, suggesting these areas might be used as feeding grounds. However, the question arises as to whether these individuals belong to the Chile-Peru population or originate from other populations. Individuals from the Atlantic population, breeding in Peninsula Valdés, Argentina, are being studied in a satellite telemetry project since 2014, where over a hundred whales have been tagged with the aim to understand their feeding areas. Specifically, during 2023, an adult female accompanied by her calf, named Athena, was tagged. After initiating its migration, this whale moved south to the southernmost tip of Cape Horn, then began moving north along the southern Chilean Pacific coast. This journey represents the first documented migratory movement of a whale that bred in Peninsula Valdés towards the waters of the southern Pacific Ocean. This event demonstrates not only the plasticity of movements of this species but also suggests potential genetic and demographic connectivity between these two populations. Furthermore, it raises doubts about the true existence of the Chile-Peru population in its southernmost distribution area. This journey highlights once again the importance of continuing satellite telemetry studies to better understand population-level movements and contribute to the global management and conservation of the species.

KEYWORDS: Satellite telemetry; movement; *Eubalaena australis*

INTRODUCTION

Southern right whales (*Eubalaena australis*, SRWs) exhibit a circumpolar distribution across the Southern Hemisphere, ranging approximately from 12°S to 65°S (Cooke & Zerbini, 2018). During the austral winter, this species typically occupies breeding and calving grounds near the subantarctic islands of New Zealand, coastal habitats off southern Australia, southern Africa, and the eastern coast of South America (IWC, 2001). Additionally, a small, critically endangered population, referred to as the Chile-Peru population, is found in the Pacific Ocean basin along the southwestern coast of South America (Aguayo-Lobo et al., 2008; Cooke & Zerbini, 2018; Galletti Vernazzani et al., 2011). All SRW populations were nearly decimated during commercial whaling and subsequently protected by international agreements starting in 1935. Since then, all but one, the Chile-Peru population, have shown varying levels of recovery (Cooke & Zerbini, 2018; Romero et al., 2022).

Currently, the SRW population in the southern Pacific is distributed from Lima, central Peru (12°11’ S) to the Golfo de Penas, southern Chile (47°58’ S). Two recognized areas of higher

concentrations exist, one in the Antofagasta region (near 23° S) and the other in central-southern Chile (between 33° to 42° S) (Galletti Vernazzani et al., 2014; Garcia-Cegarra et al., 2021). Although limited information is available regarding both historical and contemporary feeding areas, several authors hypothesize that these whales migrate annually from these coastal aggregation areas to high latitude waters off the Antarctic Peninsula (Aguayo-Lobo et al., 1992; 2008; Mackintosh, 1942; Van Waerebeek et al., 1998; 2009). A recent study reports the presence of individuals near Isla Chiloé (42.67°S, 73.92°W) almost year-round (from January to October), suggesting that this area could also be a feeding ground (Galletti Vernazzani et al., 2023). During the 19th century, according to whaling logbook records (Townsend, 1935), many SRW were hunted during the spring-summer months, both in this region and in oceanic waters. Despite these data, some authors propose instead that individuals found in these feeding areas may belong to the southwest Atlantic population (Gibbons et al., 2006), or could be shared by both populations (Aguayo-Lobo et al., 2008; Galletti Vernazzani et al., 2023; Kennedy et al., 2023).

Over the past decade, the use of satellite telemetry has provided new insights into the habitats used by major SRW populations at middle and high latitudes across all ocean basins (i.e., New Zealand and Australia, South Africa, South Georgia / Georgias del Sur Island, and Argentina) (Kennedy et al., 2023; Mackay et al., 2020; Mate et al., 2011; Vermeulen et al., 2023; Zerbini et al., 2016, 2018). For example, Vermeulen et al. (2023) reported some overlap in the use of feeding areas between the eastern and western South Atlantic populations, as individuals calving off South Africa undertook long-distance movements towards South Georgia/Georgias del Sur Island, the Falkland/Malvinas Islands, and areas near the eastern coast of South America, typically used by the western South Atlantic (Argentina, Uruguay and Brazil) SRW population.

Since 2014, 103 SRWs have been tagged with satellite transmitters in the calving ground in and around Península Valdés, Argentina. The diversity of routes and areas these individuals have traversed during their migration across their distribution is remarkable (Zerbini et al., 2015, 2016, 2018). The purpose of this note is to describe the unusual movements of one individual tagged in 2023, which migrated from Golfo Nuevo in the Península Valdés calving ground to the Pacific Ocean basin.

MATERIALS AND METHODS

On 25 October 2023 at 19:40 GMT in Golfo Nuevo (42.525°S, 64.394°W), Península Valdés, Argentina, a female SRW (named ‘Atenea’) with a newborn calf was instrumented with a new, fully integrated, consolidated (Type-C) Wildlife Computers ARGOS satellite tag (PTT ID 185113). This “blubber” tag was 130 mm in length, 24 mm in diameter, weighted 180g and was designed to penetrate and anchor into the blubber layer of SRWs (Zerbini et al., 2023). Prior to deployment, the tag underwent sterilization using ethylene oxide following recommendations outlined in the IWC-endorsed Cetacean Tagging Best Practices (Andrews et al., 2019). The tag was implanted on the right side of the fat neckroll, 1.5-2m behind the blowhole (Fig. 1). During tag deployment, video, photo documentation, photo-identification data and a skin biopsy were obtained.

Argos location data presented in this document were processed to eliminate spurious locations (e.g., those occurring on land, or with "Z" location quality) prior to be fitted with a correlated random walk (CRW) state-space model using “fit_smm” in the R package “aniMotum” (Jonsen et al., 2023). The CRW model was used to account for location uncertainty (Jonsen et al., 2020), and to produce an interpolated time-regularized 3-hour interval track. Also, the model was fitted with a speed filter threshold (vmax) of 6 m/s, equivalent to 20 km/h, based on previously reported rates of movement in SRW (Mate et al., 2011). Data obtained was modeled with a 2-

behavioral states discrete-time hidden Markov model (HMM) using the package "momentuHMM" (McClintock & Michelot, 2018). The HMM included 2 behavioral states: High-residency (HR) (which corresponds to slower movement with more turns, typically indicating milling, foraging, and social behavior) and directed travel or Transit (T) (when movement is faster and more straight-lined). Based on the observed distance travelled and the change of movement direction between consecutive relocations, the model estimates the step length and the turning angle distribution. The step length was modelled based on a Gamma distribution with initial values of 5.02 ± 3.11 km and 15.19 ± 3.40 km for HR and T-state, respectively. The turning angle was modelled as a wrapped Cauchy distribution with an initial concentration parameter of 0.73 for HR-state and 0.89 for T-state. The Viterbi algorithm was used to compute the most likely sequence of those two underlying states in the track (McClintock & Michelot, 2018; Zucchini et al., 2017). The data obtained were used to estimate the minimum total distances travelled, the speed, and the potential areas where Atenea spent time in different behavior patterns. Data processing and analysis were conducted in the open-source software R (version 4.3.2, R Core Team, [2023]).

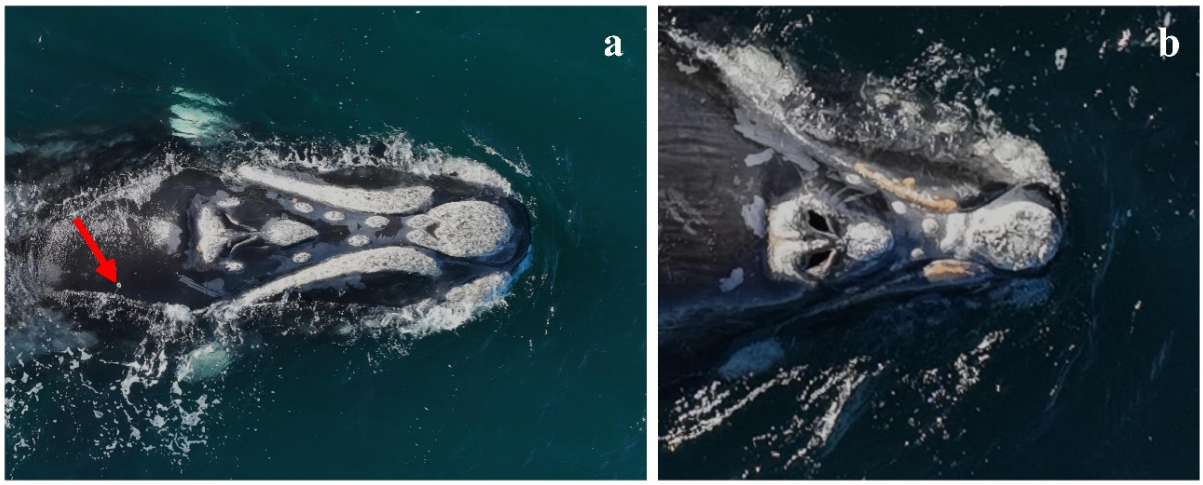

Fig. 1: Tag placement location (red arrow) and callosity patterns of a female southern right whale named Atenea (a), and her calf (b) photographed on October 25, 2023, immediately after tag deployment.

Argos location data presented in this document were processed to eliminate spurious locations (e.g., those occurring on land, or with "Z" location quality) prior to be fitted with a correlated random walk (CRW) state-space model using "fit_smm" in the R package "aniMotum" (Jonsen et al., 2023). The CRW model was used to account for location uncertainty (Jonsen et al., 2020), and to produce an interpolated time-regularized 3-hour interval track. Also, the model was fitted with a speed filter threshold (vmax) of 6 m/s, equivalent to 20 km/h, based on previously reported rates of movement in SRW (Mate et al., 2011). Data obtained was modeled with a 2-behavioral states discrete-time hidden Markov model (HMM) using the package "momentuHMM" (McClintock & Michelot, 2018). The HMM included 2 behavioral states: High-residency (HR) (which corresponds to slower movement with more turns, typically indicating milling, foraging, and social behavior) and directed travel or Transit (T) (when movement is faster and more straight-lined). Based on the observed distance travelled and the change of movement direction between consecutive relocations, the model estimates the step length and the turning angle distribution. The step length was modelled based on a Gamma distribution with initial values of 5.02 ± 3.11 km and 15.19 ± 3.40 km for HR and T-state, respectively. The turning angle was modelled as a wrapped Cauchy distribution with an initial

concentration parameter of 0.73 for HR-state and 0.89 for T-state. The Viterbi algorithm was used to compute the most likely sequence of those two underlying states in the track (McClintock & Michelot, 2018; Zucchini et al., 2017). The data obtained were used to estimate the minimum total distances travelled, the speed, and the potential areas where Atenea spent time in different behavior patterns. Data processing and analysis were conducted in the open-source software R (version 4.3.2, R Core Team, [2023]).

RESULTS

After tag deployment, Atenea and her calf remained along the northeastern shore of Golfo Nuevo for three days (Fig. 2), covering 135.36 km at an average speed of 1.96 km/h. On 28th October 2023, Atenea left Golfo Nuevo and initiated a southward journey in the Argentine Sea towards the tip of the South American continent (Fig. 2a). On 7th November, she reached the Le Maire Strait, which separates the Island of Tierra del Fuego from Isla de los Estados, approximately 1,560 km to the south of Península Valdés (Fig. 2).

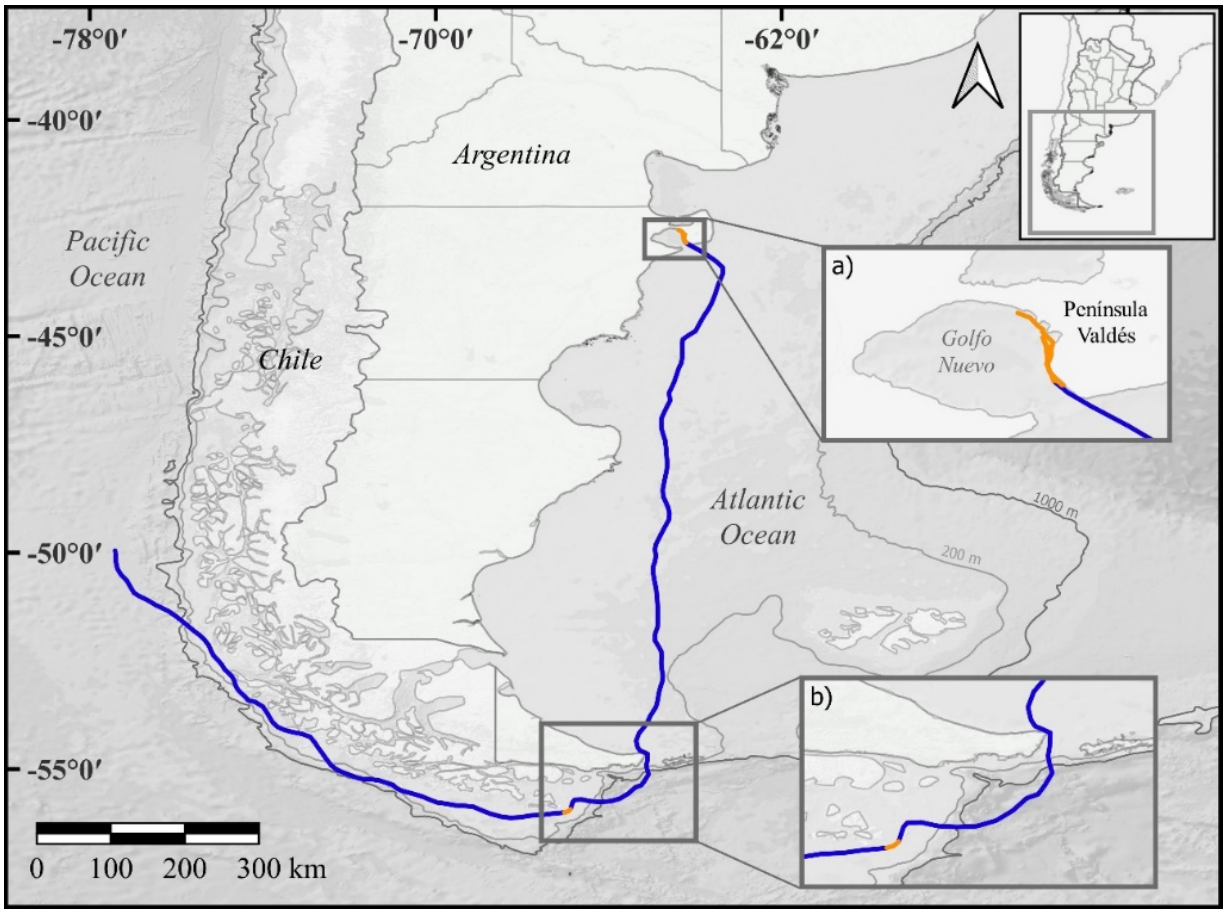

Fig. 2 – Map illustrating the migratory route of Atenea, an adult female southern right whale with calf tagged in Golfo Nuevo, Península Valdés breeding area in 2023. Detailed map of High-residency behavior (orange) within the breeding area (a) and at the southern tip of Cape Horn (b). Transit behavior is colored in blue. Isobaths of 200 and 1000 m are incorporated to demarcate the continental slope.

The average speed during this initial 10-day migration (behavioral states classified as "T") was 5.42 km/h. After navigating westward around Cape Horn (~56°S), Atenea exhibited HR-behavior, reducing her movement speed by half (2.24 km/h) for one day before she began moving north, along the Pacific coast of southern Chile (Fig. 2b). Initially, the whale navigated close to shore over the continental shelf (between latitudes 56°S and 51°S; Fig. 2) before

moving into deeper waters beyond the continental slope. The last location (50.03°S, 77.42°W) was received on 19th November 2023, at 12:35 GMT, 24.5 days after tag deployment. The recorded journey spanned 2,767 kilometers; an average of 112.95 km travelled per day.

DISCUSSION

Atenea's journey is the first documented movement of a SRW from the western South Atlantic population into the range of the endangered Chile-Peru SRW population in the eastern South Pacific. This finding offers valuable insights into the migratory movement plasticity of SRWs and suggests the potential for genetic and demographic connectivity between SRW populations in the eastern and western sides of South America, at least in their southernmost distribution area.

Except for the time spent at the Península Valdés breeding ground and near Cape Horn, Atenea consistently exhibited a typical migratory behavioral (T-behavioral state) while transiting between Argentina and the Chilean coast. Considering her northward trajectory did not show changes in behavioral states once she was in the southwest Pacific basin, it is possible to speculate that Atenea was still heading towards a potential feeding ground. Unfortunately, due to the relatively short duration of transmissions from the tag, which is typical of tags anchoring in the blubber (Zerbini et al., 2023), inferences regarding Atenea's destination in the Pacific Ocean are limited.

In baleen whales, fidelity to reproductive and feeding areas is passed-on from mothers to their calves during their first migratory journey (Hoelzel, 1998; Valenzuela et al., 2009). SRW calves from Península Valdés learn the locations of the feeding grounds from their mothers, and this culturally inherited site fidelity to feeding grounds appears to be passed on for several generations (Valenzuela et al., 2009). Atenea's incursion into Pacific waters could indicate that this area was previously frequented by her and her mother, or it could suggest an early sign of a possible distributional shift or expansion of their feeding grounds (Bedriñana-Romano et al., 2022). Alternatively, it could simply be an exploratory or temporary migration event, a phenomenon more commonly observed in solitary adults and juveniles, rather than females with calves (Arias et al., 2018; Burnell, 2001; Sueyro, 2023). Life history of Atenea would add information on her visits to Península Valdés or, potentially, to the Pacific waters, her calving record, and other demographic data. A way to build that history is by searching existing photoidentification catalogs based on SRW's unique callosity patterns on their head (Kraus et al., 1986; Payne et al., 1983). Atenea has not been matched to any whale in the Península Valdés catalog (started in 1971 by Ocean Alliance/Instituto de Conservación de Ballenas), which contains more than 4,300 individuals. Matching to the Pacific SRW catalogs is pending. Re-sighting Atenea or her calf (Fig. 1) in the future would be indicative of some degree of site fidelity, either to the reproductive area of Península Valdés or to the SE Pacific coast.

At the last meeting of the IWC Eastern South Pacific Southern Right Whale Conservation Management Plan, an increase in the number of individual sightings in the region of Isla Chiloé and Golfo de Penas was reported (Galletti Vernazzani, 2023). This rise led researchers to consider whether it was due to a population increase or if it could be attributed to recolonization by individuals from other populations (Galletti Vernazzani, 2023). If the latter is true, it could indicate the shared used of these areas, facilitating genetic connectivity (Carroll et al., 2015). Recent genetic analysis of samples from individuals of the Chile-Peru population showed that the potential for gene flow between populations on both sides of South America. Tissue samples from lactating female SRWs observed in the region of Antofagasta, Chile, and in Peru had mitochondrial DNA haplotypes also seen in whales from Argentina (Garcia-Gegarra et al., this meeting).

A similar phenomenon has been observed in North Pacific gray whales (*Eschrichtius robustus*). This species was believed to encompass two distinct populations, one on each side of the North Pacific Ocean: the western gray whale, with only about 130 individuals, is classified as critically endangered by IUCN (Cooke et al., 2018), and the eastern gray whale population, which has rebounded from historical commercial exploitation to approach carrying capacity limits (Rugh et al., 2005). Through data derived from individual tagging, as well as genetic and photo-ID comparisons between both gray whale populations, the existence of these two populations as separate entities has been questioned (Mate et al., 2015). These authors propose the possibility that the western population may be extinct, and individuals from the eastern population could be utilizing the feeding grounds historically attributed to the western gray whale population. Another possibility is that both populations are co-mingling in this feeding area, potentially resulting in a significantly lower number of whales in the western population than estimated. Considering this evidence, Atenea's journey, combined with the aforementioned genetic connectivity, could suggest a linkage between the two South American SRW populations. Furthermore, as proposed by Mate et al. (2015), it prompts questions regarding whether individuals from the southernmost distribution of the Chile-Peru population truly belong to this critically endangered South Pacific population or if they are individuals from the western South Atlantic population recolonizing their pre-whaling distribution area.

Atenea's journey underscores the importance of continuing to instrument individual SRWs with satellite tags to better understand population level movement and connectivity. Advancements in the development of less invasive and more durable tagging devices will allow for longer-term observation of the variability in the species' migratory movements, contributing to its global management and conservation.

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