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Introduction

Southern right whales (*Eubalaena australis*) are distributed throughout the southern hemisphere between 20°S to 60°S latitude. In late fall and winter, they gather in shallow water areas in the north of their range where they give birth and raise their calves during their first three months of life. As plankton begins to bloom in spring, the whales begin migrating to their more southerly feeding grounds where they are found from late spring through summer. In comparison to most other species of large whales, southern right whales are easy to observe on their calving grounds where they have been studied extensively since 1970. The discovery of individually distinctive white markings on their heads (callosities) and white and gray blazes on their bodies (Payne 1986) has made it possible to follow the lives of known individual right whales for decades and thus make accurate estimates of population sizes, growth rates and distribution (Cooke et al. 2011, Rowntree et al. 2001, Cooke et al. 2015).

The population that calves off the eastern coast of South America occupies two calving grounds separated by 2,100 km: one is found along the 500-km coastline of Península Valdés (PV), Argentina (*ca.* 42°30'S, 63°50'W) and the other is found along 400 km of the coast of Southern Brazil (*ca.* 28°29' S, 48°45' W). Here we summarize data on the movement of right whales between these two calving grounds. This study was undertaken to enable a more accurate assessment of the size and recent growth of the population defined as including whales that frequent both of these calving grounds.

Materials and Methods

Península Valdés right whales. The PV right whales have been surveyed annually since 1971 by conducting at least one aerial survey per year of the entire perimeter of the Península at the time of peak whale abundance. During surveys, a 4-place light aircraft is flown along the perimeter of the Peninsula until it encounters a whale or group of whales. The pilot then circles over the whale(s) while a photographer, seated behind the pilot, takes a sequence of full-body photos of each whale, to provide (if possible) clear images of the whale's head and any white or grey patterns or wounds on its back. A note-taker simultaneously gives each group a letter, records its location, and notes whether the whale is accompanied by a calf. Photographs taken during surveys are cataloged and analyzed after the field season. The Hiby-Lovell Right Whale Identification System (Hiby & Lovell 2001) is used to create a digital extract of the callosity pattern on each whale's head, and to search for that pattern in the existing catalog of whales previously identified off PV. When found, matches usually appear in the top 20 whales but searches continue down to the 70th whale in the ranked list of possible matches. Searches for whales with similar back marks are done manually. The PV catalog currently includes 3,813 individual right whales photo-identified during aerial surveys from 1971 through 2017.

The Brazilian right whales. Aerial surveys of right whales have been conducted off Brazil since 1987, for photo-identification. Surveys were conducted on an irregular basis from 1987 to 1994 (1987, 1988, 1992, 1993 and 1994) and annually from 1997 to 2018 (except 2014), during September, the time of peak whale abundance. In some years there were monthly surveys throughout the whale season (July to November). The extent of the coastline surveyed varied in some years but one 120 Km region of the coast was included in every survey. Surveys were conducted from a single-engine aircraft from 1987 to 1997 and from a helicopter from 1998 on. Surveys were conducted at an average altitude of 1000ft (~300m), a mean speed of 60kt (100km/h) and ~500m off and parallel to the shoreline. One to three observers were in the aircraft in addition to the pilot. Whenever a whale or group of whales was spotted they were approached and circled at a minimum height of 328ft (100m) for taking the photographs. Simultaneously, the number of whales, the group composition and the position of the group were noted. The analysis of the photographs was aided by the automated Right Whale Identification Software (Hiby & Lovell 2001). A catalog was created at the beginning of the study and each new year of aerial survey photographs are compared to the existing catalog to look for matches. If a whale is not found in the catalog, it is given a new number and added to the catalog. The Brazilian catalog includes 1,021 individual right whales photo-identified during aerial surveys from 1987 through 2019.

The 2020 search for right whales photo-identified off Brazil in the Argentine catalog. The Hiby-Lovell system was used to search for matches between the right whales photo-identified off Brazil from 1987 through 2017 in the catalog of right whales photo-identified off Argentina from 1971 through 2017. Searches for Brazilian right whales with distinctive gray or white back marks were conducted manually.

Results and Discussion

We found 124 individually identified southern right whales that have been seen on both the Brazilian and Argentine calving grounds (Table 1). No whales were seen on both calving grounds within the same year. Seventy-eight (63%) of the whales that changed calving grounds were females, which is not surprising because they are the easiest whales to photo-identify because they spend most of their time at the surface in shallow water (Payne 1976). The percentage of the Brazil catalog seen in the Argentina catalog by the end of 2017 was 13.8%, which equals the percentage found in the previous comparison (see below).

Table 1. Movements of the individual southern right whales that were sighted in both Argentina (A) and Brazil (B) photo-identification catalogs between 1971-2017 and 1987-2017, respectively.

Movements between calving grounds	Number of whales
Whales first seen in A and then later in B	65
Whales first seen in A then in B and then back in A	11
Whales alternating locations as A-B-A-B	6
Whales alternating locations as A-B-A-B-A	1
Whales first seen in B and then later in A	37
Whales first seen in B then in A and then back in B	3
Whales alternating locations as B-A-B-A	1
Total	124

Movements from Argentina to Brazil. The majority of whales that changed calving grounds (83 = 67%) were first identified off Argentina and later sighted off Brazil (see Table 1). Sixty-five of these whales continued returning to Brazil (as of 2017). Most of them had multiple sightings with calves before and after their move. Of the remaining whales that moved to Brazil, 11 returned to Argentina in the following

years, 7 alternated twice between locations, 6 were last seen off Brazil and one was last seen off Argentina.

Movements from Brazil to Argentina. Forty-one right whales moved from Brazil to Argentina (41= 33%). Thirty-seven of these whales were first seen off Brazil and later seen only on the Argentine calving ground (as of 2017), 3 returned to the Brazilian calving ground and one alternated twice between calving grounds (B-A-B-A).

Results from catalog comparisons

2010 Comparison

% of Brazil catalog seen off Argentina by end of 2004 = $51/332 = 15.3\%$

Number of whales in Arg catalog by end of 2010 when compared = 2,858

Number of whales in Brazilian catalog in 2011 when compared = 653

% of Brazil catalog seen off Argentina by end of 2010 = $90/653 = 13.8\%$ as of the end of 2010

% of Arg catalog seen off Brazil by end of 2010 = $90/2858 = 3.15\%$

2020 Comparison

Number of whales in Arg catalog by end of 2017 when compared = 3,813

Number of whales in Brazil catalog by end of 2017 when compared = 896

% of Brazil catalog by end of 2017 seen off Argentina = $124/896 = 13.8\%$

% of Arg catalog by end of 2017 seen off Brazil = $124/3813 = 3.25\%$

The results from the comparison of catalogs in 2020 differ very little from those in 2010. The proportion of whales in the Brazilian catalog that was seen off Argentina remained the same, 13.8% and the proportion of whales in the Argentine catalog that was seen off Brazil increased slightly from 3.15% to 3.25% during the seven years between catalog comparisons.

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