

RECENT RAPID INCREASES IN THE RIGHT WHALE (*EUBALAENA AUSTRALIS*) POPULATION OFF SOUTHERN BRAZIL

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ABSTRACT: Right whales (*Eubalaena australis*) that gather on a wintering ground off southern Brazil have been aerial surveyed and photographically identified since 1987. As of 2003 the Brazilian Right Whale Catalogue has 315 different individual whales of which 31 were resighted in other years (23 females, 3 yearlings and 5 whales of unknown age/sex). No resightings occurred prior to 1994 and 71% (n=24) were recorded in 2003. The modal observed interval between calving events is 3 years, consistent with successful reproduction. From 1997 to 2003 the number of reproductive females in the Central Survey Area off Brazil increased at a rate of 29.8% per year (95% CL 15.7, 44.0), and at 14% per year (95% CL 7.1, 20.9) from 1987 to 2003. These rates are significantly different from zero (t=4.133, p<0.009 and t=4.06, p<0.004, respectively). The increase from 1997 to 2003 is higher than the rates observed for right whales in other wintering grounds in the South Atlantic. The right whales on the Brazilian wintering ground are not just transients. Ten percent of the whales have been resighted. If the number of whales continues to increase they will probably expand their distribution throughout their historical 2,400km range and come into increasing conflict with human activities.

RESUMO: As baleias francas (*Eubalaena australis*) que freqüentam a área de concentração reprodutiva de inverno no sul do Brasil têm sido monitoradas através de levantamentos aéreos e fotoidentificadas desde 1987. Até 2003, o catálogo brasileiro de identificação das baleias francas conta com 315 baleias identificadas individualmente, das quais 31 foram reavistadas em outros anos (23 fêmeas, 3 baleias de um ano de idade e 5 baleias de sexo/idade indeterminados). Nenhuma reavistagem foi registrada antes de 1994 e 71% (n=24) foram registradas em 2003. O intervalo modal observado entre o nascimento dos filhotes foi três anos, o que é consistente com o sucesso reprodutivo. De 1997 a 2003, o número de fêmeas registradas com filhotes na Área Central sobrevoada no sul do Brasil aumentou a uma taxa de 29,8% ao ano (95% CL 15,7 - 44,0), e de 14% ao ano (95% CL 7,1 - 20,9) de 1987 a 2003. Essas taxas são significativamente diferentes de zero (t=4,133, p<0,009 e t=4,06, p<0,004, respectivamente). O aumento de 1997 a 2003 é maior que as taxas observadas para as baleias francas nas outras áreas de concentração reprodutiva de inverno no Oceano Atlântico Sul. As baleias francas na área de concentração reprodutiva de inverno no sul do Brasil não são apenas transientes. Dez por cento das baleias têm sido reavistadas. Se o número continuar a aumentar, pode-se esperar que as baleias francas recupem sua área de distribuição histórica ao longo de cerca de 2400km de costa, aumentando a possibilidade de conflitos entre as baleias francas e atividades humanas.

KEYWORDS: southern right whales, population increase, southern Brazil, wintering ground, *Eubalaena*, calving interval.

Introduction

Southern right whales (*Eubalaena australis*) were severely depleted by commercial whaling from the 18th through the early 20th centuries. Tormosov *et al.* (1998) describe unreported Soviet catches of right whales in their pelagic summer grounds in the mid 20th century despite international protection since 1935. In addition, right whales were also subjected to intensive commercial whaling along the southern Brazilian coast until 1973, when the whale population appeared to be extirpated from the region (Palazzo and Carter, 1983). In the early 1980s, whales were 'rediscovered' in this region and have been studied there since 1981 (Castello and Pinedo, 1979; Câmara and Palazzo, 1986).

From May to December groups of right whales use the shallow, protected waters of southern Brazil as a wintering ground (Castello and Pinedo, 1979; Lodi *et al.*, 1996; Câmara and Palazzo, 1986; Palazzo and Flores, 1998; Simões-Lopes *et al.*, 1992; International Wildlife Coalition/Brazil, 1999; Greig *et al.*, 2001). Their main aggregation area occurs off Santa Catarina state, particularly the central-southern coast from Ilha de Santa

Catarina (27°25'S, 48°30'W) to Cabo de Santa Marta, Laguna (28°36'S, 48°48'W)¹ (Figure 1) (Simões-Lopes *et al.*, 1992; Palazzo and Flores, 1998; International Wildlife Coalition/Brazil, 1999). The time of peak abundance is from August to October⁴ (Simões-Lopes *et al.*, 1992; Groch, 2000; Groch *et al.*, 2003).

The whales have been surveyed along the southern coast of Brazil since 1987. During aerial surveys, the presence and location of individual whales is documented by photographing the individually distinctive pattern of callosities on each whale's head and marking its location on a map (Payne *et al.*, 1983). The growth rate and other demographic parameters of right whale populations in the Southern Hemisphere have been estimated from the number of whales photo-identified each year during aerial surveys off their wintering grounds (*e.g.*, Bannister, 1990; Best *et al.*, 2001; Cooke *et al.*, 2001). The annual growth rates of these right whale populations range between 7 to 8% (IWC, 2001). In this paper we address two questions about the right whales off southern Brazil: 1) what is their rate of increase? and 2) do they show inter-annual fidelity to this region?

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Material and Methods

From 1987 through 2003 we conducted aerial surveys of right whales off Brazil in which we photo-identified individuals and marked their locations on a map. Surveys were conducted on an irregular basis from 1987 to 1994 (1987, 1988, 1992, 1993 and 1994) and annually from 1997 to 2003, during the time of peak whale abundance. Photographs taken from all aerial surveys have been used to create a catalogue of right whales identified off southern Brazil.

The extent of the coastline surveyed each year varied (Table 1) but one 120Km region of the coast was included in every survey (south of Ilha de Santa Catarina (27°53'S, 48°34'W) to Cabo de Santa Marta, Laguna (28.36S, 48.48W)) (Figure 1), and is hereafter called the Central Area. In some flights we surveyed 400km of coastline, a region we called the Total Area. The results for the Central and Total Areas were compared to look for evidence of habitat segregation (Payne, 1986; Best, 1990).

Surveys were conducted from a single-engine aircraft from 1987 to 1997 and from a helicopter from 1998 to 2003. Despite the higher cost/hour, the helicopter has proved to be a better platform because of its safety, maneuverability and more panoramic view of the whales. Surveys were conducted at an altitude of ~300m, a speed of 167km/h and ~500m off the shoreline. Attempts were made to conduct surveys during days with optimal conditions, i.e. low wind, low sea states (<3 Beaufort Sea Scale) and adequate lighting.

One to three observers were in the aircraft in addition to the pilot. With more than one observer, the principal observer sat beside the pilot and looked continuously out in front of the aircraft and recorded whale number, group composition, location, behavior and photographic information. The second observer sat behind the pilot, watched for whales on the pilot's side of the aircraft, took photographs and observed whale behavior and group composition. The third observer sat next to the photographer, watched for whales on the other side of the aircraft and assisted the photographer.

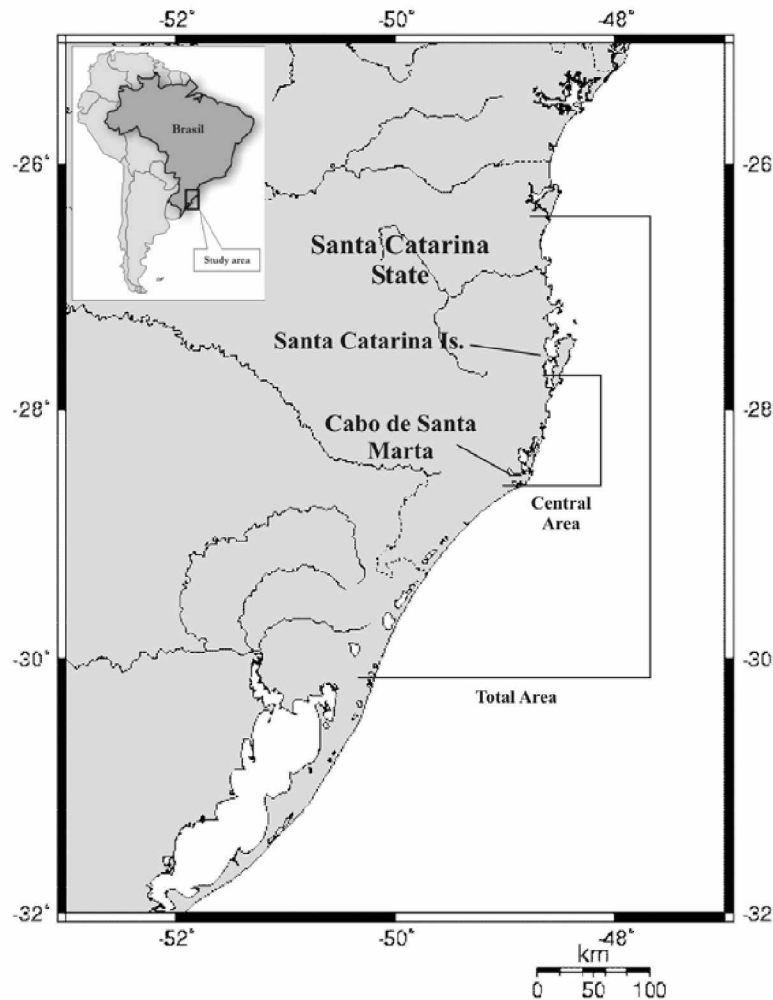


Figure 1. Map of the study area showing the boundaries of Total Area and the Central Area, which were surveyed for photo-identification of southern right whales on their wintering ground off southern Brazil from 1987 to 2003.

Whenever a whale or group of whales was spotted they were approached at a minimum height of 100m and the number of whales was counted. The helicopter hovered over the group and as the callosity patterns of individuals became visible, they were photographed. From the airplane, the whales were circled until all animals were photographed. An approach was halted if it appeared to change the whales' behavior, even if it resulted in not photographing all of the counted whales. We followed the methodology described by Payne *et al.* (1983) for taking and analyzing photographs. The analysis of the photographs was aided by the automated Right Whale Photo-identification Software developed by Hiby and Lovell (2001). A catalogue was created at the beginning of the study and, for each new year of aerial survey, photographs were compared to the existing catalogue to look for matches. If a whale was not found in the catalogue, it was given a new number and added to the catalogue. Whales accompanied by calves were assumed to be females. Individuals were considered calves if they were between 1/3 to just over 1/2 of their (presumed) mother's length.

To describe the increase in the number of whales off Brazil we assumed a constant survey effort over time and a constant growth rate and used a linear regression

of the natural log of the number of identified females with calves in each year seen in the Central Area. We used females with calves because of their greater sightability, longer residency times, tendency to spend long periods of time at the surface, and distribution close to shore in shallow water (Payne, 1986, Best, 1990; Cooke *et al.*, 2001). Only data from the Central area were used to look for population trends because this area was covered in all aerial surveys.

Results

The Brazilian Right Whale Catalogue has 315 different individual whales including 120 females, 149 whales of unknown sex/age and 46 calves identified in their calf year. Thirty-one whales (10%) have been resighted including 23 females, 3 yearlings (photographed in 2002 as newborn calves), and 5 whales of unknown age/sex. There were no resightings prior to 1994 and 71% (n=24) were recorded in 2003. The intervals between resightings varied from one to 16 years. One female was resighted in three different years with newborn calves and another was resighted in two different years with newborn animals. All the other whales were resighted only once.

Table 1. Summary of aerial surveys from 1987 to 2003 used to document the increase of right whales in the Brazilian wintering ground.

YEAR	NO. OF FLIGHTS	FLIGHT CONSIDERED FOR THIS ANALYSIS	AIRCRAFT	TOTAL LENGTH OF COASTLINE (Km)	EFFECTIVE FLYING TIME (h)	NO. OF OBSERVERS	MAXIMUM NO. WHALES SIGHTED / SURVEY IN TOTAL AREA	NO. OF WHALES SIGHTED IN THE CENTRAL AREA
1987	2	1-Sep	Piper PA-22 singlemotor	400	7.8	2	33	9
1988	2	28+29 Sep*	Cessna 170 singlemotor	400	9	2	16	2
1992	2	30+31 Aug*	Cessna 182 singlemotor	400	4.5	2	16	5
1993	1	27-Aug	Cessna 182 singlemotor	400	NA	2	28	16
1994	1	1-Sep	Cessna 182 singlemotor	400	5.3	1	27	12
1997	4	27-Sep	Citabria Singlemotor	400	2	1	20	20
1998	5	23-Sep	Enstrom helicopter	150	3.5	2	24	16
1999	4	10-Sep	Enstrom helicopter	150	3.2	2	20	16
2000	3	8-Oct	Squirrel helicopter	300	4	2	24	24
2001	4	13+14 Sep*	Jet Ranger helicopter	250	5.3	3	44	30
2002	4	23+24 Sep*	Jet Ranger helicopter	400	8.0	3	128	84
2003	4	12-Sep	Jet Ranger helicopter	400	6.5	3	112	49

(*) Two complementary flights covering adjacent areas, (NA) precise location and time information not available.

The modal calving interval for whales resighted in Total Area was 3 years (Figure 2). The distribution of calving intervals does not necessarily imply the true calving interval because it is likely that not all calves were observed and the time series is too short for longer calving intervals to yet become apparent. In addition, resightings of females photographed in Brazil that were also photographed in other years

with calves in the wintering ground off Península Valdés, Argentina (Best *et al.*, 1993) indicate that some females use different calving grounds in different years.

Table 2 shows the number of whales identified (calves excluded) during single surveys at the time of peak whale abundance from 1987 to 2003 in both the Total and Central Areas.

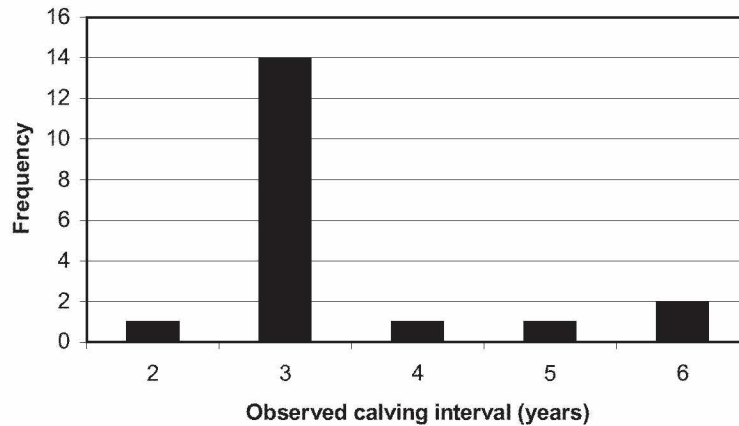


Figure 2. Distribution of observed calving intervals of female right whales identified in Total Area off southern Brazil.

Table 2. Number of whales individually identified and sighted during aerial surveys from 1987 to 2003, off southern Brazil, divided into Total Area and Central Area.

Year	WHALES SIGHTED BUT NOT IDENTIFIED									
	TOTAL AREA		CENTRAL AREA		RESIGHTINGS IN TOTAL AREA		TOTAL AREA		CENTRAL AREA	
	Adults without calves	Females with calves	Adults without calves	Females with calves	Adults without calves	Females with calves	Adults without calves	Females with calves	Adults without calves	Females with calves
1987	4	5	1	4	0	0	17	1	0	0
1988	3	3	0	1	0	0	1	3	0	0
1992	7	0	4	0	0	0	5	2	1	0
1993	8	0	NA	0	0	0	12	4	NA	NA
1994	7	4	4	4	1	0	0	6	0	0
1997	6	5	6	3	1	1	2	1	2	3
1998	0	9	0	6	0	1	0	3	0	2
1999	0	10	0	7	0	0	0	0	0	1
2000	1	11	2	11	0	2	1	0	0	0
2001	0	18	0	11	0	2	0	4	0	4
2002	39	37	15	31	0	2	7	4	3	2
2003	45	26	17	15	10	14	15	0	2	0

(NA) Available data are incomplete.

We made two estimates for the increase in numbers of whales seen off Brazil. One includes all survey years from 1987 to 2003 and the other includes only the later years (1997-2003) when the effort and timing of the surveys were more consistent. Both estimates are presented here because we are unsure which estimate is most representative of the observed changes in population size. The variability of the low numbers of whales identified in the early years of the study and a possible sudden immigration of whales later in the study contribute to this uncertainty. We believe the estimate for 1997-2003 might be more realistic because the effort during this time period was more consistent and there were surveys in every year at the time of peak whale abundance in the Central Area. However, by including the earlier years we have a longer time series that resulted in lower confidence intervals for the increase rate.

Figure 3 shows the linear regression of the natural log number of females with calves identified each year from 1997 through 2003 and for the entire period (1987-2003) in the Central Area. If these counts are considered reliable indices of growth rate, the number of calving females off southern Brazil increased at a rate of 29.8% per year (95% CL 15.7, 44.0) for 1997-2003 and 14% per year (95% CL 7.1, 20.9) for 1987-2003. Both estimates are significantly different from zero ($t = 4.133$, $p < 0.009$ and $t = 4.06$, $p < 0.004$). Non-calving whales appear to be increasing at rates of 34.4% for

1997-2003 and 10.2% per year for the entire period but the increases were not significant at the 95% level ($t = 1.721$, $p < 0.1240$ and $t = 1.761$, $p < 0.1390$). The estimated growth rate for calving females from 1997-2003 is higher than the 10.4% rate of increase of identified females with calves calculated by Whitehead *et al.* (1986) using a similar methodology for the right whales off Península Valdés, Argentina. However, the lower 95% confidence interval for the longer period includes the 10.4% rate calculated by Whitehead *et al.* (1986) as well as several of the increase rate values estimated for Argentina. Whitehead *et al.* (1986) calculated a rate of 6.8% for the growth of the entire population but later analysis of the Península Valdés population using different models estimated growth rates from 6.8 to 7.6% (Payne *et al.*, 1990; Cooke *et al.*, 2001; 2003). These later models cannot yet be applied to the Brazilian whales due to insufficient data.

Discussion

The right whales on the Brazilian wintering ground are not just transient in this area; 10% of the whales have also been resighted. Most of the resighted females with calves had three-year calving intervals, consistent with successful reproduction. Even those females with two, four and five year calving interval (indicative of failed pregnancies) (Knowlton *et al.*, 1994) returned to Brazil for their subsequent calvings.

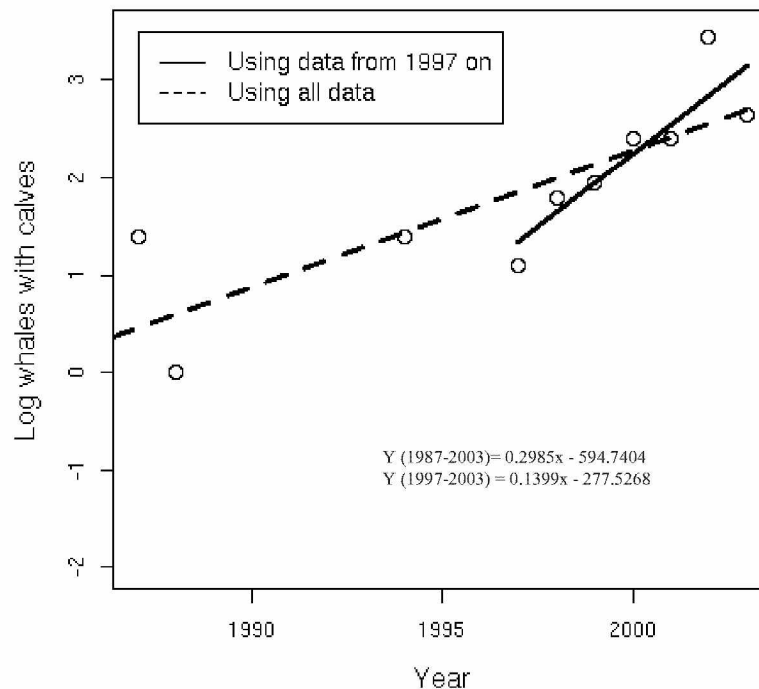


Figure 3. Linear fit of the log number of identified females with calves photographed during aerial surveys off southern Brazil (data from Central Area only).

The number of right whales off southern Brazil appears to have increased at a rate of 29.8% per year in the last seven years of the study and at a lower rate of 14% per year over the entire period. It is unlikely that this rapid increase could have been the result of the productivity of whales seen off Brazil earlier in the study, given the probable age of first reproduction of approximately 8 or 9 years (Best *et al.*, 2001; Cooke *et al.*, 2001). Plausible rates of increase have been calculated for humpback whales (*Megaptera novaeangliae*) and it is suggested that growth rates greater than 12.6% are unlikely to be biologically realistic (Brandão *et al.*, 2000; Clapham *et al.*, 2001). Both point estimates calculated for southern right whales in our study lie outside the range of biological plausibility for a natural rate of increase for southern right whales (Best *et al.*, 2001), although the lower 95% confidence interval for the lower estimate does overlap with estimates of the maximum intrinsic rate of increase. Thus, at least the higher rate of increase must include some other element, such as immigration, distributional shift or increasing survey effort. The increase is not limited to females with calves but also occurs in the number of whales without calves, though their rates of increase are not significant. A possible explanation for the increase is immigration from other wintering grounds such as Península Valdés, Argentina, where the whale numbers have been increasing from 6.8 to 7.6% for the past 32 years (Whitehead *et al.*, 1986; Payne *et al.*, 1990; Cooke *et al.*, 2001; 2003). In addition, the whales in Argentina are being severely harassed by kelp gulls (Thomas, 1988; Rowntree *et al.*, 1998), suggesting that the harassment might contribute to emigration to Brazil. Resightings in Brazil of whales previously photographed off Argentina supports this hypothesis (Best *et al.*, 1993), as well as observations of whales with kelp gulls attack marks (Groch *et al.*, unpublished). An ongoing comparison of catalogues from these two wintering grounds will help define the extent of the overlap, as well as the direction of movement between these wintering areas.

If the numbers of right whales off Brazil continue to increase, we can expect the whales to expand their range as they have off Argentina and South Africa (Best, 1990; Rowntree *et al.*, 2001). Whaling records indicate that right whales were found from Bahia to Santa Catarina state (Ellis, 1969), along some 2,400km of coastline. Much of this area is now developed which will increase the potential of conflicts between right whales and human activities as the whales reoccupy or expand their range. In fact, the number of right whale sightings has been increasing along the southeastern Brazilian coast along with the number of reported strandings (Barros, 1991; Lodi *et al.*, 1996; Santos *et al.*, 2001). Because the population appears to be growing, it will likely undergo a rapid change in distribution. Our estimates of the size and growth rate of the right whale population using the Brazilian wintering ground will become more accurate as we extend the time series of the data. To ensure the recovery of this right whale population off

the coast of Brazil, it is vitally important to continue and expand comprehensive annual monitoring of this population.

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