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## RESUMO

As baleias francas austrais (*Eubalaena australis*) eram historicamente distribuídas do Nordeste ao Sul do Brasil, mas a intensa caça comercial realizada até 1973 quase levou-as à extinção. De 1986 a 2003 foram realizados sobrevôos ao longo da costa sul do Brasil principalmente para fotoidentificação individual da população remanescente de baleias francas. Um total de 481 baleias (223 grupos) foi avistado em 16 sobrevôos durante o pico de abundância de baleias. Os grupos consistiram principalmente de dois indivíduos (67,3%, n=150), mas grupos de até oito baleias foram avistados. Foram registradas 149 avistagens de pares de fêmea com filhote, e 183 de indivíduos não-acompanhados de filhotes. As baleias estavam concentradas entre os 'bins' (unidades de 12 minutos de latitude) J (Garopaba) e N (Araranguá), com pico de avistagem em L (Laguna). A distribuição dos pares de fêmea e filhote e dos indivíduos não-acompanhados está um pouco sobreposta, mas uma principal área de concentração foi identificada, especialmente para as fêmeas com filhotes, o que coincide com a área de agregação previamente reconhecida no Brasil.

Em 2002 e 2003, anos em que foram realizados sobrevôos mensais, as baleias chegaram na região em Julho/Agosto, atingindo pico em Setembro, e declinando em Outubro/Novembro. Padrões de reavistagem intra-anual foram obtidos a partir de 39 baleias reavistadas. A maioria das reavistagens foi de fêmeas com filhotes, reavistadas pelo menos uma vez em dois sobrevôos consecutivos.

Até 2003, o Catálogo Brasileiro de Fotoidentificação das Baleias Francas tem 315 baleias identificadas individualmente, das quais 31 foram reavistadas em outros anos (23 fêmeas, 3 filhotes de um ano e 5 baleias de sexo e idade desconhecidos). Nenhuma reavistagem ocorreu antes de 1994 e 71% (n=24) foram registradas em 2003. Das 120 fêmeas identificadas no Brasil, 19,2% (n=23) têm mostrado algum nível de fidelidade de área. O intervalo modal observado entre nascimentos foi de três anos, consistente com o sucesso reprodutivo.

De 1997 a 2003, o número de fêmeas reprodutivas na área Central sobrevoada aumentou a uma taxa de 29,8% por ano (95% CL 15,7, 44,0) e de 1987 a 2003 14% por ano (95% CL 7,1, 20,9). Ambas as taxas são significativamente diferentes de zero ( $t=4,133$ ,  $p<0,009$  e  $t=4,06$ ,  $p<0,004$ , respectivamente), e mais altas que as taxas observadas para as baleias francas em outras áreas de concentração reprodutiva no Atlântico Sul. A abundância das baleias francas na costa sul do Brasil foi estimada em no máximo 555 indivíduos, utilizando-se a Taxa Anual Reprodutiva (de uma população estável). Este número reflete o aumento observado na população em anos recentes, porém devido à estimativa não ter incorporado parâmetros como mortalidade e/ou emigração e imigração, deve ser utilizado com cautela, e considerado somente uma estimativa preliminar.

As interações entre as baleias francas e as embarcações de turismo foram estudadas em 2002, utilizando-se um teodolito. Foram realizadas 65,5 horas de observações antes, durante e depois dos encontros entre fêmeas com filhotes e embarcações, durante 25 cruzeiros de “whalewatching” em cinco enseadas diferentes. A média da velocidade de natação das baleias antes, durante e depois dos encontros com embarcações variou de acordo com a enseada e a fase de aproximação, ( $t=4,133$ ,  $p<0,009$  e  $t=4,06$ ,  $p<0,004$ , respectivamente). Não foi encontrada nenhuma alteração significativa nas velocidades médias de natação nestas três fases ( $p>0,05$ ), porém houve variação significativa durante alguns intervalos de tempo. As probabilidades previstas das baleias nadarem em direção aos barcos em função do tempo foram significativamente próximas aos valores esperados na Gamboa e Ibraquera ( $p>0,05$ ) porém variaram significativamente durante alguns intervalos em Garopaba, Silveira e Rosa. As baleias reagiram tanto a distâncias curtas e longas das embarcações, e as reações variaram de acordo com as enseadas. Apesar da dificuldade de avaliar impactos a longo prazo, nenhuma evidência clara sobre distúrbios a esta população foram observados durante este estudo, sugerindo que as embarcações de “whalewatching” que operam segundo as legislações Brasileiras não alteram o comportamento das mesmas.

Se o número de baleias francas continuar a aumentar, pode-se esperar que as baleias francas reocupem 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. O uso de técnicas de rastreamento com teodolito, se realizadas em conjunto com as usadas para o monitoramento a longo prazo dos indivíduos e seus padrões de uso de habitat poderão permitir aos cientistas uma melhor possibilidade de manejo das atividades de “whalewatching” de modo a assegurar a conservação apropriada da espécie alvo e a sustentabilidade da indústria deste turismo a longo prazo.



## ABSTRACT

Southern right whales (*Eubalaena australis*) in Brazil were historically distributed from northeastern to southern coast, but intensive commercial whaling held until 1973 almost extirpated whales from the region. From 1986 through 2003 aerial surveys were conducted off southern Brazil primarily for photo-identification of the remnant population. A total of 481 whales (223 groups) were sighted in 16 surveys during peak whale abundance. Groups consisted mostly of two whales (67.3%, n=150) and groups of up to eight whales were sighted. From the total, 149 sightings were of females with calves and 183 were unaccompanied whales. Whales concentrated between bins (unit with 12 minutes latitude long) J (Garopaba) and N (Araranguá), with a peak in L (Laguna). Distribution of females with calves and unaccompanied whales is somewhat overlapped, but a major concentration area was identified, especially for mother/calf pairs, which coincides with a previously recognized aggregation area off Brazil.

In 2002 and 2003, when monthly surveys were conducted, whales arrived in July/August, reaching peak in September, and declining in October/November. Intra-annual resighting patterns were obtained from 39 non-calf whales. The majority of resightings were of females with calves, resighted at least once in two consecutive surveys.

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 before 1994 and 71% (n=24) were recorded in 2003. From 120 females identified in Brazil, 19.2% (n=23) have shown some level of site fidelity. 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. Both rates are significantly different from zero (t=4.133, p<0.009 and t=4.06, p<0.004, respectively) and higher than the rates observed for right whales in other wintering grounds in the South Atlantic.

The abundance of right whales off southern Brazil was estimated to be possibly as high as 555 whales, using the Gross Annual Reproductive Rate (GARR) of a stable population. This number reflects the increase observed in the population in the recent years, but because this estimate does not incorporate parameters like mortality and/or emigration and immigration, it should be treated with caution and as a preliminary rough estimate only.

Interactions between southern right whales and whalewatching boats were studied in 2002 using a surveyor theodolite. It were recorded 65.5 hours of observations before, during and after encounters between mother/calf pairs and boats during 25

whalewatching cruises in five different bays. Mean swimming speed varied by bay and approaching phase, ( $t=4.133$ ,  $p<0.009$  and  $t=4.06$ ,  $p<0.004$ , respectively). No significant differences were found in mean swimming speeds of whales tracked before, during and after encounters with boats ( $p>0.05$ ). The predicted probabilities of whales heading towards the boats as a function of time were significantly near the expected values in Gamboa and Ibiraquera ( $p>0.05$ ) but varied significantly during certain time intervals ( $p<0.001$ ) in Garopaba, Silveira and Rosa. Whales reacted at both long and short distances from boats and the reactions varied with bays. Although long-term impacts are difficult to assess, no clear evidence of immediate disturbance to this right whale population was observed during the study, suggesting that the whalewatching boats operation under Brazilian regulations did not disrupt their behavior.

If the number of whales continues to increase they will probably expand their distribution throughout their historical 2,400 km range and come into increasing conflict with human activities. The use of the theodolite techniques, if taken together with those used for long-term monitoring of individual whales and their pattern of habitat use may enable scientists to provide the best possible management advice for whalewatching in order to ensure the proper conservation of target species and the sustainability of this industry on a long-term basis.

## **CAPÍTULO 1**

## INTRODUÇÃO

### 1. Classificação

As baleias francas *Eubalaena sp.* pertencem à Ordem Cetacea, Subordem Mysticeti. Junto com as baleias “bowhead” (*Balaena mysticetus* Linnaeus, 1758) compõe a família Balaenidae (Cummings, 1985). Duas espécies do gênero *Eubalaena* são reconhecidas: *E. glacialis* (Muller, 1776), a baleia franca boreal, com duas populações que habitam o Atlântico e Pacífico Norte, e *E. australis* (Desmoulin, 1822), a baleia franca austral, com várias populações que habitam o Hemisfério Sul (Rice, 1998; IWC, 2001). Recentes estudos baseados na análise de DNA mitocondrial indicam, porém, uma forte evidência genômica para a existência de uma terceira espécie, *Eubalaena japonica*, com uma população que habita o Pacífico Norte (Rosenbaum *et al.* 2000; Gaines *et al.*, 2005).

As populações do Hemisfério Norte e Sul aparentemente apresentam distribuição descontínua através do Equador e são geograficamente isoladas devido a diferenças temporais no comportamento reprodutivo (Cummings, 1985). Possuem pequena diferenciação morfológica e fisiológica, como segue: diferenças no esqueleto (Omura apud Rosenbaum *et al.*, 2000, p.1794) variação no comprimento do corpo (Best, 1987), diferenças de frequência no aparecimento das calosidades (Best, 1970; Kraus *et al.*, 1986), associação diferenciada de parasitas (Scarff, 1986), diferenças nas manchas dorsais e ventrais (Payne *et al.* 1983; Payne, 1986; Schaeff & Hamilton, 1999; Schaeff *et al.*, 1999) e níveis contrastantes de variabilidade genética baseado na análise de DNA mitocondrial (Schaeff *et al.*, 1991; Schaeff *et al.*, 1997; Rosenbaum *et al.*, 2000). As análises filogenéticas realizadas por Rosenbaum *et al.* (2000) mostraram, ainda, que as *E. glacialis* do Pacífico Norte são distintas das *E. glacialis* do Atlântico Norte, e mais proximamente relacionadas às *E. australis* do que às *E. glacialis* do Pacífico Norte.

### 2. Características Gerais do Gênero *Eubalaena*

As baleias francas podem ser facilmente distinguidas dos outros grandes cetáceos por várias características. A principal delas é a ausência da nadadeira dorsal, característica exclusiva dentre as baleias que habitam o Hemisfério Sul, e ausência de pregas ventrais características dos balenopterídeos. Possuem os orifícios respiratórios bastante

separados, originando um vapor característico em forma de “V” durante a respiração (Cummings, 1985).

Uma característica única do gênero são as calosidades de pele características na região da cabeça, ao redor do orifício respiratório e da boca (Payne *et al.*, 1983). Essas calosidades são espessamentos da epiderme infestados por colônias de crustáceos anfípodos da família Cyamidae (piolhos-de-baleia, *Cyamus* sp.), responsáveis pela coloração branca ou amarelada (Payne *et al.*, 1983; Rowntree, 1993, 1996). A distribuição das calosidades nas baleias francas segue um padrão geral, mas o formato, tamanho e número de calosidades variam entre os indivíduos e em geral são assimétricos num mesmo indivíduo (Payne *et al.*, 1983). Esta distribuição se estabelece logo nos primeiros meses de vida dos filhotes, permanecendo constante ao longo do tempo e permitindo a identificação individual (Payne *et al.*, 1983). Apesar da sutil diferença, os machos possuem calosidades em maior quantidade e tamanho que as fêmeas (Payne & Dorsey, 1993). Acredita-se que as calosidades sejam utilizadas para o reconhecimento entre os indivíduos e, baseado na maior quantidade de marcas e arranhões temporários existentes no dorso dos machos em relação às fêmeas, sugere-se que as calosidades funcionem como instrumento para agressão intraespecífica (Payne & Dorsey, 1993).

A coloração do corpo das baleias francas pode variar do preto ao acinzentado, com manchas brancas no ventre e no mento (Payne *et al.*, 1983; Cummings, 1985). Alguns indivíduos de baleias francas austrais podem apresentar manchas brancas ou acinzentadas no dorso, que também podem ser usadas para fotoidentificação. Cerca de 10% da população de baleias francas que frequenta as áreas de concentração reprodutiva na Argentina e África do Sul apresentam estas manchas (Schaeff *et al.*, 1999). Uma análise genética mostrou que indivíduos que apresentam manchas acinzentadas, ou a combinação destas com manchas brancas são invariavelmente fêmeas, e indivíduos com manchas brancas apresentam proporção sexual de 1:1. Estas manchas podem ocorrer em todo o corpo, resultando em indivíduos parcialmente albinos. O indivíduo parcialmente albino possui a maior parte do corpo branca com pequenas pintas pretas quando filhote, mas escurece nos primeiros anos de vida adquirindo aparência marrom ou acinzentada (Payne *et al.*, 1983; Best, 1990a; Schaeff *et al.*, 1999). Através de uma análise genética mostrou-se que esses indivíduos são invariavelmente machos (Schaeff *et al.* 1999). As nadadeiras peitorais são curtas e largas, com formato de trapézio, e a cauda larga e pontuda. A cabeça é robusta (cerca de 1/3 do comprimento total do corpo) com rostró estreito, mandíbulas bastante arqueadas e numerosos pelos na região da mandíbula e maxila (Cummings, 1985).

As fêmeas adultas são maiores que os machos, atingindo até 18 m de comprimento e pesando de 50 a 56 toneladas (Cummings, 1985; Evans, 1987). Os filhotes nascem em média com 6 metros de comprimento (Best, 1994) pesando 4-5 toneladas (Whitehead & Payne, 1981).

A maturidade sexual é atingida em torno dos 6 anos (Payne, 1986) e a idade da primeira gestação ocorre em torno dos 9 anos (Payne, 1986; Payne *et al.* 1990; Knowlton *et al.*, 1994; Cooke *et al.*, 2001; Hamilton *et al.*, 1998). O período de gestação é de 11-12 meses (Payne, 1986; Best, 1994; Burnell & Bryden, 1997) e as fêmeas têm, em média, um filhote a cada 3 anos (Payne, 1986; Bannister, 1990; Best, 1990a; Payne *et al.* 1990; Hamilton & Mayo, 1990; Burnell, 2001; Cooke *et al.*, 2001; Hamilton *et al.* 1998). O desmame parece ocorrer após o primeiro ano de idade (Thomas & Taber, 1984; Hamilton *et al.*, 1995; Burnell, 2001; Hamilton *et al.*, 1998). A expectativa de vida reprodutiva da fêmea é de aproximadamente 30 anos, sendo que uma fêmea pode produzir até nove filhotes e viver pelo menos 65 anos (Hamilton *et al.*, 1998). A taxa de mortalidade estimada está em torno de 1-3% para os adultos, porém esta estimativa é considerada abaixo do que é geralmente proposto para os mysticetos (Payne *et al.* 1990; Knowlton *et al.*, 1994; Cooke *et al.*, 2001; Best & Kishino, 1998).

### **3. Distribuição e Uso de Habitat**

As baleias francas passam o verão nos pólos onde se alimentam, e migram para águas tropicais mais quentes durante o inverno para acasalamento e procriação (Cummings, 1985). Apesar da maioria dos autores considerarem este padrão de migração como regra geral para os mysticetos, evidências diretas só foram obtidas recentemente, através de reavistagens de indivíduos fotoidentificados em áreas de reprodução e alimentação (Best *et al.*, 1993; Bannister *et al.*, 1997; Bannister *et al.*, 1999; Moore *et al.*, 1999).

Existem quatro estoques<sup>1</sup> reprodutivos principais de baleias francas austrais reconhecidos no Hemisfério Sul, definidos com base na existência de diferentes áreas de concentração reprodutiva. Porém em função da ausência de barreiras geográficas entre estas áreas de concentração, e dos hábitos migratórios dos cetáceos, a definição de estoques

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<sup>1</sup> O termo “estoque” se refere a uma "unidade estabelecida para fins de manejo populacional" (Wells, *et al.* 1999).

genéticos, essencial à conservação da diversidade genética, representa um desafio (Hoelzel, 1994). Além disso, a escassez de muitas informações biológicas sobre as populações de cetáceos tem colocado em discussão a validade dos diferentes estoques para a efetiva conservação e manejo dos cetáceos (IWC, 1986, 2001; Donovan, 1991).

Com relação às baleias francas que frequentam o Brasil e a Argentina, segundo Ott (2000), embora algumas diferenças genéticas tenham sido observadas em nível mitocondrial, estas populações não se enquadram nas classificações tradicionais, como a proposta por Waples (1991) e Moritz (1994) como distintas Unidades Evolutivamente Significativas, nem nas definições de Unidades de Manejo apresentadas por Moritz (1994), devido à alta homogeneidade genética detectada em nível nuclear, ao elevado número de haplótipos compartilhados, e à alta proporção de deslocamentos individuais entre as duas regiões.

Para Camus e Lima (2002), a definição de uma população é um problema fundamental para a compreensão da dinâmica ecológica, e tem grandes implicações em questões como manejo e conservação. Segundo os critérios apresentados por Berryman (2002), os grupos de baleias francas que frequentam, por exemplo, Brasil e Argentina, seriam populações locais que fariam parte de uma metapopulação. Ainda segundo Berryman (2002), a dinâmica das populações locais será fortemente influenciada pela dispersão e imigração, enquanto que a da metapopulação somente será influenciada pela difusão rara e/ou aleatória entre populações vizinhas.

Para fins desta tese, o termo população será aplicado referindo-se a concentrações reprodutivas, quando necessário, porém sem a pretensão de uma definição conclusiva, haja visto principalmente a carência, até o presente, de informações conclusivas referentes às áreas de alimentação utilizadas pelas baleias francas que frequentam a América do Sul.

Os estoques reprodutivos principais de baleias francas austrais reconhecidos no Hemisfério Sul estão localizados na África do Sul, Austrália, América do Sul e região sub-Antártica da Nova Zelândia, com pequenas populações locais associadas a eles (IWC, 1986; Klinowska, 1991; IWC, 2001). Na Austrália, concentrações reprodutivas de baleias francas são encontradas principalmente a oeste e sul (abaixo dos 32°S) desde a região do Cabo Leewin até a Grande Baía da Austrália, a leste da Baía Israelite, durante os meses de junho a outubro, com pico de avistagens em agosto e setembro (Bannister, 1990; Burnell & Bryden, 1997; Bannister, 2001). Na África do Sul, as maiores concentrações ocorrem também abaixo dos 32°S, entre a Baía de Walker e de Plettenburg, de junho e outubro, com pico de avistagens

em setembro e início outubro (Best, 1990b). Na região sub-Antártica da Nova Zelândia, a principal área de concentração reprodutiva conhecida está nas Ilhas Auckland, de junho a outubro, com pico de avistagens em Julho-Agosto, com alguns indivíduos avistados nas proximidades das Ilhas Campbell (Patenaude *et al.* 1998; Barrett, 2000; Patenaude & Baker, 2001). Na América do Sul a principal concentração reprodutiva ocorre nas águas costeiras da Península Valdés, Argentina (Payne, 1986; Payne *et al.* 1990), com uma pequena área de concentração encontrada no sul do Brasil (IWC, 2001) com indivíduos provavelmente relacionados à população da Argentina (Best *et al.*, 1993; Ott, 2000). As avistagens na Península Valdés ocorrem de junho a dezembro, com pico e entre o final de setembro e início de outubro (Payne, 1986). Outra pequena concentração reprodutiva é encontrada na região de Tristão da Cunha e Ilhas Gough, onde evidências demonstram uma possível relação com Argentina ou África do Sul (Best *et al.*, 1993).

As áreas de alimentação dos misticetos estão associadas a áreas de alta produtividade primária, onde há grandes concentrações de zooplâncton (Laws, 1985; Evans, 1987; Moses & Finn, 1997; Clapham, 1999). Áreas de alimentação conhecidas no Hemisfério Sul são as regiões próximas à Convergência Antártica (Goodall & Galeazzi, 1986) e no entorno das Ilhas Geórgias do Sul (Moore *et al.*, 1999).

Nas áreas de reprodução a distribuição das baleias francas é frequentemente relacionada a águas calmas e rasas. Evans (1987) sugere a manutenção de determinadas áreas de reprodução simplesmente por tradição, como um reflexo da história evolutiva dos misticetos, e menciona a preferência por regiões com águas calmas bem como regiões que ofereçam proteção contra predadores como orcas (*Orcinus orca* Linnaeus, 1758) e tubarões. Na Península Valdés, Argentina, o ataque de uma orca a duas baleias francas fez com que estas se movessem de uma região com 30 m de profundidade para uma área com 7-11 metros (Cummings *et al.*, 1972). Clapham (1999) relata haver uma maior frequência de baleias francas em águas rasas com fundo relativamente plano, e com temperaturas entre 10° e 14 °C, na única área de concentração reprodutiva conhecida para as baleias francas do Atlântico Norte. Entretanto, o autor não deixa clara a existência de uma relação entre estes fatores e a preferência por esta área, mas menciona a predominância de águas calmas na região como provável fator determinante. Pares de mãe-filhote parecem ter preferência por águas rasas para evitar interações de alto custo energético com grupos sociais de baleias francas (Lockyer 1981; Corkeron & Connor, 1999; Thomas & Taber, 1984).

Estudos de fotoidentificação a longo prazo realizados em várias áreas de concentração das baleias francas no Hemisfério Sul demonstram haver uma certa fidelidade às



áreas de reprodução. As fêmeas grávidas tendem a retornar à mesma região a cada 3 anos, em geral no mesmo local ou em áreas adjacentes ao local do primeiro ano de avistagem, para concepção de um novo filhote (Payne, 1986; Bannister, 1990, 2001; Best, 1990b, 2000; Payne *et al.*, 1990; Burnell, 2001). Já os adultos não acompanhados por filhotes são reavistados a intervalos variados podendo ser avistados em anos subsequentes, seguindo o mesmo padrão de fidelidade por área. Payne (1986), Bannister (1990), Best (1990b, 2000) e Burnell & Bryden (1997) mencionam haver preferência por determinadas áreas de agregação dentro das áreas de concentração reprodutiva, bem como uma separação entre áreas de concentração de fêmeas com filhotes e grupos de acasalamento, porém sem associação direta com nenhum tipo de fator ambiental. Na área de concentração reprodutiva da África do Sul, Elwen & Best (2004) sugerem a preferência por áreas que oferecem proteção contra a ondulação em mar aberto e ventos sazonais, bem como áreas de fundo sedimentar e pouca declividade. Em geral, as baleias francas são encontradas próximas da costa. Adultos não acompanhados de filhotes permanecem mais afastados da região das ondas (em locais com profundidades de até 60-80 m) e fêmeas com filhotes são avistadas logo após a arrebentação das ondas ou a distâncias de até 1000 m da costa, em profundidades menores que 20m e mais freqüentemente em torno de 10m (Payne, 1986; Thomas, 1986; Best, 1990b; Patenaude & Baker, 2001).

Não se sabe ao certo se os acasalamentos observados em determinada região resultam nos filhotes observados no ano seguinte (Payne, 1986). Porém, a concepção ocorre na mesma região onde as fêmeas são avistadas com seus filhotes (Payne, 1986; Best, 1990b; Burnell & Bryden, 1997). As fêmeas grávidas se aproximam da costa alguns dias antes do nascimento dos filhotes, e permanecem com os recém-nascidos em torno de 11 semanas na mesma área de concentração; o tempo de permanência observado para adultos sem filhotes varia bastante e, pelo menos em algumas regiões, permanecem próximos à costa durante menos tempo que fêmeas com filhotes (em torno de seis semanas) (Bannister, 1990; Burnell & Bryden, 1997). Fêmeas com filhotes apresentam menos movimentação ao longo da costa do que outros indivíduos (Bannister, 1990; Best, 1990b, 2000; Burnell & Bryden, 1997; Rowntree *et al.*, 2001). A estação reprodutiva dura em torno de cinco meses (Payne, 1986; Bannister, 1990; Best, 1994; Burnell & Bryden, 1997), ao término do qual os pares de fêmeas com filhote iniciam a migração para as áreas de alimentação (Taber & Thomas, 1982; Thomas & Taber, 1984).

#### 4. Organização Social e Aspectos Comportamentais

As baleias francas são animais pouco gregários tanto em áreas de alimentação, quanto em áreas de reprodução (Payne, 1986; Bannister, 1990; Best 1990b; Patenaude & Baker, 2001; Best *et al.* 2003). Animais solitários ou grupos de dois indivíduos são os mais freqüentemente observados, podendo vários grupos estarem distribuídos em pequenas áreas de agregação (Payne, 1986; Bannister, 1990; Best, 1990b; Palazzo & Flores, 1996; Simões-Lopes *et al.*, 1992; Palazzo *et al.*, 1999; Groch, 2000; Patenaude & Baker, 2001). Grupos de baleias francas podem ser compostos por indivíduos solitários, pares de mãe e filhote ou grupos de adultos (Payne, 1986; Cassini & Vila, 1990). Interações sociais entre grupos e/ou indivíduos são observados, podendo ocorrer durante horas, principalmente em se tratando de grupos de acasalamento (Payne, 1986; Patenaude & Baker, 2001). Raramente são observadas interações entre pares de mãe e filhote, mesmo estando próximos uns dos outros (Thomas, 1986).

Vários níveis de interações inter-específicas são relatadas entre baleias francas e aves, bem como com outros mamíferos marinhos. Dentre as aves o caso mais extremo já relatado é o que ocorre com os gaivotões, *Larus dominicanus* (Lichtenstein, 1823), na Península Valdés, Argentina (Cummings, 1972; Thomas, 1988; Verheyden, 1993; Rowntree *et al.*, 1998). Os gaivotões têm o hábito de se alimentar de pedaços de pele descamada e da gordura do dorso das baleias francas. O molestamento provocado por este comportamento aumentou cinco vezes em 1995, em relação ao primeiro estudo realizado por Thomas (1988) na Península Valdés. Diversos episódios foram observados recentemente no litoral de Santa Catarina, Brasil (Groch, 2001b, dados não-publicados) Os ataques dos gaivotões podem alterar o comportamento calmo e tranqüilo que pode ser vital para as baleias francas em fase de lactação (Thomas, 1988), podendo comprometer o desenvolvimento dos filhotes e provocar o abandono de determinadas áreas de reprodução (Rowntree *et al.* 1998; Rowntree *et al.*, 2001).

No que diz respeito a mamíferos marinhos já foram observadas interações com leões-marinhos (*Phocarctos hookeri* Gray, 1844) (Stewart and Todd, 2001), baleias jubarte (*Megaptera novaeangliae* Borowski, 1781) (Goodall & Galeazzi, 1986; Cremer, 1996; Engel *et al.*, 1997), golfinhos nariz-de-garrafa (*Tursiops truncatus* Montagu, 1821) (Ellis, 1980 *in* Goodall & Galeazzi, 1986; Flores, pers. comm.) e golfinhos Dusky (*Lagenorhynchus obscurus* Gray, 1828) (Ellis, 1980 *in* Goodall & Galeazzi, 1986).

Os comportamentos mais freqüentemente observados em grupos de baleias francas em áreas de reprodução são: 1) natação (deslocamento aparente e em velocidade constante); 2) descanso (sem movimento aparente, com a parte dorsal da cabeça e corpo acima da água); 3) atividade sexual (grupos com presença de machos e fêmeas, e observação de macho com pênis estendido); 3) atividade social (grupos com presença somente de adultos, possivelmente machos e fêmeas, em geral em intensa atividade); e 4) brincadeiras (diversas atividades realizadas entre fêmeas e filhotes). Atividades individuais observadas incluem: exposição caudal, batida da nadadeira caudal, exposição peitoral, batida de nadadeira peitoral, exposição da cabeça, salto, exposição ventral (Cummings, 1972, 1974; Clark, 1983; Thomas & Taber, 1984; Payne, 1986; Cassini & Vila, 1990).

Experimentos realizados por Clark & Clark (1980), demonstraram que as baleias francas reconhecem os sons produzidos por indivíduos da mesma espécie e diferenciam estes de outros sons do ambiente. Clark (1983) correlaciona algumas atividades comportamentais exibidas pelas baleias francas e seu contexto social com o tipo de som produzido pelos grupos observados. Oito padrões sonoros são descritos e, embora não se saiba ao certo sua função comunicativa, sabe-se que os diferentes padrões estão relacionados a diferentes níveis de interação entre os indivíduos e entre estes e seu habitat (Clark, 1983).

## **5. Conservação**

As populações de baleias francas foram alvo da exploração comercial no mundo inteiro até o início do século passado. Estima-se que a população original no Hemisfério Sul, antes das atividades de caça, era em torno de 90.000 indivíduos (Richards, 1998) e atualmente esteja entre 7000 a 8000 indivíduos (IWC, 2001). A proteção internacional teve início em 1935, mas mesmo após esta data, atividades de exploração ilegais tiveram continuidade em diversas regiões (Palazzo & Carter, 1983; Klinowska, 1991; Tormosov *et al.*, 1998). Segundo Best (1988) a maioria das populações de baleias francas no Hemisfério Sul foram reduzidas a níveis extremamente baixos até metade da década de 30, e aparentemente não demonstraram recuperação até cerca de 40 anos atrás. A única exceção é a população que freqüenta Tristão da Cunha. Esta população teria escapado da atenção dos baleeiros no final do século XIX e início do século XX, período de maior atividade de caça comercial, demonstrando sinais de recuperação há cerca de 60 anos atrás.

A baleia franca glacial, *Eubalaena glacialis*, está listada como “ameaçada” segundo a classificação da União Internacional para Conservação da Natureza e dos Recursos Naturais (IUCN) (Klinowska, 1991). É considerada a espécie mais ameaçada de extinção dentre os grandes cetáceos e não tem demonstrado sinais de recuperação desde o término das atividades de caça (Caswell *et al.*, 1999). Atualmente, a população de baleias francas que vive no Atlântico Norte Ocidental está reduzida a cerca de 300 indivíduos, e a taxa de crescimento populacional estimada em 1994 é de 0,97% ao ano, 0,02 % menor do que a estimada em 1980 (Caswell *et al.*, 1999). A população do Atlântico Norte Oriental é considerada extinta (Schaeff *et al.*, 1997; Caswell *et al.*, 1999). Não se sabe ao certo quantos indivíduos existem na população do Pacífico Norte, mas dados sugerem que esta população esteja na mesma situação que a do Atlântico Norte (IWC, 2001).

No Hemisfério Sul, a proteção contra a caça em áreas de reprodução parece estar surtindo efeito na recuperação populacional da baleia franca austral, *Eubalaena australis*. Na Argentina, onde a população total estimada em 1997 foi de 2500 indivíduos e na África do Sul, onde a população estimada estava em torno de 3000 indivíduos, acredita-se que a taxa de crescimento populacional seja de 7,8 % ao ano (IWC, 2001).

Na região das Ilhas Geórgias do Sul, área de alimentação das baleias francas no Hemisfério Sul, a espécie mais avistada em um levantamento de dados feito por Moore, *et al.* (1999) desde 1979 foi *Eubalaena australis* (n=68). A partir da reavistagem entre indivíduos fotoidentificados nesta região e em outras áreas do Atlântico Sul (e.g. Argentina e África do Sul) e da similaridade genética entre estas populações, Moore *et al.* (1999) sugerem a mesma taxa de crescimento populacional estimada para estas áreas de concentração para a população das Geórgias do Sul.

Apesar das populações do Hemisfério Sul apresentarem sinais de recuperação, ainda são consideradas vulneráveis. Vários fatores de ameaça à recuperação tanto das populações do Hemisfério Sul quanto do Hemisfério Norte são indicados, como: condição nutricional dos indivíduos, poluição química, emalramento em equipamentos de pesca, interações com embarcações (e.g. colisões com navios e distúrbios sonoros) e perda e degradação de habitat (IWC, 2001; Clapham (ed.), 1999; Clapham *et al.*, 1999).

Clapham (ed.) (1999) e Clapham *et al.* (1999) sugerem que dentre os vários fatores que potencialmente afetam os mysticetos, emalramento em equipamentos de pesca e colisões com navios são os mais significantes a nível populacional. Segundo Caswell *et al.* (1999), a única chance da população de baleias francas glaciais que vivem no Atlântico Norte

se tornar viável é reduzir o risco de mortalidade causado por estes dois fatores. Estes autores estimam, ainda, que, sob as condições atuais, esta população estará extinta em 191 anos.

## **6. Turismo de observação de baleias (“Whalewatching”)**

O turismo de observação de baleias, “whalewatching”, é uma das atividades turísticas que mais cresce no mundo inteiro. Este uso não letal dos cetáceos pode trazer benefícios econômicos a comunidades locais, incluindo as que realizavam caça comercial, propiciar pesquisa científica, desenvolver campanhas educacionais e a conservação do ambiente marinho e dos próprios animais (IFAW, Tethys and Europe Conservation 1995; IFAW, 1997, IFAW, 1999, IWC, 2001).

As atividades de “whalewatching”, se não conduzidas de acordo com normas apropriadas podem causar vários impactos às baleias. Estes impactos não são necessariamente negativos, e podem ser neutros, positivos ou não conhecidos (Watkins, 1986; IFAW, Tethys and Europe Conservation, 1995). Vários parâmetros podem ser usados para se avaliar os impactos das atividades de “whalewatching” sobre os cetáceos. Parâmetros comportamentais, fisiológicos e acústicos podem ser medidos a curto prazo, e produtividade, condição física dos indivíduos, distribuição, habituação e tolerância como efeito a longo prazo. As reações das baleias a atividades humanas tais como “whalewatching” variam de acordo com a espécie e ao longo do tempo. As baleias francas podem reagir de várias maneiras de acordo com o tipo de aproximação da embarcação. Aproximações bruscas e ofensivas podem resultar em respostas negativas das baleias, enquanto aproximações mais cautelosas podem resultar na aproximação à embarcação (Cummings, *et al.*, 1972; Payne, *et al.*, 1983; Findlay, 1998; IWC, 2001; Rivarola *et al.*, 2001).

Estudos dos impactos antropogênicos sobre os cetáceos têm sido desenvolvidos em diversos lugares no mundo todo. Enquanto a maioria tem relatado alterações significantes no comportamento dos cetáceos, tem sido mencionado, quase sem exceção, que o significado biológico a longo prazo destas alterações não está claro (Richter *et al.*, 2000). Ademais, o pouco que se sabe provém de observações relativas a determinadas espécies em algumas regiões, e geralmente as informações obtidas não podem ser diretamente comparadas com outras espécies ou outros lugares (Richter *et al.*, 2000). Tendo em vista o crescimento e expansão das atividades de “whalewatching” em nível mundial, torna-se cada vez mais necessário o desenvolvimento planejado e controlado das atividades de

“whalewatching”, bem como estudos sobre seu impacto a longo prazo nos cetáceos (IFAW, Tethys and Europe Conservation, 1995).

### **7. *Eubalaena australis* no Brasil**

O litoral sul do Brasil representa uma importante área de concentração reprodutiva das baleias francas austrais, *Eubalaena australis*, durante os meses de maio a dezembro (com maior frequência de agosto a outubro), principalmente ao longo da costa de Santa Catarina (~ 26°00' - 28°25' S) (Lodi & Bergallo, 1984; Câmara & Palazzo, 1986; Simões-Lopes *et al.* 1992; Palazzo & Flores, 1996, 1998).

Desde o século XVII tem-se registro de atividades de caça à baleia franca no litoral do Brasil, desde a Bahia até Santa Catarina. A partir de meados daquele século, estações baleeiras chamadas “Armações” começaram a ser instaladas em diversos pontos do litoral de Santa Catarina. A baleia franca era considerada a “baleia certa” para caçar por sua docilidade e vulnerabilidade, lentidão e espessa camada de gordura. Por isso, era o principal alvo das atenções dos baleeiros que utilizavam a sua espessa camada de gordura para a extração de óleo empregado na iluminação, lubrificação e fabricação de argamassa para construções, bem como as barbatanas para a fabricação de espartilhos (Ellis, 1969).

Não se sabe ao certo quantas baleias francas foram mortas no Brasil durante o período de caça, mas estima-se que centenas delas possam ter sido dizimadas. Na costa brasileira a espécie era abundante com uma distribuição desde a divisa com o Uruguai até a baía de Todos os Santos, Bahia (Ellis, 1969). O último registro de caça da baleia franca no litoral do Brasil data de 1973 na cidade de Imbituba, SC (Palazzo & Carter, 1983). Após esta data, a população parecia ter sido eliminada na região, e a maioria das informações sobre a presença destes animais se tratava de casos isolados, muitas vezes não confirmados, ou provenientes de animais encalhados (Castello & Pinedo, 1979; Câmara & Palazzo, 1986; Lodi *et al.* 1996). Somente a partir da década de 80 foram reavistados no litoral sul-sudeste do país os primeiros indivíduos após o término das atividades de caça (Lodi & Bergallo, 1984; Câmara & Palazzo, 1986; Ximenez *et al.* 1987; Simões-Lopes & Ximenez, 1993; Lodi *et al.*, 1996). Apesar das baleias francas estarem protegidas internacionalmente desde 1935, a proibição oficial da caça comercial de cetáceos no Brasil ocorreu somente em 1987 (Lei Federal Nº. 7643, de 18 de dezembro de 1987). Desde 1989 a baleia franca encontra-se citada

na Lista Oficial Brasileira das Espécies Ameaçadas de Extinção (Portaria IBAMA Nº. 1522, de 19 de dezembro de 1989).

Desde 1981 este grupo de baleias francas vem sendo monitorado pelo Projeto Baleia Franca - International Wildlife Coalition/Brasil. Através de avistagens a partir de terra e censos aéreos, foi possível estabelecer uma área principal de concentração destes animais em Santa Catarina entre o Cabo de Santa Marta, Laguna (28°36' S, 48°49' W) e Florianópolis (27°25' S, 48°30' W) (Simões-Lopes *et al.*, 1992; Palazzo & Flores, 1998a). Esta região caracteriza-se por possuir a costa bastante recortada, com inúmeras enseadas e pequenas baías, oferecendo às baleias francas alguma proteção contra os fortes ventos característicos dos meses de inverno (Palazzo & Flores, 1998a). Nesta área, a maioria das avistagens consiste de pares de mãe/filhote, que são observados por vários dias nas mesmas enseadas próximos à arrebentação, ou ao longo de alguns quilômetros durante semanas, movendo-se lentamente de uma enseada para outra (Simões-Lopes *et al.*, 1992; Palazzo & Flores, 1996, 1998a; Palazzo *et al.*, 1999; Groch, 2000). A observação de indivíduos solitários e ausência de filhotes nos primeiros meses (maio a julho) da “estação reprodutiva”, e uma maior frequência de avistagem de fêmeas com filhotes a partir de agosto, com registros de neonatos, é evidência de que os nascimentos ocorram nesta região (Simões-Lopes *et al.* 1992; Palazzo & Flores, 1998a). Grupos de acasalamento têm sido observados com mais frequência no litoral norte do Rio Grande do Sul (29°19' S, 49°43' W a 31°15' S, 50°54' W) (Simões-Lopes *et al.*, 1992; Moreno *et al.*, 1996), o qual caracteriza-se por uma longa praia de mar aberto. Recentemente, porém, grupos sociais e/ou de acasalamento tem sido observados ao longo de todo o litoral centro-sul de Santa Catarina (Palazzo & Flores, 1998a; Flores *et al.*, 2000; Groch, 2001a; obs. pessoais). Conforme Palazzo & Flores (1998a), parece haver áreas definidas separadas para grupos de acasalamento e grupos de mãe-filhote, mas somente estudos a longo prazo poderão assegurar esta hipótese. Palazzo *et al.* (1999) relatam a reavistagem de um par de fêmea e filhote a um intervalo de três anos no litoral de Santa Catarina, sugerindo para esta área de concentração reprodutiva o mesmo padrão de fidelidade observado em outras áreas no hemisfério sul (Payne, 1986; Bannister, 1990; Best, 1990b; Payne *et al.*, 1990).

Em função da importância do litoral catarinense para a espécie, a baleia franca foi declarada, em 1995, Monumento Natural do Estado de Santa Catarina pelo Decreto Estadual Nº. 171, de 06 de junho de 1995. Mais recentemente, em 2000, a principal área de concentração reprodutiva da espécie recebeu proteção especial, através da "Área de Proteção Ambiental (APA) da Baleia Franca", criada pelo Decreto de 14 de Setembro de 2000. A APA

da Baleia Franca possui 156.100 hectares e abrange desde o Sul da Ilha de Santa Catarina até o Balneário de Rincão.

O número de avistagens de baleias francas no litoral Sul do Brasil (Câmara & Palazzo, 1986; Secchi, E.R. 1994; Lodi *et al.* 1996; Moreno *et al.*, 1996; Palazzo & Flores, 1998a), bem como em algumas regiões do Sudeste (Lodi *et al.* 1996; Santos *et al.*, 2001) e Nordeste (Lodi *et al.* 1996; Engel *et al.*, 1997; Baracho *et al.*, 2002) vem aumentando a cada ano, e acredita-se que a espécie esteja recuperando sua distribuição original no Atlântico Sul Ocidental. Porém, em sua maioria, são observações casuais e pontuais, muitas delas provenientes de encalhes (Greig *et al.*, 2001). Apesar do histórico de intensa caça comercial, estudos moleculares revelaram que a variabilidade genética das populações no Atlântico Sul Ocidental é relativamente elevada (Ott, 2002), o que sem dúvida está contribuindo para o crescimento populacional.

Em anos recentes tem se registrado o aparecimento cada vez mais freqüente de baleias francas na costa do Uruguai (García *et al.*, 1996; García & Sabah, 1998; García, 2000). Uma rede de avistagens foi montada desde 1995, para obter dados sistemáticos ao longo dos anos. Não se sabe ainda até que ponto esta região é apenas uma rota migratória dos indivíduos que vem para o Brasil, ou uma área de concentração reprodutiva, porém a maior parte dos grupos avistados são grupos de acasalamento (García, 2000), e possivelmente este indivíduos façam parte do estoque de baleias francas que freqüenta Santa Catarina (IWC/Brasil, 1999). Em função do padrão de ocorrência da espécie no Atlântico Sul Ocidental e da possível relação entre os grupos que ali frequentam, a baleia franca foi declarada Patrimônio Natural do Mercosul, e denominada "Ballena Mercosureña" na XV Reunião Plenária da Comissão Parlamentar Conjunta do Mercosul, a 5 de Julho de 2000, em Santa Fé, Argentina.

Observações sistemáticas sobre os padrões de ocupação sazonal, composição dos grupos e comportamento das baleias francas no litoral centro-sul de Santa Catarina são realizadas em desde 1998 (Groch, 2000, 2001a, 2002, 2005). A maioria das avistagens consiste de pares de mãe-filhote, mas grupos com até sete indivíduos foram avistados em algumas áreas. As avistagens dos grupos sem filhotes ocorreram nas mesmas enseadas que os pares de mãe-filhote, observando-se diversas vezes interações entre os grupos, e comportamento de acasalamento (Groch, 2001a; 2002; 2005; dados não publicados). Um aumento na freqüência dos grupos sem filhotes pode ser percebido, assim como um aumento no número total de avistagens ao longo destes anos. Esse aumento no número de avistagens pode ser um reflexo do aparente aumento populacional ou pode ser meramente casual, e



somente a continuação deste estudo a longo prazo e de forma sistemática, e a intensificação dos estudos de fotoidentificação poderão verificar tais fatos.

Apesar das baleias francas estarem protegida através de legislação federal, a recente implantação das atividades de turismo de observação de baleias, "whalewatching", desde 1999 (Groch, 2001a; Mourão, 2000), em Santa Catarina, pode representar uma potencial ameaça, se não conduzida de acordo com as normas apropriadas. As embarcações para operarem na região devem estar cadastradas junto a APA da Baleia Franca, e as atividades devem ser conduzidas de acordo com as normas federais de aproximação aos cetáceos (Portaria IBAMA No. 117, de 26 de dezembro de 1996). Um estudo preliminar realizado em 2000 (Groch, 2001a) mostrou que a reação das baleias durante os encontros com a embarcação foi de "desinteresse" em 52% dos encontros observados, "positiva" em 36% e "negativa" em 12%. Em 87,9% dos grupos aproximados, estes eram compostos por pares de mãe-filhote, sendo o restante grupos sem a presença de filhotes. O aumento de 150% na procura por este serviço registrado em 2000 em relação ao ano anterior (Mourão, 2000), a conseqüente perspectiva de aumento no número de embarcações e o grande potencial para o desenvolvimento desta atividade no litoral de Santa Catarina (IWC/Brasil, 1999), tornam a caracterização dos padrões de uso de hábitat e do comportamento das baleias francas com e sem a presença de embarcações, um instrumento valioso para o manejo adequado desta atividade (IFAW, Tethys and Europe Conservation, 1995, IWC/Brasil, 1999).

Dentre as linhas de pesquisa fundamentais a serem desenvolvidas no sentido de se obter melhores informações sobre a as baleias francas em Santa Catarina, recomendadas pelo "Plano de Ação para a Conservação da Baleia Franca, *Eubalaena australis*, em Santa Catarina" (IWC/Brasil, 1999), Plano de Ação para os Mamíferos Marinhos do Brasil (IBAMA, 2001) e conforme enfatizado na "Reunião Especial do Comitê Científico da Comissão Internacional da Caça a Baleia - CIB para avaliação do status mundial das baleias francas" realizada em Cape Town, África do Sul, de 16 a 25 de março de 1998 (IWC, 2001; Palazzo & Flores, 1998b), destacam-se:

a) a continuidade dos vôos regulares de censagem e fotoidentificação das baleias;

b) o aprofundamento e a sistematização de estudos comportamentais referentes, em especial, aos pares mãe-filhote, visando definir padrões de uso do habitat e a monitorar reações advindas de ações antrópicas.

Com vistas a assegurar a proteção e garantir a recuperação populacional da espécie na sua área de concentração reprodutiva no sul do Brasil torna-se necessário a realização dos estudos recomendados, bem como a continuação e intensificação do monitoramento da espécie durante a sua ocorrência não só no Brasil como também nas outras áreas de ocorrência no Atlântico Sul Ocidental.

## OBJETIVOS

Considerando-se as lacunas existentes no que diz respeito à biologia das baleias francas, *Eubalaena australis*, no sul do Brasil, e às atividades de pesquisa recomendadas, a presente tese tem os seguintes objetivos em relação as baleias francas austrais:

### 1) Objetivo Geral:

**a)** Analisar a biologia e dinâmica populacional das baleias francas no Sul do Brasil.

### 2) Objetivos Específicos:

**a)** Verificar a distribuição espacial das baleias francas austrais identificadas individualmente no litoral centro-sul de Santa Catarina e Norte do Rio Grande do Sul;

**b)** Analisar e determinar os padrões de ocupação sazonal dos indivíduos fotoidentificados;

**c)** Estimar o tamanho e o crescimento do grupo de baleias francas que freqüenta o litoral sul do Brasil;

**d)** Verificar a taxa de retorno dos indivíduos fotoidentificados e o intervalo reprodutivo das fêmeas;

**e)** Verificar o comportamento dos grupos-alvo das operações de “whalewatching”.

## CAPÍTULO 2

**RIGHT WHALES (*EUBALAENA AUSTRALIS*) OFF SOUTHERN BRAZIL: ANNUAL AND SEASONAL PATTERNS OF OCCURRENCE, SITE FIDELITY AND GROUP STRUCTURE.**

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**Keywords:** southern right whales, habitat use, coastal movements, southern Brazil, wintering ground, aerial surveys.

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## ABSTRACT

Southern right whales (*Eubalaena australis*) in Brazil were historically distributed from northeastern to southern coast, but intensive commercial whaling held until 1973 almost extirpated them from the region. From 1986 through 2003 we conducted aerial surveys off southern Brazil primarily for photo-identification of the remnant population. A total of 481 whales (223 groups) were sighted in 16 surveys during peak whale abundance. Groups consisted mostly of two whales (67.3%,  $n=150$ ) and groups of up to 8 whales were sighted. From the total, 149 sightings were of mother/calf pairs and 183 were unaccompanied whales. Because unequal survey coverage and irregularity throughout the period, we compared cumulative density of whales/bin (unit with 12 minutes latitude long) between blocks of years with similar survey coverage and approximate date of flight to verify tendencies on distribution. Whales concentrated between bins J (Garopaba) and N (Araranguá), with a peak in L (Laguna). Distribution of mother/calf pairs and unaccompanied whales were apparently different, though not supported statistically (Mann-Whitney:  $U=71.5$ ,  $z=0.301$ ,  $p=0.763$ ,  $n_1=11$ ,  $n_2=14$ ). Within-season distribution was described after monthly surveys conducted between July and November in 2002 and 2003. Whales arrived in July/August, reaching peak in September, and declining in October/November. The identification of 39 non-calf whales provided information on intra-annual resighting patterns. Thirty-one whales were resighted inter-annually at least once (sighting interval: 1-10 years). There were 71% of resightings in 2003 (none before 1994), and 93.5% ( $n=29$ ) of whales were resighted at least once. From 120 females identified in Brazil, 19.2% ( $n=23$ ) have shown some level of site fidelity. 82.6% ( $n=19$ ) of these females were in calving years. From the 149 identified unaccompanied whales, 3.4% ( $n=8$ ) have been resighted, at a one-year modal interval. The distribution of right whales along the southern Brazilian coast was not uniform, indicating specific areas as important wintering habitat for this recovering species. Survey effort varied, but patterns of distribution are identified. Distribution of mother/calf pairs and unaccompanied whales is somewhat overlapped, but a major concentration area was identified, especially for mother/calf pairs, which coincides with a previously recognized aggregation area off Brazilian coast.

## INTRODUCTION

Southern right whales (*Eubalaena australis*) migrate to coastal waters of continents and oceanic islands during the austral winter/spring time seeking for shallow and protected areas to give birth, nurse their calves and apparently mate (Payne 1986; Best 1988; Bannister 1990; Best 1990, 2000; Burnell and Bryden 1997; Patenaude and Baker 2001). These areas are the preferred habitat of females with calves, mainly because they enable energy conservation by the calves (Lockyer 1981; Thomas and Taber 1984; Corkeron and Connor 1999). According to Thomas (1987), shallow waters and gently sloping beaches are preferred for being areas free from underwater obstacles where whales can drift freely following the tides. Additionally, it has been suggested that shallow waters offer protection against killer whales (Thomas and Taber 1984; Thomas 1987; Corkeron and Connor 1999).

The right whales that frequent the southern Brazilian coast were severely depleted by commercial whaling in the 19<sup>th</sup> and early 20<sup>th</sup> centuries. Although protected from hunting by international agreements since 1935, illegal catches on the right whales' pelagic summer grounds in the mid 20<sup>th</sup> century were recently reported (Tormosov *et al.* 1998). Historically, right whales in Brazil were distributed from the northeastern to southern coast, but were also subject to intensive commercial whaling until 1973. By that time the whale population appeared to be extirpated from the region (Palazzo Jr. and Carter 1983). It was only in the early 1980s that whales were 'rediscovered' in this region, and have been studied since then (Câmara and Palazzo 1984).

Groups of right whales have been sighted from May to December especially along the southern Brazilian coast (Lodi and Bergallo 1984; Câmara and Palazzo 1986; Palazzo and Flores, 1996, 1998; Simões-Lopes *et al.* 1992; International Wildlife Coalition/Brazil 1999) with peak abundance from August to October (Simões-Lopes *et al.* 1992; Palazzo and Flores 1996; Groch 2000, 2001).

Aerial surveys for the individual identification of southern right whales using their callosity patterns (Payne *et al.* 1983) have been conducted since 1986 along the southern Brazilian coast when the whales are on their wintering ground. The first years of the surveys combined with incidental sightings and shore-based counts have shown a main aggregation area along the waters of Santa Catarina State particularly the central-southern coast from Santa Catarina Island (27°25'S, 48°30'W) to Santa Marta Cape, Laguna (28°36'S, 48°48'W) (Simões-Lopes *et al.* 1992; Palazzo and Flores 1996, 1998; International Wildlife Coalition/Brazil 1999). An increase in the number of right whales off Brazil has been

observed and the population is estimated to be increasing at a rate of 14% per year (Groch *et al.* in press) The authors have also reported on a higher rate of 29% of increase during the latest years of their study (1997-2003).

Sightings from aerial surveys have been used to describe distribution, movements and coastal residence periods in many wintering areas (Payne 1986; Bannister 1990; Best 1990, 2000; Burnell and Bryden 1997; Rowntree *et al.* 2001). Right whales can be flexible in many aspects of their habitat use (Rowntree *et al.* 2001). Patterns of use may change over time but a preference by certain aggregation areas is reported as well as the segregation of concentration areas between females with calves and mating groups (Payne 1986; Bannister 1990; Best 1990, 2000; Burnell and Bryden 1997; Rowntree *et al.* 2001). In addition, females with calves have shown longer coastal residence periods than adults unaccompanied by calves (Bannister 1990; Burnell and Bryden 1997) and present less movement along the coast (Bannister 1990; Best 1990; Rowntree *et al.* 2001).

In this paper we describe inter-annual and seasonal patterns of distribution of right whales sighted along the Southern Brazilian coast during aerial surveys for individual identification, as well as movements and site fidelity of individually identified whales.

## MATERIALS AND METHODS

From 1986 through 2003 we conducted aerial surveys off southern Brazil with the main purpose of photographing whales for individual identification. We have also recorded the distribution, number and group composition of all right whales seen. Surveys were conducted on an irregular basis from 1986 to 1994 (1986, 1987, 1988, 1992, 1993 and 1994) and annually from 1997 to 2003, preferable during the time of peak whale abundance (Table 1). The surveys from 1986 to 1997 were made using fixed wing aircrafts and from 1998 to 2003 we have used a helicopter. No sightings were recorded in 1986.

The extent of the coastline surveyed each year varied but a standard 120km region of the coast between Santa Catarina Island and Santa Marta Cape, Laguna, was always included (Figure 1). In some flights we extended the surveyed area to include 400km of coastline (between bins A to T shown in figure 1, through different combinations of successive bins). Techniques and personnel were kept as constant as possible but varied according to the aircraft. The flight crew consisted of the pilot and one to three observers, depending on the



aircraft. One observer acted as the annotator and recorded whale number, group composition, location, behavior and photographic information for each whale or group of whales spotted.

The surveys were flown generally at an altitude of 1000 ft (300m), at a mean ground speed of 90 knots (167km/h) and at ~500m from the coastline. Surveys were conducted preferable during days with optimal conditions, i.e. low surface winds, sea states (<3 Beaufort Sea Scale) and adequate lighting. Searching was conducted in the zone from beyond the breaking waves to not more than 1500m from the coastline. Whenever a whale or group of whales was spotted they were approached at a minimum height of 300ft (100m) for determination of the number of whales, group composition, and location. Locations of whales during the surveys made until 1997 were recorded relative to buildings and distinct geographic features along the coast, and from 1998 on using a Global Positioning System. When using the airplane each whale or group of whales was circled for taking the photographs; while the helicopter enabled us to hover above the group. When using a GPS, the position of the whales was recorded at this moment.

Whales accompanied by calves were assumed to be females and were classified as females with calves. Calves are all young-of-the-year whales with 1/3 to 1/2 of their mother's length. One-year-old whales identified in the previous year are called yearlings and immature whales of unknown age were classified based on relative length and morphology of the head and referred to as 'subadults'. Adult whales not accompanied by calves will be here referred as unaccompanied whales. This category contains mostly whales of unknown sex but also previously identified and thus known females in non-calving years as well as animals of unknown age (excluding subadults). For all analysis subadults and yearlings were included in the unaccompanied whales category because of the low sample size. Whales were considered to be in a group when two or more whales were seen within close proximity of one another (at least approximately 15m or one adult whale length). Animals more than one whale length apart were also considered a group if their behavior appeared to be coordinated (Clark, 1983).

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). All whales identified were included in a catalogue created at the beginning of the study.

### ***Distribution***

Since the coastline runs primarily in northeast-southeast direction and the flight path was made along the coast, we divided the survey area into bins of 12 minutes of latitude long (Figure 1). The total survey area resulted in 20 bins with the length of the coastline varying from 23 to 56km ( $31.2 \pm 7.8$ km). Because positions recorded without GPS (1987 to 1997) are not geographically precise, the processing of data into this scale also contributed on minimizing bias for the study of overall coastwise distribution. In 9 flights (1986-1988, 1992-1994, 2001-2003) we have surveyed bins G to S and in 1993 we have extended the flight to bin T (Table 1). Bins A to F were surveyed in October 2000 and August 2003, and bins E and F in September 1988 but no whales were sighted.

The distribution of whales is described in terms of density of whales sighted per bin and an overall distribution pattern is given for the entire period, using flights conducted during the peak of whale abundance in the region (Table 1). All data presented here are considered minimum counting of whales sighted because whales that were underwater were not seen when we were passing above them.

### ***Inter-annual distribution***

Because the unequal survey coverage as well as the irregularity throughout the period, we divided the data series in order to see whether there was any tendency on the distribution throughout the years of the study. The first set was grouped according to the survey coverage and consist of the following three periods: 1987 through 1994 (hereafter referred to as 1987-94), 1997-2000 and 2001-2003. The second set was grouped according to the approximate date of flight: 1987, 1992-1994 (27 August to 1<sup>st</sup> September) (hereafter referred to as Block A); 1988, 1997, 1998, 2002 (23-27 September) (hereafter referred to as Block B) and 1999, 2001, 2003 (10-14 September) (hereafter referred to as Block C). The survey of the year 2000 was made in 8 October and because we considered it somewhat skewed of the dataset in terms of the date of the survey, it was not included in this analysis. The timing of the flights included in each block differed between 4 and 7 days. We have also divided the survey area into five distinct sub-regions according to physical characteristics of the coastline (Fig. 1) to see whether there was any evidence of habitat segregation. The resulting sub-regions also reflect the different survey effort over the years (see Table 1). For this reason two of them comprise different number of bins. Sub-regions 'SC1' and 'SC2' group six and two

successive bins, respectively, and have different number of bins in relation to sub-regions 'SC3', 'SC4' and 'RS1', each with four successive bins (Figure 1). Sub-regions 'SC4' and 'RS1' are similar in their physical features, separated only by a few coastal cliffs, but were divided in order to comprise the same number of bins of sub-region 'SC3' for comparison purposes. Sighting data were processed using a GIS software package (ArcView 3.2a, Environmental Systems Research Institute, Inc., ESRI).

We used Mann Whitney and Kruskal-Wallis Tests to compare the density of whales in each set of years, and the Chi-square contingency test to examine tendency in whale distribution by sub-region.

#### ***Within-season distribution***

To describe the within-season distribution of whales sighted along the study area we used data from 2002 and 2003. In these years we conducted four surveys each year covering the same stretch of the coast (bins G to S). Monthly surveys were made from July to November in 2002 (with the exception of October) and from August to November in 2003. The Kruskal-Wallis Test was used to compare the density of whales between months in each year.

#### ***Coastal movements and approximate residence period***

Resightings of individual whales during monthly surveys conducted in 2002 and 2003 provided information on within-season movements and period of stay in the region. Females with calves sighted during shore and boat-based observations in the study area have been reported to stay at least 20-25 days in the same bay (Groch 2000; Groch *et al.* 2003) and as long as 69 days moving between different bays (Palazzo *et al.* 1999; Groch *et al.* 2003). For this reason movements that occurred within a wintering season were considered to have been made in coastal waters, with the assumption that movements took place along the coast and that between these sightings whales remain within the aggregation area. Because these assumptions can potentially overestimate whales' true period of stay, data provided in this paper are considered to be approximate residence period. In addition, whales could have been in the area before the survey was conducted and hence this data could also have been underestimated. The approximate residence period was based on minimum distance traveled between sightings in different days, and was measured on a 1:280,000 nautical chart. Unaccompanied whales are known to spend less time than females with calves in wintering

grounds (Burnell and Bryden 1997) but no previous information on residence period is available for the study area. For this reason, the same assumptions as for females with calves were considered for unaccompanied whales, and so the information provided here should be treated more carefully when used for comparison purposes.

In September 2002 the survey was made during two consecutive days with flights covering two adjacent areas. Some whales were sighted in both flights but included only once in the above analysis. We used sightings of these whales to provide information on swimming speed and daily movements, combining the time and position of sightings in both flights.

### *Site fidelity*

The Brazilian Right Whale Catalogue has 315 different individual whales (120 females, 149 whales of unknown sex/age and 46 calves identified in their calf year) (Groch *et al. in press*). Ten percent (n=31) of the whales have been resighted providing information on site fidelity. In addition to the main surveys conducted during the time of peak whale abundance, and the monthly surveys conducted in 2002 and 2003, we have also included for this analysis whales identified during 13 surveys made in non-regular basis between July and October in 1988 (August, n=1), 1997 (September, n=3), 1998 (September, n=4), 1999 (July-October, n=3) and 2000 (October, n=2). These surveys covered mainly the standard survey area (120km of coast) and will be hereafter referred as non-main flights. Data considered for this analysis comes from the first sighting of each individual in a year.

Southern right whales, specially females with calves, are considered to exhibit levels of site fidelity for wintering areas (Bannister 1990; Best 1990, 2000; Burnell and Bryden 1997; Rowntree *et al.* 2001). We used individual identified whales resighted at least once during aerial surveys in different years to verify the degree of fidelity in the study area. An individual was considered to display some level of fidelity when it was sighted at least twice, each in different year, in a particular region.

## RESULTS

### *Population structure*

Between 1987 and 2003, 481 whales were sighted in 16 aerial surveys conducted during the time of peak whale abundance along the Southern Brazilian Coast (Table 2). The majority of sightings were of groups with two whales (67.3%, n=150) and groups of up to four whales were the most commonly sighted. The maximum number of whales sighted in a group during the surveys was eight (0.9%, n=2). From the total number of whales, 149 were females, 149 were calves, and 183 unaccompanied whales, distributed in 223 groups. Most of the groups (58.3%, n=130) consisted of single pairs of females with calves and 35.9% (n=80) were sightings of 1 to 8 unaccompanied whales. Single females with calves were seen accompanied by non-calf whales in 11 occasions and in one occasion two pairs of females with calves were sighted associated with four unaccompanied whales. Unaccompanied whales were most commonly seen as single individuals (16.6%, n=37), though groups of two individuals were also very frequent (12.1%, n=27). Three subadults and two yearlings were sighted and included in the category of unaccompanied whales. The subadults were sighted each in groups of up to four whales (one in a group with a female with calf) and the yearlings in groups of two and six unaccompanied whales.

### *Inter-annual distribution*

The density of whales sighted per bin in the surveys conducted during the time of peak whale abundance in the entire study period is given in Figure 2. Whales concentrated between bins J (Garopaba) and N (Araranguá) with a peak of sightings in bin L (Laguna) and it is coincident with the previously identified aggregation area. This area is also coincident with the standard surveyed area, and the concentration of sightings could have been biased by the higher survey effort in relation to the total area. A region with lower density occurred between O and S with a peak in Q and R. Females with calves followed the same overall pattern of distribution but there were no sightings in bins G, H and T. The distribution of unaccompanied whales extended further south and along a wider area, from bin L to bin R, with a peak in the outmost bins. A high density was also observed in bin J, though half the peak in the main density area. A lower density occurred between G and I, K and S-T. Although the distribution of mother/calf pairs and unaccompanied whales was apparently

different, this was not supported statistically (Mann-Whitney:  $U = 71.5$ ,  $z = 0.301$ ,  $p = 0.763$ ,  $n_1 = 11$ ,  $n_2 = 14$ ), maybe because of the low sample size.

*a) Distribution by survey coverage*

The distribution of whales grouped according to the survey coverage over the years is shown in Figure 3. In 1987-1994 bins G to S were surveyed, with an extension to bin T in 1993. Whales were concentrated along bins J to N and P to R, and the cumulative density of whales per bin peaked in bins J and L. A region with lower cumulative density of whales occurred between bins G and I, and S-T. There were no sightings in bin O. The period 1997-2000 had the most variable survey coverage, varying between bins G and N, thus the resulting pattern of distribution could have been biased towards higher densities in bins with greater survey effort. The distribution of whales was concentrated in bins J to L with a peak in J and L. Bins I and M to O had lower cumulative densities with a peak in bin N. In 2001-2003 bins G to T were surveyed but no sightings were recorded in bins G, H and T. The whales were concentrated between bins J to M with a peak in bin L, and a lower concentration occurred in bin I and from bin N to S.

As expected after the overall distribution of whales during the entire study period, a region of major concentration in the three blocks of years was observed between bins J and N, and secondly in bins Q and R. When comparing the cumulative density of whales per bin between 1987-1994 and 2001-2003, which had similar survey coverage, the distribution of all whales sighted was significantly different (Mann-Whitney:  $U = 19$ ,  $z = 3.0417$ ,  $p = 0.0024$ ,  $n_1 = 13$ ,  $n_2 = 11$ ). The distribution was not significantly different when comparing only unaccompanied whales (Mann-Whitney:  $U = 32$ ,  $z = 1.8463$ ,  $p = 0.0649$ ,  $n_1 = 12$ ,  $n_2 = 10$ ), but no significant difference was observed in the distribution of females with calves (Mann-Whitney:  $U = 27.5$ ,  $z = 1.6714$ ,  $p = 0.0946$ ,  $n_1 = 9$ ,  $n_2 = 11$ ). The low number of sightings in bin T could have been biased in 1987-1994 because this bin was surveyed in only one out of five years. However, bin T was flown in all surveys from 2001 to 2003 and no sightings were recorded as well.

*b) Distribution by approximate date of flight*

The resulting distribution of whales from the combination of the aerial surveys by approximate date of flight is shown in Figure 4. During the surveys combined in block A, whales were concentrated from bins J to N and bins Q-R. In block B the whales were concentrated mostly between bins J and N while in block C three major areas of concentration

are observed, in bins I-J, L-M and O-R. The distribution of whales in block A was significantly different from blocks B and C (*Kruskall-Wallis*:  $n = 3$ ,  $H = 6.246$ ,  $p = 0.044$ ;  $p(A \times B) = 0.0317$ ,  $p(A \times C) = 0.0423$ ;  $p(B \times C) = 0.8659$ ), but blocks B and C were not significantly different from each other. However, when comparing the distribution by category of whales no significant differences were found (females with calves: *Kruskall-Wallis*:  $n = 3$ ,  $H = 5.1771$ ,  $p = 0.0751$ ; unaccompanied whales: *Kruskall-Wallis*:  $n = 3$ ,  $H = 0.2001$ ,  $p = 0.9048$ ).

### *c) Distribution by sub-region*

The distribution of whales along four sub-regions in the study area is given in Table 3. Sub-region ‘SC1’ corresponds to bins A to F and, as mentioned above, had no sightings over the entire period.

Females with calves showed the same pattern of distribution over the years. The sightings were concentrated in sub-region ‘SC3’ in all blocks of years, followed by ‘SC4’ and ‘RS1’. No sightings were recorded in sub-region ‘SC2’ in 1987-1994 and 2001-2003. For unaccompanied whales in 1987-1994, the higher number of sightings was recorded in sub-region ‘RS1’ followed by ‘SC3’, ‘SC4’ and ‘SC2’. In 1997-2000 and 2001-2003 the higher number of sightings was recorded in sub-region ‘SC4’, followed by ‘SC3’. In 2001-2003 a lower number of sightings was recorded in sub-region ‘RS1’ and no sightings were recorded in ‘SC2’. It’s important to note that in 1997-2000 only sub-regions ‘SC3’ and half of ‘SC4’ were surveyed. The number of whales sighted in sub-regions ‘SC3’ to ‘RS1’ was significantly different between 1987-1994 and 2001-2003 for both unaccompanied whales (*Chi-square*:  $\chi^2 = 5.783$ ;  $df = 2$ ;  $p = 0.0555$ ) and females with calves (*Chi-square*:  $\chi^2 = 0.704$ ;  $df = 2$ ;  $p = 0.7034$ ), although for unaccompanied whales the level of significance was low. The 1997-2000 period was not compared because of low sample size and variable survey coverage.

### ***Within-season distribution***

Sightings in 2002 and 2003 indicate that whales began arriving in the study area in July/August, reaching a peak of occurrence in September, and declining in October/November (Fig. 5). This pattern is also apparent both to females with calves and unaccompanied whales when treated separated. Within-season distribution of whales sighted per bin in 2002 and 2003 is shown in Figures 6 and 7.

In 2002, 210 whales were sighted (including double sightings), being 61.9% (n=130) females with calves and 38.1% (n=80) unaccompanied whales. From the total, 58.6% (n=123) of whales were sighted in September, 29% (n=61) in August, 11.4% (n=24) in July and 1% (n=2) in November. There was no aerial survey during October. Because November had only one sighting, a female with calf, it was not included in the statistical analysis. The distribution of females with calves was not continuous along the survey area, but significantly uniform through the months (*Kruskal-Wallis*:  $n=3$ ,  $H=4.9379$ ,  $p=0.0847$ ), concentrated in the northernmost bins, between H and N (Fig. 6). A few isolated sightings occurred in bins R (in August) and S (in September). The distribution of unaccompanied whales was continuous in July, but not continuous in August and September, and varied through the months. In July and August whales were concentrated along the southernmost bins, from M to T, but in September there was two major concentration areas, one along the northernmost bins, from I to N, and the other in bins R and S. The distribution of unaccompanied whales was significantly similar between July and August, but differed significantly in September (*Kruskal-Wallis*:  $n=3$ ,  $H = 8.2342$ ,  $p = 0.0163$ ;  $p$  (*jul x aug*) = 0.5506;  $p$  (*jul x sep*) = 0.0079;  $p$  (*aug x sep*) = 0.0319).

In 2003, 191 whales were sighted (including double sightings), being 55.5% (n=106) females with calves and 44.5% (n=85) unaccompanied whales. From the total, 59.2% (n=113) of whales were sighted in September, 23% (n=44) in October and 17.8% (n=34) in August. There was no aerial survey in July, and no sightings were recorded in November. The distribution of females with calves was significantly uniform over the months (*Kruskal-Wallis*:  $n=3$ ,  $H=1.643$   $p=0.4398$ ), but not continuous in September and October, and somewhat skewed to the south when compared to 2002. A concentration area is observed between bins K and O with a few sightings between bins P and T. The distribution of unaccompanied whales was not continuous over the months and whales were concentrated from bins O to R in August, and I to M in October. In September, a major concentration area occurred from bins O to R, but the peak of sightings occurred in bin L. Although the distribution in October was apparently different from August and September, this was not supported statistically (*Kruskal-Wallis*:  $n=3$ ,  $H=3.8114$ ,  $p=0.1487$ ).

### ***Coastal movements and approximate residence period***

Sighting frequencies of whales identified during monthly surveys in 2002 and 2003 were analyzed and data on monthly resighting patterns of non-calf whales are presented in Tables 4



and 5. A total of 37 whales were resighted, 20 in 2002 and 17 in 2003 (Table 5). In 2002, most of the resightings occurred in September (85.7%, n=18) and in 2003 in October (66.7%, n=12) (Table 4). Patterns of resighting were not repeated between 2002 and 2003, but there was no flight in October 2002 and July 2003 to enable a direct comparison between all months.

The majority of resightings both in 2002 and 2003 were of females with calves, resighted at least once in two consecutive monthly surveys. From the total number of whales identified in 2002 (n=145), 13.8% (n=20) were resighted at least once in different surveys, of which 85% (n=17) are females with calves and 15% (n=3) unaccompanied whales. In 2003, 12.3% (n=17) of the whales identified (n=138) were resighted at least once, of which 94.1% (n=16) are females with calves and 5.9% (n=1) unaccompanied whales. Most of the resightings were in two consecutive months either in 2002 (80%, n=16) or 2003 (94.1%, n=16) (Table 5). Considering that during this period the whales remained in the area, these whales spent between 25 and 37 days in the region. Two females with calves were sighted in three consecutive months, one in 2002 and another in 2003, and may have spent 62 and 64 days in the region. In 2002 three females with calves were sighted in two interrupted months (*i.e.*, July – September). One of these females with calves was sighted in September and November but there was no survey in October, so the approximate residence period was not speculated. The sample size was not large enough to test for significant differences in the resighting rates among the females with calves and unaccompanied whales.

Table 6 shows data on the within-season movements of the non-calf whales resighted in 2002 and 2003. Females with calves resighted in 2002 displayed more northbound movements (61.1%, n=11) between sightings in relation to southbound movements (38.9%, n=7), which were displayed mostly between August and September. Unaccompanied whales displayed more southbound (66.7%, n=2) than northbound (33.3%, n=1) movements and all resightings were between August and September. In 2003 females with calves displayed similar rates both southbound and northbound (52.9% and 47.1% respectively) and the only unaccompanied whale resighted displayed a southbound movement. Similar proportions of southbound and northbound movements were displayed in the three possible monthly combinations of resighting patterns in 2003 (see Table 6).

The spatial distribution of the within-season movements of females with calves resighted in 2002 and 2003 is shown in Figures 8 and 9. The position of whales when first sighted, in terms of bins of latitude, was plotted according to the direction of movement in relation to the

position of the resighting (Figure 8). Data from 2002 and 2003 were grouped because of the small sample size. There appears to be a tendency for whales first sighted in the northernmost bins being resighted in a southernmost bin as well as the opposite movement, and these patterns were significantly similar (*Mann-Whitney:  $U = 16.5$ ,  $z = 1.0222$ ,  $p = 0.3067$ ,  $n_1 = n_2 = 7$* ). Whether whales movement from the first sighting was constantly northbound or southbound is not known and because data presented here comes from punctual observations it is not intended to be exhaustive. In Figure 9 the position of whales when first sighted was plotted by bin, according to the month of first sighting. Monthly distribution followed the overall pattern of movements (shown in Figure 8) and no obvious tendency was observed between months. The number of unaccompanied whales resighted was too small to detect any tendency or pattern of spatial distribution.

Eleven non-calf whales were sighted in the two complementary flights in the 23 and 24 of September 2002, most of which being females with calves and only one unaccompanied whale. The mean minimum distance traveled between sightings by females with calves was  $6.5 \pm 6.2$  km during  $16.8 \pm 0.3$  h at a mean swimming speed of  $0.4 \pm 0.4$  km/h. The unaccompanied whale traveled a minimum of 11 km at 0.7 km/h. All but one sighting and resighting were in bin K, the exception being a female with calf sighted in bin L and resighted in bin K, indicating that at least some whales demonstrate fidelity to some particular bin over a short period of time.

### ***Site fidelity***

Data from the 31 whales identified and resighted between 1987 and 2003 are shown in Table 7. There were no resightings before 1994 and 71% of the resightings occurred in 2003. The time period between sightings varied from one to 10 years. With the exception of two females resighted in two and three different years, all other whales were resighted only once. Five whales (16.1%) included in this analysis were first sighted only in non-main flights but resighted in main flights, and another four whales (12.9%) were resighted only in non-main flights.

Seventeen whales (48.4%) were resighted in the same sub-region of the first sighting ('SC3' or 'SC4'), 10 (32.3%) in adjacent sub-regions ('SC3' and 'SC4') and 6 (19.4%) between 'RS1' and 'SC3'. The number of bins traversed between sightings was obviously lower between the same or adjacent sub-regions than in non-adjacent ones. Most of the

resighted whales were females (74.2%, n=23), which were predominantly resighted in the same sub-region of first sighting ('SC3'). 'SC3' was the preferred sub-region either for first or subsequent sightings for most of the whales (96.8% were sighted at least once in 'SC3').

From the total number of females individually identified in Southern Brazil (n=120), 19.2% (n=23) have shown some level of site fidelity by returning to this wintering ground. From the total number of females resighted, 82.6% (n=19) were sighted with newborn calves (and thus were in calving years) in both first and the subsequent year of sighting. Of the 18 females first sighted in sub-region 'SC3', 83.3% (n=15) were in their calving year and 38.7% (n=11) were resighted in the same sub-region in another calving year. From the four females sighted only once with calves, two were sighted with their calves in sub-region 'SC3', one when first sighted and the other when resighted. The females resighted in two and three different years were in their calving year during all sightings and were sighted mostly in sub-region 'SC3' (the last resighting of both females was in 'SC4'). Both females have traversed 1 to 3 bins between resightings.

Only 3.4% (n=8) of the total unaccompanied whales identified (n=149) have been resighted, mostly in the sub-region adjacent to the first sighting ('SC3' and 'SC4'). The modal interval between sightings for unaccompanied whales was one year. It's worth noting that three of these whales were yearlings (6.5% of the total unaccompanied whales identified), returning to their region of birth, one to five bins far from the bin where first sighted. The three yearlings were first identified accompanied by their mothers in September 2002, and resighted in 2003 without their mothers, one in August and the other two in September. Their mothers were not sighted in 2003, indicating that by the time of the sighting the yearlings were already weaned.

When resightings did not occurred in the same sub-region of first sighting, females have dispersed equally either northwards or southwards. Dispersal of unaccompanied whales was mostly towards a southernmost region. There was a tendency for unaccompanied whales (87.5%) to return to the same or adjacent sub-region slightly more frequently than females (78.3%). The pattern of resighting of females and unaccompanied whales did not varied significantly (*Mann-Whitney*:  $U = 4.5$ ,  $z = 1.3472$ ,  $p = 0.1779$ ,  $n_1 = 5$ ,  $n_2 = 4$ ).

## DISCUSSION

The distribution of southern right whales within the study area was not uniform, indicating that some specific areas are important wintering habitats for this recovering species. Whales were sighted mostly in pairs of females with calves, characterizing the area as an important nursery area, as previously mentioned (Simões-Lopes *et al.* 1992; Palazzo and Flores 1996, 1998; International Wildlife Coalition/Brazil 1999). Right whale associations of many individuals are not common in breeding areas (Payne 1986; Bannister 1990; Best 1990; Patenaude and Baker 2001; Best *et al.* 2003), excepting the temporary associations of groups engaged in social or sexual activity (Donnelly 1967; Payne *et al.*, 1983; Best *et al.* 2003).

Survey effort varied among years, but patterns of right whale distribution can be identified. The distribution of females with calves and unaccompanied whales is overlapped to some extent, but a major concentration area can be identified, especially for females with calves, in the northernmost bins. This area is coincident with the previously recognized aggregation area in the region (Simões-Lopes *et al.* 1992; Palazzo and Flores 1996, 1998; International Wildlife Coalition/Brazil 1999). A smaller concentration area occurs in the southernmost bins. This pattern is also observed when data is grouped by blocks of years with similar survey coverage and also by approximate date.

When grouped by sub-regions with distinct geographic features, two major adjacent areas of concentration can be identified. The first, SC3, is characterized by small bays in all extension, and had mostly sightings of females with calves. The second, SC4, is a straight coastline and had mostly sightings of unaccompanied whales. The relatively small proportion of females with calves in the southernmost region of this study indicates a geographic segregation is occurring, as previously mentioned (Palazzo and Flores 1998; International Wildlife Coalition/Brazil 1999). Geographic segregation of different group categories has also been observed in Argentina (Payne 1986) and South Africa (Best 1981; Best 1990, 2000). In these areas different bays or stretches of coastline are used for nursing and mating. Because we could not sex the unaccompanied whales, it is not possible to assert that the SC4 region is a mating area but the behavior of some of the groups without calves indicates that this may be the case.

Regions of concentrations have also been identified for other wintering areas (e.g. Argentina (Payne, 1986), South Africa (Best 1990; 2000) and Australia (Bannister 1990)). In

these areas, some stretches of the coast are more favored than others and have higher number of whales. Elwen and Best (2004) suggested that environmental factors play an important role on the distribution of right whales in South Africa. According to these authors, whales concentrate in areas that provide reasonable protection from open ocean swell and seasonal winds, as well as areas with sedimentary floors and gentle slopes. In a study using data from shore-based observations, Groch (2000) found no evidence on the influence of wind on the distribution of right whales in their main concentration area off southern Brazil, but did not tested the other factors found by Elwen and Best (2004) to have influence.

Best (2000) and Rowntree *et al.* (2001) reported shifts in distribution of right whale along South African and Península Valdés coasts, respectively. In South Africa, the preferred areas along the coastline have not changed over 30 years of study (Best, 2000). However, the number of right whales has changed, increasing in some areas and decreasing in others, shifting the median number of whales in some areas 40-46 min to the west. According to Best (2000) one explanation for this shift could be the females' previous experience in the choice of the nursery area. Though no changes in distribution were observed in southern Brazil during the study period, females' previous experience may also influence the choice of females with calves for the some specific wintering region off southern Brazil. On the other hand, right whales in Península Valdés, have shifted their distribution in recent years, abandoning the Outer Coast in favor of the northern and southern bays of the Peninsula (Rowntree *et al.* 2001). One possible explanation for this shift was major changes in bottom topography due to storms. Inside the bays, whales were also observed moving from the center of a whalewatching industry to areas with intense development of human activities and high incidence of gull harassment. The authors attributed such movements more to individual preference and social cohesion than disturb caused by whalewatching boats.

Despite no aerial survey was made in July 2003, a few sightings in this month were reported in the standard survey area during systematic land based observations (bins I to L) (Groch, *unpublished*), indicating that whales begun arriving at this time of the year, as in 2002. From July on the population builds up reaching a peak in September and declines in October/November, following the overall pattern of occurrence of the other wintering grounds in the Southern Hemisphere (e.g. Península Valdés, Argentina (Payne 1986), South Africa (Best and Scott 1993) and Australia (Bannister 1986)).

The greater number of females with calves in relation to unaccompanied whales resighted both in 2002 and 2003 reflects the tendency of females with calves to stay longer in Southern

Brazil than unaccompanied whales, a pattern also observed in other wintering grounds (Payne 1986; Bannister 1990; Burnell and Bryden 1997; Best 2000; Rowntree *et al.* 2001). Given the time between the surveys, female right whales may spend ~30 days or more in the region, a residence period also observed during shore and boat-based observations (Palazzo *et al.* 1999; Groch 2000; Groch *et al.* 2003). According to Taber and Thomas (1982) the main reason for this period of stay of females with calves in wintering areas is the need of newborn calves to pass through specific developmental stages during the first months of life. During this period, calves have to acquire motor ability, some level of competency in swimming, ability to protect themselves and to identify and remain with their mothers. The time of departure is probably given by compensation between the semi-starved mother and the pre-migratory stage in behavior (Taber and Thomas 1982; Thomas and Taber 1984). At this time calves are prepared for the relatively rapidly depart for their summer feeding grounds (Taber and Thomas 1982; Thomas and Taber 1984), which results in a rapid decline in the number of whales sighted at the end of the season, as observed between October and November in southern Brazil.

Females with calves present less movements along the coast in wintering areas than unaccompanied whales (Bannister 1990; Best 1990, 2000; Burnell and Bryden 1997; Rowntree *et al.* 2001), but little is known on the movement patterns of unaccompanied whales. They can be males looking for receptive females, pregnant females in their conception year (especially those sighted early in the season) or subadults. Burnell and Bryden (1997) reported sightings of unaccompanied whales at widely separated aggregation areas and great variations in residence period. To these authors, the variation in distribution does not necessarily represent less residence period in the area but could be simply less site fidelity to particular areas than the pattern shown by calving females. Additionally, Burnell (2001) reported that the residency of non-accompanied whales is often interrupted by periods away from the wintering ground. Subadults and yearlings in Peninsula Valdés, Argentina, have presented similar resighting patterns as females in calf years, indicating the importance of that region for this class of whales (Rowntree *et al.* 2001). From the five whales classified in this category, two of them (yearlings) were resighted, representing 5% of the total number of whales resighted, indicating that the waters in southern Brazil are not being used as frequently as Peninsula Valdés by young whales. Whether whales born in southern Brazil are going to Peninsula Valdés in the following wintering season or to other wintering ground is not known.

The mean swimming speed of  $0.4 \pm 0.4$  km/h of the females with calves resighted during the two complimentary flights is lower than the mean swimming speeds of 0.9 to 2.78 km/h of females with calves tracked by theodolite from shore during the monitoring of boat-based whalewatching activities in the study area (Groch *et al.* 2003). One explanation for this discrepancy is the implicit assumption that the whales traveled in a straight line between the two sightings. In South Africa, Best (1990) reported very similar average speeds (0.8 to 2.89 km/h) of females with calves resighted within a one day period during aerial surveys, but higher average speeds (0.4 to 3.62 km/h) from shore based observations. However, data from shore-based observations in South Africa are presumably of undisturbed whales, differently from data from aerial surveys, where whales could have potentially been disturbed by the aircraft. Females with calves tracked in Peninsula Valdés averaged 2.3 km/h in presumably undisturbed conditions (Colombo *et al.* 1990). In Brazil, data from shore-based observations were collected before, during and after whales were approached by whalewatching boats (Groch *et al.* 2003). The mean swimming speeds of 0.9 to 2.78 km/h are of females tracked before being approached by boats and thus are also presumably from undisturbed whales. Notwithstanding, comparable values for the aerial survey data are the ones recorded during approaches. In this phase the mean swimming speeds of the whales ranged from 1.10 to 2.71 km/h, which are also much higher than the value obtained during the aerial surveys. Burnell (2001) recorded average speeds of 1.1 to 3.66 km/h for unaccompanied whales, values higher than the recorded for this category of whales in Brazil, but only one unaccompanied whale was resighted during these complimentary flights and no data from shore-based observations is available. Swimming speeds of unaccompanied whales tracked in Peninsula Valdés averaged 1.7 to 3 km/h (Colombo *et al.* 1990). The low speed values recorded for right whales in this work reinforces that in southern Brazil at least some right whales demonstrate fidelity to some particular area over one day or more periods of time, even after being potentially disturbed during aerial surveys.

It is apparent that the southernmost regions are mostly used as transiting area. In 2002, most of the resighted females with calves were first sighted in southernmost regions and resighted in northernmost regions. In addition, these movements occurred between July and September, when whales appear to be arriving in the region. This pattern, however, was not so evident for whales resighted in 2003. On the other hand, a slightly greater number of females with calves were first sighted in a northernmost region in September, and were next sighted in

a southernmost region (in October), indicating the possible use of the southernmost region also by transiting whales at the end of the wintering season.

Despite the relatively small number of whales resighted in Brazil, these whales displayed some level of fidelity, especially to the main concentration area, where the characteristics of the coastline fit the preferred wintering habitat for this species. It was only recently that known right whales began to return in southern Brazil, thus presenting low levels of annual return (Groch *et al.* 2005). Females with calves from southern Brazil have been calving once every three years (Groch *et al.* 2005). Although rarely seen in the intervening years, this calving interval undoubtedly had influenced the rate of resightings of this category of whales. Given that most of the resightings were of females, this pattern can be viewed only as relative measures and do not represent the actual return frequencies of the different category of whales. Because the survey effort was constant towards photographing all categories, the differences in the resighting rates of females with calves and unaccompanied whales should reflect real differences in their residence period or the behavior of females with calves, which usually spend more time at surface, being more likely to be sighted than unaccompanied whales.

In South Africa, Best (2000) concluded that fidelity to the actual stretch of the coast was not too strong, because only 52.9% of the females had their first calf in the same or adjacent areas where first photographed, and 60.9% of the multigravid females. In Argentina, 52% of the females exhibited fidelity to the same region of concentration with successive calves. Burnell (2001) considered that some level of fidelity was displayed by females returning at least once to the study area and at most in as many years at other regions. Because of the low individual resighting rate presented by most of the whales in Brazil, we did not attempt to evaluate the degree of fidelity.

It is not clear which factors determine the presence and distribution of right whales in Southern Brazil. Resightings of right whales photographed off southern Brazil in Peninsula Valdés (Best *et al.* 1993; Groch *unpublished*) indicates some the degree of flexibility in the habitat use. It is likely that specific areas may have greater importance to mother/calf pairs than to unaccompanied whales, but a better understanding of this characteristic will only be possible with a longer time series of data. This flexibility and the extension of movement shown by females with calves in some wintering areas are encouraging signs of the increase in the population and the expansion to historic areas. Data presented here are initial and



further research is needed in a long-term basis for a comprehensive monitoring of this recovering population.

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**Table 1** - Summary of aerial surveys from 1987 to 2003 used to describe the inter-annual distribution of right whales along the Southern Brazilian coast (letters correspond to bins of 12 minutes of latitude long).

Year	Flight considered for this analysis	Aircraft	Bins surveyed	No. whales sighted / survey	Unaccomp. whales	Females with calves
1987	1-Sep	Piper PA-22 singlemotor	G - S	33	21	6
1988	28+29 Sep (*)	Cessna 170 singlemotor	E - S	16	4	6
1992	30+31 Aug (*)	Cessna 182 singlemotor	G - T	16	12	2
1993	27-Aug	Cessna 182 singlemotor	G - S	28	20	4
1994	1-Sep	Cessna 182 singlemotor	G - S	27	7	10
1997	27-Sep	Citabria Singlemotor	I - N	20	8	6
1998	23-Sep	Enstrom helicopter	I - O	24	0	12
1999	10-Sep	Enstrom helicopter	I - P	20	0	10
2000	8-Oct	Squirrel helicopter	G - N	24	2	11
2001	13+14 Sep (*)	Jet Ranger helicopter	G - S	44	0	22
2002	23+24 Sep (*)	Jet Ranger helicopter	G - S	128	46	41
2003	12-Sep	Jet Ranger helicopter	G - S	112	60	26

(\*) Two complementary flights covering adjacent areas.

**Table 2** – Number of whales sighted during aerial surveys conducted from 1987 to 2003, along the Southern Brazilian coast, by group category (percentage of total number of groups shown in parenthesis). (UW = unaccompanied whales; FC = females with calves).

Group Category	No. of whales	Frequency of sightings by group category (higher frequencies highlighted in bold)								No. of groups	No. of whales	Mean no. of whales by group
		1	2	3	4	5	6	7	8			
UW	Frequency	<b>37</b> (16.6)	27 (12.1)	9 (4.0)	4 (1.8)	2 (0.9)	2 (0.9)	0	1 (0.4)	82 (36.8)	164 (34.1)	2 ± 1
FC		-	<b>123</b> (55.2)	-	7 (3.1)	-	0	-	0	130 (58.3)	274 (57.0)	2 ± 0
FC+UW		-	-	<b>6</b> (2.7)	3 (1.3)	1 (0.4)	0	0	1 (0.4)	11 (4.9)	43 (8.9)	4 ± 2
<b>Total</b>		<b>37</b> (16.6)	<b>150</b> (67.3)	<b>15</b> (6.7)	<b>14</b> (6.3)	<b>3</b> (1.3)	<b>2</b> (0.9)	<b>0</b> (0)	<b>2</b> (0.9)	<b>223</b>	<b>481</b>	<b>2 ± 1</b>



**Table 3** - Number of right whales seen during aerial surveys along the Southern Brazilian coast, by sub-regions and blocks of years with similar survey coverage, from 1987 to 2003 (percentage of whales seen by sub-region in each block of years is given in parenthesis).

	Females with calves				Unaccompanied whales				TOTAL
	1987-1994	1997-2000	2001-2003	Total	1987-1994	1997-2000	2001-2003	Total	
<b>SC2 (*)</b>	0	0	0	0	4 (5.9)	0	0	4 (2.2)	4 (1.2)
<b>SC3</b>	18 (66.7)	23 (59.0)	48 (57.8)	89 (59.7)	22 (32.4)	2 (22.2)	34 (32.1)	58 (31.7)	147 (44.3)
<b>SC4 (**)</b>	7 (25.9)	16 (41.0)	26 (31.3)	49 (32.9)	19 (27.9)	7 (77.8)	49 (46.2)	75 (41.0)	124 (37.3)
<b>RS1 (*)</b>	2 (7.4)	-	9 (10.8)	11 (7.4)	23 (33.8)	-	23 (21.7)	46 (25.1)	57 (17.2)
<b>Total</b>	<b>27</b>	<b>39</b>	<b>83</b>	<b>149</b>	<b>68</b>	<b>9</b>	<b>106</b>	<b>183</b>	<b>332</b>

(\*) Apart from SC2 in 2000, these regions were not surveyed in 1997-2000.

(\*\*) Only half of this sub-region (2 bins) was surveyed in 1997-2000.

**Table 4** – Summary data on non-calf whales identified and resighted during monthly aerial surveys along the Southern Brazilian coast in 2002 and 2003 (percentage of resightings shown in parenthesis).

2002				
Month of flight	Days between flights	No. of females with calves resighted	No. of unaccompanied whales resighted	Total
<i>July – Aug</i>	25	1 (5.9)	0	1 (5.0)
<i>Aug – Sep</i>	36-37(*)	12 (70.6)	3 (100)	15 (75.0)
<i>July – Aug – Sep</i>	-	1 (5.9)	0	1 (5.0)
<i>July – Sep</i>	61-62(*)	2 (11.8)	0	2 (10.0)
<i>Sep – Nov</i>	46	1 (5.9)	0	1 (5.0)
<b>Total no. of non-calf whales resighted</b>	-	17 (85.0)	3 (15.0)	20
<b>Total no. of non-calf whales identified</b>	-	65	80	145
<b>% Resightings in relation to total identified</b>	-	11.7 %	2.1 %	13.8%
2003				
Month of flight	Days between flights	No. of females with calves resighted	No. of unaccompanied whales resighted	Total
<i>Aug – Sep</i>	31	5 (31.3)	0	5 (29.4)
<i>Sep – Oct</i>	33	10 (62.5)	1 (100)	11 (64.7)
<i>Aug – Sep – Oct</i>	-	1 (6.3)	0	1 (5.9)
<b>Total no. of non-calf whales resighted</b>	-	16 (94.1)	1 (5.9)	17
<b>Total no. of non-calf whales identified</b>	-	53	85	138
<b>% Resightings in relation to total identified</b>	-	11.6 %	0.7 %	12.3%

(\*) The survey of September 2002 was completed after two complementary flights covering adjacent areas, which resulted in two values for the interval between sightings.

**Table 5**– Number of resightings of right whales during monthly aerial surveys along the Southern Brazilian coast in 2002 and 2003.

2002								
Females with calves				Unaccompanied whales			TOTAL	
Month of survey	No. of resightings	% Resightings/month	% Resighting in relation to total whales identified	No. of resightings	% Resightings/month	% Resightings in relation to total whales identified	N	Distribution of Resightings / month (%)
<i>Aug</i>	2	11.1	1.4	0	0,0	0.0	2	9,5
<i>Sep</i>	15	85.7	10.3	3	100.0	2.1	18	85,7
<i>Nov</i>	1	5.6	0.6	0	0.0	0.0	1	4,8
<b>TOTAL</b>	<b>21</b>	<b>-</b>	<b>12.4</b>	<b>3</b>	<b>-</b>	<b>2.1</b>	<b>21</b>	<b>-</b>
2003								
Females with calves				Unaccompanied whales			TOTAL	
Month of survey	No. of resightings	% Resightings/month	% Resighting in relation to total whales identified	No. of resightings	% Resightings/month	% Resightings in relation to total whales identified	N	Distribution of Resightings / month (%)
<i>Sep</i>	6	35.3	4.3	0	0	0	6	33.3
<i>Oct</i>	11	66.7	8.0	1	100.0	0.7	12	66.7
<b>TOTAL</b>	<b>17</b>	<b>-</b>	<b>12.3</b>	<b>1</b>	<b>-</b>	<b>0.7</b>	<b>18</b>	<b>-</b>

**Table 6** – Movements of non-calf whales resighted during monthly aerial surveys along the Southern Brazilian coast in 2002 and 2003 (percentage of movements shown in parenthesis).

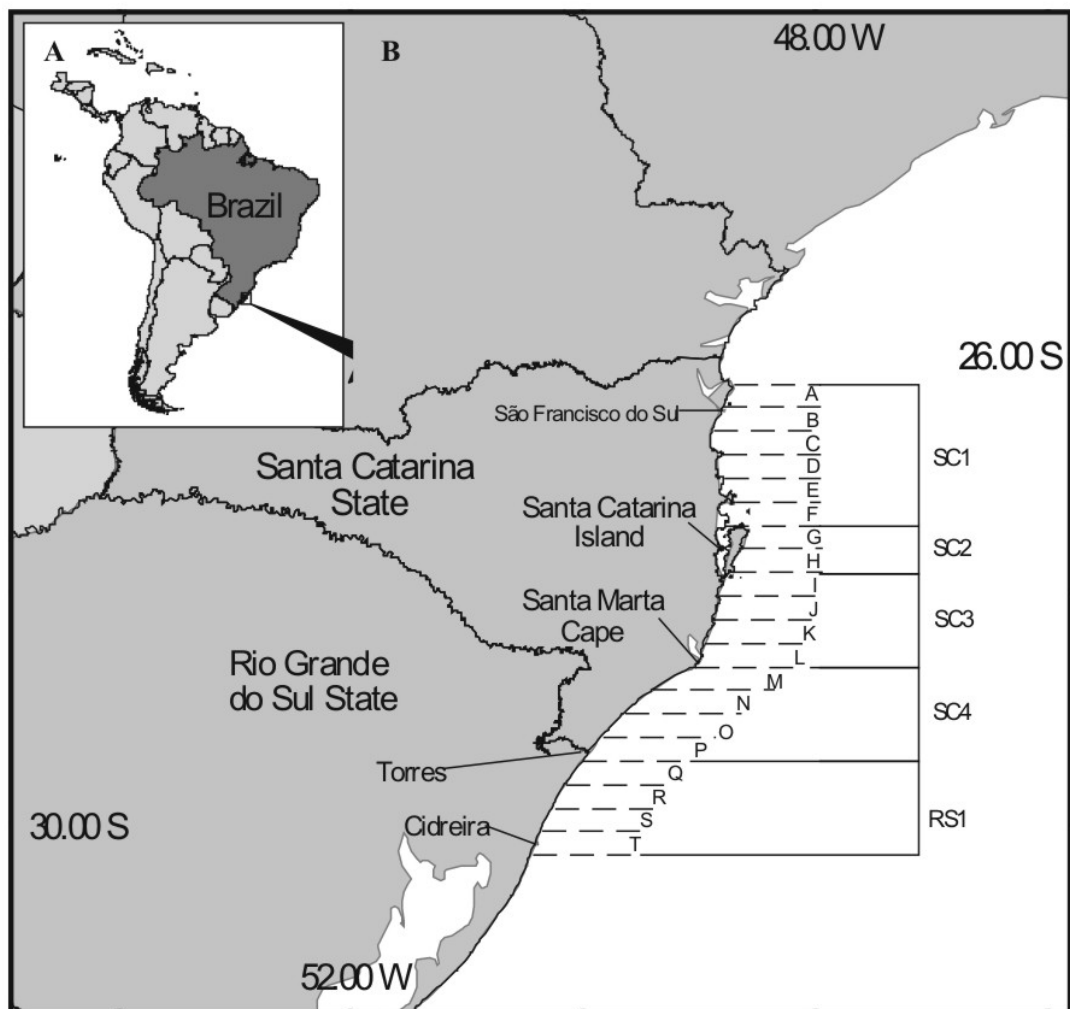
2002									
Month of flight	Days between flights	Females with calves				Unaccompanied whales			
		No. of Southbound movements	No. of Northbound movements	Mean minimum distance traveled (km)	Mean minimum bins traversed	No. of Southbound movements	No. of Northbound movements	Mean minimum distance traveled (km)	Mean minimum bins traversed
<i>Jul – Aug</i>	25	1 (5.6)	0	76.0	3	-	-	-	-
<i>Aug – Sep</i>	36-37(*)	4 (22.2)	8 (44.4)	49.5 ± 46.7	1.8 ± 1.6	2 (66.7)	1 (33.3)	84.0 ± 27.7	3 ± 1
<i>Jul – Aug – Sep</i>	-	1 (5.6)	1 (5.6)	29.5 ± 4.9	1.5 ± 0.7	-	-	-	-
<i>Jul – Sep</i>	61-62(*)	0	2 (11.1)	97.0 ± 84.8	4 ± 4.2	-	-	-	-
<i>Sep – Nov</i>	46	1 (5.6)	0	193.0	6	-	-	-	-
<b>TOTAL</b>	-	<b>7 (38.9)</b>	<b>11 (61.1)</b>	-	-	<b>2 (66.7)</b>	<b>1 (33.3)</b>	-	-
2003									
Month of flight	Days between flights	Females with calves				Unaccompanied whales			
		No. of Southbound movements	No. of Northbound movements	Mean minimum distance traveled (km)	Mean minimum bins traversed	No. of Southbound movements	No. of Northbound movements	Mean minimum distance traveled (km)	Mean minimum bins traversed
<i>Aug – Sep</i>	31	2 (11.8)	3 (17.6)	58.8 ± 59.8	1.4 ± 1.9	-	-	-	-
<i>Sep – Oct</i>	33	6 (35.3)	4 (23.5)	61.9 ± 46.6	2.1 ± 1.4	1 (100)	0	102.0	4.0
<i>Aug – Sep – Oct</i>	-	1 (5.9)	1 (5.9)	106 ± 19.8	4.5 ± 0.7	-	-	-	-
<b>TOTAL</b>	-	<b>9 (52.9)</b>	<b>8 (47.1)</b>	-	-	<b>1 (100)</b>	<b>0</b>	-	-

(\*) The survey of September 2002 was completed after two complementary flights covering adjacent areas, which resulted in two values for the interval between sightings.

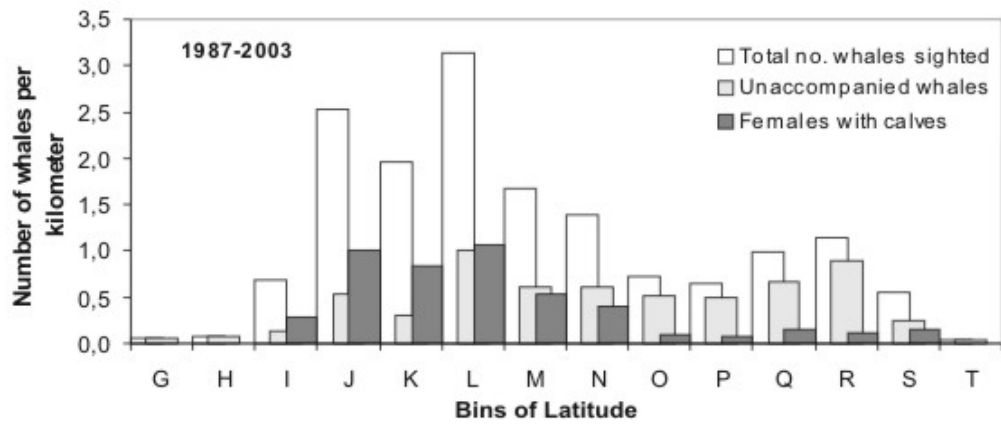
**Table 7** – Between year resighting patterns of whales identified during aerial surveys along the Southern Brazilian coast between 1987 and 2003.

Sub-region of first and second sighting	Total no. of whales resighted (%)	Females				Unaccompanied whales		
		N (% from total no. of resightings)	Mean no. of years between sightings	No. of bins traversed	Females in calving years in both sightings (% from females resighted in each combination of sub-region)	N (% from total no. of resightings)	Mean no. of years between sightings	No. of bins traversed
SC3 → SC3	14 (45.2)	12 (38.7)	3.3 ± 1.2	1.5 ± 1.5	11 (91.7)	2 (6.5) (*)	1.0 ± 0.0	1.5 ± 0.7
SC3 → SC4	7 (22.6)	3 (9.7)	2.7 ± 1.5	1.3 ± 1.2	1 (33.3)	4 (12.9) (*)	2.25 ± 2.5	3 ± 1.4
SC3 → RS1	4 (12.9)	3 (9.7)	3.0 ± 1.0	6.7 ± 2.5	3 (100.0)	1 (3.2)	1	7
SC4 → SC3	3 (9.7)	3 (9.7)	4.0 ± 1.7	1.7 ± 2.1	3 (100.0)	0	-	-
SC4 → SC4	1 (3.2)	0	-	-	-	1 (3.2)	1	1
RS1 → SC3	2 (6.5)	2 (6.5)	8.0 ± 2.8	4.0 ± 1.4	1 (50.0)	0	-	-
<b>Total</b>	<b>31</b>	<b>23 (74.2)</b>	-	-	<b>19 (82.6)</b>	<b>8 (25.8)</b>	-	-

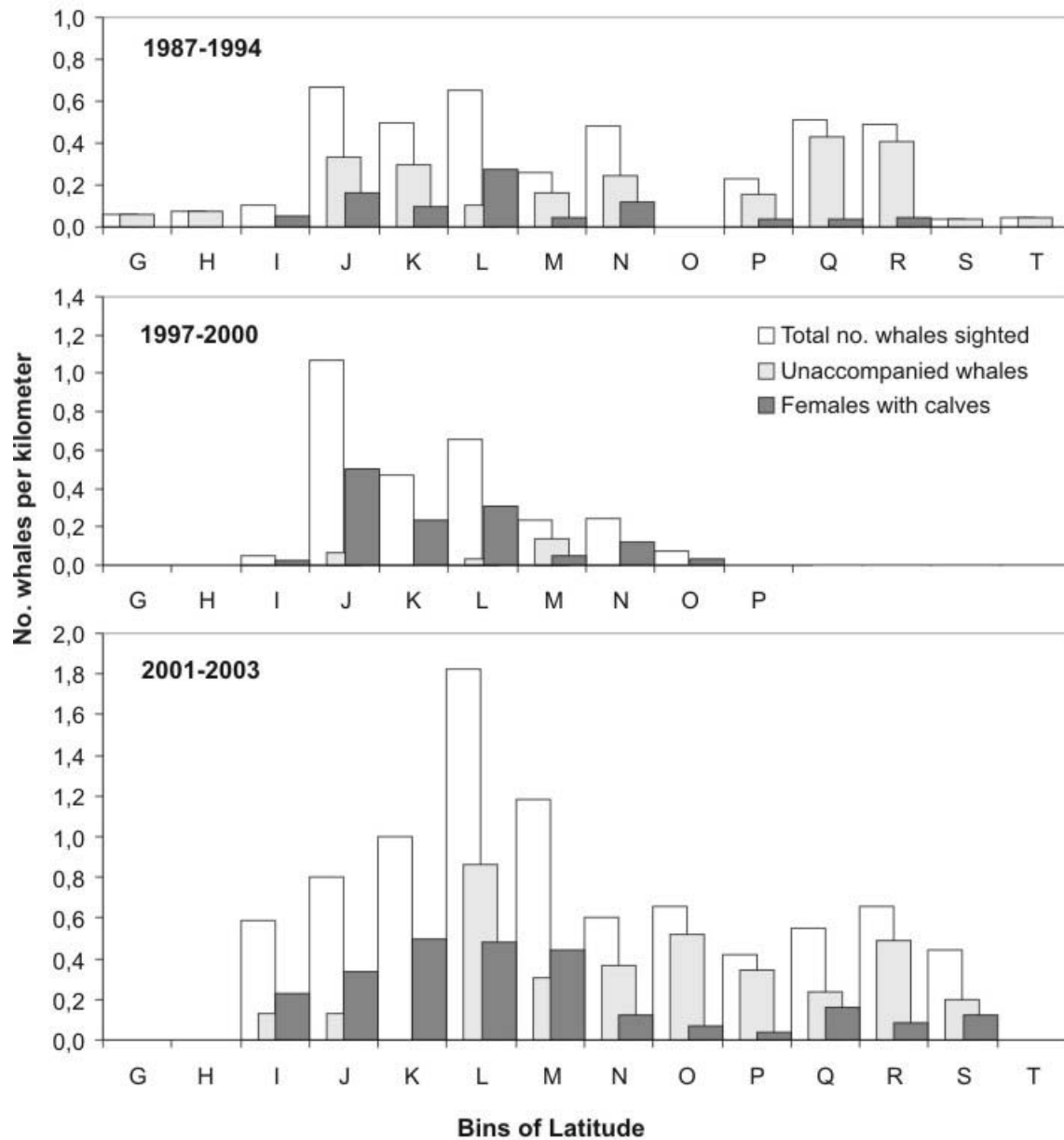
(\*) 50% of these whales are yearlings.



**Figure 1** – Map of the study area. A, South America; B, Santa Catarina State, Brazil; C, South of Santa Catarina State (letters correspond to bins of 12 minutes of latitude long).

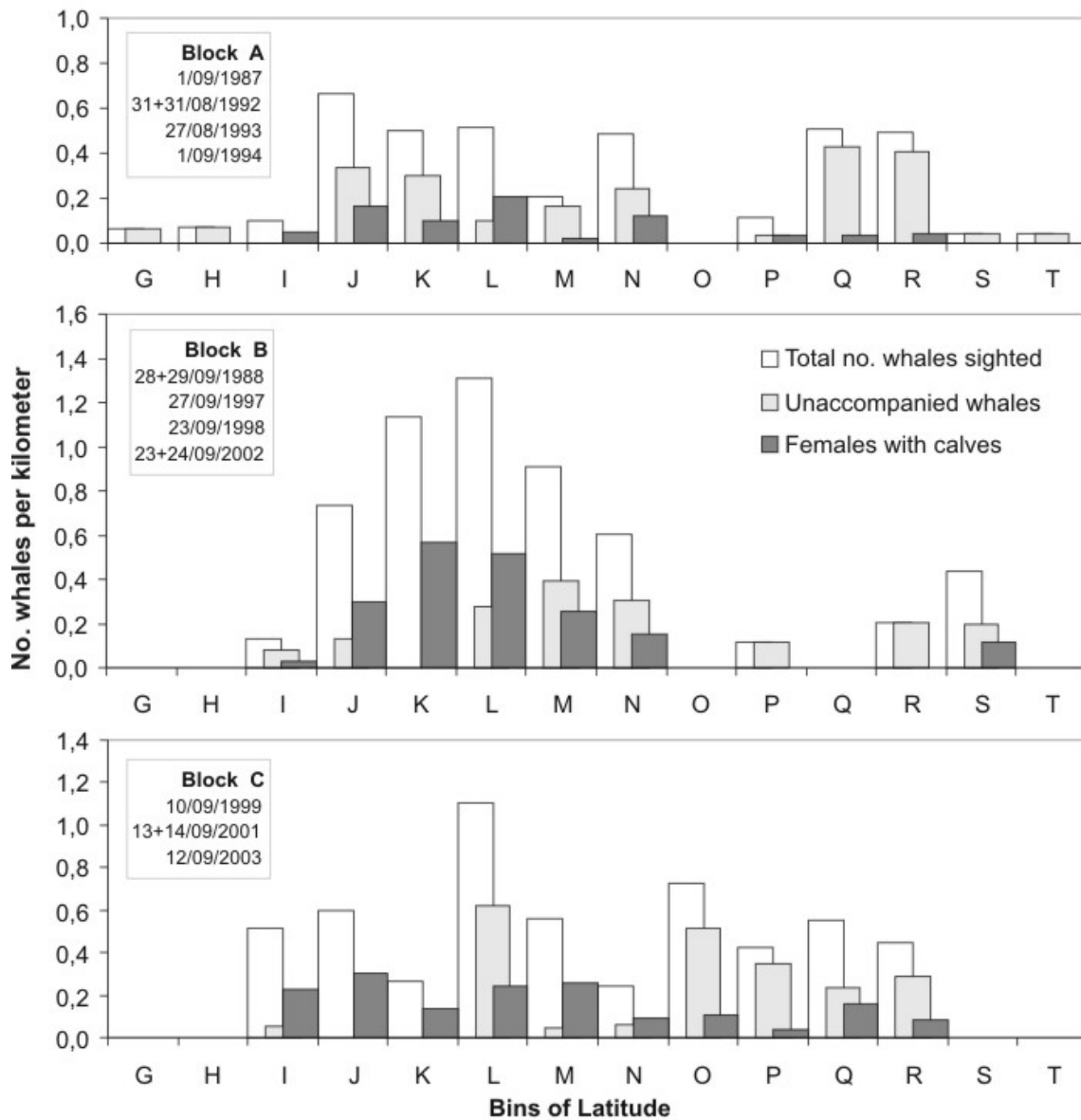


**Figure 2** – Density of right whales sighted per latitudinal bin during aerial surveys conducted from 1987 to 2003, along the Southern Brazilian coast (data series is not continuous – see text for details) (letters correspond to bins of 12 minutes of latitude long).

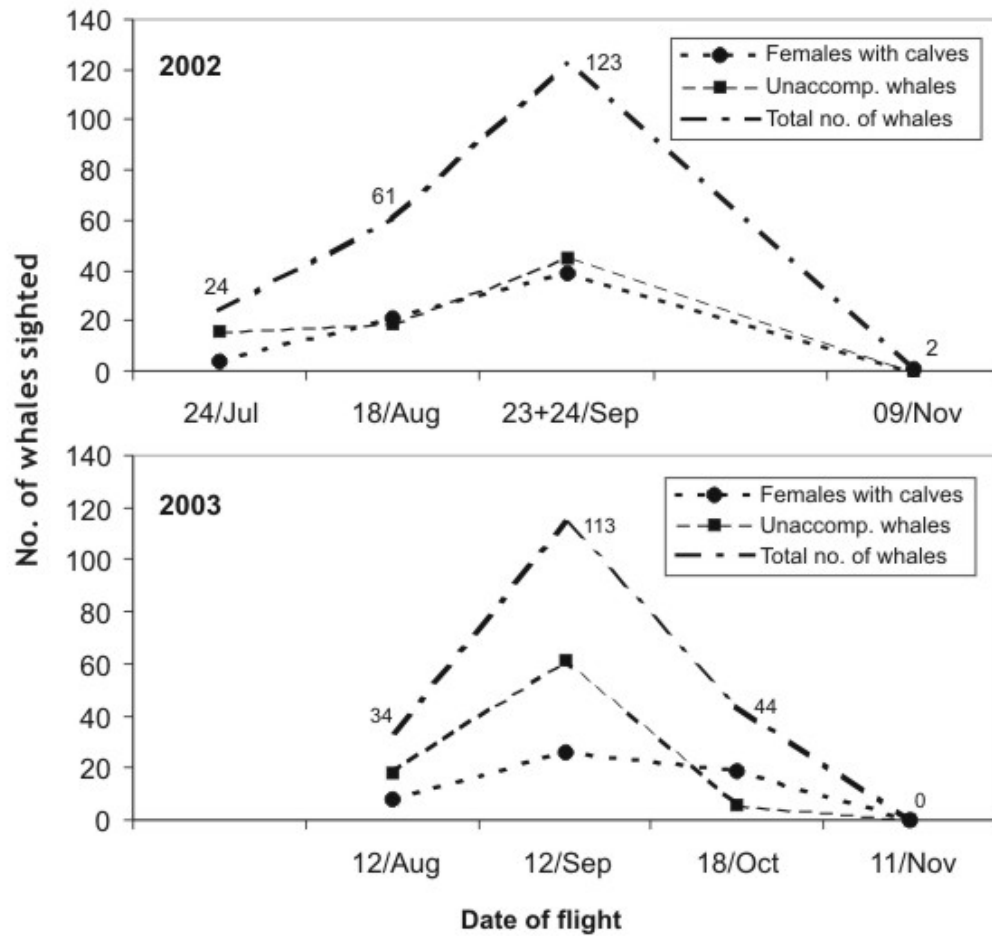


**Figure 3** – Cumulative density of right whales sighted per latitudinal bin during aerial surveys conducted from 1987 to 2003 along the Southern Brazilian coast, by blocks of years with similar survey coverage (survey effort was concentrated in bins I to O in 1997-2000 – see text for details) (letters correspond to bins of 12 minutes of latitude long).

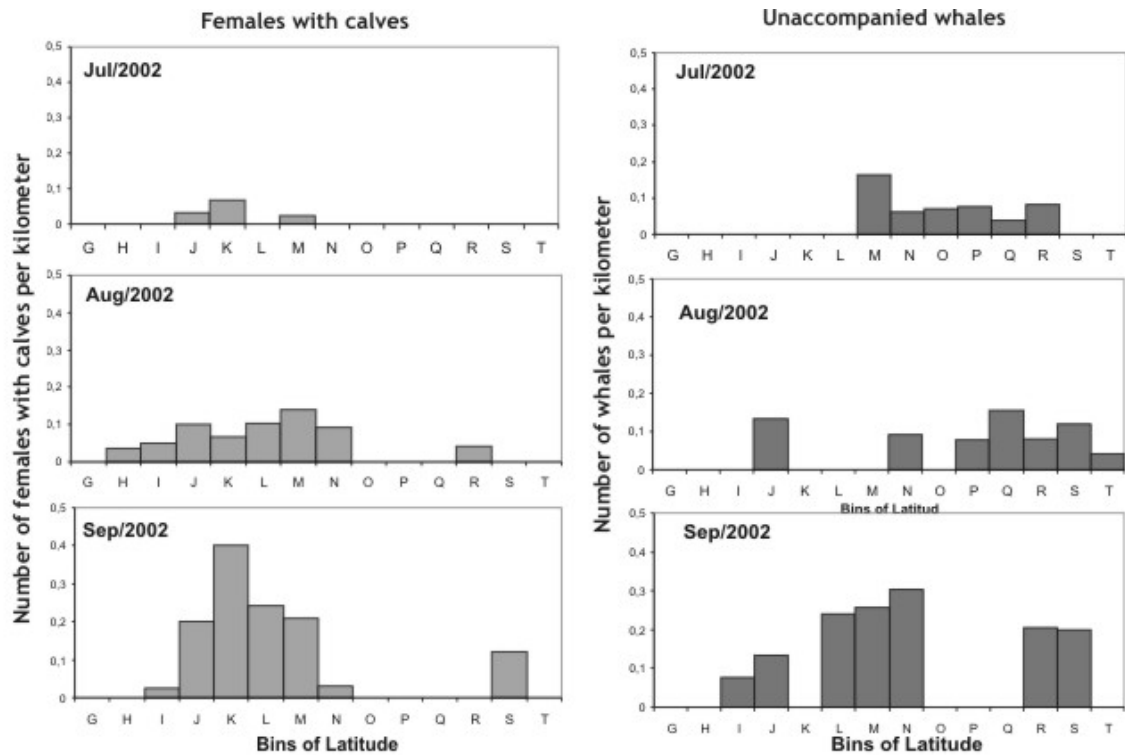




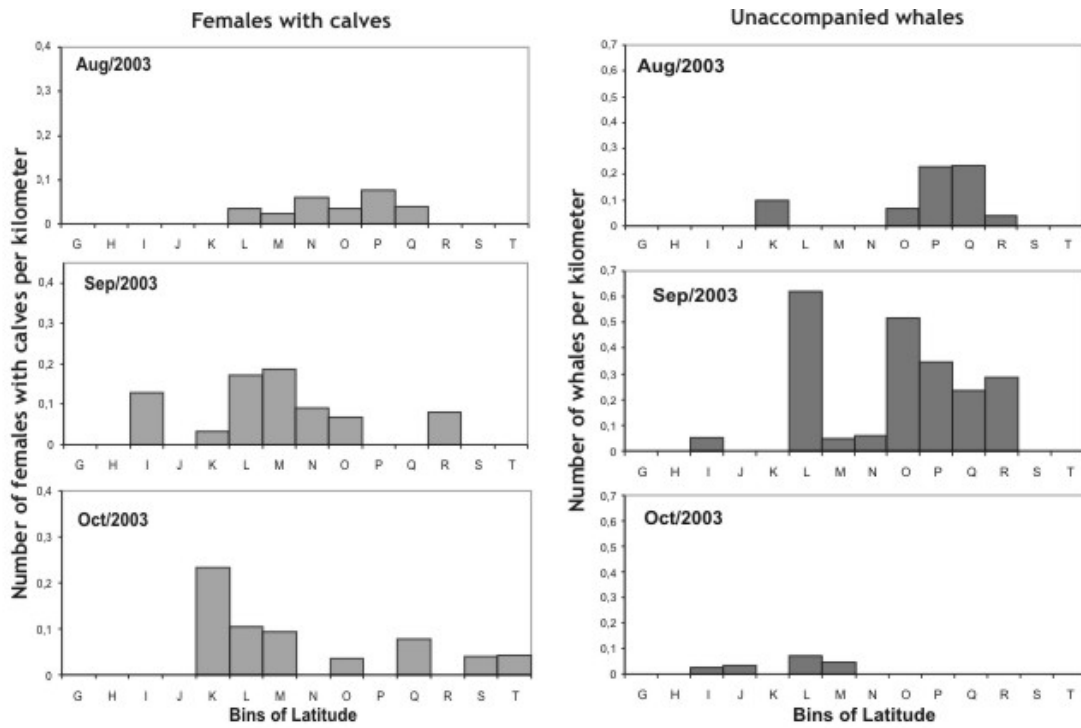
**Figure 4** – Cumulative density of right whales sighted per latitudinal bin during aerial surveys conducted from 1987 to 2003 along the Southern Brazilian coast, grouped by approximate date of flight (letters correspond to bins of 12 minutes of latitude long).



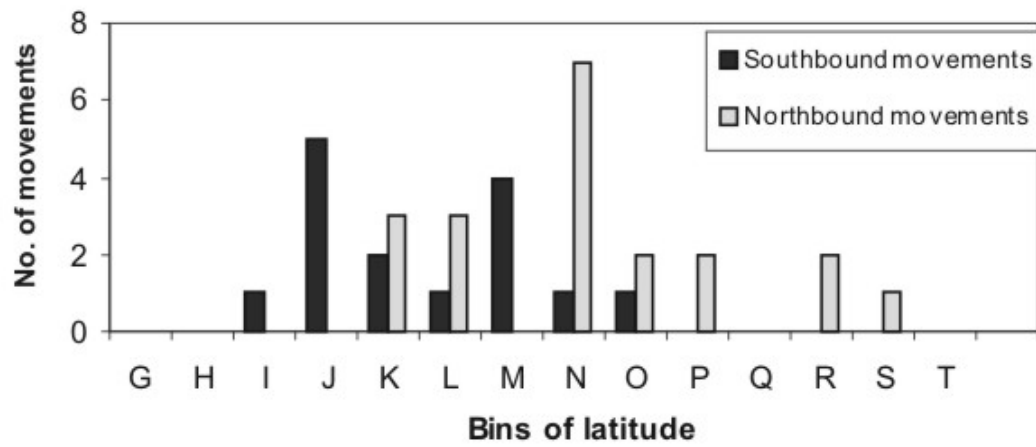
**Figure 5** – Number of right whales sighted during monthly aerial surveys along the Southern Brazilian coast, between July and November in 2002 and 2003.



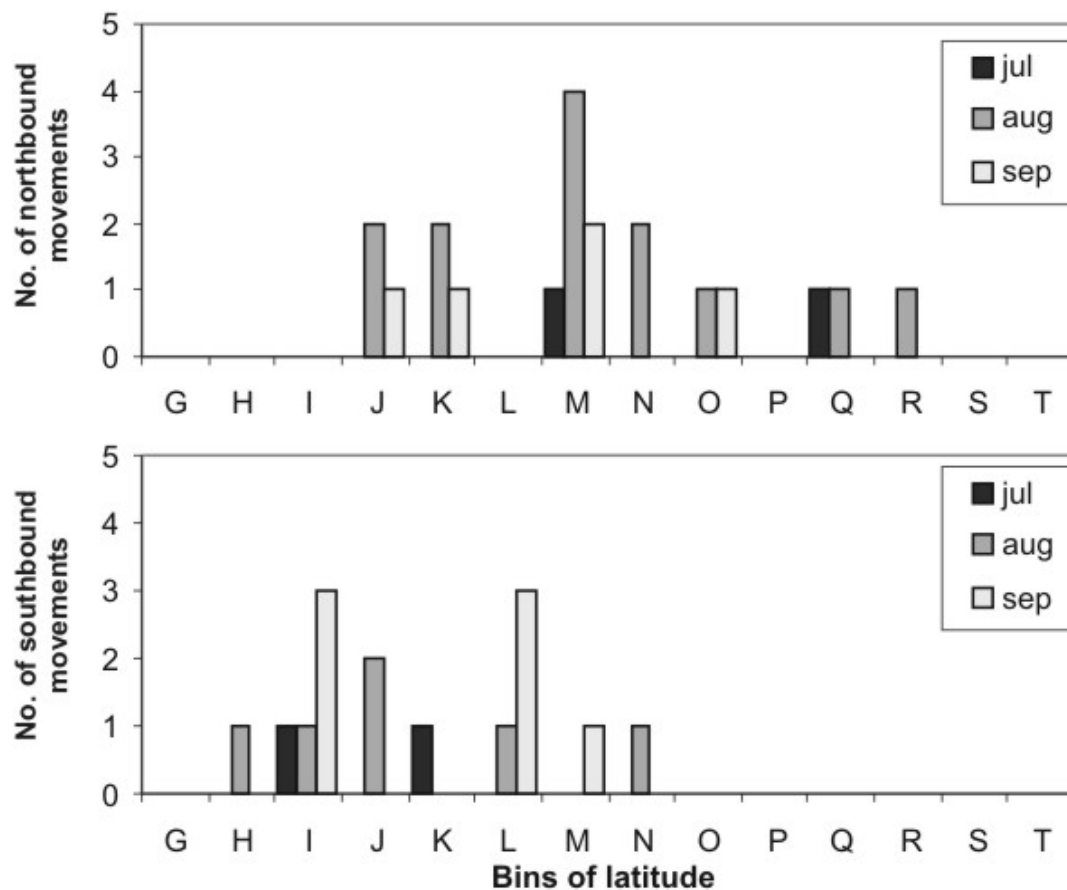
**Figure 6** – Density of right whales sighted per bin during monthly aerial surveys along the Southern Brazilian coast, from July to September 2002 (letters correspond to bins of 12 minutes of latitude long).



**Figure 7** – Density of right whales sighted per bin during monthly aerial surveys along the Southern Brazilian coast, from August to October 2003 (letters correspond to bins of 12 minutes of latitude long).



**Figure 8** - Position of the first sighting of whales resighted during monthly surveys along the Southern Brazilian coast in 2002 and 2003, according to the direction of movement between sightings (letters correspond to bins of 12 minutes of latitude long).



**Figure 9** – Distribution of whales by bin of latitude and direction of movement according to the month of first sighting during monthly surveys along the Southern Brazilian coast in 2002 and 2003 (letters correspond to bins of 12 minutes of latitude long).



## **CAPÍTULO 3**



## RECENT RAPID INCREASES IN THE BRAZILIAN RIGHT WHALE POPULATION

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**Keywords:** southern right whales, population increase, Southern Brazil, wintering ground, Eubalaena, calving interval

**\*ESTE ARTIGO FOI APRESENTADO AO COMITÊ CIENTÍFICO DA 56A. REUNIÃO DA COMISSÃO INTERNACIONAL DA BALEIA (INTERNATIONAL WHALING COMMISSION AND ASSOCIATED MEETINGS), 2004, SORRENTO, ITALIA, E ESTÁ NO PRELO DO THE LATIN AMERICAN JOURNAL OF AQUATIC MAMMALS.**

### Abstract

Right whales 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 before 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) and 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 2,400 km range and come into increasing conflict with human activities.

### Resumo

As baleias francas 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. Estas taxas são significativamente diferentes de zero ( $t=4,133$ ,  $p<0,009$  e  $t=4,06$ ,  $p<0,004$ , respectivamente) e o aumento de 1997 a 2003 é maior que as taxas observadas para as

baleias francas nas outras áreas de concentraço reprodutiva de inverno no Oceano Atlntico Sul. As baleias francas na rea de concentraço reprodutiva de inverno no sul do Brasil no so apenas transientes. Dez por cento das baleias tm sido reavistadas. Se o nmero continuar a aumentar, pode-se esperar que as baleias francas reocupem sua rea de distribuiço histrica ao longo de cerca de 2400km de costa, aumentando a possibilidade de conflitos entre as baleias francas e atividades humanas.

## Introduction

Southern right whales (*Eubalaena australis*) were severely depleted by commercial whaling from the 18<sup>th</sup> through the early 20<sup>th</sup> centuries. Tormosov *et al.* (1998) describe unreported Soviet catches of right whales on their pelagic summer grounds in the mid 20<sup>th</sup> century despite international protection since 1935. In addition, right whales were also subject 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 (Cmara and Palazzo, 1986).

From May to December groups of right whales use the shallow, protected waters of southern Brazil as a wintering ground<sup>2</sup> (Lodi *et al.*, 1996; Cmara and Palazzo, 1986; Palazzo and Flores, 1998; Simes-Lopes *et al.*, 1992; International Wildlife Coalition/Brazil, 1999). 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)<sup>1</sup> (Figure 1) (Simes-Lopes *et al.*, 1992; Palazzo and Flores, 1998; International Wildlife Coalition/Brazil, 1999). The time of peak abundance is from August to October<sup>1</sup> (Simes-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

<sup>2</sup> Palazzo Jr., J.T. and Flores, P.A.C. (1996) Progress report on the southern right whale *Eubalana australis* off Santa Catarina, Southern Brazil: 1995. Page 27 in Abstracts, VII Reunio de Trabajo de Especialistas en Mamferos Acuticos de Amrica del Sur/ Primero Congreso de la Sociedad Latinoamericana de Especialistas en Mamferos Acuticos, 22-25 Octubre, Via del Mar, Chile.

other demographic parameters of right whale populations in 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% per year (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?

## **Materials 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 120 Km 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 (Best, 1990; Payne, 1986).

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 1000ft (~300m), a speed of 90kt (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

of the 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.

Whenever a whale or group of whales was spotted they were approached at a minimum height of 328ft (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 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 called calves if they were between 1/3 to just over 1/2 of their 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 was 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 newborns), and 5 whales of unknown age/sex. There were no resightings before 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 newborns. All the other whales were resighted only once.

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 calvings 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 on the wintering ground off Peninsula Valdes, Argentina (Best *et al.*, 1993) indicate that some females are using 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.

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 think the estimate for 1997-2003 is 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 of the natural log number of females with calves identified each year from 1997 through 2003 and for the whole period (1987-2003) in the Central Area. If these counts are considered reliable indices of growth rate, the number of calving females off 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 of 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 whole 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 Peninsula Valdes, 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 Peninsula Valdes population using different models estimated growth rates from 6.8 to 7.6% (Payne *et al.*, 1990; Cooke *et al.*, 2001; and Cooke *et al.*, 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 transients. Ten percent of the whales have been resighted. Most females with calves that were resighted 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.

The number of right whales off 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 the 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 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 of the 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 Peninsula Valdes, 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; Cooke *et al.*, 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 immigration to Brazil. Resightings in Brazil of whales previously photographed off Argentina supports this hypothesis (Best *et al.*, 1993), as well 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 (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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**Table 1** - Summary of aerial surveys from 1987 to 2003 used to document the increase of right whales on the Brazilian wintering ground.

Year	No. of flights	Flight considered for this analysis	Aircraft	Total length of coastline (Km)	Effective flying Time (h)	Number 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 complimentary flights covering adjacent areas.

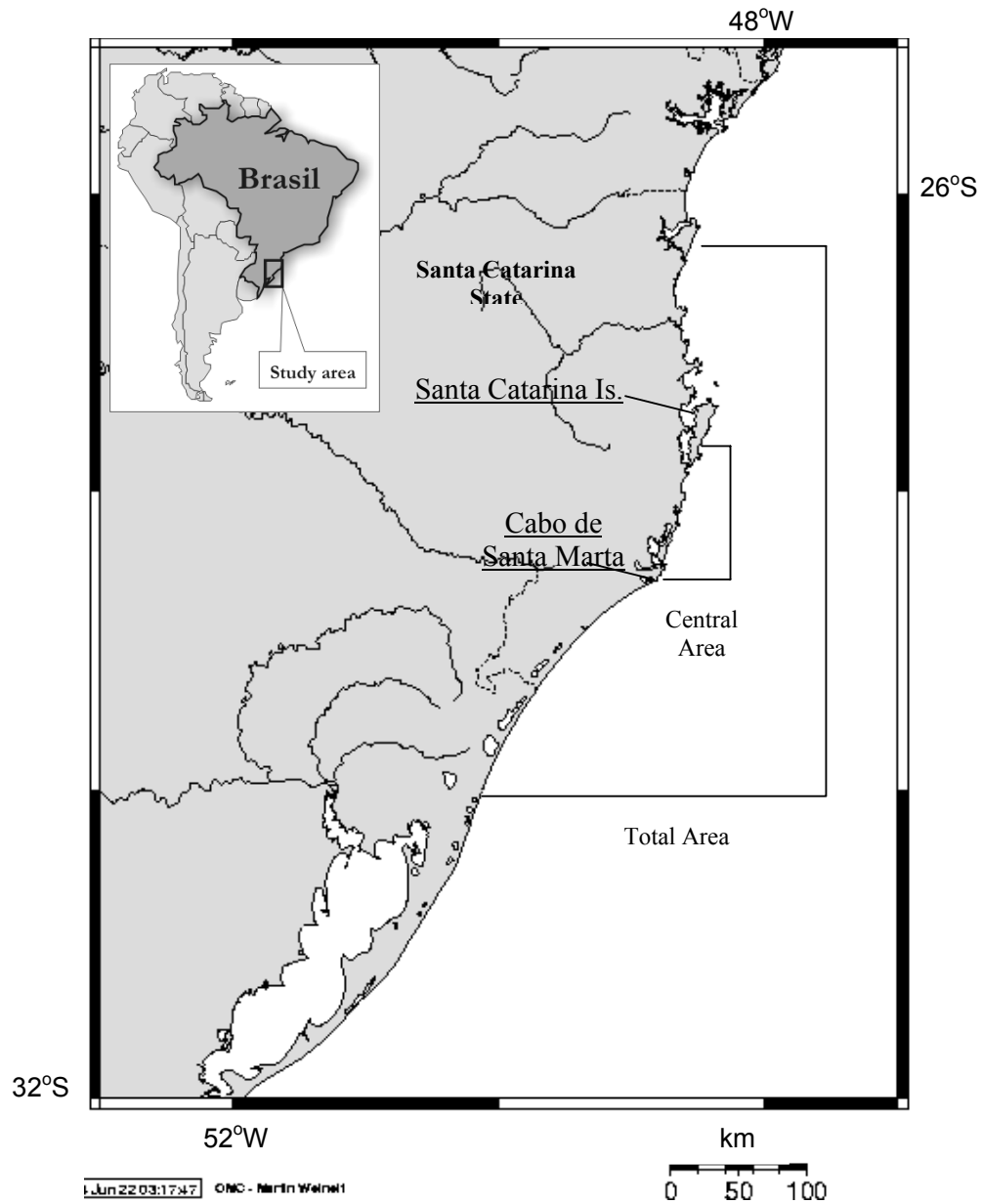
NA = precise location and time information not available.

**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.

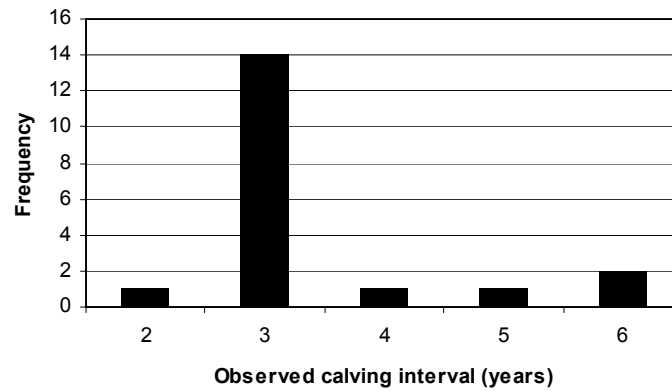
Year	TOTAL AREA		CENTRAL AREA		RESIGHTINGS IN TOTAL AREA		Whales sighted but not identified			
	Adults without calves	Females with calves	Adults without calves	Females with calves	Adults without calves	Females with calves	TOTAL AREA		CENTRAL AREA	
							Adults without calves	Females with calves	Adults 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.

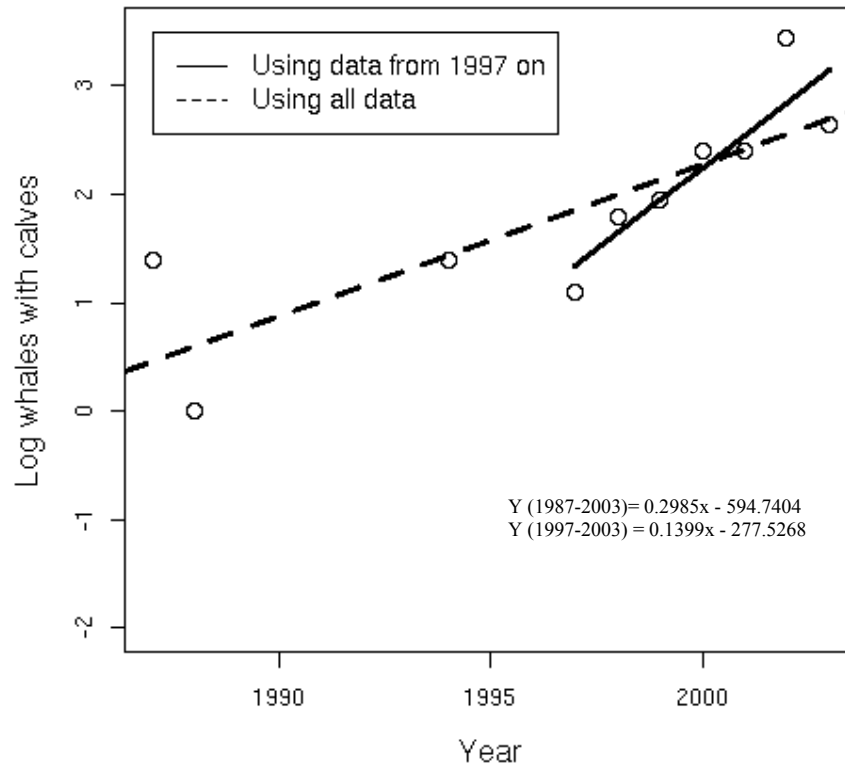




**Figure 1** – Map of the study area showing the boundaries of Total Area and the Central Area, which were surveyed for photo-identification of southern right whales on their wintering ground off Southern Brazil from 1987 to 2003.



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



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

## **CAPÍTULO 4**

## PRELIMINARY ESTIMATE FOR RIGHT WHALES OFF BRAZIL

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**Keywords:** population estimate, southern right whales, Brazil, wintering area

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## Abstract

Photographic identifications of the individually distinctive pattern of callosities on the head's of right whale's (*Eubalaena australis*) were used to estimate the size of the population of right whales that winters off southern Brazil, using the Gross Annual Reproductive Rate (GARR) of a stable population. The abundance of right whales off southern Brazil was estimated to be possibly as high as 555 whales. This number is more realistic than the previous estimate of 137 animals, because it reflects the increase observed in the population in recent years. However, because this estimate does not incorporate parameters like mortality and/or emigration and immigration, they should be treated with caution and as a preliminary rough estimate only.

**Keywords:** southern right whales, population estimate, Southern Brazil, wintering ground, *Eubalaena australis*

## Introduction

Photographic identifications of the individually distinctive pattern of callosities on the head's of right whale's (*Eubalaena australis*) have been used to estimate demographic parameters of right whale populations worldwide (e.g. Kraus *et al.* 1986; Caswell *et al.*, 1999; Payne *et al.* 1990; Bannister, 1990; Best *et al.*, 2001; Cooke *et al.*, 2001).

The right whales have been studied along the coast of Brazil since 1981, when whales were 'rediscovered' in the region after being severely depleted by four centuries of commercial whaling (Palazzo and Carter, 1983; Câmara and Palazzo, 1986; Tormosov *et al.* 1998). Aerial surveys have been conducted along the southern coast of Brazil since 1987 for the purpose of documenting the presence and location of individual right whales through photography (Simões-Lopes *et al.*, 1992; Palazzo and Flores, 1998; International Wildlife Coalition/Brazil, 1999). The recovery of right whales wintering in this area was apparently slow in the first years but a recently rapid increase in numbers has been observed (Groch *et al.*, 2005). The number of calving females off Brazil is increasing at a rate of 29.8% per year for 1997-2003 and

14% per year for 1987-2003. Both these estimates are higher than the estimated growth rates for calving females and the entire population of right whales off Peninsula Valdes, Argentina (Whitehead *et al.*, 1986; Payne *et al.*, 1990; Cooke *et al.*, 2001; and Cooke *et al.*, 2003) and are not a biologically plausible natural rate of increase for southern right whales (Best *et al.*, 2001). Resightings in Brazil of females previously photographed off Argentina indicate that at least some individuals use more than one wintering area (Best *et al.*, 1993). Groch *et al.* (in press) proposed that the increase estimated for right whales off Brazil could result from immigration, a distributional shift and/or increasing survey effort.

Estimates of the total population size of all known breeding stock areas in the Southern Hemisphere, including the Brazilian right whale stock, totalled 7,571 whales in 1997 (IWC, 2001). The Brazilian stock by 1995 was estimated to have 137 different right whales, using the Gross Annual Reproductive Rate (GARR) of a stable population (IWC, 2001). This estimate was based on 25 mature females sighted between 1993, 1994 e 1997. As of 2003 the Brazilian Right Whale Catalogue has 315 different individual whales including 130 females, of which 23 were seen in two or more years, providing a modal calving interval of 3 years (Groch *et al.*, in press). In this paper we present an update of the estimate of the Brazilian right whales population.

## **Materials 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. Flights were conducted in the time of peak whale abundance, from August to October (Simões-Lopes *et al.*, 1992; Groch, 2000, Groch *et al.*, 2003). The years 1992 and 1993 were not included in these estimates because available data is incomplete.

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). This is the main aggregation area of the whales in southern Brazil (Simões-Lopes *et al.*, 1992; Palazzo and Flores, 1998; International Wildlife Coalition/Brazil, 1999), as

well as the main aggregation for mother/calf pairs, and is hereafter called the Central Area. In some flights we surveyed 400Km of coastline, a region called in this study the Total Area. Photographs taken from all aerial surveys have been used to create a catalogue of right whales identified off southern Brazil. Detailed description of the surveys and the analysis of the photographs are given by Groch *et al.* (2005).

To estimate the number of right whales off Brazil it was used two slightly different versions of the Gross Annual Reproductive Rate (GARR) technique (IWC, 1986; IWC, 2001). These estimates were based on 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, 1990b; Cooke *et al.*, 2001). Separate estimates were derived for the Central Area and the Total Area because of unequal survey coverage over the years and for this reason estimates for the Total Area were derived only for years with complete coverage of the area.

*Method I – GARR derived from an idealized right-whale life history*

The modal age of first reproduction for female southern right whales is 9 years (Best *et al.*, 2001; Cooke *et al.*, 2001) and the modal observed calving interval is 3 years (Payne *et al.*, 1990; Best, 1990b; Best *et al.*, 2001; Cooke *et al.*, 2001; Groch *et al.*, in press). Therefore, in Method 1 we simply assume that:

- (1) each adult female has a calf every three years;
- (2) juveniles mature at age 9;
- (3) there is no mortality; and
- (4) the sex ratio is 50:50.

Then the population can be represented as the sum of the numbers in various age/sex classes as follows:

$$N = C_0 + J_1 + J_2 + J_3 + J_4 + J_5 + J_6 + J_7 + J_8 + F_I + F_{II} + F_{III} + M_I + M_{II} + M_{III} ,$$

where  $N$  is the total population size,  $C_0$  is the number of calves produced this year by adult females of cohort I ( $F_I$ ), the  $J_i$  are juveniles of age  $i$ , and the males are arbitrarily divided into three groups corresponding to the three female cohorts I, II and III.

Our assumptions imply that  $C_0 = F_I$ . In fact, *all* of the terms on the right hand side would be equal to  $C_0$  if the population were not growing, and they do not differ greatly from each other even when the population is growing, as it must be doing on



the assumption of no mortality. Thus, given our idealized right-whale life history we have that

$$N \approx 15 C_0$$

and we can therefore estimate the population size  $N$  as 15 times the number of calves produced in a year. A more realistic multiplier would probably be lower than 15 owing to juvenile mortality and population growth, but calving intervals longer than three years will offset these effects to some extent by making the number of calves an underestimate of one-third the number of adult females. Consistent with this expectation, the GARR method described by IWC (2001) uses a multiplier slightly less than 15, as explained below.

*Method II – GARR as applied by IWC (2001)*

This variation on the method uses an empirically based estimate of the ratio of juveniles to adults. As explained in IWC (2001), the population in a given year can be represented as the number of calving females multiplied by:

- (1) three to account for the 3-year calving interval (i.e., seeing only 1/3 of the females);
- (2) two to account for males (again assuming a 50:50 sex ratio); and
- (3) 2.4 to account for an estimated 1.4:1 ratio of juveniles to adults.

Multiplying these together gives 14.4 ( $3 \times 2 \times 2.4 = 14.4$ ) and we therefore estimate the population size  $N$  as 14.4 times the number of calving females of a given year. IWC (2001) notes that the ratio of juveniles and calves to adults is relatively high, as a consequence of the relatively high population growth rate. But our derivation, above, shows that this high ratio of juveniles to adults can just as well be viewed as resulting from a low mortality rate; in Method I, the ratio of calves and juveniles to adults is 9:6, which is 1.5:1.

## **Results**

Table 2 gives the estimated population sizes for each surveyed year between 1987 and 2003 using GARR Methods I and II in the Central and Total Area. The estimates of the total population size ranged between 15 and 465 for the Central Area, and 45 and 555 for the Total Area.

## Discussion

The abundance of right whales off southern Brazil was estimated to be possibly as high as 555 whales. This number is more realistic than the previous estimate of 137 animals, because it reflects the increase in the population in the recent years (Groch *et al.*, 2005). However, these numbers are not likely to be as good an estimation of the population size as mark recapture or maximum likelihood models because they do not incorporate parameters like mortality and/or emigration and immigration.

Mark-recapture methods have been used to estimate population sizes and other demographic parameters of many cetacean species (Hammond, 1986; Hammond, *et al.*, 1990), including southern right whales (Whitehead *et al.*, 1986; Bannister 1990, 2001; Best, 1990a, 1990b; Payne *et al.*, 1990; Best *et al.*, 2001; Cooke and Glinka, 1999; Cooke *et al.*, 2001, 2003). However, conventional models are not suitable for this species, because of the periodic nature of the calving process (Payne *et al.*, 1990; Cooke *et al.*, 2001). Breeding females calve at intervals of 2-5 years, (modal interval being 3 years), and tend to return to breeding areas more frequently in calving years (Bannister 1990, 2001; Best, 1990a, 1990b; Payne *et al.*, 1990; Cooke *et al.*, 2001, 2003; Best *et al.*, 2001, 2005). For this reason, the assumptions of independence of sightings probabilities from year to year or of the probability of sighting a whale being independent of whether or not it has a calf, required for most mark recapture models are not fulfilled (Barlow and Clapham, 1997). In light of this, Payne *et al.* (1990) developed their own mark-recapture model updated by Cooke *et al.* (2001), taking into account the calving sequences occurring in the population and maximizing the likelihood of the observed data. This model of the female breeding population has been used to estimate demographic parameters of southern right whales in Argentina (Payne *et al.*, 1990; Cooke *et al.*, 2001) and also in South Africa (Best *et al.*, 2001, 2005). These studies have shown that precise information of demographic parameters can only be obtained from data collected over a long enough period.

Precise information on the total number of right whales wintering off Brazil as well as other demographic parameters cannot be obtained yet due to relatively short time series of data. Moreover, resightings of females photographed in Brazil that were also photographed in other years with calves on the wintering ground off Peninsula Valdés, Argentina (Best *et al.*, 1993; Groch, unpublished data) indicate that some

females are using different calving grounds in different years. In fact, Groch *et al.* (2005) suggested that one of the reasons for the rapid increase in the population estimated for right whales off Brazil could be immigration. Cooke *et al.* (2001) pointed out on the sensitiveness of their model to immigration or emigration in light of the possible interchange between Brazil and Argentina. These authors noted that if emigration is occurring, it is not reflected in the demographic parameters and concluded that their analysis provides no evidence that significant immigration has occurred in the right whale population off Argentina. Since their model makes no assumptions about the extent of immigrations, it cannot be applied to right whales off Brazil, even provided enough time series of data.

Groch *et al.* (2005) also pointed that distributional shift and/or increasing survey effort may have also influenced their estimated rate of increase for right whales off Brazil. In addition, right whales have been observed along the northeast coast of Brazil (Engel *et al.* 1997) and the southeastern coast (Lodi *et al.*, 1996; Santos *et al.*, 2001), and this estimate was based on aerial surveys made along the southern coast of Brazil.

Nevertheless, we believe that the estimates presented here do provide a minimum estimate of the number of whales in the population that have been seen yearly off the coast of southern Brazil. Because the whales appear to be using waters off Argentina as well as Brazil, a combined estimation of right whales sighted in both areas as well as the inclusion of other parameters that may be affecting the population size is recommended, and should provide a more realistic estimate for the size of right whale population off eastern South America.

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

Year	No. of flights	Flight considered for this analysis	Aircraft	Total length of coastline (Km)	Effective flying Time (h)	Number 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

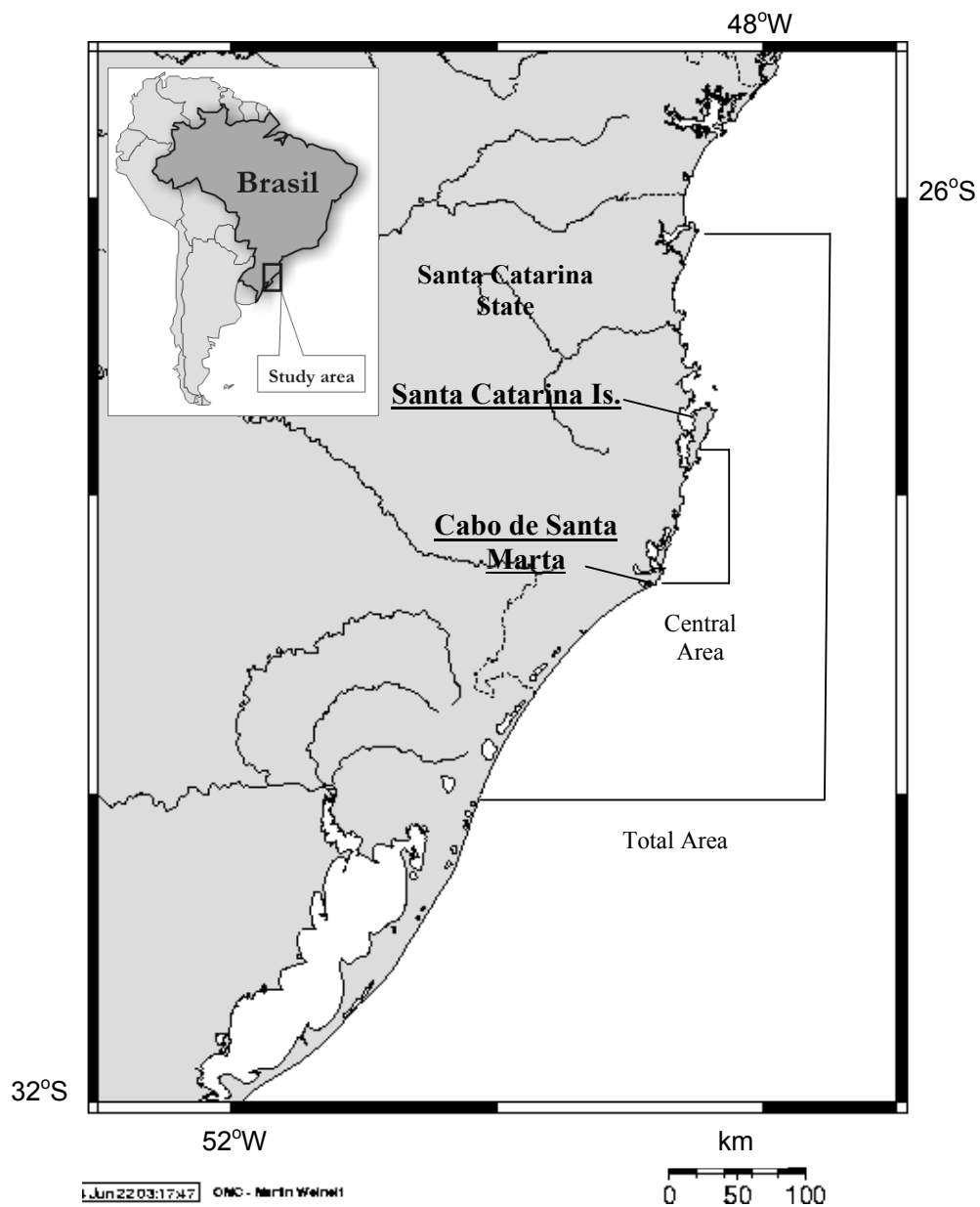
\*Two complementary flights covering adjacent areas.

NA = precise location and time information not available.

**Table 2** - Number of whales individually identified during aerial surveys from 1987 to 2003, off Southern Brazil, divided into Total Area and Central Area and the estimated number of whales in the population.

Year	TOTAL AREA			CENTRAL AREA		
	Females with calves	GARR Method I	GARR Method II	Females with calves	GARR Method I	GARR Method II
1987	5	75	72	4	60	57,6
1988	3	45	43,2	1	15	14,4
1994	4	60	57,6	4	60	57,6
1997	5	75	72	3	45	43,2
1998	-	-	-	6	90	86,4
1999	-	-	-	7	105	100,8
2000	-	-	-	11	165	158,4
2001	-	-	-	11	165	158,4
2002	37	555	532,8	31	465	446,4
2003	26	390	374,4	15	225	216

NA = available data are incomplete.



**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.

## CAPÍTULO 5

**MONITORING RESPONSES OF SOUTHERN RIGHT WHALES TO  
WHALEWATCHING ACTIVITIES IN THE SOUTHERN BRAZILIAN COAST AND  
ITS IMPLICATIONS FOR CONSERVATION**

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**Keywords:** southern right whale; whalewatching; survey-shore-based; behavior; habitat use; breeding ground; management

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## ABSTRACT

Boat based whalewatching of Southern right whales (*Eubalaena australis*) has been conducted in the species' wintering ground off Santa Catarina State, Southern Brazil since 1999. Whalewatching boats operate under guidelines of restriction in accordance with national legislation. Interactions between southern right whales and whalewatching boats were studied in 2002 using a surveyor theodolite. It was recorded 65.5 hours of encounters between mother/calf pairs and boats, during 25 whalewatching cruises in five different bays. Swimming speed, linearity and reorientation rates were examined before, during and after encounters to assess the potential impact of whalewatching activities to this population. Mean swimming speed varied by bay and approaching phase, from 0.9 to 2.78km/h. No significant differences were found in mean swimming speeds of whales tracked before, during and after encounters with boats in all bays ( $p>0.05$ ). The separate analysis of each bay also showed no significant differences. The values of linearity obtained were similar in all observation sites. The whales did not maintain constant direction during the observation period (mean values  $<0.5$ ) but were mostly travelling at low reorientation rates (mean rates  $<32$  degrees/min). The predicted probabilities of whales heading towards the boats as a function of time were calculated, and analyzed using logistic regression. Predicted probabilities were significantly near the expected values in Gamboa and Ibraquera ( $p>0.05$ ). In Garopaba, Silveira and Rosa the predicted probabilities varied significantly during certain time intervals ( $p<0.001$ ). We observed that whales reacted at both long and short distances from boats and the reactions varied with bays. Data from whales' movements in no-whalewatching days were also obtained and compared with the whalewatching days. No significant differences were observed between the datasets ( $p>0.05$ ). Although long-term impacts are difficult to assess, no clear evidence of immediate disturbance to this right whale population was observed during the study, suggesting that the whalewatching boats operation under Brazilian regulations did not disrupt the behavior of right whales on this wintering ground off Southern Brazil. While data presented here comes from the observation of a small whalewatching industry, the economic interest is likely to result in the growth of whalewatching activities. The use of the techniques described in this paper, if taken together with those used for long-term monitoring of individual whales and their pattern of habitat use, may enable scientists to provide the best possible management advice for whalewatching in order to ensure the proper conservation of target species and the sustainability of this industry on a long-term basis.

## INTRODUCTION

Whalewatching is one of the most rapidly growing and economically attractive tourist activities worldwide and provides for the “sustainable use” of cetacean populations (IFAW *et al.*, 1997). If properly managed, it can bring benefit to local economies, scientific research, educational purposes, public awareness, recreational activities and, ultimately, the whales themselves (IFAW, Tethys and Europe Conservation, 1995).

Southern right whales, *Eubalaena australis*, approach the Southern Brazilian coast during the winter and spring to use the shallow and protected waters to give birth, nurse their calves and apparently mate (Palazzo and Flores, 1996, 1998; Simões-Lopes *et al.*, 1992; International Wildlife Coalition/Brazil, 1999). This right whale population was severely depleted by commercial whaling until 1973, when the whale population seemed to be extirpated from the Southern Brazilian coast (Palazzo and Carter, 1983). Since the early 1980s, when whales were 'rediscovered' in this region, the population has been monitored by the Brazilian Right Whale Project (Projeto Baleia Franca - IWC/Brasil). The whales concentrate along the Southern coast of Santa Catarina State, from Cabo de Santa Marta, Laguna (28°36'S, 48°49'W) to Santa Catarina Island (27°25'S, 48°30'W) (Simões-Lopes *et al.*, 1992; Palazzo and Flores, 1996, 1998; International Wildlife Coalition/Brazil, 1999). Most groups sighted in this region are mother-calf pairs with a few sightings of single adults and mating groups (Simões-Lopes *et al.*, 1992; Palazzo and Flores, 1996, 1998; International Wildlife Coalition/Brazil, 1999; Groch, 2000.).

The resighting of some females along the Southern Brazilian coast (Palazzo *et al.*, 1999; Groch, *ongoing research*) indicates that at least some females return regularly to this nursing area and present the same three year return and calving interval reported for other Southern Hemisphere calving grounds (Payne, 1986; Bannister, 1990; Best, 1990; Payne *et al.*, 1990). Resighting of calving females in Santa Catarina waters that were previously photoidentified on the wintering area off Península Valdés, Argentina, (Best *et al.*, 1993 and Groch *et al.*, *ongoing research*) indicates some degree of relationship between these right whale populations. A systematic land-based research program has been conducted in Santa Catarina waters since 1998, which has provided information on the whales' preferences on habitat use and behavior (Groch, 2000; Groch, 2001a). Since 1998, sighting frequencies have increased in all group categories and the whales have expanded their distribution. This may reflect the

recovery of the southern right whale population stocks (IWC, 2001). Estimates of right whale abundance off Brazilian coast are currently under analysis.

Whalewatching activities in the Southern coast of Santa Catarina State began in 1999. Boats operate under restrictions to national legislation. Shore based whalewatching is conducted by tourism agents, local fishermen, residents and tourists. Surface behavioral responses of right whales to the whalewatching activities have been monitored since 2000 (Groch, 2001, 2002), to ensure the conservation and management of the right whale population along the coast of Santa Catarina State. Preliminary results suggested that most right whales groups are approachable by whalewatching boats and make no apparent changes in their behavior. However, the results cannot be extrapolated since observations were made from only one type of whalewatching boat. Considering the increasing interest in whalewatching, it is likely that the number of boats operating in the region will increase in the coming years. On September 14, 2000, this wintering ground in the western South Atlantic was designated a Right Whale Environmental Protection Area, to ensure the conservation and protection of this southern right whale population and its habitat. Long-term studies on habitat use and behavior of right whales in this region are needed to ensure the appropriated management of this right whale population and the adequate development of whalewatching in the protected area.

Surveyor's theodolites have been used since the 1970s to study a variety of marine mammals around the world (e.g. Würsig *et al.* 1991; Acevedo, 1991; Kruse, 1991; Smith, 1993; Frankel and Clark, 1998; Bejder, 1999; Suryan and Hervey, 1999; Heckel, *et al.* 2001; Harzen, 2002; Johnston, 2002; Williams *et al.* 2002; Jahoda *et al.* 2003). The theodolite tracking technique has been proved to be a powerful tool to observe the animals from distance and in a non-invasive manner. Successive readings of the angles and time can be used to calculate relatively precise data on their positions, movement patterns and travel speed (Würsig *et al.*, 1991).

Here we present results of a study on right whale responses to whalewatching boats using theodolite tracking in the Right Whale Environmental Protection Area off the coast of Santa Catarina State, southern Brazil. The objective was to describe short-term (immediate) responses of right whales to encounters with whalewatching boats and provide reference data for future comparisons regarding whales' behavior and movements in relation to boats in the study area.



## METHODS

### *Study area*

The study area comprises 70 km of coast on the Right Whale Environmental Protection Area off the coast of Santa Catarina State (27°52'S, 48°34'W and 28°28'S, 48°46'W) (Fig. 1), Southern Brazil. The coast is characterized by a series of small bays, created by the morphology of the Brazilian coastal Mountain Ridge. The bays range in size from 1.5 to 14 km in length, and most of them have coastal cliffs in at least some section of the bay and sandy beaches. Some bays are composed of extensive regions of high sand dunes.

### *Surveys*

Observations were carried out from July to November (winter/spring time) 2002, the months of main whales presence in the region (Simões-Lopes *et al.*, 1992; Palazzo and Flores, 1998). Twelve observation land-based sites were chosen along the study area (Fig. 1). The sites are 16 to 92m above sea level, depending on the bay. Daily surveys were made simultaneously at sites with the help of eight volunteers, who remained with the project throughout the season. The surveys were conducted on two shifts (7-10 am and 1-4pm) and provided general information on the presence and distribution of the whales along the study area. This enabled the theodolite tracking effort to be directed to places where whale sightings were recorded.

Data recorded during surveys included: date, time of the observation, number of groups sighted, group composition (mother/calf pairs, adults without calves, juveniles), position of sighting (registered on detailed nautical charts in relation to buildings and distinct geographic features along the coast). The term "group" refers to one or more whales seen within close proximity of one another (at least approximately 15m or one adult whale length). Animals more than one whale length apart were also considered a group if their behavior appeared to be coordinated (Clark, 1983). The decision for when a group had split up was made when members were more than 3-4 adult whale lengths apart for more than 10 min. For statistical purposes, a group was considered as a unit (e.g. if a change was detected in a single individual, such change was attributed to the group). Environmental data including wind speed and direction, cloud cover, visibility and Beaufort Sea state were also recorded.

Observations sessions were excluded from the analysis when the Beaufort Sea state was >4. Cloud cover and visibility are factors that can influence the sighting conditions thus were evaluated for the data collection. Visibility was scaled from 1 (poor) to 5 (perfectly visible horizon). Observations were not carried when the visibility was 1 or 2, combined with high cloud cover rates.

### ***Theodolite tracking data collection***

Observations on the movements and behavior of whales were conducted in days with and without whalewatching cruises. Whales were tracked using a surveyor's digital electronic theodolite (ALKON DE with a 30X telescope and precision of  $\pm 10''$  arc). Theodolite is a surveying instrument capable of measuring angles to a target with great accuracy. The horizontal angle is given in relation to a 'zero' reference point and the vertical angle relative to the gravity. If the altitude and position of the theodolite as well as the position of the reference point are known, one can retrieve, together with the angles, the position of the target in (x,y) coordinates. The accuracy of the readings is inherent to the precision of the theodolite, proportional to the instrument's elevation and inversely proportional to the distance of the animal. The detailed technique is described by Würsig *et al.* (1991). In order to minimize errors in the readings, the height and position of the observation sites was calculated by a professional surveyor using a Geodetic GPS receptor (Topcon Legacy-H GD with precision of  $5\text{mm}\pm 5\text{ppm}$ ). As most research techniques, theodolite tracking has some limitations: the use of the theodolite is limited to a minimum height from the sea level. The farther the animals are from the coast, the higher the theodolite station must be for reasonable precision and accuracy. In general terms, animals up to 5km away from shore must be tracked from a vantage point at least 20 m above the surface of the water (see Würsig *et al.*, 1991 for height-related errors).

Three observers were normally present at the observation site. One person operated the theodolite. A second observer provided the theodolite operator information on the position and behavior of the groups aided by Pentax 12 x 50 mm binoculars and a Bushnell 22-45 x 60 mm spotting scope, depending on the range of the individuals. A third observer recorded behavior data for each theodolite reading on a standardized datasheet for posterior input in the computer.

### ***Focal observations***

Survey protocol (Altmann, 1974) was used to search, count and identify groups of whales present in each bay at the beginning of each observation session. Continuous following of focal groups (Altmann, 1974) was used to record the following data: time and duration of sighting, whales behavior and movement patterns (swimming speed and orientation). The following behavioral states of the whales were recorded: swimming, resting, play, other activity (Table 1) (see Thomas and Taber, 1984; Clark, 1983; Thomas, 1986; Cassini and Vila, 1990; Groch, 2000). Behavioral states were recorded each time we recorded a fix on the theodolite and the time spent in each category was calculated. Because right whales mother/calf pairs in winter/spring areas prefer shallow waters (Payne, 1986; Best, 1990) and spend most of their time resting or swimming at or just below the surface (Clark and Clark, 1980; Thomas and Taber, 1984), they are more easily visible and likely to be observed most of the time. Therefore we were able to record every time they changed their orientation, displayed a surface-active behavior or at least get positions on them once every five minutes. Since mothers and calves can have different rates of behavior (Thomas and Taber, 1984) and calves are difficult to follow we recorded the behavior on mother/calf pairs in terms of mother's behavior. During whale/boat encounters, when more than one group was present in the bay, we attempted to record the position of all groups at least every 10 minutes. Behavioral states of these groups were recorded using instantaneous sampling (Altmann, 1974).

### ***Whalewatching***

Whalewatching boats operating in the region were tracked in cooperation with the whalewatching operators, through the communication with the boat operator or the tour guides present in the boat. The whalewatching operators notified us when they took tourists on whalewatching cruises in the study area, which allowed us to monitor the whales' responses to boats. On these occasions the team moved to the site where the boat was supposed to go (pre-selected bay according to whales presence in that day) and recorded the behavior of the right whales groups before, during and after the encounter with boat, as well as the boat speed and movements. The before-approach phase consisted of any period before the first boat approach; the during-approach phase consisted by the time when the boat was stopped (with the engine in neutral or turned off) close to the target group; the after-approach phase began when the boat left the group after the last approach. When more than one attempt

to approach the target group was made, the total during-approach phase was the time between the beginning of the first and the end of the last approach made by the boat.

For each whale/boat encounter, the following data were recorded: time and duration of the encounter (total during-approach phase), whales behavior and movement patterns, and kind of boats approaches to whales (Table 2).

Because cetaceans are known to detect and react to acoustic stimuli at great distances (Au and Perryman, 1982; Richardson *et.al.*, 1995), and sound propagation varies according to the physical characteristics of a given bay (Richardson *et.al.*, 1995), whalewatching boats were tracked as they entered the bays. Every group of whales within a bay was considered to be in a potentially disturbed condition. Boats were recorded less frequently than the focal groups, and were assumed to travel at a constant speed between fixes. Every time it was noticed that the boat was turning on and off the engine to change its position or reapproach the group, its position was recorded. When more than one boat approached the same whale group at the same time an attempt of monitoring both boats was made.

Whalewatching activities were monitored from July 28 to October 28, 2002. The boats were 29-ft. inflatable boats with fiberglass hull and capacity for 20 passengers each. Whales were still present in November, but no whalewatching cruises were conducted during this period. Whalewatching cruises occurred according to whales frequency and distribution, weather conditions and tourist demand. Since the whalewatching season coincide with stormy winter weather, poor weather conditions limited the number of days boats could operate. During the '2002 whalewatching season' 53 cruises were conducted by the operators, of which 35 (66%) were tracked. Approaches made by boats other than the two authorized ones were monitored on two occasions. One was an opportunistic approach (a small non-commercial whalewatching boat) driven by local residents. The other was a fisherman carrying tourists and probably conducting a 'commercial whalewatching cruise'.

Ten whalewatching cruises could not be monitored with the theodolite. During the observations of these cruises we recorded: time and duration of the encounter (total during-approach phase), whales behavior, kind of boats approaches to whales (Table 2) and whale reactions to boat operation (approach "A", no reaction "U" or move away "N", as described in Table 3).

### ***Focal observations during non-whalewatching days***

Observations on the behavior and movement patterns of whales when no whalewatching cruises were made (non-whalewatching days) were conducted as a control. The observations focused on individual identified whales and whales present in the same bays where whalewatching cruises were conducted. We tried to follow whales that could have been previously approached by boats, following the same sampling methods for observations on whalewatching days. The theodolite tracks were collected and analyzed using the same methodology as the data from whalewatching days. The observations were made in Silveira and Ibiraquera (Fig.1).

### ***Individual Identification***

Individual right whales can be recognized by the callosity patterns on their heads and other distinct body marks through aerial photography (Payne *et. al.*, 1983). The use of photographs and a standard drawing sheet, permitted to follow some of the individuals targeted by boat operators.

### ***Data Analysis***

Theodolite tracking data was analyzed using the software Pythagoras (Gailey and Ortega-Ortiz, 2000, 2002). This software provided detailed information on movements and spatial patterns of whales through the calculation of the leg speed (swimming speed between two sequential fixes, hereafter referred as swimming speed), linearity (deviation of a trackline from a straight line) and reorientation rates (magnitude of bearing changes along a trackline).

Whales responses to whalewatching boats were measured through the analysis of their movements before, during and after the encounters with boats. The non-parametric Kruskal-Wallis (ANOVA by ranks) and Mann-Whitney U tests (Siegel, 1975) were used to compare the mean swimming speed values of each sighting between each phase of the encounters. It is not known if the behavior and movements of whales can be influenced by the physical features of a given bay. For this reason we have also analyzed mean swimming speeds of whales tracked in each phase of encounters with boats in each bay. Mean swimming speed data from Praia do Rosa and Silveira were combined for statistical purposes due to limited sample sizes. In addition, we compared mean swimming speed values between

whalewatching and non-whalewatching days. The results were considered significant at the 5% level. Linearity and reorientation data permitted to trace a profile on the orientation of the movements of the right whales. Linearity values close to one indicate whales traveling in a straight trackline; values close to zero indicate that whales were constantly changing direction. The analysis were made using BioEstat 2.0.

Pythagoras allowed us to estimate distance and bearing between tracks, according to the scheme developed by Bejder *et al.* (1999) (Fig. 2), which enabled us to correlate the movements and orientation of the whales in relation to approaching boats (Gailey and Ortega-Ortiz, 2000, 2002). The program quantifies the “approaches” and “avoidances” displayed by whales towards a boat in terms of a whale’s angle to a boat (Fig. 2). The data were analyzed using logistic regression to predict the probability of the occurrence of an “orientation” as a function of the time of the encounter (Hosmer and Lemeshow, 1989). In the analysis of whale/boat distances and orientation the data was interpolated into 1-min intervals. A 600 sec critical time-interval (CTI) was used which means that fixes with time intervals longer than 600 seconds were excluded. Interpolation was necessary because it was impossible to determine the position of two targets at a time with only one theodolite (for details on the calculations see Gailey and Ortega-Ortiz, 2000, 2002).

## RESULTS

A total of 111.9 hours of observation (including time before, during and after the encounters of the whales with whalewatching boats) were conducted on 27 days (hereafter referred as ‘whalewatching day’), with a mean of 4.1 hours of observation/day. A mean of 6.5 whales were present in the bays during whalewatching days (N=175 whales). Of these 89.1% (n=156) were mother/calf pairs and 10.9% (n=19) were unaccompanied whales. Whalewatching cruises occurred at a rate of 1.4 per day and were conducted between 10AM and 1PM. On two occasions two whalewatching boats approached the whales at the same time. When more than one whalewatching cruise was conducted in the same day, they were mostly carried in the same bay. The boats approached the same group or went to different groups. The target and number of approaches were based on the whales’ first reaction to boat approach and weather conditions (wave height and wind speed). If the whales showed no reaction or moved away, the boat operator attempted to approach it again or moved to another group. The number of whalewatching cruises per month and whales approached are presented

in Table 4. Most of the cruises were conducted in October, probably due to comparatively better weather conditions.

Most of the monitored whalewatching cruises occurred in Garopaba (28.6%, n=10) and Ibiraquera (28.6%, n=10), followed by Gamboa (14.3%, n=5), Silveira (14.3%, n=5), Praia do Rosa (11.4%, n=4) and Ferrugem (2.9%, n=1) (Table 5). Since Ibiraquera had the most whale sightings during the season, it was expected to have most of the whalewatching cruises. The fact that Garopaba is the point of embarkation of the whalewatching cruises, so it is not surprising that such a high proportion of the cruises occurred there.

### ***Theodolite tracking***

During the monitored whalewatching cruises, boat operators followed national legislation guidelines. Boats stopped (with the engine in neutral or turned off) at a distance of over 100m from the whales. They mainly stopped in the path of whales and were allowed to drift onto the whale(s) (approach classified as ‘stationary’).

Whale/boat distance varied between less than 10m up to 4242m, depending on the bay where the encounter was tracked. The maximum and minimum distances between whales and boats measured in each bay are given in Table 6.

Between July to October 2002, we collected 2931 fixes (vertical and horizontal angular readings) of whales and boats over 65,5 hours period. Eighty-three percent (n=2431) were of mother/calf pairs and 17% (n=500) were of boats. No lone adults or groups of adults without calf were sighted during these observations. Tables 7 and 8 show data of the theodolite tracking sessions for each observation site. Table 9 shows mean swimming speed of whales in each bay in days with whalewatching cruises before, during and after encounters with boats.

No significant differences were found in mean swimming speeds of whales tracked before, during and after encounters with boats in all bays (Kruskall-Wallis:  $n = 107$ ,  $H = 2.1656$ ,  $p = 0,3387$ ). The separate analysis of each bay also showed no significant differences in Gamboa (Kruskall-Wallis:  $n = 54$ ,  $H = 2.6386$ ,  $p = 0.2673$ ), Garopaba (Kruskall-Wallis:  $n = 21$ ,  $H = 1.1771$ ,  $p = 0.5551$ ) and Ibiraquera (Kruskall-Wallis:  $n = 54$ ,  $H = 2.1539$ ,  $p = 0.3406$ ), as well as the combined mean swimming speeds of whales tracked in Praia do Rosa and Silveira between the during and after phases (Mann-Whitney:  $U = 8$ ,  $z = 0.4899$ ,  $p = 0.6242$ ,  $n_1 = 4$ ,  $n_2 = 5$ ).

Table 10 shows data on linearity and reorientation rates of whales tracked during whalewatching-days for each bay. The values of linearity obtained for the mother/calf pairs were similar in all observation sites. The whales did not maintain constant direction during the observation period. What was observed were mother/calf pairs moving in parallel to the coastline, traveling back and forth within a bay, wandering (not necessarily in a constant straight line). However, whales were mostly traveling at low reorientation rates (mean rates <32 degrees/min).

Figure 3 shows the predicted probability of mother/calf pairs heading toward the boats during the whale/boat encounters for each bay. If whale movement relative to the approaching whalewatching boats was random, it would be expected that the proportion of each orientation would be the same, at a rate of 0.25 (see Fig. 2). Predicted probabilities of whales heading towards the boats were significantly near the expected values in Gamboa (*Chi-square*:  $\chi^2 = 1.216$ ,  $p=0.2701$ ) and Ibiraquera (*Chi-square*:  $\chi^2 = 1.268$ ,  $p=0.26$ ), the later showing a slight decrease from the beginning to the end of the whale/boat encounter. In Garopaba, Silveira and Rosa the predicted probabilities varied significantly during certain time intervals ( $p<0.001$ ). Values higher than the expected were observed in Garopaba during the first 25 minutes, having lower probabilities until the end of the encounters. In Silveira predicted probabilities were lower than the expected during the total time of the encounter but increased towards the end, approaching expected values at the >45-50 min interval. In Praia do Rosa the predicted probabilities of heading towards boats were higher than the expected during the first 15 minutes of the encounter, but decreased during the next 25 minutes. Figure 4 shows the mean distances between whales and whalewatching boats during encounters as well as the observed probabilities of the whales heading towards boats. Whales showed similar mean probabilities of heading towards the boat at shorter ( $\leq 300\text{m}$ ) and greater ( $>300\text{m}$ ) distances (Table 11).

Total time the whales spent in different behavioral states is shown in Table 12 and Figure 5. Mother/calf pairs spent most of their time traveling in Garopaba (76.6%), Rosa (68.2%), Ibiraquera (89.2%) and Silveira (74.8%). In Garopaba and Ibiraquera mother/calf pairs played for less than 10% of the time and in Silveira for less than 5% of the time. Mother/calf pairs rested for about 20% of the time in Garopaba and Silveira and 1% of the time in Ibiraquera, and where never seen resting in Praia do Rosa. In Gamboa, whales spent almost half of the time traveling, around 30% of the time playing and 20% of the time resting.



### ***Focal observations in non-whalewatching days***

A total of 25.6 hours of focal observations were conducted on 13 days in which there were no whalewatching cruises, in October and November. During that time we followed whales for a mean of 1.9 hours of observation/day and tracked 51 groups of mother/calf pairs. Theodolite tracking data are present in Tables 13 and 14.

Swimming speed, linearity, and reorientation rates for whales tracked in the two bays are shown in Table 15. On non-whalewatching days, mother/calf pairs traveled at a mean of 0.98 km/h in Silveira and 1.32 km/h in Ibiraquera. The linearity value for the mother/calf pairs in Silveira shows that whales did not traveled in a constant direction during the sampling period, which is reinforced by the reorientation rate. Mother/calf pairs tracked in Ibiraquera showed a more directional movement with lower reorientation rate.

In the comparison of swimming speed data from non-whalewatching days to observations taken before, during and after whalewatching cruises in Ibiraquera, no significant differences were observed (Kruskall-Wallis:  $n = 87$ ,  $H=4.64$ ,  $p=0.2$ ). Mean swimming speed values in Silveira were lower during non-whalewatching days than during and after whalewatching cruises but the sample was too small for meaningful statistical treatment. The linearity values and reorientation rates obtained on non-whalewatching days also showed no difference to values recorded on whalewatching days.

Total time spent in a behavioral state for whales tracked in Ibiraquera and Silveira is shown in Table 16. Mother/calf pairs spent 83.33% of their time traveling during non-whalewatching days in Ibiraquera and 16.67% playing. There was no significant difference in time spent traveling (Mann-Whitney:  $U = 28$ ,  $z = 1.0662$ ,  $p = 0.2863$ ,  $n_1= 8$ ,  $n_2=10$ ) and playing (Mann-Whitney:  $U = 23.5$ ,  $z = 1.4661$ ,  $p = 0.1426$ ,  $n_1= 8$ ,  $n_2=10$ ) between whalewatching and non-whalewatching days. Mother/calf pairs spent no time resting in non-whalewatching days. In Silveira, mother/calf pairs spent the same amount of the time traveling (46.17%) and resting (41.63%) and 12.21% of their time playing (Table 15). Although the sample was too small for meaningful statistical treatment, these proportions were different than observed in Silveira on whalewatching days, when the tracked mother/calf pair spent most of their time traveling (74.8%) (see Table 11). It's worth noting that during two days of observations in Silveira on non-whalewatching days one mother/calf pair could be identified (through identification of the mother, named Tno.01 - sighting history in Table 16). This pair was tracked in many occasions over more than two months during this field season in different bays, and displayed a variety of proportions in behavioral states during this

period. This mother/calf pair was not in Silveira on whalewatching days so they are not included in these observations.

### *Identified individuals*

Whales were photographed from shore, boat and during aerial surveys. Analysis of the photographs showed that some individuals moved between bays during the season. On whalewatching days, three females with calves were identified and resighted on more than one day, always accompanied by their calves. The whales were individually identified during aerial surveys and also resighted on non-whalewatching days. The resightings allowed us to follow their movements through the field season as well as compare their behaviors on days with and without whalewatching cruises. The sighting history for each pair is showed in Table 17 and the values for movements are in Table 18. The female “Tno.01” had a series of propeller scars on the posterior part of her back, which helped in identifying the pair throughout the season. The scars were healed and probably acquired some time before her arrival in the study area.

The mean swimming speed of the mother/calf pair Tno. 01 was 2.6 times higher during whalewatching days than in non-whalewatching days. However, no significant differences between the mean values were found (Kruskall-Wallis:  $n = 15$ ,  $H = 5.7025$ ,  $p = 0.127$ ) throughout the period they were observed, probably due to low sample size during non-whalewatching days. This pair spent most of their time (78.3%) traveling during whalewatching days and little time playing (13.9%) and resting (7.8%). In non-whalewatching days they spent half of their time traveling (58.5%), 7.6% of their time playing and 33.9% resting. The pair Tno. 03 also presented higher mean swimming speed values during whalewatching days than in non-whalewatching days (1.9 times), with no significant differences (Kruskall-Wallis:  $n = 10$ ,  $H = 0.9056$ ,  $p = 0.3413$ ). They spent 83.7% of their time traveling in whalewatching days, 14.5% playing and 1.8% resting. In non-whalewatching days the proportions of time spent traveling (86.6%) and playing (13.4%) were similar to whalewatching days but they spent no time resting in non-whalewatching days. Tno 01 and 03 traveled at higher linearity rates in whalewatching days than in non-whalewatching days. The reorientation rates of the pair Tno 01 were lower in whalewatching days than in non-whalewatching days. The pair Tno. 03 had higher reorientation rates in whalewatching days than in non-whalewatching days. The pair Tno. 02 was tracked during only one whalewatching day so statistical comparison with non-whalewatching days was not possible.

Their swimming speeds and linearity values were similar during the observations but they reoriented their swimming direction at a slightly higher rate in non-whalewatching days than in whalewatching days (Table 18). This pair spent most of their time traveling (86.2%) during the whalewatching day they were tracked, 13.8% of their time playing and no time resting. During non-whalewatching days the pair also spent most of their time traveling (82.7%), 17.3% of the time playing and no time resting.

### ***Whalewatching monitoring without theodolite***

During the instances when no theodolite was used to monitor whale/boat interactions, a total of 32.3 hours of observation were made (28.9% from the total time of whalewatching monitoring). All but two of the cruises were carried by the two authorized whalewatching boats. The others were opportunistic whalewatching cruises taken by a small inflatable boat and a fisherman boat. Twenty approaches to whales were made by the whalewatching boats. Fifty-five percent (n=11) were directed toward nine mother/calf pairs and 45% (n=9) were directed toward five groups of adults. In 90% (n=18) of the approaches, whales showed “no reaction” to the approaching boat (the *stimuli* were apparently ignored and the whales continued their activities uninterrupted). During these occasions, whales were not necessarily unaware of the presence of the boat, but their behaviors were not changed by it. In 10% (n=2) of the approaches, whales appeared to have approached and interacted with the boat for a brief period, appearing to be curious. These whales moved from the immediate area before resuming their former activities. Whales that approached boats included mother/calf pairs. During the two opportunistic whalewatching cruises, the whales showed “no reaction” during the approach.

## **DISCUSSION**

The focal observations of the behavior of right whales in relation to boat approaches conducted during the 2002 right whale season showed that most of the whales appeared to have ignored the presence of the boats and didn't change their behavior. We observed no clear evidence of immediate disturbance of right whales, suggesting that whalewatching can be continued in the study area if conducted in agreement to the national legislation.

Minor changes in behavior were observed in few occasions when whales were seen to swim towards the boats but later, after a period of apparent interest, they moved away and resumed their former activities. Whales were never seen leaving a bay after being approached by a whalewatching boat. Whales didn't appear to react to the boat approaches even when more than one approach was made to the same group. According to Watkins (1986) whales can have some degree of negative reactions to first approaches but ignore a vessel after three or four passes, showing habituation to relatively non-disturbing *stimuli*. The author also mentioned that northern right whales (*Eubalaena glacialis*) moved slowly but consistently away from passing ships and dived quickly when disturbed. In Argentina, some southern right whales were reported to allow close boat approaches when the boat moved slowly and some whales even approached stationary boats (Cummings *et al.*, 1972; Payne *et al.*, 1983). Colombo *et al.* (1990) described faster mean swimming speeds of whales not accompanied by calves in areas with whalewatching boats when compared with areas not subjected to boats, but no differences were observed in mother/calf pairs. However, in a recent study Rivarola *et al.* (2001) described changes in swimming speed and headings as avoidance reactions of southern right whales to whalewatching boats. The authors mentioned that the behavior of the whales was affected by high impact boat maneuvers like direct approach, encircling or chasing, though the whales response was not consistent. Whales were observed to move away from boats only when the three types of maneuvers occurred during the same whalewatching trip.

Changes in swimming speed as a reaction to disturbance were also reported by studies in different cetacean species (Richardson *et al.*, 1985; Baker and Herman, 1989; Green and Green, 1990; Richardson *et al.*, 1990; Kruse, 1991; Heckel *et al.* 2001; Jahoda *et al.*, 2003). Richardson *et al.* (1985) noted strong and consistent increases in swimming speeds of bowhead whales (*Balaena mysticetus*) in response to approaching boats. Humpback whales (*Megaptera novaeangliae*) in Hawaiian waters altered swimming direction as boats approached and decreased swimming speeds after boats departed (Green and Green, 1990). When approached by whalewatching boats in their wintering area in Ecuador, humpbacks were recorded to increase swimming speeds and adopted a more direct path after the encounter (Scheidat, *et al.* 2004). Killer whales (*Orcinus orca*) in Johnstone strait responded to approaching boats by increasing their swimming velocities and by tending to swim toward open water (Kruse, 1991). Heckel *et al.* (2001) detected changes in swimming speeds of gray whales (*Eschrichtius robustus*) in the presence of boats during migration along the Mexican

coast. Jahoda *et al.* (2003) report on travel at increased velocity and reduction of time spent at the surface as avoidance behavior performed by Mediterranean fin whale (*Balaenoptera physalus*) after a disturbance by boat.

Effects of anthropogenic disturbance may range from temporary changes in behavior (Gauthier and Sears, 1999) to possible interference with feeding (Richardson *et al.*, 1990; Johnson, S.R. 2002; Jahoda *et al.* 2003), reproduction (Miller *et al.*, 2000; Weller *et al.*, 2002) or migration (Heckle *et al.*, 2001). Despite the differences in the mean swimming speeds of right whales observed in the present study were not statistically significant, it is broadly accepted that changes in swimming speed is a common cetacean response to boat disturbance. The lack of statistical significance can be a result of small sample size or the differences observed were casual. Notwithstanding, Watkins (1986) found that right whales are less easily disturbed than other species of whales like minke (*Balaenoptera acutorostrata*), fin and humpbacks, and showed over the years apparently the same variety of responses with little changes.

The predicted probabilities observed at Gamboa and Ibiraquera infers that the movements of mother/calf pairs relative to whalewatching boats were probably random throughout the encounter. A decreasing probability was observed from the beginning to the end of the encounter in Garopaba and Praia do Rosa, and an increase in Silveira. The decrease implies that mother/calf pairs were more attracted to and approached boats during the first minutes of an encounter and less attracted during the next intervals, when whales could be showing avoidance or moving randomly with respect to the boat. In Silveira the whales were less attracted to boats during the first minutes of an encounter and more attracted to the end of the encounter. Its worth noting that higher values for the predicted probabilities were observed in Praia do Rosa in relation to Garopaba. These two bays are of very different size and orientation to the open sea. Praia do Rosa is smaller than Garopaba, which results in a shorter distance between the whales and boats at the beginning of an encounter. It is possible that the mother/calf pairs could be reacting in a different way at that place as a result of having different perception on the acoustic *stimuli*.

Right whales may appear not to react to boat approaches for many reasons but sometimes they simply appear indifferent to the presence of a boat. We observed that whales were approaching boats at either shorter or greater distances. Sometimes boats maintained great distances from the whales, not only as a precautionary conduct due to the limits on the distance of approach imposed by the national legislation but due to adverse weather

conditions (high waves and strong winds) which could hurl the boat towards whales direction or the breaking waves.

As mentioned by Bejder *et al.* (1999), measuring distances are an ambiguous analysis because you can get the same distance measure from a boat leaving or approaching a group of whales. In their study the authors observed no clear relationship between the distance of the boats and the orientation of the Hector's dolphins (*Cephalorhynchus hectori*). We observed that whales reacted at both long and short distances from boats and the reactions varied with bays. For example, Silveira and Rosa are very similar in size and the mother/calf pairs showed opposite swimming orientations in relation to the whalewatching boats at similar distances.

Boat speed may also influence the perception of boat approaches and whales reactions may have been to boat speed. Whalewatching boats typically entered the bays at about 4.96 km/h (SD=2.62 km/h), slowed down when approaching the whales, and then put the engine in idle or turned it off when getting close to 100m from the whales. This type of approach makes the sound level diminish as the boat approaches the whales and probably reduces the potential for disturbance during boat approaches. According to Richardson *et al.*, 1995, many reactions to ships or boats are presumably reactions to noise but responsiveness may vary widely between and within-species, according to physical and biological factors, which must be considered in determining the radius of responsiveness and zone of noise influence (Richardson *et al.*, 1995). Underwater sound appears to be the primarily *stimuli* of reaction by whales (Watkins, 1986; Novacek *et al.*, 2004). However, there is limited information on noise produced by small boats typically used in coastal waters (Richardson *et al.*, 1995), as well as on the frequency range of hearing and sensitivity of baleen whales (Ketten, 1994; National Research Council, 2004).

Avoidance responses to oncoming vessels have also been noted in many species of small odontocets including spotted (*Stenella attenuata*), spinner (*S. longirostris*) and striped (*S. coeruleoalba*) dolphins (Au and Perryman, 1982), arctic beluga whales (*Delphinapterus leucas*) (Richardson, 1995), harbour porpoises (*Phocoena phocoena*) (Evans *et al.* 1994), bottlenose dolphins (*Tursiops truncatus*) (Janik and Thompson, 1996; Williams *et al.*, 2002; Hastie (2003); Constantine *et al.*, 2004; Goodwin and Cotton, 2004), Hector's dolphins (Bejder *et al.* 1999) and sperm whales (Magalhães *et al.* 2002). Despite these studies have indicated boat-avoidance behavior of cetaceans to approaching boats, only few of them reported clear patterns of short-term reactions. Moreover, whether the *stimuli* were caused by

the physical presence of the boat, the underwater noise generated or the interaction between both agents is not known.

The time mother/calf pairs spend on the nursery ground is of great importance for calf growth and development (Taber and Thomas, 1982). During this period, females probably do not feed and channel most of their energy into nursing and taking care of their calves and as a consequence appear to show low levels of activity. In fact, despite traveling during most of the time we observed mother/calf pairs, their average swimming speed was less than 2 km/h (see Table 9). It is known that right whales are very slow swimmers. They can average 2kt (~4km/h) and rarely exceed 5 kt (~9km/h) (Slijper, 1979; Cummings *et al.* 1972), but can travel at speeds of 16 km/h when frightened (Slijper, 1979) and an average of 5-11km/h during migration (Lockyer, 1981). Satellite-monitored northern right whales in feeding areas have been reported to travel at average speeds of 3.5 km/h (Mate *et al.* 1997). Swimming speeds of right whales tracked with theodolite on their wintering ground at Peninsula Valdes averaged 2-3km/h (Colombo *et al.*, 1990) and off South Africa  $1.67 \pm 0.85$ km/h (Best, 2000). Additionally, mother/calf pairs on nursery grounds generally presents less movements along the coast than other individuals (Bannister, 1990; Best, 1990). The theodolite data presents here actual speeds of mother/calf pairs on the wintering ground and can be used for future comparisons of whale movements in this and other areas.

## **CONCLUDING REMARKS AND RECOMMENDATIONS**

Marine mammals are target of a growing ecotourism industry worldwide and the whalewatching activities are exposing these animals to potential disturbance at an ever-increasing rate. In some places the numbers of recreational vessels approaching whales and dolphins is cause for serious concern. The whale and dolphinwatching industry has considerable economic and educational potential, creating concern about its impacts on cetacean populations. But techniques exist that can be used to assess impacts on a short and long-term basis, with different efficacies and from different platforms (IFAW, Tethys Research Institute and Europe Conservation, 1995).

Studies of anthropogenic impacts on cetaceans have been developed in many places all over the world. Most of them found some significant change in cetacean behavior, but almost all stated without exception that the long-term, biological meaning of these changes is not

clear (Richter *et al.*, 2000).

While data presented here comes mainly from the observation of a small whalewatching industry operating under the guidelines of national legislation, the growing economic interest increases the potential for the growth of uncontrolled activities if whalewatching is not permanently monitored and not properly managed. A general increase in the interest is apparent in the region not only by tourists but also by local residents to conduct boat and shore based whalewatching.

Some aspects of both whalewatching operation and the protection of this right whale population must be considered with respect to the monitoring and management of whalewatching in the study area:

1) whalewatching has been operational for only four years and is carried out within restrictions imposed by national legislation, in a controlled way;

2) the geography of the study area provides many advantageous observation sites for studying the whales and their encounters with boats;

3) whalewatching is carried out near to shore and whales are distributed just outside the breaking waves region;

4) the current national legislation can be improved if specific studies are conducted for each cetacean species;

5) right whales appear to be recovering after many decades of commercial whaling (Groch *et al.*, 2004), along with the rest of the as the South Atlantic “stock”, which is estimated to be increasing annually at about 8% (IWC, 2001);

6) short-term studies cannot document long-term effects on marine mammals, hence long-term monitoring is vital for this right whale population and a valuable tool for the development of appropriate management of whales in this area.

Information derived from theodolite tracking studies can be coupled to other types of studies in order to provide a more complete dataset for the management of whalewatching and the development of whale conservation strategies. For instance, while theodolite itself cannot detect habitat use changes over time, long-term photo-ID studies can document changes in the whale distribution which, when analyzed in conjunction with theodolite data and other field studies, may help clarify the actual impact of whale watching on whale populations. It is to be noted that, from a management perspective, whalewatching needs to be part of a more



comprehensive assessment of all possible disturbances (e.g. fishing, ship traffic) within the right whale wintering ground. Therefore, the systematic gathering of more comprehensive records of other human activities are strongly advisable, so that researchers and managers can adequately assess the conservation status and propose management measures for targeted populations.

The year 2002 was the third year of monitoring of the whalewatching operations in the study area. Further research to assess potential impacts of the whalewatching operations on the right whale population in a long-term basis in the region is advisable, as well as the continuing development of educational programs for tourists and local residents.

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**Table 1** - Description of behavioral states recorded during focal observations of whales.

Behavioral State	Description
Travelling	Directional forward movement in constant speed, that resulted in a change of location.
Resting	Individuals remain motionless without any evidence of physical exertion, in general with the dorsal surface of the head and body above the water.
Play	Activities between mother and calf not directly related to any of the above categories.
Other activity	Activity not directly related to any of the above categories.

**Table 2** - Types of boat approaches during whalewatching encounters with whales (adapted from Findlay, 1998).

Type Of Approach	Description
<b>SA (Side on approach)</b>	Slow speed approach (no-wake speed) from the left or right side of the whale(s).
<b>HA (Head on approach)</b>	Slow speed approach (no-wake speed) towards the head of the whale(s).
<b>TA (Tail on approach)</b>	Slow speed approach (no-wake speed) from behind the whale(s).
<b>OA (Obtrusive approach)</b>	Higher speed approach (with wake produced), with direction and speed changes and circling of whale(s).
<b>S (Stationary)</b>	Boat stopped (with the engine in neutral or turned off) at a distance of over 100 m from the whales in the path of whales and were allowed to drift onto the whale(s).

**Table 3** - Reactions of whales to boat approaches during whalewatching encounters (adapted from Watkins, 1986).

Whale Reaction	Description
<b>A (approach)</b>	Whales showed apparent curiosity and appeared to provide some reward. Whales' previous activities were suspended and they permitted close approaches or they approached and interacted with the boat. After a period of such interest, whales often moved away from the immediate area before resuming their former activities.
<b>U (no reaction)</b>	The stimuli were apparently ignored and the whales continued their activities uninterrupted. Whales are not necessarily unaware of the presence of the boat, but their behaviors were not interrupted by it.
<b>N (move away)</b>	Sudden changes in behavior (include: persistent movements away from the boat, turn sharply away or dive quickly).

**Table 4** - Number of whalewatching cruises, number and group composition of right whales encountered by month during the monitoring of the whalewatching activities off the central-southern coast of Santa Catarina State, Southern Brazil, from July to October, 2002.

Month	No. Cruises monitored (%)	No. mother/calf pairs sighted* (%)	No. Adults without calves sighted* (%)	No. whales sighted* (%)
July	3 (8.6)	0 (0.0)	7 (4.3)	7 (4.3)
August	7 (20.0)	14 (8.6)	3 (1.9)	31 (19.1)
September	9 (25.7)	18 (11.1)	0 (0.0)	36 (22.2)
October	16 (45.7)	44 (27.2)	0 (0.0)	88 (54.3)
<b>TOTAL</b>	<b>35</b>	<b>76 (46.9)</b>	<b>10 (6.2)</b>	<b>162</b>

\* Includes possible double-counting.

**Table 5** - Distribution of the whalewatching cruises monitored from July to October 2002, according to the site, number and group composition of the right whales sighted off the central-southern coast of Santa Catarina State, Southern Brazil.

Site of the cruises	No. WW Cruises monitored (%)	No. mother/calf pairs sighted* (%)	No. Adults without calves sighted* (%)	Total No. of whales sighted* (%)
Gamboa	5 (14.3)	11 (6.8)	0 (0.0)	22 (13.6)
Garopaba	10 (28.6)	14 (8.6)	7 (4.3)	35 (21.6)
Ibiraquera	10 (28.6)	28 (17.3)	0 (0.0)	56 (34.6)
Praia do Rosa	4 (11.4)	13 (8.0)	0 (0.0)	26 (16.0)
Silveira	5 (14.3)	8 (4.9)	3 (1.9)	19 (11.7)
Ferrugem	1 (2.9)	2 (1.2)	0 (0.0)	4 (2.5)
<b>TOTAL</b>	<b>35</b>	<b>76 (46.9)</b>	<b>10 (6.2)</b>	<b>162</b>

\* Includes possible double-counting.

**Table 6** - Distances measured during encounters between right whales and whalewatching boats monitored from July to October 2002, in the central-southern coast of Santa Catarina State, Southern Brazil.

Observation site	Maximum distances (m)	Minimum distances (m)
<b>Gamboa</b>	1316.6	14.9
<b>Garopaba</b>	4242.1	6.1
<b>Silveira</b>	1167.3	63.1
<b>Praia do Rosa</b>	1710.8	27.5
<b>Ibiraquera</b>	3201.0	6.7

**Table 7** - Total theodolite tracking data obtained during the monitoring of right whales in whalewatching days, by observation site, in the central-southern coast of Santa Catarina State, Southern Brazil, from July to October 2002.

TOTAL TRACK	Duration (hh:mm:ss)	#Fix Points	No. of whales tracked*
<b>Gamboa</b>	13:36:45	768	11
<b>Garopaba</b>	10:38:11	445	15
<b>Silveira</b>	6:19:23	371	6
<b>Praia do Rosa</b>	2:48:15	133	4
<b>Ibiraquera</b>	32:08:44	1214	65
<b>TOTAL</b>	<b>65:31:18</b>	<b>2931</b>	<b>101</b>

\*Includes possible double counting of individual whales tracked.

**Table 8** - Mean rates of theodolite tracking data obtained while monitoring right whales on whalewatching days, by observation site, in the central-southern coast of Santa Catarina State, Southern Brazil, from July to October 2002.

TOTAL TRACK	Mother/calf pairs		Whale/boat encounter*			
	Duration (h:mm:ss)	Fix points / min	Duration (h:mm:ss)	Fix points / min		
<b>a) Gamboa</b>						
Mean	2:34:24	0.36	0:55:31	0.32		
SD	1:45:08	0.20	0:17:22	0.07		
Maximum	5:40:28	---	1:22:10	---		
Minimum	0:29:30	---	0:38:21	---		
<i>Total no. of fix points</i>	<b>678</b>	---	<b>90</b>	---		
<b>b) Garopaba</b>						
Mean	1:11:26	0.23	1:09:17	0.38		
SD	0:39:14	0.17	0:12:41	0.1		
Maximum	3:10:41	---	1:25:11	---		
Minimum	0:32:44	---	0:56:54	---		
<i>Total no. of fix points</i>	<b>288</b>	---	<b>157</b>	---		
<b>c) Silveira</b>						
Mean	1:49:28	0.52	0:40:18	0.34		
SD	1:01:37	0.21	0:13:12	0.05		
Maximum	2:43:18	---	0:51:30	---		
Minimum	0:08:00	---	0:21:23	---		
<i>Total no. of fix points</i>	<b>316</b>	---	<b>55</b>	---		
<b>d) Praia do Rosa</b>						
Mean	1:02:09	0.63	0:48:37	0.29		
SD	0:31:54	0.68	0:14:40	0.07		
Maximum	1:30:11	---	0:59:00	---		
Minimum	0:34:06	---	0:38:15	---		
<i>Total no. of fix points</i>	<b>106</b>	---	<b>27</b>	---		
<b>e) Ibiraquera</b>	Mother/calf pairs		Whale/boat encounter*		Other boats**	
	Duration (h:mm:ss)	Fix points / min	Duration (h:mm:ss)	Fix points / min	Duration (h:mm:ss)	Fix points / min
Mean	1:34:13	0.20	0:46:40	0.31	0:18:12	0.58
SD	1:13:05	0.15	0:16:36	0.08	0:13:17	0.53
Maximum	4:33:37	---	1:06:45	---	0:29:11	---
Minimum	0:02:26	---	0:14:20	---	0:03:26	---
<i>Total no. of fix points</i>	<b>1043</b>	---	<b>161</b>	---	<b>10</b>	---

\* Encounter with authorized whalewatching boats.

\*\* Encounter with other than the authorized whalewatching boats.

**Table 9** - Mean values for swimming speed of right whales mother/calf pairs tracked in each bay before, during and after encounters with whalewatching boats in the central-southern coast of Santa Catarina State, Southern Brazil, from July to October 2002.

		Distance Between Fixes (m)	Swimming Speed (km/h)	Time of Observation (h:mm:ss)	Time Dec (min)	No. of phase(s)**
<b>a) Gamboa</b>						
<b>Before</b>	Mean	0.05	0.90	0:44:45	44.75	3
	SD	0.05	0.94	0:28:01	28.02	---
<b>During</b>	Mean	0.03	1.39	0:42:48	42.80	11
	SD	0.05	1.65	0:21:01	21.02	---
<b>After</b>	Mean	0.03	1.55	0:34:20	34.33	8
	SD	0.04	2.10	0:24:17	24.28	---
<b>b) Garopaba</b>						
<b>Before</b>	Mean	0.08	1.67	0:18:21	18.35	5
	SD	0.08	1.78	0:07:47	7.78	---
<b>During</b>	Mean	0,12	2,71	0:30:22	30,37	12
	SD	0,15	2,77	0:20:53	20,88	---
<b>After</b>	Mean	0.06	2.46	1:02:34	62.57	4
	SD	0.07	1.89	0:58:57	58.95	---
<b>c) Ibiraquera</b>						
<b>Before</b>	Mean	0.08	1.51	0:37:43	37.72	12
	SD	0.08	1.59	0:12:59	12.98	---
<b>During</b>	Mean	0.10	1.85	0:26:54	25.17	29
	SD	0.11	1.52	0:14:57	15.93	---
<b>After</b>	Mean	0.09	1.51	0:48:49	48.82	13
	SD	0.08	1.30	0:24:23	24.38	---
<b>d) Rosa</b>						
<b>Before</b>	Mean	0.06	2.78	0:34:57	34.95	1
	SD	0.07	3.34	0:00:00	0.00	---
<b>During</b>	Mean	0.04	1.99	0:39:38	39.63	3
	SD	0.05	2.37	0:17:29	17.48	---
<b>After</b>	Mean	0.07	1.08	0:30:56	30.93	2
	SD	0.04	0.88	0:01:07	1.12	---
<b>e) Silveira</b>						
<b>Before*</b>	Mean	---	---	---	---	---
	SD	---	---	---	---	---
<b>During</b>	Mean	0.03	1.10	0:44:46	44.77	2
	SD	0.03	0.66	0:02:43	2.72	---
<b>After</b>	Mean	0.04	1.80	0:26:22	26.37	2
	SD	0.03	1.74	0:18:34	18.57	---

\* There was no data collected during this phase.

\*\*Before (B), during (D) and after (A) the encounter with whalewatching boats.

**Table 10** - Mean values for linearity and reorientation rates of right whales mother/calf pairs tracked in each bay during whalewatching days, in the central-southern coast of Santa Catarina State, Southern Brazil, from July to October 2002.

Observation Site	Linearity		Reorientation Rate (degrees/min)	
	Mean	SD	Mean	SD
<b>Gamboa</b>	0.36	0.35	23.57	8.08
<b>Garopaba</b>	0.38	0.22	15.94	8.03
<b>Silveira</b>	0.17	---	23.74	---
<b>Rosa</b>	0.34	0.19	31.63	20.97
<b>Ibiraquera</b>	0.49	0.27	13.42	13.20

**Table 11** - Mean probability of mother/calf pairs heading towards whalewatching boats at shorter and greater distances during whale/boat encounters tracked in each bay during whalewatching days, in the central-southern coast of Santa Catarina State, Southern Brazil, from July to October 2002.

	Prob. at distance $\leq 300\text{m}$		Prob. at distance $>300\text{m}$	
	Mean	SD	Mean	SD
<b>Garopaba</b>	0,16	0,07	0,21	0,06
<b>Gamboa</b>	0,24	0,01	0,24	0,01
<b>Ribanceira</b>	0,18	0,01	0,20	0,01
<b>Rosa</b>	0,18	0,22	0,17	0,16
<b>Silveira</b>	0,06	0,03	0,11	0,08



**Table 12** - Behavioral states of mother/calf pairs tracked on days that included whalewatching encounters in the central-southern coast of Santa Catarina State, Southern Brazil, from July to October 2002.

	Gamboa		Garopaba		Rosa		Ibiraquera		Silveira*	
	Mean time spent (%)	SD	Mean time spent (%)	SD	Mean time spent (%)	SD	Mean time spent (%)	SD	Total time spent (%)	SD
<b>Travel</b>	47.92	22.75	76.60	25.70	68.18	19.28	89.20	5.28	74.8	-
<b>Play</b>	31.58	20.74	5.48	7.27	31.82	19.28	9.74	4.87	3.5	-
<b>Rest</b>	20.50	34.63	17.91	25.91	0.00	0.00	1.06	1.77	21.7	-

\*SD values for Silveira are not provided because only one mother/calf pair was included in this analysis.

**Table 13** - Theodolite data collected on non-whalewatching days, by observation site, in the central-southern coast of Santa Catarina State, Southern Brazil, from October to November 2002:

TOTAL TRACK	Duration (hh:mm:ss)	#Fix Points	No. of mother/calf pairs tracked*	Days of observation
<b>Silveira</b>	6:24:21	271	8	3
<b>Ibiraquera</b>	19:10:03	614	43	10
<b>TOTAL</b>	<b>25:34:24</b>	<b>885</b>	<b>51</b>	<b>13</b>

\*Includes possible double counting.

**Table 14** - Mean rates of theodolite tracking data obtained while following mother/calf pairs on non-whalewatching days, by observation site, in the central-southern coast of Santa Catarina State, Southern Brazil, from October to November 2002:

	Mother/calf pairs	
TOTAL TRACK	Duration (h:mm:ss)	Fix points/min
<b>a) Silveira</b>		
Mean	2:05:03	0.45
SD	1:17:22	0.14
Maximum	3:21:43	---
Minimum	0:43:17	---
<i>Total no. of fix points</i>	<b>258</b>	---
<b>b) Ibiraquera</b>		
Mean	1:09:14	0.24
SD	0:46:39	0.29
Maximum	3:22:42	---
Minimum	0:01:49	---
<i>Total no. of fix points</i>	<b>529</b>	---

**Table 15** - Mean values for swimming speed, linearity and reorientation rates of right whales mother/calf pairs tracked in each bay during non-whalewatching days, in the central-southern coast of Santa Catarina State, Southern Brazil, from October to November 2002:

Observation Site	Swimming Speed		Linearity		Reorientation Rate (degrees/min)	
	Mean	SD	Mean	SD	Mean	SD
Silveira	0.98	0.87	0.17	0.12	28.58	10.38
Ibiraquera	1.32	1.33	0.57	0.31	10.50	11.31

**Table 16** - Behavioral states of mother/calf pairs tracked in no-whalewatching days in Silveira and Ibiraquera, during the monitoring of whalewatching activities in the central-southern coast of Santa Catarina State, Southern Brazil, from October to November 2002.

	Silveira		Ibiraquera	
	Mean time spent (%)	SD	Mean time spent (%)	SD
<b>Travel</b>	46.17	32.48	83.33	11.00
<b>Play</b>	12.21	17.33	16.67	11.00
<b>Rest</b>	41.63	41.23	0.00	0.00

**Table 17** - Sighting history of individually identified mother/calf pairs tracked while monitoring right whales on whalewatching and non-whalewatching days in the central-southern coast of Santa Catarina State, Southern Brazil, from August to October 2002.

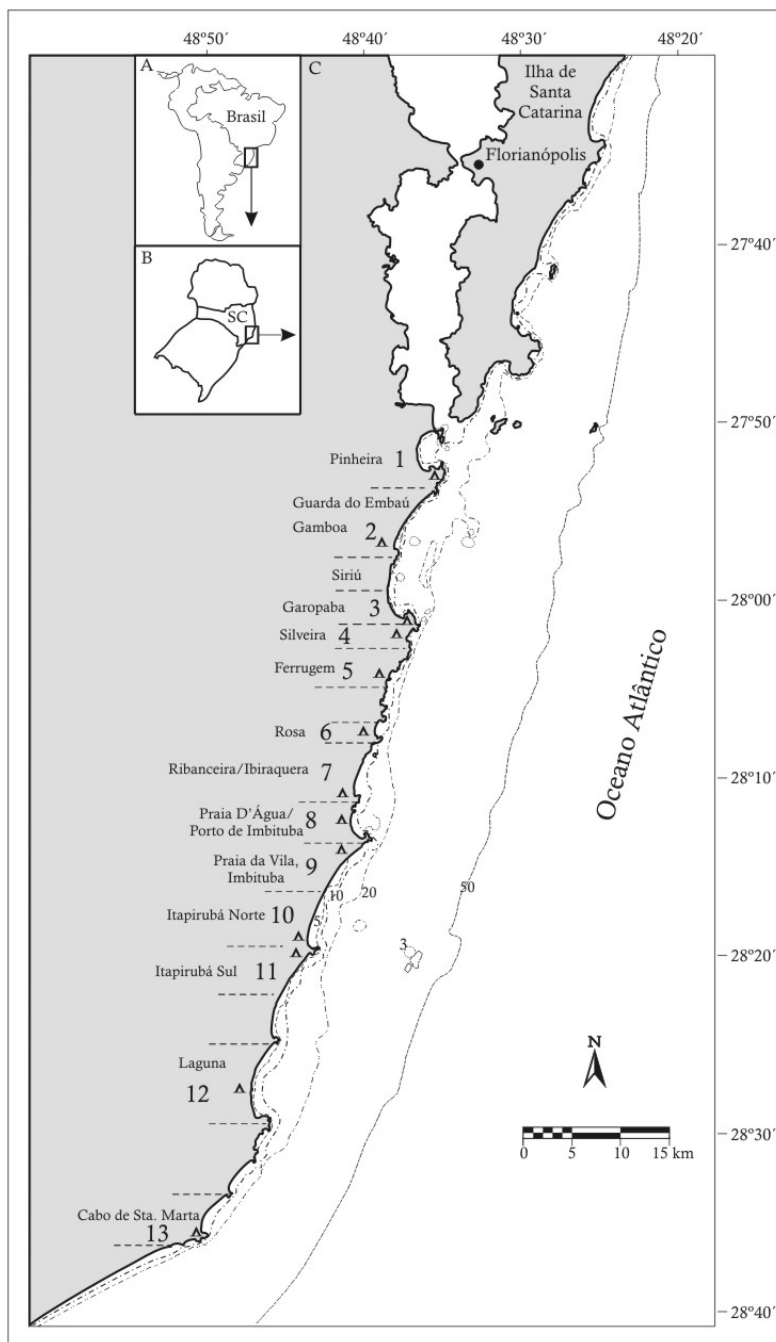
Mother/ calf pair	Date of first sighting	Date of last sighting	Observation sites in which the pair was sighted	No. of follows		Total Time of tracking (hours)		Period between first and last sighting (days)
				whalewatch . days	non- whalewatch days	whalewatch. days	non- whalewate h days	
<b>Tno. 01*</b>	18/08/02	26/10/02	Gamboa Garopaba Silveira Ibiraquera	01 03 - 04	- - 02 02	17.5	4.1	69
<b>Tno. 02*</b>	24/09/02	28/10/02	Ibiraquera Praia da Vila	01	03 01	2.2	3.2	33
<b>Tno. 03*</b>	14/10/02	28/10/02	Ibiraquera	03	05	10.7	6.9	25

\* Mother/calf pairs identified during aerial surveys.

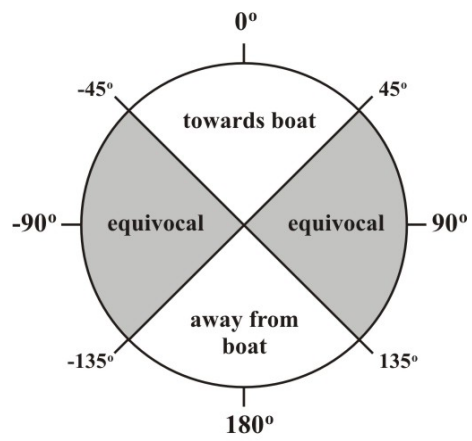
**Table 18** - Mean swimming speed, linearity and reorientation rates of individually identified mother/calf pairs tracked while monitoring right whales on whalewatching and non-whalewatching days in the central-southern coast of Santa Catarina State, Southern Brazil, from August to October 2002.

Mother/calf pair	Mean swimming speed		Linearity		Reorientation Rate	
	Whalewatching days	Non-whalewatching days	Whalewatching days	Non-whalewatching days	Whalewatching days	Non-whalewatching days
<b>Tno. 01*</b>	2.21±0.72	0.85±0.2	0.44±0.34	0.21±0.13	14.42±9.65	22.46±5.66
<b>Tno. 02*</b>	0.85±0.19	0.77±0.31	0.61	0.53±0.57	6.49	9.26±6.26
<b>Tno. 03*</b>	1.70±1.05	0.89±0.55	0.55 ± 0.13	0.39 ± 0.39	15.50 ± 6.14	7.78±3.56

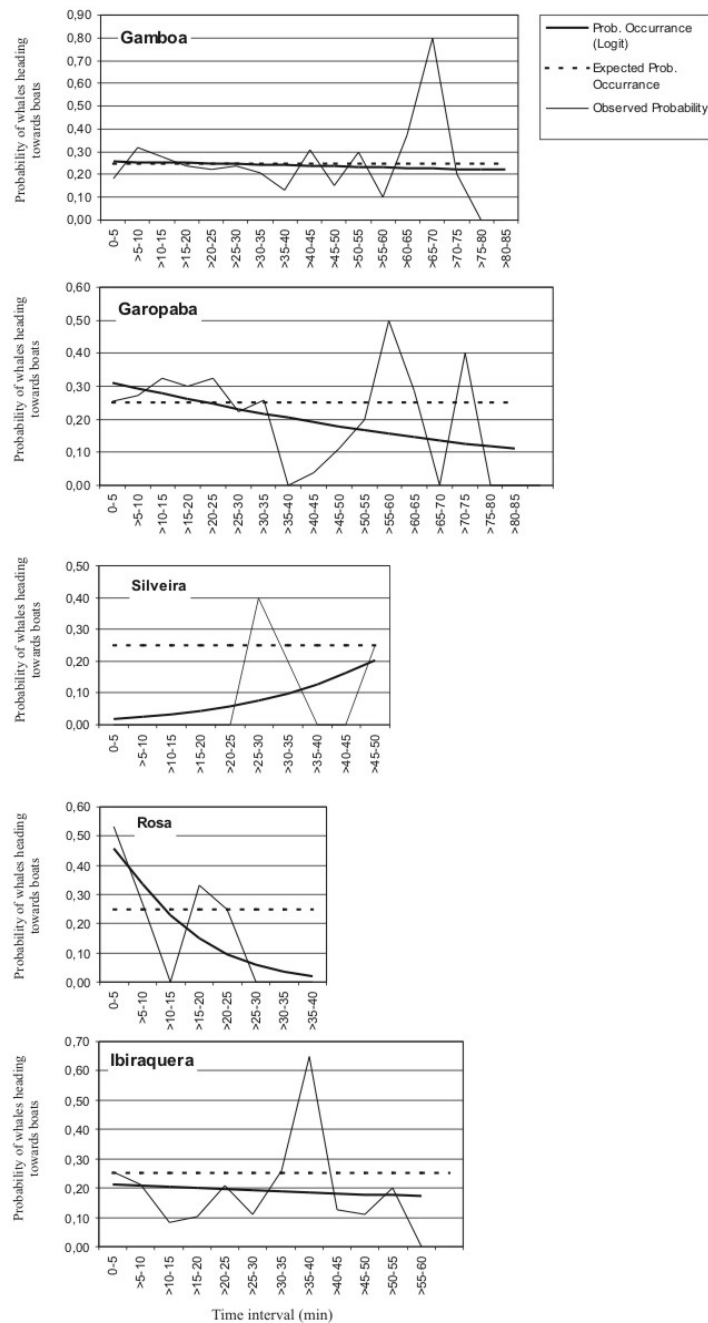
\* Mother/calf pairs identified during aerial surveys.



**Figure 1** – Map of the study area. A, South America; B, Santa Catarina State, Brazil; C, South of Santa Catarina State. Triangles indicate observation sites.

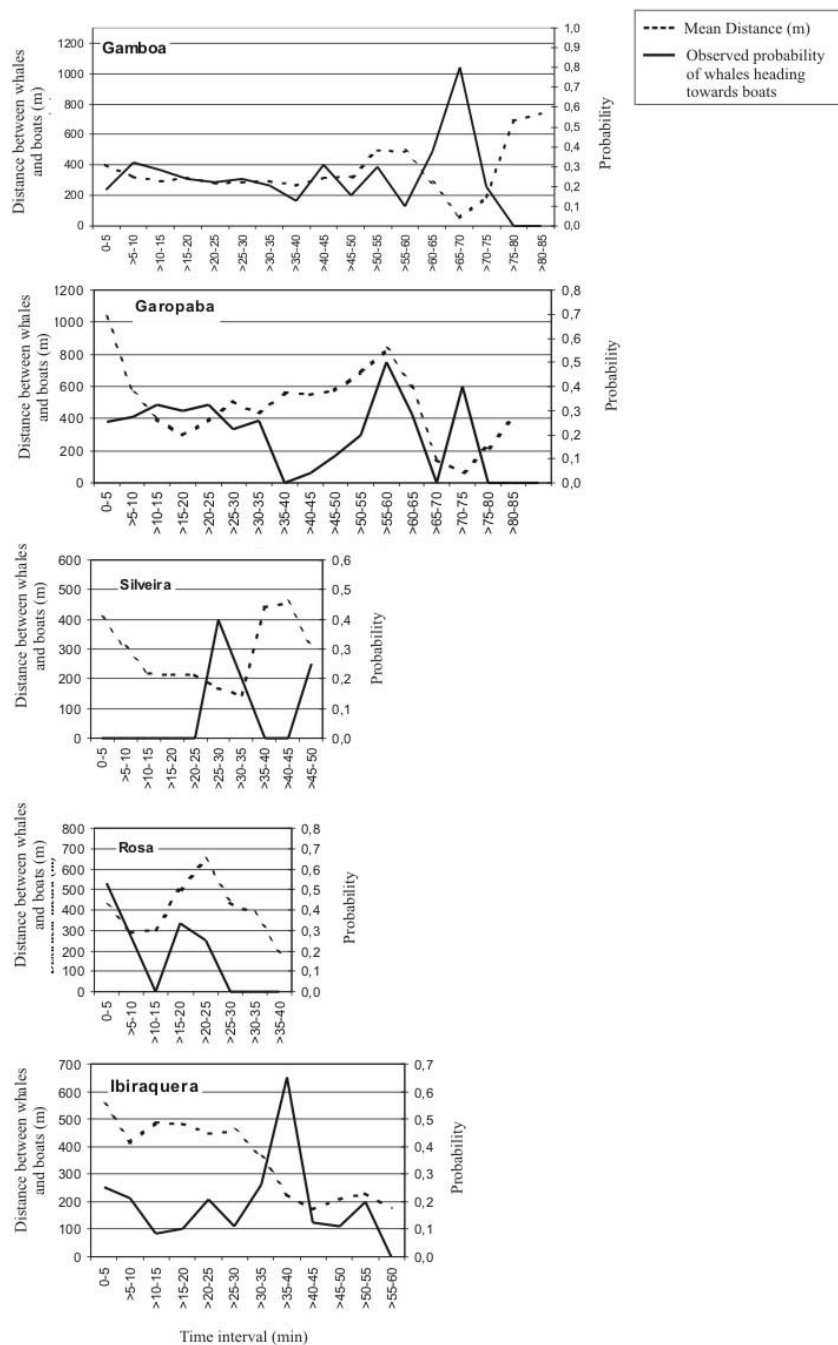


**Figure 2** - Classification of whale/boat orientation (according to Bejder *et al.*, 1999).

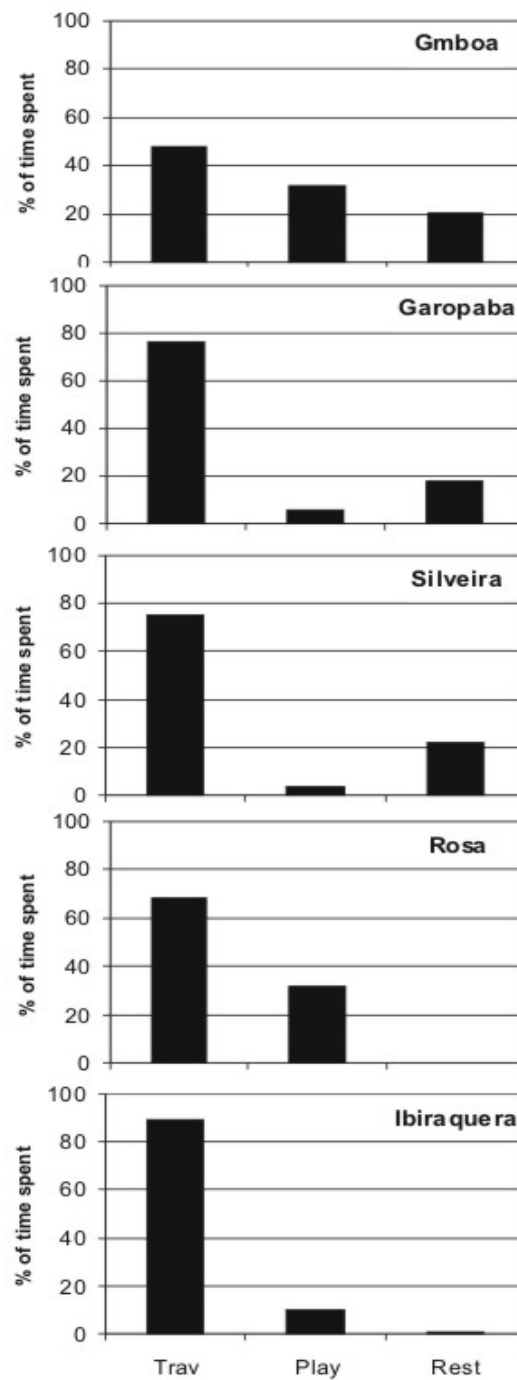


**Figure 3** – Probability of mother/calf pairs traveling towards the whalewatching boats as a function of the time of the encounter during the monitoring of whalewatching activities in the central-southern coast of Santa Catarina State, Southern Brazil, from July to October 2002.





**Figure 4** – Mean distances between mother/calf pairs and boats observed during the monitoring of whalewatching activities in the central-southern coast of Santa Catarina State, Southern Brazil, from July to October 2002.



**Figure 5** - Behavioral states of mother/calf pairs tracked in whalewatching days during the monitoring of whalewatching activities in the central-southern coast of Santa Catarina State, Southern Brazil, from July to October 2002.

## CONSIDERAÇÕES FINAIS

O litoral centro-sul de Santa Catarina e o norte do Rio Grande do Sul é uma importante área de concentração durante os meses de inverno e primavera para as baleias francas austrais, *Eubalaena australis*, que consistem no período reprodutivo desta espécie. A distribuição nesta região, no entanto, não é uniforme indicando a ocorrência de algumas áreas específicas de maior relevância. A maioria das avistagens registradas durante os sobrevôos consistiram de pares de fêmeas com filhotes, caracterizando esta área como um importante berçário, confirmando estudos anteriores (Simões-Lopes *et al.* 1992; Palazzo and Flores 1996, 1998; International Wildlife Coalition/Brazil 1999). Apesar de grupos de até oito indivíduos terem sido avistados, associações de diversos indivíduos em áreas de reprodução não são comuns (Payne 1986; Bannister 1990; Best 1990; Patenaude and Baker 2001; Best *et al.* 2003), excetuando-se associações temporárias de grupos envolvidos em atividades social ou sexual (Donnelly 1967; Payne *et al.* 1983; Best *et al.* 2003).

Apesar do esforço amostral variado ao longo dos anos, alguns padrões de distribuição podem ser identificados. A distribuição das fêmeas com filhotes e dos adultos não-acompanhados está sobreposta até certo ponto, mas uma área principal de concentração pode ser identificada especialmente no que se refere às fêmeas com filhotes, nos ‘bins’(unidades de 12 minutos de latitude) localizados mais ao norte. Essa área coincide com a área de concentração previamente reconhecida em estudos anteriores (Simões-Lopes *et al.* 1992; Palazzo and Flores 1996, 1998; International Wildlife Coalition/Brazil 1999).

Duas grandes áreas de concentração com distintas características geográficas foram identificadas. Nestas áreas, há ocorrência distinta de pares de fêmeas com filhotes e indivíduos não-acompanhados, indicando a existência de uma segregação geográfica mais ao norte dos pares de fêmeas com filhotes, conforme observado em estudos anteriores (Palazzo and Flores 1998; International Wildlife Coalition/Brazil 1999). Durante este estudo não foi

possível, porém, definir a região de maior ocorrência de indivíduos não-acompanhados como área de acasalamento, devido aos indivíduos não terem sido sexados. Porém o comportamento observado de alguns grupos indica essa possibilidade.

A frequência de avistagens ao longo dos meses de inverno e primavera indica que as baleias francas começam a chegar na área de estudo em julho, aumentando em número e atingindo um pico em setembro, e declinando rapidamente em outubro e novembro. Fêmeas com filhotes tendem a permanecer períodos mais longos em áreas de reprodução no inverno do que os indivíduos não-acompanhados (Payne 1986; Bannister 1990; Burnell and Bryden 1997; Best 2000; Rowntree *et al.* 2001), podendo permanecer na área de estudo em torno de 30 dias ou mais, coincidindo com informações anteriores (Palazzo *et al.* 1999; Groch 2000; Groch *et al.* 2003). As fêmeas com filhotes apresentam menos movimentos ao longo da costa do que indivíduos não-acompanhados enquanto que estes parecem apresentar um menor grau de fidelidade de área. Ao contrário do que ocorre em outras áreas de concentração reprodutiva como a Península Valdés, na Argentina (Rowntree *et al.* 2001), o litoral sul do Brasil não parece ser tão importante para indivíduos subadultos e filhotes de um ano.

Os baixos valores de velocidade de natação observados para os indivíduos avistados em dois dias consecutivos, quando comparados com observações a partir de terra, bem como valores obtidos em outras áreas, indicam que pelo menos alguns indivíduos demonstram fidelidade a algumas áreas em particular, ainda que por curtos períodos de tempo, mesmo que potencialmente perturbados, por exemplo, durante os sobrevôos.

Aparentemente a região mais ao sul da distribuição observada é utilizada como área de trânsito para a região mais ao norte no início da temporada, e mais ao sul final. Apesar do pequeno número de baleias reavistadas interanualmente no Brasil, estas demonstraram algum nível de fidelidade, especialmente à principal área de concentração, onde as características da costa condizem com o habitat preferido desta espécie no inverno e primavera.

O índice de reavistagem interanual das baleias francas identificadas no sul do Brasil demonstra que as mesmas não são de ocorrência esporádica, e principalmente as fêmeas retornam à região para o nascimento e cuidados com os filhotes. O intervalo modal entre filhotes é de três anos, o que é consistente com o sucesso reprodutivo da espécie.

O número de baleias francas que frequenta o sul do Brasil parece estar crescendo no Brasil a uma taxa de 14% ao ano, quando considerado todo o período de

estudo, e de 29,8% nos últimos sete anos de estudo (Groch *et al.* 2005). Ambas as taxas estão acima dos níveis considerados biologicamente realísticos de crescimento natural para a espécie até o presente momento (Best *et al.*, 2001). É pouco provável que este crescimento seja resultado da taxa reprodutiva das baleias avistadas no Brasil nos primeiros anos de estudo, devido à provável idade da primeira reprodução de 8 a 9 anos (Best *et al.*, 2001; Cooke *et al.*, 2001) Possivelmente esse crescimento se deva à imigração de outras áreas de concentração reprodutiva como a Argentina, visto a existência de indivíduos reavistados em ambas a áreas em anos diferentes (Best *et al.*, 1993).

O número estimado de baleias francas que freqüenta o sul do Brasil pode ser de até 555 baleias. Este número pode ser considerado mais realista do que a estimativa realizada em 1997, pois reflete o aumento populacional observado recentemente, porém deve ser tratado com cautela, pois não incorpora parâmetros como mortalidade e imigração.

Se o número de baleias francas continuar a aumentar, pode-se esperar que as baleias francas reocupem 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.

As observações focais do comportamento das baleias francas em relação às aproximações de embarcações de turismo em 2002 mostraram que algumas baleias aparentam ignorar a presença das embarcações e não alteram o seu comportamento. Não foram observadas evidências claras de distúrbio imediato às baleias francas, sugerindo que as atividades de ‘whalewatching’ podem continuar na área de estudo se conduzidas segundo a legislação brasileira. Pequenas alterações no comportamento foram observadas em algumas ocasiões em que as baleias foram observadas nadando em direção às embarcações, mas após um período de interesse, as baleias se afastaram e restabeleceram suas atividades prévias. As baleias francas podem não reagir às aproximações de embarcações por várias razões, podendo às vezes simplesmente estar indiferentes à presença de uma embarcação. Esse comportamento pode ser resultante de vários aspectos, inclusive da propagação de som nas enseadas resultante da entrada das embarcações nas mesmas. Porém não se sabe se o estímulo para determinado comportamento deve-se à presença da embarcação ou ao som gerado embaixo d’água, ou à combinação dos dois agentes.

Apesar do considerável potencial econômico e educativo das atividades de “whalewatching”, há grande preocupação sobre os possíveis impactos desta atividade nas populações de cetáceos. Existem diversas técnicas de avaliação destes impactos a curto e a longo prazo, em diferentes níveis de eficácia e a partir de diferentes plataformas de pesquisa

(IFAW, Tethys Research Institute and Europe Conservation, 1995). Apesar disso, a maioria dos estudos de impacto realizados até hoje, que demonstraram alterações comportamentais, não deixam claro o significado biológico de efeitos a longo prazo nas populações estudadas (Richter *et al.*, 2000). Dada a importância e o potencial crescimento do turismo de observação de baleias, principalmente em Santa Catarina, torna-se imprescindível a continuidade de estudos a longo prazo visando documentar possíveis efeitos das atividades embarcadas sobre as baleias francas, para o apropriado manejo da espécie na área de estudo.

Não se sabe ao certo quais os fatores que determinam a presença e distribuição das baleias francas no sul do Brasil, porém reavistagens na Península Valdés de indivíduos fotografados no Brasil (Best *et al.* 1993; Groch, dados não publicados) indicam algum grau de flexibilidade no uso de habitat por esta população. É provável que algumas áreas tenham maior importância para os pares de fêmeas com filhotes que para os indivíduos não-acompanhados, porém somente estudos a longo prazo permitirão um melhor entendimento dessa característica. A flexibilidade e a extensão dos movimentos demonstrados pelas fêmeas com filhotes em algumas áreas de concentração reprodutiva no inverno são sinais encorajadores do crescimento da população e da expansão para áreas históricas de distribuição.

Informações derivadas de rastreamento utilizando-se teodolitos se combinadas com outras técnicas como estudos de longo prazo de foto-identificação individual podem ajudar a esclarecer, de uma perspectiva de manejo, as necessidades envolvendo as atividades como a de 'whalewatching' que possam fazer parte de uma avaliação mais abrangente dos possíveis distúrbios, como por exemplo pesca e tráfego de embarcações, na principal área de concentração reprodutiva da espécie no Brasil. Portanto, a coleta sistemática de informações mais aprofundadas sobre outras atividades humanas relacionadas às baleias francas deve ser feita de forma intensiva de modo que pesquisadores e administradores possam avaliar adequadamente o estado de conservação da espécie e propor medidas de manejo para as populações alvo.

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