SILVANA DE SANFILLI BOTTINI

DISTRIBUIÇÃO ESPACIAL E PADRÕES DE MOVIMENTO DA BALEIA-FRANCA-AUSTRAL (*Eubalaena australis*) EM TORRES, RIO GRANDE DO SUL, BRASIL

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SUMÁRIO

CAPÍTULO I

Introdução Geral

RESUMO

Os cetáceos, como a maioria dos organismos vivos, não estão aleatoriamente distribuídos no ambiente onde vivem. Conhecer aspectos fundamentais de sua ecologia, como a relação entre uma espécie e seu ambiente, são fundamentais para a elaboração de ações de conservação. A baleia-franca-austral frequenta a costa brasileira durante a estação reprodutiva, de Junho a Novembro e, apesar de bem estudada na costa catarinense, sua distribuição e relação com fatores ambientais não foi descrita para o Rio Grande do Sul. O propósito deste estudo foi contribuir para a construção do conhecimento fundamental a respeito da espécie caracterizando sua distribuição em um ponto da costa deste estado, relacionando sua presença com as variáveis ambientais. As observações foram realizadas a partir de um ponto fixo na costa, o Morro do Farol em Torres, Rio Grande do Sul, localizado a 41,5 metros acima do nível do mar. Posições sucessivas dos animais foram obtidas com o auxílio de um teodolito eletrônico a fim de descrever as trajetórias percorridas por cada grupo dentro do limite da área de estudo. A direção e velocidade do vento, temperatura e estado do mar eram coletadas a cada hora durante as observações. Um total de 41 grupos foi observado, ao longo de 256,5 horas de esforço realizado com 44,5 horas de acompanhamento animal. A maior parte das ocorrências (85%) foi de pares de fêmeas com filhotes e a maior concentração de baleias ocorreu em águas com profundidade menor do que 5 metros. A direção do vento e o estado do mar apresentaram influência significativa na presença ou ausência dos animais (p=0,0001 e p=0,024), sendo nos ventos de sul e sudeste a ausência de animais maior do que esperada e nos estados do mar 3 e 4 os animais foram menos detectados do que o esperado. Quando analisada pela composição de grupo, a direção do vento e o estado do mar não demonstraram diferença significativa (p=0,861 e p=0,372), respectivamente. A velocidade do vento não demonstrou exercer influência na presença ou ausência dos animais para todas as categorias (p=0,632), nem para composições de grupos diferentes (p=0,984). É importante salientar que as observações ocorreram com velocidades de vento <20 nós (Beaufort ≤ 4). A média de velocidade de natação para todas as categorias foi de 1,50 km/h (DP ± 1,15km/h), para fêmeas com filhotes 1,53 km/h (DP ± 1,14 km/h) e para adultos desacompanhados 1,7 km/h (DP ± 1,08km/h). A maioria dos grupos apresentou movimento em direção sul (63%) e a distância média da costa foi de 515,28 m (amplitude 87,9 – 1.971,6 m). Os resultados deste trabalho corroboram a preferência por águas rasas, próximas à costa bem como reforça o fato de que as baleias evitam águas turbulentas como ocorre em outras regiões. As observações ainda demonstram que a costa do Rio Grande do Sul é um importante sítio reprodutivo para a espécie, podendo ser considerada uma área berçário, onde predominam pares de fêmeas com filhotes (85% dos grupos observados). Estes fatos reforçam a importância e urgência de ações de conservação e manejo das atividades humanas na região para que a espécie continue crescendo e retomando sua área de ocupação histórica.

INTRODUÇÃO GERAL

Cetáceos são encontrados em quase todos os diferentes ambientes marinhos e sua distribuição pode ser afetada por fatores demográficos, evolutivos, ecológicos, influência antrópica e aspectos relacionados ao habitat. Dentre os fatores demográficos estão abundância, idade, estrutura sexual da população, status reprodutivo e ciclo de vida dos indivíduos. Fatores evolutivos incluem aspectos morfológicos, fisiológicos e comportamentais de adaptação da espécie. Fatores ecológicos dizem respeito à produtividade biológica, distribuição de presas, predadores e competidores. Temperatura da água, salinidade, densidade, profundidade da termoclina, tipo de substrato e batimetria estão entre os fatores relacionados ao habitat. Alterações no ambiente causadas pela ação humana são capazes de alterar a distribuição dos mamíferos marinhos, através da poluição, emissão de sons subaquáticos, degradação do ambiente, capturas acidentais, colisões com embarcações e também pelo aquecimento global (Forcada, 2002). O impacto do tráfego de embarcações talvez seja a atividade humana mais bem documentada, e pode causar sérias alterações no comportamento de uma população, como o abandono temporário ou definitivo de alguma região em particular, e, em último estágio, um hiato de distribuição (Rowntree *et al.*, 2001; Acevedo-Gutiérrez, 2002; Cartwright *et al.*, 2012).

Entre os cetáceos, os misticetos, também chamados de baleias verdadeiras ou de cerdas, são exemplos de espécies migratórias que têm, portanto, sua distribuição alterada também sazonalmente. A migração destes animais consiste em um movimento repetido e de longa distância, em que alternam suas áreas de vida entre áreas de reprodução em águas tropicais de baixas latitudes e áreas de alimentação em altas latitudes (Cummings, 1985; Corkeron & Connor, 1999; Forcada, 2002; Stern, 2002). Três razões têm sido utilizadas para tentar explicar o motivo pelo qual os misticetos migram. A primeira seria a tentativa de minimizar o stress termal dos filhotes, mas segundo Stern 2002, é um argumento pouco eficaz, pois, mamíferos de tamanho corporal menor estão adaptados a nascer e viver em tais condições, e devido ao grande tamanho dos filhotes, baleias não seriam tão afetadas pela diferença de temperatura (Stern, 2002). Por outro lado, filhotes têm maior razão entre volume e superfície e teoricamente perdem calor mais rápido do que adultos (Brodie, 1975). A segunda razão seria evitar a presença de predadores (Leduc, 2002; Kenney, 2002). Logo após o nascimento, fêmea e filhote estão mais vulneráveis e, em águas mais quentes a presença de predadores de grande porte é menor, reduzindo a mortalidade por esta causa. A última razão tem fundo evolutivo, a herança genética: indivíduos migram porque seus ancestrais migravam. A seleção natural teria favorecido os animais que obtiveram sucesso em migrar, se alimentar, reproduzir e responder às mudanças nas condições ambientais (Stern, 2002). Esta hipótese não tem muito suporte, pois animais de espécies migratórias, não o fazem todos os anos (Corkeron & Connor, 1999). Estes autores sugerem que evitar a predação de *Orcinus orca* seja a principal pressão seletiva favorecendo o comportamento migratório. Por outro lado, Clapham (2001), considera precipitada esta conclusão e o descarte da hipótese energética, estudos de longo prazo realizados com a população de baleias-jubartes (*Megaptera novaeangliae*) no hemisfério norte revelam que tal predação seria nada mais que ocasional para as Orcas, não representando uma força evolutiva capaz de direcionar o comportamento. Este e outros autores reforçam que a economia de energia pelo filhote pode ser direcionada em crescimento (Whitehead & Moore, 1982; Clapham, 2001) e o desenvolvimento do filhote nestas águas levaria a um adulto de maior tamanho e um maior sucesso reprodutivo, e este sim, poderia ser o fator selecionando o comportamento (Clapham, 2001; Rasmussen *et al.*, 2007).

O modo como uma espécie se relaciona com o ambiente é um dos fatores que definem a base de sua ecologia, conhecer e identificar relações é fundamental para a efetividade de estratégias de manejo e conservação, pois permite fazer inferências e previsões sobre sua distribuição e abundância (Ballance, 2002). A íntima associação entre os organismos e seus ambientes através do tempo evolutivo é a base para a especialização ecológica e para os limites resultantes das distribuições de organismos e populações (Ricklefs, 2011). Estudos de uso de habitat visam descrever, explicar e prever a distribuição e abundância dos organismos. Para tal, é fundamental identificar quais são estes fatores e com que intensidade eles atuam, em diferentes escalas espaciais e temporais (Smultea, 1994; Acevedo-Gutiérrez, 2002; Clapham *et al.*, 2004). Para a maioria das espécies, pouco se sabe a respeito de que fatores bióticos e abióticos fazem com que sejam encontradas em certos locais e outros não (Jefferson *et al.*, 2008). Variáveis relacionadas com produtividade e, consequentemente disponibilidade de alimento tem grande influência na distribuição de cetáceos. Porém, devido ao comportamento migratório das baleias, faz-se necessário avaliar separadamente as variáveis que influenciam a distribuição entre áreas de reprodução e alimentação.

Variáveis ambientais

Estudos relacionando a presença de misticetos com características físicas do ambiente em suas áreas de reprodução têm demonstrado que fêmeas de baleias-jubartes e de baleias-francas (*Eubalaena* sp.) acompanhadas de filhotes, em geral, ocupam águas mais rasas que adultos desacompanhados (Payne, 1986; Smultea, 1994; Groch, 2000; Martins *et al.*, 2001; Ersts & Rosenbaum, 2003; Bisi, 2006;). Elwen & Best (2004a, 2004b) realizaram um intenso estudo com baleias-francas na costa da África do Sul, onde ficou demonstrado que fêmeas acompanhadas de filhotes são encontradas com maior frequência em águas rasas, protegidas de ventos e ondulações e com fundo arenoso. O principal benefício citado por estes autores seria a conservação de energia para lactação e crescimento (Elwen & Best, 2004a, 2004b; Elwen & Best, 2004c). Rasmussen *et al.* (2007) afirmam que baleias-jubartes são encontradas em águas amenas em suas áreas de reprodução em todo o globo, independentemente da latitude, suportando a hipótese de conservação de energia como motivo da migração.

Mudanças drásticas na topografia de fundo que seguiram fortes tempestades na Argentina parecem ter sido o motivo pelo qual as baleias-francas-austrais (*Eubalaena australis*) abandonaram a região externa da costa da Península Valdés (Rowntree *et al.*, 2001). Neste estudo, a autora confirma a plasticidade da espécie com relação aos fatores determinantes na escolha do habitat. O comportamento de fêmeas e filhotes foi muito bem estudado nesta região, demonstrando a importância dos estágios iniciais para o desenvolvimento de habilidades motoras e sociais dos filhotes (Taber & Thomas, 1982; Thomas & Taber, 1984). Neste contexto, a comunicação entre fêmea e filhote pode ser beneficiada na presença em águas mais quentes. A velocidade do som na água é 4,5 vezes maior que no ar e diretamente proporcional à temperatura, salinidade e pressão. A elevação de 1°C na temperatura aumenta a velocidade do som em 4 m/s. (Schmiegelow, 2004). Esta característica pode ter efeito importante nesta fase inicial de aprendizado, facilitando a comunicação e encontro entre os pares.

A temperatura superficial do mar (TSM) está intimamente relacionada à latitude, pois regiões equatoriais recebem de 1,5 a 2 vezes mais calor do que regiões polares, devido ao maior ângulo de incidência dos raios solares, causando a formação de linhas de mesma temperatura, chamadas isotermas (Schmiegelow, 2004). Estas linhas podem ter seus limites alterados devido aos movimentos das correntes marinhas e fenômenos meteorológicos como El Niño e La Niña. A TSM é normalmente relacionada à produtividade primária de uma região e, consequentemente, às áreas de alimentação de baleias migratórias. Uma avaliação em uma área de reprodução na costa dos Estados Unidos, demonstrou que a TSM desempenha um importante papel na distribuição de *Eubalaena glacialis* (Keller *et al.*, 2006), sendo a Corrente do Golfo, que traz águas quentes para a costa norte americana, o fator limitante neste aspecto.

A baleia-franca-austral (*Eubalaena australis*)

As baleias-francas pertencem à ordem Cetartiodactyla, à superfamília Mysticeti e à família Balaenidae. A família Balaenidae possui dois gêneros: *Eubalaena,* representado pelas baleias-francas e *Balaena,* monoespecífico, representado pela baleia da Groenlândia, ou "Bowhead" (*Balaena mysticetus*). Análises morfológicas (Churchill *et al.*, 2012) e moleculares (Rosenbaum *et al.*, 2000; Gaines *et al.*, 2005) suportam a existência de três espécies de baleias-francas: *Eubalaena australis* (Desmoulins, 1822), *Eubalaena glacialis* (Müller, 1766) e *Eubalaena japonica* (Lacépède, 1818), que habitam o Hemisfério Sul, Oceano Atlântico Norte e Oceano Pacífico Norte, respectivamente.

A baleia-franca-austral, *E. australis*, habita regiões entre 20°S e 60°S de latitude, alternando entre áreas de alimentação e de reprodução. Nas áreas de reprodução, são observadas de Junho a Novembro (Cummings, 1985), permanecendo nas áreas de alimentação de Dezembro a Maio, quando recomeçam a viagem às baixas latitudes. A localização das áreas de alimentação ainda é incerta, porém, já foram registradas perto das Ilhas Geórgia do Sul, sul da Austrália e Península Antártica (Kenney, 2002). São reconhecidas quatro principais concentrações reprodutivas no hemisfério sul: América do Sul, África do Sul, Austrália e região subantártica da Nova Zelândia (IWC, 2001).

Comparando o DNA mitocondrial das populações do leste e oeste do Atlântico Sul (Argentina e África do Sul), Rowntree *et al.* (2001) encontraram restrito fluxo gênico, considerando as duas populações como distintas, para fins de manejo e conservação. O comitê científico da Comissão Internacional Baleeira (*International*

Whaling Commission – IWC, em inglês) concordou em 2001 que as baleias-francas da Argentina e África do Sul representam diferentes estoques populacionais e devem ser consideradas duas unidades de manejo. O mesmo foi descrito para as populações da Austrália e Nova Zelândia, sendo considerados também dois estoques distintos (IWC, 2001). Na América do Sul, a principal e talvez mais estudada, área de concentração reprodutiva, localiza-se na região da Península Valdés, Argentina. Nesta região, estudos moleculares (Ott, 2002) e de foto-identificação (Rowntree *et al.*, 2001) demonstram o intercâmbio existente entre estes indivíduos e os encontrados na costa do Brasil.

Situação populacional de *Eubalaena australis*

As baleias-francas foram o grande alvo da caça comercial durante os séculos XVIII a XX e suas populações foram seriamente diminuídas, chegando próximo à extinção (Cummings, 1985). Eram consideradas as baleias "certas", por isso o nome popular *Right Whale* (em inglês), pois seu comportamento de natação lenta, permanecendo muito tempo na superfície, as tornava alvo fácil, a partir das pequenas embarcações utilizadas no começo da caça comercial. Além de renderem grandes quantidades de gordura, principal produto extraído destes animais na época, seu corpo permanecia boiando na superfície, permitindo que caçassem maior número de baleias por vez. Com o aprimoramento das técnicas de caça, como os navios-fábrica, que possibilitavam maior tempo de permanência no mar, alcançavam maiores distâncias e permitiam o processamento da carne e subprodutos à bordo, a caça de grandes cetáceos foi tomando conta do globo terrestre. Todas as espécies de baleias passaram a ser alvo, mas o dano causado às populações de baleias-francas pode ser irreversível. Estima-se que a população original de baleias-francas-austrais no mundo todo, antes da caça, superasse 100 mil indivíduos e hoje esteja reduzida a pouco mais de 10%, com aproximadamente 13 mil animais (IWC, 2013). As populações de *E. australis* têm demonstrado sinais de recuperação entre 7 e 8% (IWC, 2001), mas as duas espécies do hemisfério norte são as grandes baleias mais ameaçadas atualmente (Kenney, 2002) e, apesar dos esforços de pesquisa e ações de conservação, a população de *E. glacialis* não vem demonstrando recuperação e a estimativa é de que restem apenas cerca de 400 indivíduos (IWC, 2013). Estudos recentes realizados em Santa Catarina mostram que a população de *E. australis* que frequenta a área de concentração reprodutiva do sul do

Brasil vem se recuperando (Santos *et al.*, 2001), a uma taxa de 12% ao ano, de 1987 a 2010 (IWC, 2013).

A União Internacional para a Conservação da Natureza (IUCN, em inglês) classifica *E. australis* como "LC" (*least concern* em inglês), menos preocupante. A espécie consta também no apêndice I do CITES, como "*lower risk - conservation dependent*", ou seja, de baixo risco, mas dependente de conservação. A proibição da caça comercial aos cetáceos no Brasil só ocorreu em 1987 (Lei Federal n° 7643, de 18 de Dezembro de 1987) e, desde 1989, a espécie consta na Lista Brasileira de Espécies Ameaçadas (Portaria IBAMA n° 1522, de 19 de Dezembro de 1989). Na Lista Oficial das Espécies da Fauna Brasileira Ameaçadas de Extinção, em vigor desde 2003 (MMA, 2003), *E. australis* consta como espécie Em Perigo. Na Lista da Fauna Silvestre Ameaçada de Extinção do Rio Grande do Sul, *E. australis* consta como Vulnerável (Decreto n°51.797 de 8 de Setembro de 2014).

Ameaças atuais

Entre as principais ameaças para a recuperação das populações de baleias-francas estão a poluição do ambiente por contaminação química ou perturbações sonoras, o emalhamento em redes de pesca, a colisão com embarcações e a perda de habitat (IWC, 2001; Greig *et al.*, 2001).

Como ressaltado por Smultea (1994), o aumento no número de indivíduos pode causar um aumento no risco de colisões com embarcações, principalmente devido à sobreposição das áreas de uso dos animais e das embarcações, próximo à costa, gerando maior conflito. Diante destas constatações, é questão fundamental para a conservação das populações e manutenção das taxas de crescimento, um mapeamento detalhado das áreas de uso, para posterior regulamentação das atividades humanas.

Uma tentativa de minimizar estes impactos é a criação de áreas marinhas protegidas (AMP's), unidades de conservação que têm por finalidade reduzir e fiscalizar as atividades humanas, com intuito de proteger espécies e ambientes marinhos como um todo, preservando sua biodiversidade. Neste sentido, as grandes baleias têm sido citadas como espécies bandeira e guarda-chuva (Hoyt, 2002), pois despertam carisma na população humana e utilizam grandes extensões marinhas e, protegendo seu hábitat, inúmeras outras espécies são protegidas também.

A COP 10, Conferência entre as Partes (Nagoya, 2010) aprovou, como parte de seu novo Plano Estratégico 2011-2020, um conjunto de 20 metas, das quais se destaca, para a zona costeira e marinha, o estabelecimento, de 10% de áreas marinhas protegidas, principalmente as áreas de particular importância para a biodiversidade e para a manutenção dos serviços ambientais. A meta nacional de conservação da biodiversidade para a Zona Costeira e Marinha – fixada pela Resolução nº 03/2006, do Conselho Nacional de Biodiversidade (Conabio), estabeleceu um mínimo de 10% da área dos ecossistemas efetivamente protegidos por meio de unidades de conservação. Atualmente, as unidades de conservação no ecossistema marinho brasileiro perfazem 1,57% da área do bioma (ICMBio, 2014). Conforme Decreto nº 5.092, de 21 de maio de 2004, e Portaria MMA nº 9, de 23 de janeiro de 2007 a região costeira do Rio Grande do Sul consta como "extremamente alta" prioridade, na avaliação de áreas Prioritárias para a conservação da biodiversidade na zona costeira e marinha. No Plano de Ação Nacional para Conservação dos Mamíferos Aquáticos - Grandes Cetáceos e Pinípedes (ICMBio, 2011), entre as ações prioritárias para a conservação da espécie estão a ampliação de conhecimento sobre movimentos e rotas migratórias, bem como a influência de fatores ambientais na dinâmica populacional, nas áreas de reprodução e alimentação da espécie.

A costa de dois estados da região sul (Santa Catarina e Rio Grande do Sul) é reconhecida como área de reprodução das baleias-francas no Brasil (Simões-Lopes *et al.*, 1988), importantes estudos foram realizados na costa catarinense (Groch, 2000, 2005; Danielski, 2008) gerando grande quantidade de informação sobre a espécie, mas o mesmo não se pode dizer para a costa do Rio Grande do Sul. Existem estudos sobre a diversidade genética (Ott, 2002; Heinzelmann *et al.*, 2009), proporção sexual da população (Oliveira *et al.*, 2009) e uma compilação de encalhes ocorridos na região (Greig *et al.*, 2001). Relatos de avistagens de pares de mãe e filhote e encalhes de recém-nascidos (GEMARS, dados não publicados) evidenciam que a costa do Rio Grande do Sul pode representar uma área de reprodução para a espécie (Greig *et al.*, 2001), não apenas um corredor migratório como se pensava anteriormente (Simões-Lopes *et al.*, 1988). Este estudo pretende contribuir para a geração de conhecimento no que se refere à ecologia comportamental da espécie analisando a composição dos grupos e as posições e rotas percorridas pelos animais dentro da área de estudo, relacionando com as variáveis ambientais coletadas.

Objetivo geral

O presente estudo tem como objetivo geral caracterizar a distribuição espacial e a composição de grupo das baleias-francas em Torres, litoral norte do Rio Grande do Sul.

Objetivos específicos

1. Avaliar a influência da composição e tamanho de grupo na distribuição espacial e nos padrões de movimento (velocidade e direção de deslocamento) de baleias-francas em Torres.
2. Verificar se há influência de variáveis ambientais na escolha e uso do espaço pelos animais.

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CAPÍTULO II

Spatial distribution of Right Whales in Southern Brazil

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Spatial distribution and movement patterns of Southern Right Whales (*Eubalaena australis*) in Torres, Southern Brazil

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Abstract

Like the majority of the living organisms, marine mammals are not randomly distributed in the environment. The relationship between a species and its habitat form the fundamental knowledge about its ecology and to identify patterns that are driving the animal's choice is critical for effective management and conservation. Southern right whales visit the Brazilian coast during the breeding season and, despite they are well studied in the Santa Catarina State, in the Rio Grande do Sul State remains little known. This study aim is to contribute to the fundamental knowledge about this species in a particular site in Southern Brazil, describing the spatial distribution and correlating it to environmental factors. Successive positions of the groups were obtained by theodolite tracking and the environmental conditions were collected every hour. A total of 256.5 hours of observation effort were carried out, focal groups were followed for 44.5 hours within 41 groups. The majority of sightings was mother and calf pairs (85%) and higher concentration occurs in waters less than 5 m. The wind direction and sea state shows significant difference for the presence of the animals of all categories (p=0.0001 and p=0,024), but no difference was found by group composition (p=0,861 and p=0,372), respectively. The mean swim speed for all categories was 1.50 km/h and the majority was southbound movements. The mean distance from shore was 515.28 m (range 87.9 – 1,971.6 m). This study confirmed not only the use of the Rio Grande do Sul state coast as an important calving ground for the species, but suggests that these may be a nursery area, because the high proportion of mother-calf pairs (85%) and the recurrent number of calf stranded in the area. We reinforce the importance and urgency of conservation actions and management of the human activities for the continuing of the species reestablishment of historical range.

Key words: *Eubalaena australis*, Southern right whale, theodolite tracking, spatial distribution, environmental factors, group composition, mother and calf pairs, Rio Grande do Sul, Southern Brazil;

INTRODUCTION

Like the majority of the living organisms, marine mammals are not randomly distributed in the environment and their distributions can be affected by demographic, evolutionary, ecological, habitat related, and anthropogenic factors (Forcada, 2002). The relationship between a species and its habitat form the fundamental knowledge about its ecology and to identify patterns that are driving the animal's choice is critical for effective management and conservation (Ballance, 2002). Habitat use studies aim to describe and explain the organism's distribution and abundance, identifying the factors that cause influence, and its intensity, at different spatial and temporal scales (Smultea, 1994; Acevedo-Gutiérrez, 2002; Clapham *et al.*, 2004). For most species, little is known of the particular factors that make them to be found in some areas and not in another (Jefferson, 2008).

Relations between baleen whales and physical environmental characteristics in breeding areas have shown females accompanied by calves occupy shallower waters than unaccompanied adults (Payne, 1986; Smultea, 1994; Martins *et al.*, 2001; Ersts & Rosenbaum, 2003; Elwen & Best, 2004a, 2004b). Among the suggested explanations for this pattern are the avoidance of predators (Corkeron & Connor, 1999), avoidance of male harassment (Smultea, 1994; Craig *et al.*, 2014) and as a reflection of social organization (Ersts & Rosenbaum, 2003). Some authors also refer that the preference for calm waters may minimize the energy expenditure by female and calf (Whitehead & Moore, 1982; Elwen & Best, 2004a, 2004b). Within these breeding grounds, it seems to be some differentiation between nursery areas, occupied primarily by females and calves and other areas where predominantly adults and active groups are found (Payne, 1986; Elwen & Best, 2004c), showing that social organization could be as important as environmental conditions in reproductive success of southern right whales. Sea surface temperature (SST), which is, in most of cases, directly influenced by latitude, shows to be a important factor in right whales distribution in the northern hemisphere (Keller *et al.*, 2006).

Southern right whale, *Eubalaena australis* (Desmoulins, 1822), is a migratory species, distributed along the southern hemisphere between 20°S e 60°S, alternating the distribution between low latitudes breeding grounds and higher latitudes feeding grounds (Cummings, 1985). Right whales were the main target of the whaling activities between the 18th and 20th centuries in the southern hemisphere. The high levels of hunted whales drove the species near to extinction (Kenney, 2002). Recent estimates indicate there are about 13000 specimens in Southern Hemisphere, which may represent a little more than 10% of its original size (IWC, 2013). Recent studies reveal a recovery in these southern hemisphere populations, about 7 – 8% annually (IWC, 2001). *E. australis* is listed as 'Lower Risk/Conservation Dependent' (LR/CD) in the IUCN Red List of Threatened Species (IUCN, 2007), and it is included in the Brazilian Red List of Threatened Species as ‘Endangered’ (IBAMA, 2003).

The most representative calving ground known in the South Atlantic Ocean for *E. australis* are Brazil, Argentina and South Africa, although, the last one should be considered a separated unit for management purposes (IWC, 2001). Southern states of Brazilian coast are recognized as a calving ground for the species and, despite the great effort in studies in state of Santa Catarina (Groch, 2000, 2005; Danielski, 2008), the status and behavior of the species in state of Rio Grande do Sul remains little known. The coast of this State is characterized by a linear continuous sandy beaches, with no protected bays, and because of this, it was considered a migratory corridor for the southern right whales (Simões-Lopes *et al.*, 1988). However, reports of sightings of several mother-calf pairs and stranding of newborns during the reproductive season (Appendix I and II) (GEMARS, unpublished data) indicate this area may represent an important calving/nursery ground for the species (Greig *et al.*, 2001).

To define conservation strategies we need first, to understand the species requirements and ecological relationships with the environment. Following individual animals to collect data on their behavior and associated environmental variables can provide insight into resource and oceanographic parameters associated with decision-making processes at various scales (Clapham *et al.*, 1999). Understanding habitat use and social organization and its correlation with environmental aspects is important for evaluating and predicting the distribution patterns of a species. This knowledge is fundamental to the development of marine protected areas (MPA), conservation initiatives and management plans. The aim of this study is to describe the spatial distribution of *E. australis* in a particular region in the southern Brazil evaluating the group composition and correlate this pattern with some environmental factors, to verify if that could be driving animal’s choice in fine scale.

MATERIAL AND METHODS

Study area

Land-based observations were conducted from the Morro do Farol, a cliff located 41,5 m above the sea level, in Torres, Rio Grande do Sul, southern Brazil (29°20’45.10”S; 49°43’42.73”W) (Figure 1). This site was chosen because represents one of the few places where a land based study can be conducted, with hills near the coast line. The study area encompassed the coastal waters within 2.5 km radius of the observation station, including “Refúgio de Vida Silvestre Ilha dos Lobos” a Marine Protected Area formed by a very small rocky island and the surrounded waters, comprising 1.42 km². This region plays an important role in the southern right whale distribution, because is in the middle of the two most important aggregations in the southern Atlantic breeding ground, the Santa Catarina state (Brazil) and the Argentinean coast, which major concentration occur in Peninsula Valdés.

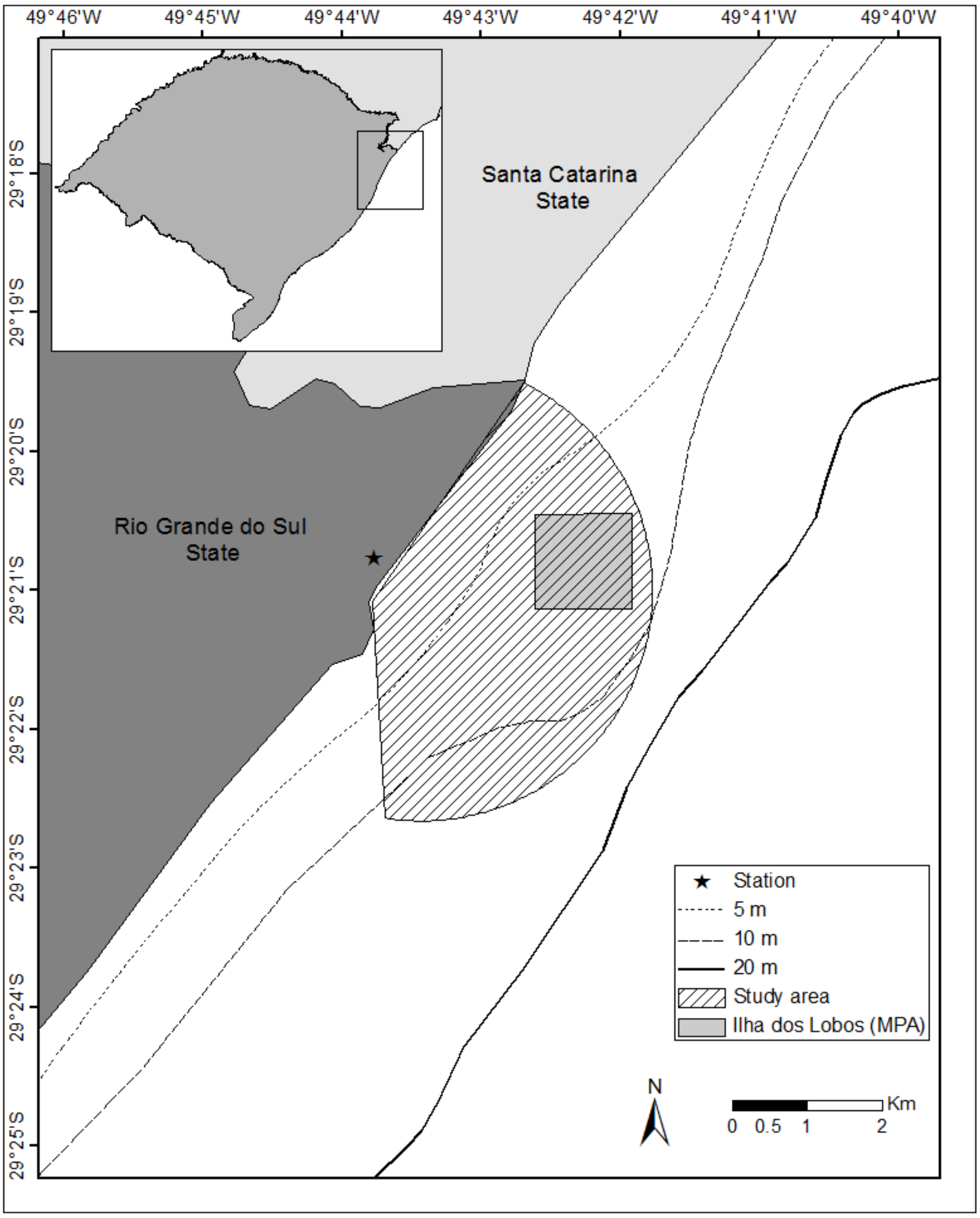

Fig. 1. Study area map showing the land-based station and the study perimeter, encompassing a Marine Protected Area (REVIS Ilha dos Lobos), in Torres, southern Brazil.

Data collection

Observations were made from 7 August to 4 September 2012 and from 7 August to 11 October 2013, dates coinciding with the known seasonal occurrence of the majority of right whales during the breeding season (Groch, 2005). A surveyor's theodolite (10 s precision, 30 x magnification) was used to track whales as described by Würsig (Würsig *et al.*, 1991). The observation was conducted by two or three people, equipped with 7x50 FUJINON binoculars, naked eye and the electronic theodolite. In order to avoid fatigue, observer's positions were rotated every hour, between the theodolite operator, binoculars and data recorder. Scan sampling of 15 min was done by the observer with binoculars to evaluate the distribution of individuals in the study area. If there were more than one group in the visual range of the observers, one was randomly selected for the focal-group. The theodolite operator follows the group and tells the angles of the animal's position for the annotator, every since it was possible or every minute if the animal keeps floating at the surface. Groups were divided in mother-calf pairs (M/C) and unaccompanied whales (Un.). Unaccompanied whales were considered all individuals which were not accompanied by calves. Calves were all individuals within ¾ of mother's body length (Taber & Thomas, 1982). Since we could not differ between adult and sub-adult from the coast, individuals with little difference in size were considered adults, for the purpose of this study. Focal follow sampling protocol was used (Altmann, 1974), where one group is continuously observed at a time, and all of its behavior was recorded. The advantage of this technique is that it provides accurate data about behaviors or positioning of one group, but the disadvantage is the lack of behaviors that may occur and not be counted when the animal is out of sight (Lehner, 1996). Successive positions were taken whenever possible, during the time the group was in the study area and categories of states and events as described by Altmann (1974), were attributed to each position of each group to evaluate the group behavior. The states were defined as "resting" when individuals were at the surface without apparent movement, "navigating" when they are actively swimming with defined direction and "milling" when they swim with no defined direction (convoluted movements), based on previous work focused in whale behavior (Groch, 2000, 2005; Bisi, 2006; Morete, 2007; Danielski, 2008).

Information on weather condition (i.e., Beaufort sea state, wind force and direction) was collected with Kestrel Wind Meter and naked eye (for sea state), at the beginning of the observation period and every hour, except if an alteration was noticed. Observation was interrupted in the presence of rain, Beaufort ≥4 (wind speed >20 km/h) or if the visibility conditions were affected by nebulosity or sun glare.

Data processing and analysis

Successive positions obtained in angles by the theodolite tracking were imported to Pythagoras software (Texas A&M University at Galveston), which transform it into geographic coordinated positions. Each group trajectory was obtained and plotted in a map in GIS environment using ArcMap 10. Point Density analysis was performed in order to characterize the most utilized areas. The relationship between environmental variables and the presence/ absence of animals, and group composition was tested in the SPSS statistical software.

RESULTS

During the two seasons (2012 and 2013) a total of 256.5 hours of observation effort were carried out during 92 days. Focal groups were followed for 44.5 hours within 41 groups. Relationship between survey effort and sightings were distributed weekly and are shown in Figure 2. Of the total groups followed, 35 (85%) were females accompanied by calves and 6 (15%) of adults unaccompanied, its weekly distributions are shown in Figure 3.

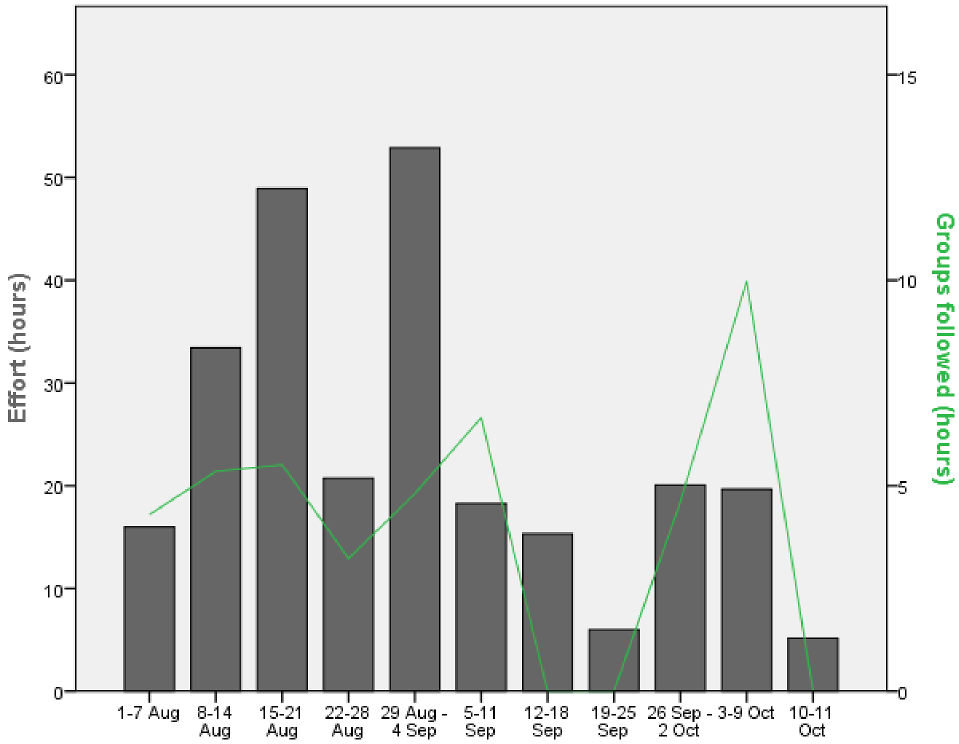

Figure 2. Weekly distribution of survey effort *versus* group sighting of *E. australis* in Torres, southern Brazil, during 2012 and 2013 field seasons.

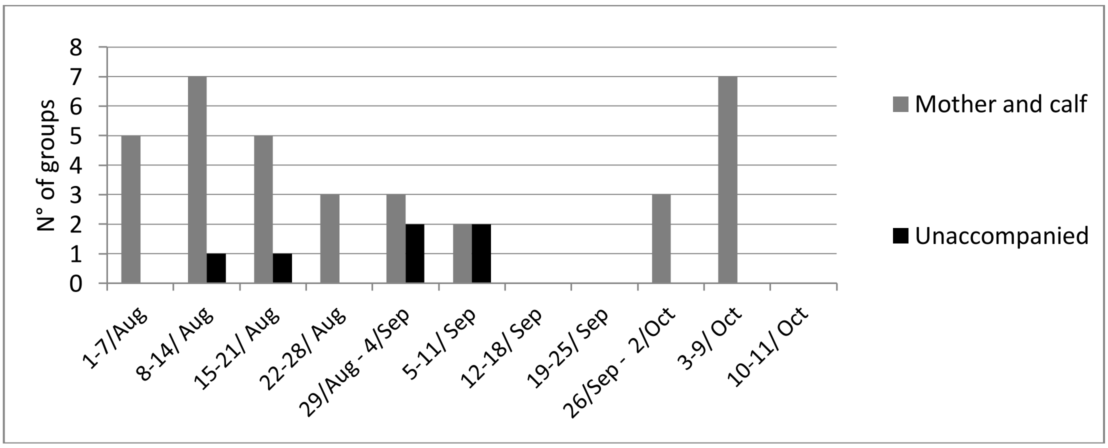

Fig. 3. Weekly distributions of group sighting, by group composition (mother-calf and unaccompanied whales) in Torres, southern Brazil (2012 and 2013).

The majority of the groups were navigating (64%), followed by milling (33%). In between group compositions we found a similar pattern with the majority of groups navigating, except the fact that no mother and calf pairs were observed resting. The Figure 4 demonstrates the proportion of behavior states in all categories, and Figure 5 shows its proportion within group composition.

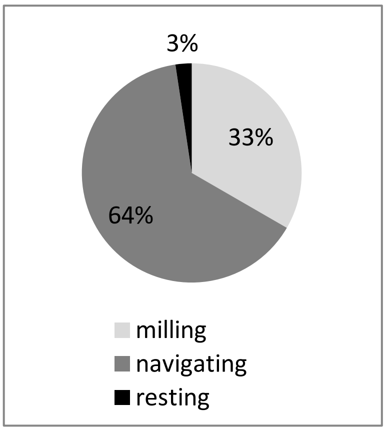

Fig. 4. Proportion of behavior states exhibit by all categories of groups of *E. australis* in Torres, southern Brazil.

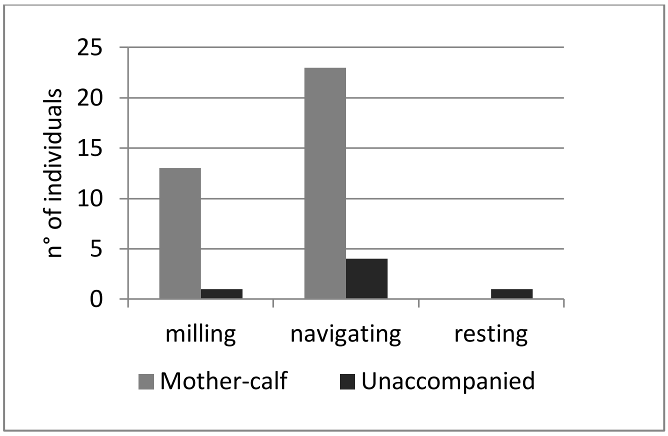

Fig. 5. Behavior states by group composition of *E. australis* in Torres, southern Brazil

Environmental variables

Majority of sightings occurred with northeast - NE wind direction (59%), followed by east - E (26%). Wind direction predominant in the study area was NE (37%), followed by south - S (19%) and E (16%). The wind direction shows significantly difference for presence/absence of whales (Fisher's exact test, 99% CI, p=0.001) and the residual analyses demonstrated the difference is in the S and southwest - SW directions, where the absence of individual was higher than expected and the presence was lower than expected. However, when compared with group composition, wind direction was not significantly different (Fisher's exact test, 99% CI, p=0.861), in other words, whales avoid the area when the wind direction is S and SW, regardless of group composition.

Wind speed was not significantly different in the presence or absence of whales (*t* test 95% CI, p=0.632), neither for the group composition (*t* test 95% CI, p=0,984). Mean wind speed in presence of animals was 5.58 kt (SD ± 2.47) and for absence 5.81 (SD ± 3.85). Mean wind speed for Mother-calf was 5.57 kt (Std. Dev ± 3) and for Unaccompanied was 5.64 kt (SD ± 2.24). The mean wind speeds for each wind direction are demonstrated in Figure 6.

Fig. 6. Mean of wind speed observed for each wind directions in Torres, southern Brazil (August and September of 2012 and 2013).

Sea state was significantly different for presence/absence when the state was 3 and 4 (Chi-squared test, 99% CI, p= 0.024), what means the detection of whales was lower than expected and non-detection higher than expected when the sea was turbulent (beaufort 3 or 4). An increase in the Beaufort state leads to a decrease in the whale detection by the observers, in other words, the whales may be in the study area but could not be seen, reason why we treat "detection" instead of "presence". As well as wind direction, sea state do not show difference between group composition (Fisher's exact test, 99% CI, p=0.372). Frequencies of occurrences of the sea state according with Beaufort scale are shown on Figure 7.

Fig. 7. Frequencies of occurrences of sea state according with Beaufort scale in Torres, southern Brazil, during 2012 and 2013 field seasons.

Movements

Mean swim speed for all categories pooled together was 1.50 km/h (SD ± 1.15km/h), for M/C pairs was 1.53 km/h (SD ± 1.14 km/h) and for unaccompanied whales was 1.17 km/h (SD ± 1.08km/h), suggesting that M/C pairs were slightly faster swimmers than unaccompanied whales, (*t* test, p=0.0001). A summary of swim speeds are shown in the Table 1.

Table 1. Swim speeds (km/h) recorded for right whales in coastal waters of Torres, southern Brazil (2012 and 2013).

Category	N	Mean	SD	Range
Mother/calf	35	1.53	1.14	0.15-4.57
Unaccompanied	6	1.17	1.08	0.07-5.14
All categories	41	1.50	1.15	0.07-5.14

The majority of groups showed north-south movement (63%), followed by south-north (21%) movements and convoluted movements with no defined direction (16%). When analyzed by month, in August the north-south was 51.85%, south-north 25.92% and no direction 22.22%. In September, the north-south was 81.25%, south-north 12.5% and no noticed direction 0.06%. The mean distance from shore for all group categories was 515 m (range 87 – 1,971m), for M/C pairs 520 m (range 87 – 1,971 m) and for unaccompanied 417m (range 147 – 993 m). Distances from shore (mean, maximum and minimum) observed for each group are shown in Figure 8. Depth of the sea floor for all occurrences was less than 10 m, but greatest concentration of whales occurs in waters of 5 m or less as shown by the result of all positions of all groups (Fig. 9) and evidenced by the point density map (Fig. 10).

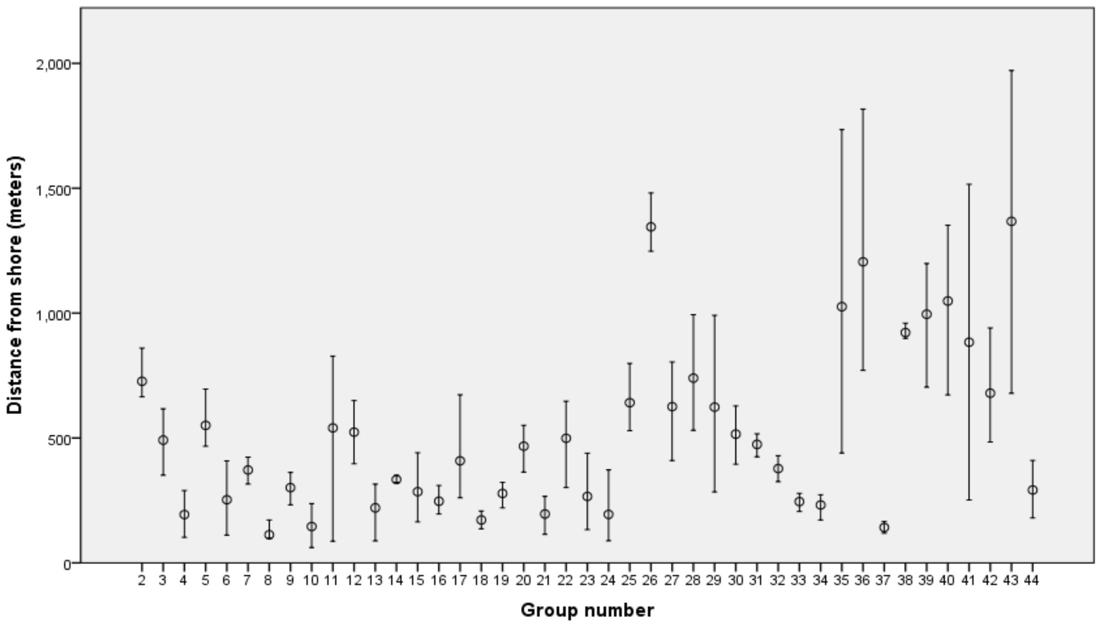

Fig. 8. Range distances from shore for each group of right whales (mean, maximum and minimum) observed in Torres, southern Brazil.

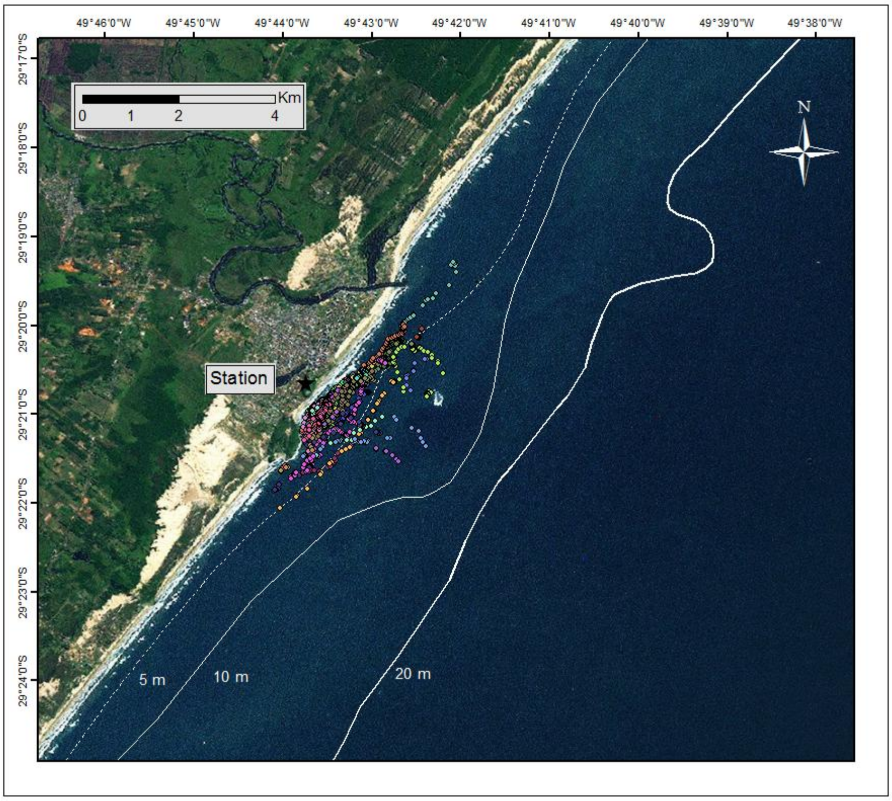

Fig. 9. All positions collected for all groups of southern right whales in Torres, southern Brazil (each color represents a different group). The map shows the station and the bathymetric contour (5, 10 and 20 meters).

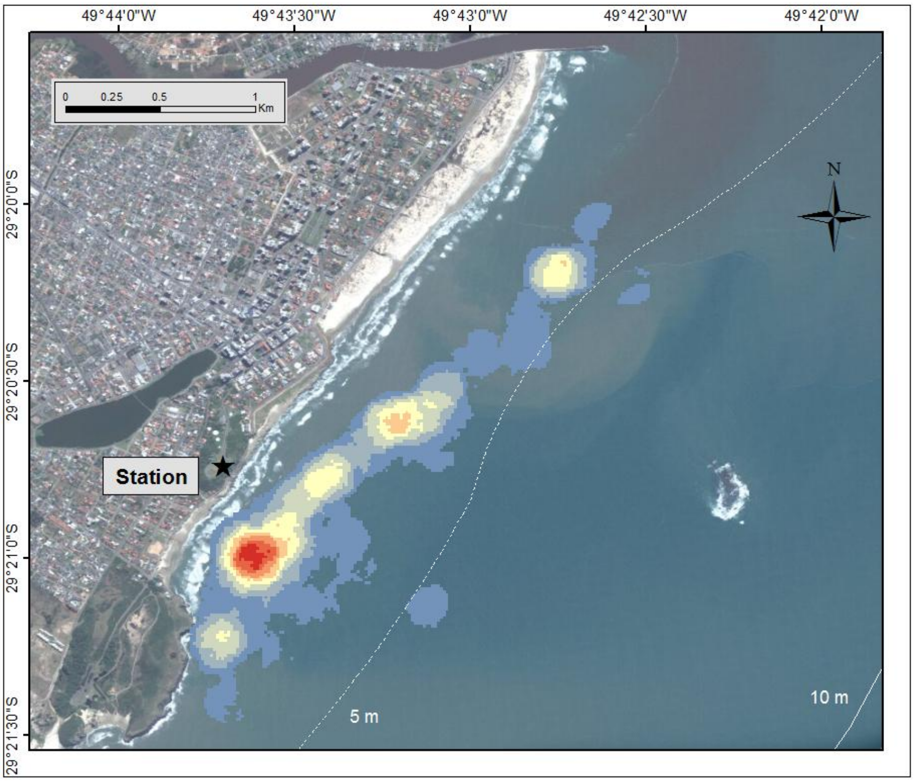

Fig. 10. Point Density map. The map shows the preferred areas of use by the southern right whales in Torres, southern Brazil. The majority of whales used the area close to shore, with less than 5m deep.

DISCUSSION

Environmental variables

Wind direction and Beaufort state seems to play some role in the habitat choice for southern right whales in the area, since they show avoidance to turbulent waters, mainly as a reflection of the minimizing energy expenditure theory. The wind direction predominant in the northern part of Rio Grande do Sul coast, is the Northeast (Ferraro & Hasenack, 2009), then the high number of sightings in this wind direction was expected. Statistical analysis shows difference in the South and Southwestern directions, when animals are less present than expected. Once the predominant swim direction was southbound, the wind coming from the south, probably makes the whales spend more energy in swimming against the current, and they seem to avoid this situation. Wind speed does not show to affect habitat choice for right whales in the area. The avoidance of the area when the sea state was 3 or 4 corroborates the preference for calm waters reported in other studies (Elwen & Best, 2004a, 2004b; Elwen & Best, 2004c). From Uruguay to Rio Grande do Sul there is more than 700 km in a straight line with no particular bays, where whales can get protection. In this sense, *Ilha dos Lobos* conservation unit may play an important role in species distribution, offering a point of resting between SC and Argentina, the two main aggregations in the southern Atlantic breeding ground, by forming a barrier against undulation or stronger wind. In fact, a higher concentration of whales was observed in an area where the shoreline makes a little inlet, forming a narrow bay, where they can probably find calmer waters (Fig. 10). Since more than one group in the area was unusual, the pattern exhibited in Figures 9 and 10 reflects exactly the area used by the whales within the study area. The results confirm that the distance covered by the study was adequate, encompassing the great majority of animals that could pass by the study area.

Movements

Our data shows females with calves swim faster than unaccompanied whales, while other studies on right whales shows the contrary (Mate *et al.*, 2011; Hain *et al.*, 2013). The difference observed in our study may be due to one out of the six groups of unaccompanied whales that was resting, standing still for very long period, bringing the average down. When we exclude this animal, the average swim speed for the category goes to 1,81km/h, in agreement with previous studies. The low number of groups for the category may have also caused an influence. Mean speed for mother-calf pairs were similar to the found for other areas, as shown on Table 2. Mother and calf pairs are thought to be slower swimmers because they need to conserve energy for lactating and growing respectively, in addition the smaller body of the calves, what makes them swim slowly.

Table 2. Swim speeds (km/h) recorded for right whales in other reproductive areas.

Reproductive area	Category	Mean	SD	Range	Reference
Northeastern Florida	mother/calf	1.20	0.76	0.05-4.07	Hain *et al.* (2013)
	Single pair	1.86	1.27	0.48-5.37	
	Group	1.26	0.50	0.81-2.44	
	All categories	1.3			
South Africa	All categories	1.7	0.9	0.4-3.6	Best, 2000
South Africa (telemetry)	M/C	1.1		0.6-1.5	Mate *et. al.* (2011)
	All categories	1.6	0.59		
Southern Brazil	All categories	1.88	0.99		Renault-Braga *et. al.* (2013)
Southern Brazil	mother/calf	1.53	1.14	0.15-4.57	This study
	Unaccompanied	1.17	1.08	0.07-5.14	
	All categories	1.50	1.15	0.07-5.14	

Hain *et al.* (2013) suggest that swim speeds are different from between-habitat and transitory or migratory mode for right whales in the southeastern USA, and states 1.3 km/h as a within-habitat median speed. The average net speeds found by Mate *et al* (1997) for *E. glacialis* in the western North Atlantic between-habitat and within-habitat movement were 3.5 km/h and 1.1 km/h respectively. Mate *et al.* (2011) found 3.3 km/h in between-habitat and 1.8 within-habitat mean speeds for *E. australis* in South African coast. In our study, four groups presented mean net speed higher than 3.0 km/h (9.75%), and were all mother and calf pairs in parallel to the coast movement, in waters shallower than 5 m. In the Rio Grande do Sul State, movements were generally parallel to the coast, despite the occurrence of convoluted movements and stationary periods. Examples of each type of movement are shown in Appendix 3. In August, whales presented all types of movements, north-south, south-north and convoluted. In September, we only observed north-south or convoluted movements, indicating they are returning to feeding areas in the South, even that some of them still spend some time in the area.

The mean distance from shore for all categories was 515 m, confirming its preference for shallower waters, as known for the right whales around the world (Payne, 1986; Groch, 2000; Rowntree *et al.*, 2001; Patenaude, 2003; Elwen & Best, 2004a, 2004b, 2004c). Whales were concentrated in close to shore waters, with approximated 5m depth or less, as showed in the point density map (Fig. 10), suggesting the preference area for right whales in their passage along Torres coast. As stated for Península Valdés, they seem to use a corridor, a "whale road", in waters of around 5 m deep, where they could more easily encounter each other (Payne, 1986).

Segregation has been reported for other reproductive areas, with regions where more unaccompanied whales are seen and other areas where mother-calf are predominant (Payne, 1986; Elwen & Best, 2004c). Elwen & Best (2004c) suggests that may be a reproductive benefit in this behavior, especially for young and inexperienced mothers, who are more susceptible to loss calves. The Uruguayan coast, another area of right whales aggregation in the western South Atlantic, located between RS and Argentina, is considered a socialization ground due the high proportion (92%) of unaccompanied whales (Costa *et al.*, 2007). The high proportion of females with calves (85%) found in this study is a strong evidence that this region represent a nursery area for the species. In Santa Catarina State the main concentration area for right whales is protected by "Right Whale Environmental Protection Area" ("*APA da Baleia Franca*"), a Marine Protected Area dedicated for the species and covering around 150 km of the coast. In this area all categories of groups can be observed, however mother and calf pairs are the majority (58.3%) (Groch, 2005). Other studies conducted in the same area of this study, Morro do Farol in Torres, found 27.7% of Mother and Calf and 72.3% of Unaccompanied for 2002 season (Danilewicz, unpublished data) and 56.4% of M/C and 41.8% of Unaccompanied whales for 2007 (De-Rose-Silva *et al.*, 2008). A compilation of proportion of mother and calf pairs for other areas in the Southeastern Atlantic is shown in Figure 11. The proportions of mother and calf pairs presented in this figure indicates the importance of the study area for the right whales reproduction, there was a clear increase in proportions of mother and calf pairs over the years. Furthermore, the presence of mother and calf pairs in this area in the beginning of the reproductive season indicates that births can occur somewhere between Rio Grande do Sul and Uruguayan coast, but no direct evidence was observed. Moreover, strandings of newborns with small body lengths and some with presence of umbilical cord (GEMARS, 0045 and GEMARS 1305) are a strong evidence that birth can take place in the Rio Grande do Sul State coast (33^{o}S to 29^{o}S).

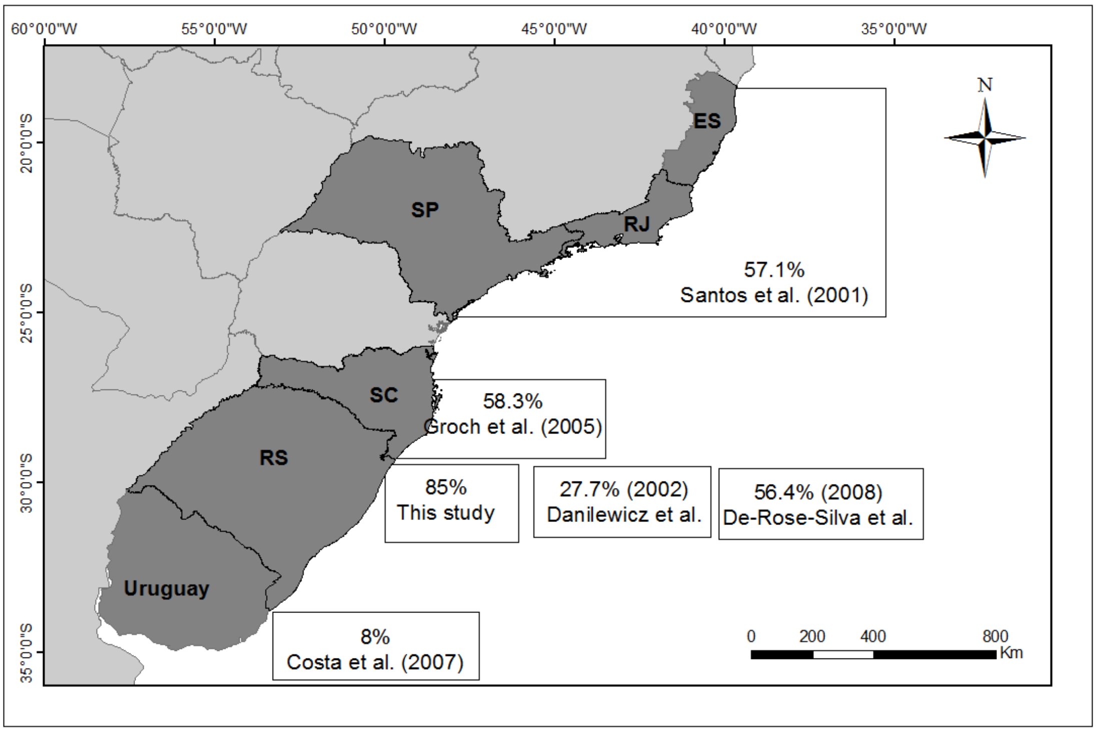

Fig. 11. Proportion of Mother and calf pairs along Southeastern Brazil and Uruguayan coast.

Right whales have shown some plasticity in habitat choice, as observed in Peninsula Valdés, when they moved from a particular bay for another, after a storm changed the sea bottom (Rowntree *et al.*, 2001). These changes in habitat could be a result of human disturbing, as humpback whales demonstrated in Hawaiian waters, where they exhibit a distribution pattern that contrast to the other areas (Cartwright *et al.*, 2012). Southern right whales exhibit philopatry to their coast of birth and (to a lesser degree) particular bays (Best, 2000), but movements along South American coast between calving grounds in different years have been reported (Patenaude *et al.*, 2007). The IWC committee agrees that genetic information would be of considerable value in determining stock separation and migratory interchange among these regions. This factors together reinforces the fragility and plasticity of the whales habitat choice, and the importance of monitoring these population in a coordinated international effort in all occurrence area.

Conservation implications

The major pressures precluding the recovery of southern right whale's population have anthropogenic origin (IWC, 2001). From entanglement in fishing gear to ship strike and habitat loss, including the low genetic variability, evidence of bottleneck effect caused by whaling activities. In the study area, right whales are subject of many of these threats, in different levels. As all the coastlines around the world, Torres suffers with the growing pollution and habitat degradation caused by urban sprawl. Whale watching in South America is growing at rates of 10% per year (O'Connor *et al.*, 2009). It is generally accepted that the impacts of whale watching boats is probably minor compared to other threats such as whaling, entanglement, pollution and climate change. However, several studies have recorded changes in cetacean behavior in response to whale watching. There is evidence that short-term impacts can have cumulative and corresponding possible long-term impacts on cetacean individuals, groups, or populations causing reduced reproductive success, changes in spatial movement patterns in critical habitat areas, and disruptions of critical behaviors such as feeding and mating. Although whale watching activities in the study area are incipient, in Santa Catarina State it was indefinitely suspended by the Federal Court after complains of infractions of the guidelines, in addition to the lack of structure to ensure monitoring and enforcement of the regulations of the activity.

Even though there is a small MPA in the region, the perimeter of "Ilha dos Lobos" reserve does not cover the area used by *E. australis*, since it was not the target species for its creation. Brazilian photoidentification catalogue of southern right whales, maintained by "Projeto Baleia Franca" had 670 whales cataloged until 2010, the growing rate for this population is 12% per year and it is believed that nearly 100 individuals came to Brazilian waters each year, and 500 are thought to visit regularly (Groch *et al.*, 2013). This study confirmed not only the use of the Rio Grande do Sul state coast as an important calving ground for the species, but suggests that these may be a nursery area, because the high proportion of mother-calf pairs (85%) also supported by the recurrent number of calves stranded in the area (Greig *et al*., 2001).

As human population is increasing as well human activities, supervision and regulation of anthropogenic disturbance became fundamental to maintenance of one species that is going through an important recovery (IWC, 2013; Groch, 2005). We reinforce the importance and urgency of creation of new ones or enlargement of the existing Marine Protected Areas but, moreover, the monitoring of these conservation units. An educational program with the tourists, local people and vessel operators is mandatory to involve people in conservation, for the maintenance of the growing rates of this right whale population. All those practices integrated will ensure the continuing of the species reestablishment of historical range.

ACKNOWLEGDEMENTS

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Conclusões gerais

- A alta ocorrência de pares de fêmeas com filhote permite-nos sugerir que esta região da costa do Rio Grande do Sul seja uma importante área de reprodução para a espécie.

- Ao longo dos últimos doze anos a proporção de fêmeas com filhotes nesta área vêm aumentando, o que reforça utilização pelas baleias-francas-austrais como uma área de reprodução e sugere ainda, que esta seja uma região berçário, onde se concentram para o nascimento e amamentação de filhotes.

- Os resultados deste estudo confirmam o padrão encontrado para baleias-francas em outras regiões reprodutivas, de preferência por águas calmas, próximas à costa com profundidade em torno dos 5 metros.

- A direção do vento e o estado do mar (escala Beaufort) parecem exercer influência na escolha do hábitat, pois as baleias-francas evitaram a área quando o mar estava agitado ou com vento de direção Sul e Sudoeste. Esta direção de vento, em geral, contrário à direção de natação exibida pela maioria dos grupos, o que faria elas gastarem mais energia no deslocamento ou mesmo tentando se manter em repouso.

- O fato de a região ser ocupada preferencialmente por fêmeas com filhotes, aliado aos flagrantes de perturbação de origem antrópica, tornam de caráter de urgência o monitoramento e regulamentação das atividades humanas na região.

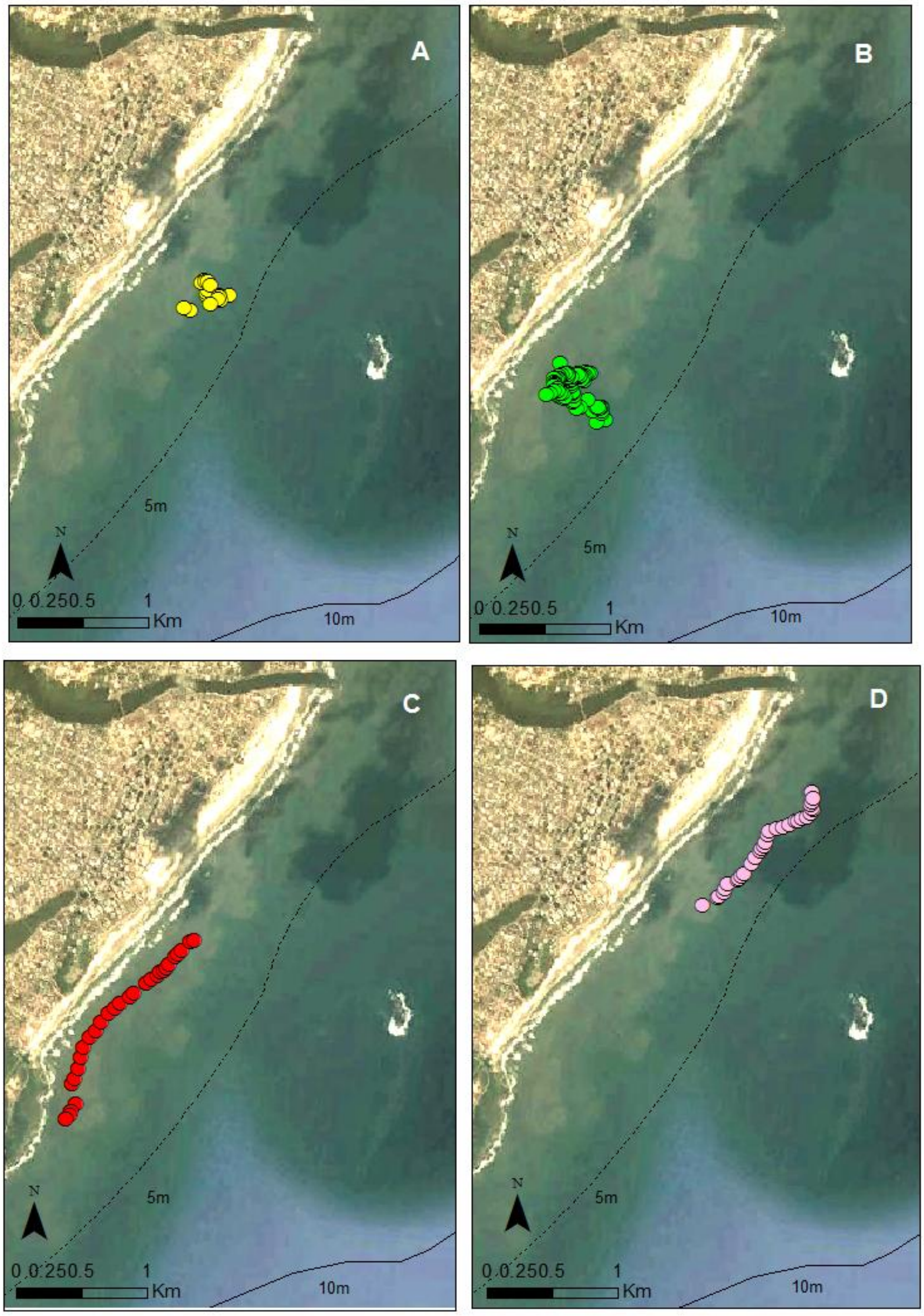
APPENDIX I

GEMARS 1305 – Animal stranded dead in August 2008, in Balneário Pinhal/ Rio Grande do Sul, Southern Brazil. The individual was a male (extroverted penis), with 5.6 m length (A). In detail, the vestigial of umbilical cord, above the penis, at right on the picture(B). (Photo: Maurício Tavares/ GEMARS)

APPENDIX II

GEMARS 1410 – Animal stranded dead in August 2010, in Arroio do Sal/ Rio Grande do Sul, Southern Brazil. The individual was a male (extroverted penis), with 5.58 m length. In A, the fetal folds still visible and the cyamid colonies are still in the beginning. The pattern formed by callosities of the rostrum colonized by the whale lice is used to photo-identification of individuals. In B, is visible the umbilical scar. (Photo: Ignacio Moreno/UFRGS)

APPENDIX III



Examples of movements exhibited by southern right whales in Southern Brazil. A and B: examples of movement with no defined direction, animal “milling”. C and D: navigation-mode examples, parallel to the coast, with northbound direction.

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Headings. Follow the style and hierarchy for each section as shown below (but see later for taxonomy):

INTRODUCTION, MATERIALS AND METHODS (1st heading, upper case, left justified).

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Taxonomy should be presented as follows:

SYSTEMATICS (1st heading, upper case, centre justified)

Order AMPHIPODA Latreille, 1816

Suborder GAMMARIDEA Latreille, 1803

Family UROTHOIDAE Bousfield, 1978

Genus *Carangolia* Barnard, 1961

Carangolia barnardi sp. nov.

(Figures 1–6)

Carangolia spp.: Elizalde *et al*., 1993; Sorbe & Weber, 1995; Dauvin & Sorbe, 1995. (left justified)

TYPE MATERIAL (taxonomic sub-headings, small caps, left justified)

Holotype: adult female (oostegites developed) 2.69 mm, completely dissected and mounted on 12 slides. (OXYBENT VIII, TS05-R, N4; coordinates: 43°49.34′N 02°02.74′W; water depth: 550 m) (MNHN-Am5129); coll. J.-C. Sorbe, 19 April 1999.

Paratype: adult male (penile papillae developed) 3.88 mm partially dissected, with both first antennae, maxillipeds, epimeral plates, pleopods, and second antenna and second gnathopod mounted on three slides; rest as five pieces preserved in 70% ethanol. (ECOMARGE 93, TS08-A, Ni; 44°34.57′N 02°12.60′W; water depth: 740–746 m) (MNHN-Am5130); coll. J.-C. Sorbe, 23 June 1993. Twenty-one additional specimens in J.-C. Sorbe Collection.

COMPARATIVE MATERIAL EXAMINED

Carangolia cornuta Bellan-Santini & Ledoyer, 1986. Holotype: female completely dissected on single slide (Museo Civico di Storia Naturale di Verona, slide no. 3276); RV 'Marion Dufresne' Cruise MD08 to Marion and Prince Edward Islands, Station 17BB97 (Marion Island: 46°52.5′S 37°53.5′E); collected on 25 March 1976 with Okean grab on muddy sand, 110 m depth.

DIAGNOSIS

Carangolia with well developed pointed process on posterolateral corner of head. Coxal plate 1 with anterior and posterior margins subparallel, distal margin straight. Coxal plate 7 pointed. Basis of pereopod 6 slender, not oblong. Dactylus of pereiopod 5 elongate (more than 12 times longer than wide). Telson devoid of spines.

KEY FOR THE GENERA OF THE ALVINOCARIDIDAE (small caps, left justified)

1. Posterior telson margin armed only with spines, without plumose seta……………..........…..2

— Posterior telson margin armed with plumose setae……………………………………….……..3
(Insert a line space between each point)

2. Rostrum long, depressed laterally; pterygostomal spine present; lash on first maxilliped rudimentary……………………………………………………………………..….*Alvinocaris*

— Rostrum short, compressed dorsoventrally, without teeth; pterygostomal spine absent; lash on first maxilliped well developed……………………..….....................................….*Iorania*

3. Short rostrum present; exposed eyes separated from each other; distolateral spine present on *scaphocerite*……………………………………..……………….…………..……...*Chorocaris*

Text files should be submitted as line-numbered Microsoft Word files and should include Figure legends.

Figures. Should be referred to in full in the body of the text (e.g. Figure 1). Figure legends should take the following style:

Fig. 1. *Ceratothoa collaris* Schioedte & Meinert, 1883, adult female: (A) pereopod 1; (B) pereopod 7; (C–G) pleopods 1–5 ventral view; (H) uropods. Scale bars: A–G, 2 mm; H, 3 mm.

Figures' submission. IMAGES should be submitted as tif (preferably), jpg or png file-types. FIGURES SUPPLIED AS EMBEDDED OBJECTS IN MICROSOFT WORD OR AS PDF FILES CANNOT BE ACCEPTED. To ensure adequate print quality, please submit greyscale tif files NO LESS than 1200 pixels wide and NO MORE than 2500 pixels wide. These correspond to 300 dpi (118 pixels/cm) resolution at single (8.5 cm) and double (17.5 cm) column size respectively. The width should be checked in image editing software such as Photoshop, PaintShop Pro etc. Very high resolution images should be reduced to 2500 pixel width BEFORE submission to avoid uploading problems during submission.

Colour images cost £700 (GBP) per page in print but are free in the online version. To have a colour image online and a greyscale version in print it is ESSENTIAL to submit BOTH greyscale and colour versions. THE JOURNAL WILL NOT CONVERT COLOUR IMAGES TO GREYSCALE. Authors who wish to have colour images printed should make this clear at the time of submission so that an invoice can be prepared.

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All figures should be labelled with a medium weight sans serif font of an appropriate size to result in 8 point (3.33 mm) type when reduced to published size. If figures are in parts, please label with upper case letters (A, B, C etc.) in the top left corner of each part.

Tables should be submitted as Microsoft Word tables. the journal cannot accept text formatted with tab characters or images of tables embedded in word files.

Tables should not be excessive in size and headed by informative legends. Legend, headings and footnote are delimited by horizontal lines as shown in the example below; table headers are centred and roman (normal) typeface. Column headings are bold. The table below gives an example of layout:

Table 1. Tenacity of *Elminius modestus* and *Balanus perforatus* cypris larvae to natural biofilms developed at high (83 s-1) and low (15 s-1) shear rates. Forces of temporary adhesion are given as 104Nm-2.

	Eliminus modestus			*Balanus perforatus*		
Surface	**N**	**Mean**	**±SE**	**N**	**Mean**	**±SE**
No biofilm	30	8.19	0.258	30	6.75	0.179
Low shear	30	7.59	0.274	30	4.94	0.136
High shear	30	9.20	0.219	30	6.50	0.162
	Bartlett's statistic = 1.44; *P* = 0.486			Bartlett's statistic = 2.79; *P* = 0.248		

N, number; SE, standard error.

Failure to follow these guidelines may delay the processing of manuscripts.

Genus and species names should be *italicized* and appear in full at each mention in a new section and if starting a sentence. In italicized text (Abstracts) species names should be normal typeface.

Citation of literature. References in the text should refer to the author's name (no initials) and year of publication. Two authors should be cited using '&' (Rainbow & Dellinger, 1993); for more than two authors, the name of the first author followed by '*et al.*' (Lallier *et al*., 1987). When citing more than one publication use date order and a semi-colon as a separator, e.g. (Mykels & Skinner, 1985a, b; Skinner, 1996; Gorind *et al*., 1997). The manuscript should be carefully checked to ensure the details of authors and dates cited in the text exactly match those in the reference list. Cross checking of references in the text to the cited literature and vice versa is the responsibility of the author. All literature quoted in the text must be listed in alphabetical and chronological order of author names at the end of each manuscript. When more than one publication with the same first author is cited the following order alphabetically applies: (a) single author, according to publication dates; (b) same author and one co-author; (c) same author and more than one co-author.

The style follows the full name according to the 'World List of Scientific Periodicals' latest edition, London. Titles of journals must be written in **FULL** (not abbreviated) and references to books should include the place of publication and the publisher.

Dashes. Hyphen between connecting words; en-dash between ranges e.g. 3–10, B–G, and between opposite words e.g. male–female pairs, size–frequency, etc.

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