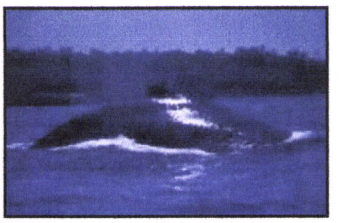
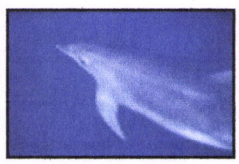



Ocorrência e Conservação de Cetáceos nas águas em torno da ilha de S. Tomé, Arquipélago de São Tomé e Príncipe

Cristina Isabel de Caré Picanço

Dissertação para obtenção do Grau de Mestre em
Biologia da Conservação



Orientador: **Mestre Cristina Maria Ribeiro da Silva Brito (Escola de Mar)**

Co-Orientador: **Doutor Paulo Alexandre Cunha e Sá de Sousa (DBio, UE)**

Évora
2008

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ÍNDICE

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RESUMO

ESTUDO E CONSERVAÇÃO DE CETÁCEOS EM SÃO TOMÉ E PRÍNCIPE, GOLFO DA GUINÉ

O arquipélago equatorial de S. Tomé e Príncipe está situado no Golfo da Guiné e é constituído por duas ilhas principais e diversos pequenos ilhéus. Determinadas zonas das águas costeiras da Ilha de S. Tomé e do Ilhéu das Rolas parecem constituir locais de agregação dos cetáceos devido aos seus elevados níveis de actividade biológica e potenciais presas. No entanto, em comparação com outras regiões do mundo, muito pouco se sabe acerca das comunidades de cetáceos que ocorrem neste arquipélago. Entre os anos 2002 e 2005 realizou-se um estudo para conhecimento das espécies de cetáceos que ocorrem naquelas águas. Foram observadas seis espécies: baleia-corcunda (*Megaptera novaengliae*), golfinho-roaz (*Tursiops truncatus*), golfinho-malhado-pantropical (*Stenella attenuata*), orca (*Orcinus orca*), cachalote (*Physeter macrocephalus*) e baleia-piloto (*Globicephala spp*).

Em termos históricos, o arquipélago de S. Tomé e Príncipe é referido como uma provável área de reprodução de baleia-corcunda, desde o século XIX. Esta espécie, depois de ter sido o alvo principal da baleação comercial, parece estar a voltar a esta região, motivo pelo qual a sua conservação se torna prioritária. O país não possui legislação específica para a protecção dos mamíferos marinhos que ali ocorrem, nem para a regulamentação das actividades humanas que lhes possam estar relacionadas. Neste sentido, é também de referir o crescimento do chamado turismo ambiental e actividades de observação de cetáceos que se tem verificado nos últimos anos naquela região. O presente estudo teve como objectivo a obtenção de dados acerca da ocorrência e distribuição das populações de cetáceos, os quais servirão de base para se criar legislação que regulamente as actividades humanas que afectam directa ou indirectamente estas populações.

ABSTRACT

STUDY AND CONSERVATION OF CETACEANS IN SAO TOMÉ AND PRÍNCIPE, GULF OF GUINEA

Sao Tome and Principe is an equatorial archipelago located in the Gulf of Guinea and formed by two main islands and several islets. This archipelago seems to be an important area for cetaceans, probably due to large concentrations of prey, as well as the existence of several small bays and shallow water that constitute preferred rest areas. However, in comparison to other areas of the world, little is know about cetacean communities in this archipelago. A biological research to study cetacean's occurrence was conducted between 2002 and 2005. Sightings of humpback whales (*Megaptera novaengliae*), bottlenose dolphins (*Tursiops truncatus*), pantropical spotted dolphins (*Stenella attenuata*), orcas (*Orcinus orca*), sperm whale (*Physeter macrocephalus*) and pilot whales (*Globicephala spp*) were recorded.

Historically, this archipelago has also been reported as a possible breeding ground of humpback whales in the Gulf of Guinea region since the whaling period. After the end of the commercial whaling humpback whales seems to be returning to this coastal areas and its conservation must faced as a priority. Sao Tome and Principe do not have any legislation regarding marine mammals or the marine environment. It is also important to refer that a significant nature tourism and whale watching industry is presently beginning in the archipelago. The present research allowed obtaining new data on these cetacean's populations and efforts are being made to create a legal background to regulate human activities that may affect directly or indirectly whales and dolphins' populations.

1 – INTRODUÇÃO GERAL

O interesse nos mamíferos marinhos aumentou exponencialmente nas últimas décadas, o que é evidenciado pelo número de livros, artigos científicos e conferências dedicadas a estes animais. Deste facto resultaram conhecimentos únicos que em alguns casos ajudaram na identificação de problemas de conservação de algumas espécies (Evans & Raga, 2001). No entanto o interesse pelo estudo dos mamíferos marinhos não despertou uniformemente em todo o mundo. Iniciou-se mais seriamente na América do Norte, onde em 1981 foi criada a "*Society of Marine Mammalogy* – SMM", passando à Europa em 1987, com a consequente fundação da "*European Cetacean Society* – ECS". Nos anos 90 esta necessidade e interesse em conhecer o que existe a nível científico sobre mamíferos marinhos estendeu-se a outras partes do mundo (Evans & Raga, 2001).

1.1 – Os Cetáceos

O grupo dos cetáceos (Ordem Cetacea) é constituído por 84 espécies pertencentes a duas sub-ordens, a Mysticeti, dos misticetos ou baleias de barbas, e a Odontoceti à qual pertencem os odontocetos ou baleias de dentes (Reeves *et al.*, 2002; Hoyt, 2005). Esta ordem é representada por um grupo grande e bastante variado de mamíferos marinhos, com adaptações e especializações ao meio aquático altamente desenvolvidas, os quais se distribuem pelos oceanos e mares de todo o mundo e por alguns dos principais grandes rios. Os cetáceos ocupam diversos nichos ecológicos, possuem modos de vida variados e diferentes sistemas sociais (Würsig, 1986). São animais de vida longa, cognitivamente avançados, altamente móveis e que são capazes de comunicar a longas distâncias, o que facilita a evolução de comportamentos sociais complexos.

Os mamíferos marinhos em geral, e os cetáceos em particular, vivem, alimentam-se e reproduzem-se num vasto ambiente fluido e tridimensional – o oceano (Bjorge, 2002).

Apesar de possuírem uma ligação ao meio aéreo, onde precisam de vir respirar o ar atmosférico, o conhecimento sobre oceanografia é primordial no estudo dos cetáceos. O seu habitat e distribuição são afectados pelas propriedades físicas e químicas da água onde nadam e comunicam, pela topografia do fundo onde muitas vezes se alimentam, pelo estado físico da superfície da água onde vêm respirar, e por numerosos factores que influenciam a distribuição dos organismos que fazem parte da sua rede trófica (Fiedler, 2002; Molina-Schiller *et al.*, 2005).

Tal como outros animais, os cetáceos podem ter zonas preferidas – áreas preferenciais – onde passam a maior parte do tempo ou onde desenvolvem a maior parte das actividades da sua história vital, tais como o nascimento das crias e a busca de alimento (Bjorge, 2002; Johnston *et al.*, 2005). O conjunto de factores físicos e biológicos que caracterizam estes locais formam o habitat de uma espécie ou de uma determinada população (Bjorge, 2002; Evans, 2002). Apesar de a defesa contra predadores, a competição inter-específica e as estratégias reprodutivas afectarem a distribuição dos cetáceos de alguma forma, estudos de gastos energéticos indicam que a maioria dos cetáceos têm que se alimentar todos os dias. Neste sentido, presume-se que a distribuição de alguns cetáceos e a sua utilização dos habitats seja determinada primariamente pela disponibilidade de alimento (Baumgartner *et al.*, 2001; Bjorge, 2002; Gannier, 2005; Johnston *et al.*, 2005). No entanto, características do meio como a batimetria parecem também influenciar a distribuição dos cetáceos (Hooker *et al.*, 1999; Hastie *et al.*, 2003; Macleod *et al.*, 2003; Yen *et al.*, 2004; Molina-Schiller *et al.*, 2005).

Como já foi referido, os cetáceos são animais altamente móveis e que são capazes de viajar longas distâncias. Algumas espécies (como as grandes baleias de barbas) realizam longas migrações sazonais, principalmente entre zonas de alimentação e zonas de reprodução, enquanto que outras podem seguir as suas presas num padrão de migração sazonal entre zonas costeiras e zonas oceânicas. Outras ainda, apesar da sua capacidade para migrarem, são residentes em zonas relativamente pequenas durante todo o ano e tornam-se dependentes do contínuo de disponibilidade alimentar nos seus habitats. Nalguns casos, ocorrem desvios na distribuição dos cetáceos que não estão

relacionados com as migrações anuais, eventos estes que podem reflectir alterações na qualidade ou na disponibilidade de presas nos seus habitats preferidos (Bjorge, 2002). A distribuição de espécies de cetáceos está também presumivelmente relacionada com a dinâmica dos factores oceanográficos, através das interacções físicas e biológicas entre o fitoplâncton, o zooplâncton e as presas dos golfinhos e baleias (Mignucci-Giannoni, 1998; Baumgartner *et al.*, 2001).

Sendo espécies que caçam activamente as suas presas e com taxas de reprodução baixas, os cetáceos têm um grande (provavelmente o maior) efeito na estruturação dos ecossistemas nos quais se inserem. Para além disso, sendo predadores de topo da cadeia alimentar, são igualmente indicadores úteis da condição de um ecossistema (Bouquegneau *et al.*, 1997). De qualquer forma, o papel ecológico dos cetáceos na dinâmica trófica dos ecossistemas marinhos ainda não é completamente compreendido, existindo poucos dados sobre a composição de espécies, a distribuição e a sazonalidade de cetáceos em muitas regiões mundiais (Kenney *et al.*, 1997).

1.2 – Características oceanográficas

As temperaturas do ar e da superfície do mar normalmente diminuem do equador para os pólos, no entanto, alguns processos locais complicam este padrão aparentemente simples. Por exemplo, as correntes de *upwelling* transportam água fria para a superfície ao longo do equador e ao longo das fronteiras orientais entre os oceanos e os continentes, enquanto que outras transportam água quente na direcção dos pólos ao longo das fronteiras ocidentais. Por outro lado, a salinidade à superfície da água também varia bastante entre as águas árcticas e as águas tropicais. Embora estas variações não tenham um impacto directo sobre os mamíferos marinhos, influenciam bastante toda a cadeia trófica, da qual estes predadores de topo dependem, através da estratificação e circulação das massas de água. Em zonas costeiras é ainda de referir que processos como a

precipitação e a evaporação, ou ainda as descargas fluviais podem alterar significativamente os valores de salinidade (Fiedler, 2002).

Assim, as características oceanográficas que provavelmente influenciam a vida dos cetáceos incluem a temperatura da água, a profundidade, o regime de marés, as correntes, áreas de *upwelling*, movimentos ou concentrações de presas e o declive do fundo marinho. Destas condições, a temperatura da água parece ser o factor mais importante na determinação de zonas de reprodução e alimentação, pois altera também a distribuição do plâncton e de várias espécies de peixe (Lusseau *et al.*, 2004). De igual modo, parece existir uma relação directa entre a distribuição dos cetáceos e a topografia do fundo em certas áreas. Em várias situações, o contorno do fundo parece ser o factor limitante que afecta a agregação de espécies de cetáceos. Provavelmente, à medida que aumenta a complexidade da topografia do fundo, também aumenta a complexidade de todo o ambiente marinho. Esta complexidade é caracterizada por áreas sazonais de *upwelling*, que transportam elevados níveis de nutrientes os quais fazem aumentar a produtividade primária, facilitando deste modo o crescimento dos consumidores primários e secundários tais como o zooplâncton, os cefalópodes e os peixes. Consequentemente, surgem os predadores de topo como os golfinhos e as baleias (Mignucci-Giannoni, 1998).

1.3 – O Golfo da Guiné

Em termos oceanográficos, o Golfo da Guiné é atingido por duas importantes correntes oceânicas: (1) a contra-corrente equatorial que atravessa o Oceano Atlântico no sentido da América do Sul para África; (2) a corrente anti-ciclónica equatorial, que se move no sentido contrário aos ponteiros do relógio entre o Atlântico Sul (no limite da região polar antárctica), a zona de Benguela (passando pelo Golfo da Guiné) e a zona oeste do Atlântico (passando pela costa do Brasil). Estas correntes, ao movimentarem massas de água entre diferentes zonas do oceano Atlântico, alteram a distribuição dos parâmetros

oceanográficos, como a temperatura, a salinidade e, deste modo, influenciam indirectamente os recursos alimentares dos cetáceos (Fiedler, 2002).

A caça aos cetáceos no Golfo da Guiné data do séc. XIX e a razão para o desenvolvimento desta actividade baleeira deve-se ao facto destas águas constituírem provavelmente áreas de reprodução da baleia corcunda, *Megaptera novaeangliae*. Foi só depois da entrada em vigor das recomendações da Comissão Internacional Baleeira (*International Whaling Commission*) em 1986, que a captura destas baleias deixou de ser exercida. Entre 1913 e 1952, foram capturados mais de 10.000 exemplares de grandes baleias, incluindo várias espécies de baleias de barbas e também cachalotes (Figueiredo, 1958). Quanto à legislação, das onze referências às actividades humanas associadas ao meio marinho, seis estão relacionadas com a baleação e as restantes, posteriores a este período, referem aspectos gerais de protecção ambiental.

A fauna de mamíferos marinhos da costa ocidental africana, bem como das ilhas oceânicas do Golfo da Guiné, não está ainda devidamente estudada. Apesar de existir uma grande diversidade faunística, há muito pouca informação sobre as espécies de mamíferos marinhos que ocorrem nesta região (Hoyt, 2005). Na literatura científica datada de várias décadas atrás são referidas para esta região populações costeiras de golfinhos-roazes (*Tursiops truncatus*), de golfinhos-comuns (*Delphinus delphis*) e de baleias-piloto (*Globicephala spp.*); populações migratórias de orcas (*Orcinus orca*), de cachalotes-anão (*Kogia spp.*) e de baleias (*Balaenoptera spp.*); e ainda populações pelágicas, que migram cada ano vindas do Árctico ou da Antártida, de cachalotes (*Physeter macrocephalus*) e também diversas espécies de baleias (*Balaenoptera spp.*). Para além destas espécies, também está referida, a partir de dados de baleação, a ocorrência de baleias-corcunda (*Megaptera novaeangliae*). Estão referenciadas para este arquipélago cerca de vinte e oito espécies de cetáceos (Reeves *et al.*, 2002).

Determinadas zonas das águas costeiras da Ilha de S. Tomé e do Ilhéu das Rolas parecem constituir locais de agregação dos cetáceos devido possivelmente aos seus elevados níveis de actividade biológica e potenciais presas. Existem poucos trabalhos até à data sobre a fauna ictiológica desta região. Desde os trabalhos pioneiros nos fins do

século XIX, poucas informações originais sobre os peixes de S. Tomé têm sido publicadas (Afonso *et al.*, 1999). Recentemente foi feito um inventário dos peixes costeiros que ocorrem na Ilha de S. Tomé, onde foram registados um total de 185 espécies de peixes, com predominância das famílias Carangidae, Serranidae, Gobiidae e Scombridae (Afonso *et al.*, 1999). Os resultados deste trabalho evidenciaram que a fauna ictiológica desta ilha é peculiar, albergando várias espécies anfi-atlânticas (i.e. que habitam tanto no Atlântico oriental como no ocidental) que no seu lado oriental apenas existem nas ilhas oceânicas.

Tendo em consideração os resultados obtidos nos estudos preliminares, bem como as características oceanográficas especiais desta região, presume-se que este ecossistema suporte uma grande diversidade de espécies de cetáceos pelo facto de fornecer potencialmente um grande número de nichos ecológicos. Um estudo preliminar, realizado em 2002 mostra a ocorrência de uma grande variedade de cetáceos nesta região: baleias-corcunda (*Megaptera novaeangliae*), golfinhos-roazes (*Tursiops truncatus*), golfinhos-malhados pantropicais (*Stenella attenuata*), orcas (*Orcinus orca*) e baleias-piloto (*Globicephala spp.*) (Carvalho *et al.*, 2003). Apesar do seu carácter exploratório, este trabalho parece igualmente indicar uma certa distribuição temporal da ocorrência das diferentes espécies.

Figuras 1, 2 e 3- Algumas das espécies com ocorrência comprovada nas águas de S. Tomé: 1) baleia-corcunda (*Megaptera novaeangliae*), 2) golfinhos-malhados (*Stenella attenuata*) e 3) cachalote (*Physeter macrocephalus*) (Fotos da autora, 2005).

Assim, torna-se muito importante avaliar que processos afectam a distribuição dos cetáceos e a que escalas espaciais e temporais operam estes processos. Apesar de ser muito exigente, é, sem dúvida, um trabalho necessário para compreender de que modo as condições oceanográficas afectam a ecologia dos cetáceos nesta região.

1.4 – Conservação de Cetáceos

A conservação é um processo dinâmico que nunca é considerado completo. As medidas de conservação aplicadas necessitam de ser avaliadas e reavaliadas constantemente de acordo com as novas ameaças que surgem (Reeves *et al.*, 2003). Estamos na Era do estudo de baleias e golfinhos a partir de espécimes vivos, em detrimento do estudo de animais arrojados mortos, estudos estes que vieram, em muitos casos pela primeira vez, revelar detalhes acerca das necessidades destes animais. No entanto, ainda existem muitas lacunas no que refere à maioria das espécies no seu meio ambiente natural (Hoyt, 2005).

Os cetáceos, devido ao seu valor educacional, científico e económico, necessitam de grandes áreas de conservação, funcionando com espécies-chave na protecção dos habitats oceânicos, assim como permitindo a conservação de novas áreas (Whitehead *et al.*, 2000). Os melhores planos de conservação são aqueles que consideram o ecossistema como um todo, protegendo e monitorizando animais, plantas e microorganismos, não descurando as pessoas (Hoyt, 2005).

Aproximadamente 12% da área terrestre tem algum estatuto de protecção, comparado com menos de 1% dos oceanos e mares adjacentes (Bates, 2003; Hoyt, 2005), sendo que pouco mais de 3% destas últimas foram criadas para protecção de cetáceos (Evans & Pascual, 2001). Isto deve-se fundamentalmente às diferenças existentes no pensamento e execução de formas de conservação entre estes dois sistemas, assim como à falta de estudos existente no meio aquático. Nos oceanos estamos perante um mundo tridimensional, com diferentes biomas, com espécies e ecossistemas a ocorrerem a diferentes camadas da coluna de água, contrariamente ao ambiente estático terrestre (Hoyt, 2005).

O aspecto mais difícil na criação de reservas de protecção para cetáceos é a definição e identificação das suas áreas vitais. O habitat crítico para os cetáceos é considerado a área que é regularmente utilizada por um grupo, população ou espécie para desenvolver as suas tarefas essenciais que permitam a sobrevivência e a manutenção de

uma taxa de crescimento populacional saudável, sendo cruciais as áreas de alimentação, acasalamento e nascimentos. Estas áreas de protecção devem também estender-se às áreas consideradas críticas para as presas dos cetáceos (Hoyt, 2005).

Alguns cientistas e conservacionistas envolvidos no estudo dos cetáceos consideram que as Áreas Marinhas Protegidas não são efectivas na protecção destes animais, pois o seu tamanho e escala não é adequado, o habitat dos cetáceos é difícil de definir em termos de limites de protecção e é necessário uma coordenação entre países para a conservação surtir algum efeito (Hoyt, 2005).

Nenhuma estratégia simples de conservação vai facilitar a recuperação de populações ameaçadas ou a recuperação de habitats. Têm de ser utilizadas técnicas robustas, multifacetadas e adaptáveis a condições locais ou regionais particulares (Reeves *et al.*, 2003).

Existem duas grandes razões para considerar os cetáceos na criação de Áreas Marinhas Protegidas: o valor intrínseco dos cetáceos por si só e o papel importante que têm na conservação de outras espécies e ecossistemas (Whitehead *et al.*, 2000; Hooker & Gerber, 2004; Hoyt, 2005). Das 84 espécies de baleias e golfinhos conhecidas, 50% têm o estatuto de "dados insuficientes" (DD) ou "não avaliado" (NE), o que é muito preocupante (Hoyt, 2005).

1.5 – Objectivos

Em diversas regiões tropicais do mundo, as comunidades de cetáceos estão bem estudadas, mas sobre as comunidades costeiras e oceânicas de cetáceos que ocorrem em S. Tomé e Príncipe não existe praticamente nenhum conhecimento, visto que os primeiros estudos científicos são ainda muito recentes. Que espécies ocorrem? Onde podem ser encontradas e com que frequência? Como é que estes padrões variam ao longo do tempo e do espaço? Estas são algumas das perguntas que ainda se colocam sobre os cetáceos que ocorrem nestas ilhas oceânicas. À medida que o conhecimento

sobre as populações naturais de cetáceos nos vários oceanos aumenta, torna-se possível comparar as comunidades de diferentes locais. Neste sentido, é importante compreender melhor como as variações nos ecossistemas, sejam naturais ou induzidas pelo homem, se manifestam sobre a biologia, ecologia e comportamento dos cetáceos.

Informação acerca da distribuição e abundância de cetáceos é importante na avaliação de espécies potencialmente ameaçadas por actividades humanas no mar (Macleod *et al.*, 2003). Estas informações são tão mais importantes numa altura em que a exploração petrolífera se inicia em S. Tomé e Príncipe. Esta é também uma região cada vez mais escolhida como destino turístico. Os operadores turísticos vêm no *whale watching* mais uma forma de atrair turistas para os *resorts* que continuam a aparecer nas ilhas principais e ilhéus deste arquipélago. Por isso é importante que se conheça o que existe nas águas destas ilhas, e se implemente legislação que regule esta actividade. É também importante o conhecimento das áreas mais importantes de ocorrência de cetáceos, para estabelecer áreas prioritárias para conservação destes animais.

Existem muitos factores que influenciam a distribuição espacial e temporal, bem como a abundância dos cetáceos. A correlação entre as características ambientais e os dados dos avistamentos pode aumentar a nossa compreensão sobre a ecologia dos cetáceos e indicar quais os factores oceanográficos que afectam a sua distribuição (Davis *et al.*, 1998).

Neste sentido, os objectivos principais para a realização deste trabalho são:

- Estudar a ocorrência de cetáceos no arquipélago de S. Tomé e Príncipe e identificar as várias espécies que ai ocorrem (Artigo I);
- Relacionar a ocorrência das espécies de cetáceos com diferentes variáveis ecológicas, biológicas e físicas (Artigo I);
- Perceber quais as actividades humanas que podem afectar a distribuição dos cetáceos (Artigo II);
- Com base na revisão da legislação existente acerca da conservação dos cetáceos (histórica e recente), fazer uma avaliação das condições de conservação destes animais (Artigo II).

OCCURRENCE AND DISTRIBUTION OF CETACEANS IN SAO TOME AND PRINCIPE TROPICAL ARCHIPELAGO AND THEIR RELATION TO ENVIRONMENTAL VARIABLES

Picanço, C.[1,2], Carvalho, I.[2,3,4] & Brito, C.[5]

[1] UBC – Unidade de Biologia da Conservação, Universidade de Évora, Pólo da Mitra, Valverde, 7002-554 Évora, Portugal. [2] Projecto Delfim – Centro Português de Estudos dos Mamíferos Marinhos, Apartado 23051 1147-601 Lisboa, Portugal. [3] Faculdade de Ciências do Mar e Ambiente – Universidade do Algarve, Campus Gambelas, 8000-139 Faro, Portugal. [4] Centre for Biodiversity and Conservation - American Museum of Natural History 79 th Street and Central Park West, New York, NY, 10024, USA. [5] Escola de Mar, Rua Actriz Virgínia, 17 C, 1900-026 Lisboa, Portugal.

ABSTRACT

Sao Tome and Principe is an archipelago located in the Gulf of Guinea. This archipelago seems to be an important area for cetaceans, probably due to large concentrations of prey, as well as the existence of several small bays and shallow water that constitute preferred rest areas. In comparison to other areas of the world, little is know about cetacean communities in this archipelago. A biological research to study cetacean's occurrence was conducted between 2002 and 2005. In order to accomplish that we intended: (1) to determine the occurrence and distribution of cetaceans in the waters around the S. Tome Island, and (2) to relate the occurrence of the different cetaceans' species with oceanographic parameters, such as sea surface temperature (SST) and depth. Sightings of humpback whales (*Megaptera novaengliae*), bottlenose dolphins (*Tursiops truncatus*), pan-tropical spotted dolphins (*Stenella attenuata*), orcas (*Orcinus orca*), sperm whale (*Physeter macrocephalus*) and pilot whale (*Globicephala spp*) were recorded. Cetaceans were found throughout a range of temperatures between 24 and 29ºC and a wide range of depths, with significant differences, when we compare the general pattern of the special distribution of the mysticetes and odontocetes bearing in mind these two variables. Humpback whales showed a preference for shallower waters between 20 and 100 meters. Bottlenose dolphins occurred most commonly along the continental shelf (20 to 100 m) and pan-tropical spotted dolphin occurred in deep slope waters (> 1000 m) and for SST of 26 and 27 ºC. In general, assessing species distribution across their habitat in relation to environmental variables is essential to obtain a more completed understanding of the dispersion of upper-trophic marine predators and the nature and location of habitat hot-spots. This study represents the first attempt to document occurrence and distribution of cetaceans in S. Tome and Principe Archipelago. Care should be taken, however, because results presented here only pertain to some months of the year, and may not reflect accurately what happens in the area during the remaining period.

INTRODUCTION

Tropical waters make up nearly one-half the area of the world's oceans (Longhurst & Pauly, 1987), and about one-half the known cetacean species have tropical or broader distributions. However, relatively little is known about the ecology of pelagic tropical cetacean communities in most areas of the world (Hooker *et al.*, 1999).

Oceans are naturally heterogeneous on a wide range of spatial scales. The complexity of this environment creates a variety of habitats that marine organisms exploit throughout their lifetimes. Species have evolved to recognize and utilize particular features of their environment for locating food, avoiding predation, finding a mate, and producing young. Marine populations also tend to aggregate for reproduction, feeding, protection, and migration. Their ability to perform these functions is dependent not only on cues from other organisms, but on features of their physical environment (Palacios *et al.*, 2006).

There is some evidence that the distribution and relative abundance of marine predators in the world can be used as an indication of underlying prey distributions and ecosystem processes (Tershy *et al.*, 1991; Croll *et al.*, 1998; Hooker & Gerber, 2004). Species distributions are determined by a combination of spatial and temporal processes, closely linked to habitat (Ross *et al.*, 1987; Borcard *et al.*, 1992; Frankel *et al.*, 1995; Davis *et al.*, 1998). In the marine environment, species' spatial distributions may be determined by both fixed spatial features such as topography and variable oceanographic features such as sea surface temperature (SST) and salinity (Hooker *et al.*, 1999). To understand the habitat and population characteristics of cetaceans, it is necessary to consider environmental variables such depth, salinity, SST and prey distribution. This could help to define conservation and management strategies for these species, severely threatened by fishing activities. In theory, bathymetric features, such as shallow-water topographic, may provide a means of predicting important foraging habitats for upper trophic-level marine predators, and cetaceans displayed relatively persistent bathymetric associations through time (Yen *et al.*, 2004; Balance *et al.*, 2006). These habitats are likely associated with elevated ocean productivity and prey retention, thereby making dense prey patches

available to predators. Furthermore, there is some evidence that cetaceans persistently aggregate at these habitat features, though species redistribute over time (Yen *et al.*, 2004).

Distribution and abundance of food resources, predation risk, and some of the physical characteristics of the habitat are known to influence group size of cetacean populations too (Norris & Dohl, 1980; Wells *et al.*, 1980; Silva *et al.*, 2003). Animal populations may change in size and distribution over time for a wide variety of reasons. Monitoring those changes and then identifying the causes for them forms the core of conservation research. Information on spatial and temporal variation in cetacean abundance, as with other taxa, is essential to determine both whether management actions are necessary and the effectiveness of any actions that are taken (Evans & Hammond, 2004). But monitoring spatial and temporal patterns in cetacean abundance involves a variety of approaches depending upon the target species and the resources available (Evans & Hammond, 2004). Also global warming and other effects of climate change threaten the survival of cetaceans and other wildlife around the world. Changes in ocean temperature shift the distribution of plankton and fish species, and consequently the distribution of cetaceans. But the effects of climate variations on higher trophic levels can be difficult to understand because they involve several relationships that may be non trivial and nonlinear (Lusseau *et al.*, 2004).

The Sao Tome and Principe Archipelago seems to be an important area for cetaceans, probably due to large concentrations of prey as well as the existence of several bays and shallow water that constitute rest areas (Carvalho, 2004). Besides the presence of coastal species, it must be remembered that the volcanic origin of the islands produces great depths near to the shore, which may favour the approach of pelagic species (Aguilar, 1985). But in comparison to other areas of the world, little is known about the spatial and temporal patterns of distribution and abundance of cetaceans around this archipelago.

The main objective of this study was to conduct a preliminary evaluation of this region for the occurrence of cetaceans. In order to accomplish that we intended: (1) to determine the occurrence and distribution of cetaceans in the waters around the Sao Tome

Island, and (2) to relate the occurrence of the different cetaceans' species with some oceanographic parameters, such as sea surface temperature (SST) and depth.

METHODS

Study area

Sao Tome and Principe is an African equatorial archipelago located in the Gulf of Guinea in front of the Gabonese coast. This oceanic and tropical archipelago is the second smallest African country and is composed of two main islands and several small islands and islets. Despite their small size (850 Km^2 covered by Sao Tome and 140 Km^2 by Principe), the islands of Sao Tome and Principe are mainly composed of a dense tropical forest, with just small areas occupied by man, and have a great biodiversity. The underwater world around the islands has also a very rich and diverse fauna, with sharks, cetaceans and sea turtles in the top of the food chain.

Figure 1 – Localization of S. Tome and Principe archipelago, in reference to the coast of the West Africa. *(Image obtained from www.unicef.org).*

The climate of Sao Tome is under the influence of its geographical position and especially of the relief of the islands. There are two distinct climate seasons: the dry and fresh season – *Gravana* – between June and September and January (*Gravanito*) and the rainy season in the other months (especially October to December). The coast line where numerous rivers, cascades and other water streams flow into is outlined by bays and rocky recesses. Its volcanic origin and its pronounced relief originate a very reduced continental shelf. On the island of Sao Tome, the continental shelf is very narrow. In fact, it is never wider than 436 Km^2 above 200 metres deep (Afonso *et al.*, 1999). In oceanographic terms, the Gulf of Guinea is influenced by two significant ocean currents: the equatorial counter-current, which flows through the Atlantic Ocean from South America to Africa, and the

equatorial anti-cyclonic current, which moves anti-clockwise between the south of the Atlantic and the area of Benguela and the western area of the Atlantic.

Survey effort

A biological research was conducted between 2002 and 2005 in Sao Tome and Principe. A total of 201 boat-based surveys were conducted around S. Tome Island, in order to evaluate cetaceans' presence, their distribution and habitat use. During 2002 and 2003, we were based on Ilhéu das Rolas (also known as Ilhéu Gago Coutinho) in the south of Sao Tome Island and our surveys always started and ended there. In the following years, surveys began from the city of Sao Tome located northeast on the main island. Surveys were carried-out from July to December in 2002, January and August to October in 2003, October and November in 2004 and from August to October in 2005. Weather and logistical constraints were the main reason for the selection of the study period in each year (e.g. Silva *et al.*, 2003).

The study area extends from the coast to the 2000 meters isobaths around the island of S. Tome. The survey route was selected to cover a large part of the island and included areas known to be used by cetaceans and was limited primarily by sea and wind conditions. Within these constrains, efforts were made to cover an area as wide as possible, extending as far alongshore and offshore as possible, given fuel and sea constraints. As in MacLeod & Bennett (2007), the dedicated boat surveys were conducted using locally available boats ranging in length from 5 meters in years 2004-2005 to 7 meters in years 2002-2003 (powered by 40 HP outboard engines). At least two observers and one crewman were onboard during each survey. The occurrence of surveys was strongly weather-dependent and were conducted whenever the sea conditions were suitable (i.e. wind less than or equal to 6 Beaufort). Survey routes, were not pre-determined with fixed waypoints, but normally ran parallel to the coastline, with some variation, depending on prevailing weather conditions (e.g. Weir *et al.*, 2007). During the surveys, at least one observer was stationed on each side of the boat and scanned an area from directly ahead of the vessel to approximately 135° from the bow of the vessel. Due to the

low eye-height above sea level (generally between 1.5 and 2.0 m) and the stability of the vessels being used, scans were primarily conducted with the naked eye to detect cetaceans. When cetaceans were sighted, groups were approached to confirm species identity. Then, a non intrusive and constant distance was kept from the animals in order to allow the data collection. For each sighting, the time, GPS position, species identity, composition and behaviour were noted. Cetaceans were identified to the lowest taxonomic level possible based on descriptions in field guides and scientific literature (e.g. Reeves *et al.*, 2002; Maze-Foley & Mullin, 2006). Photographs were taken when possible using Minolta and Nikon F70 analogical cameras, using respectively a 75-300 mm and 70-300 mm auto focus zoom lens (2002-2003) and a Nikon D70 digital camera, using a 100-300 mm auto focus zoom lens (2004-2005). The group was subsequently followed until either the group was lost or it was determined that the survey would have to be continued in order to be able to complete it in the available time.

The main study area was subdivided into six geographic sectors according to latitude and longitude coordinates (see figure 2) to eliminate any variability potentially caused by the different amount of time (minutes) spent in each one.

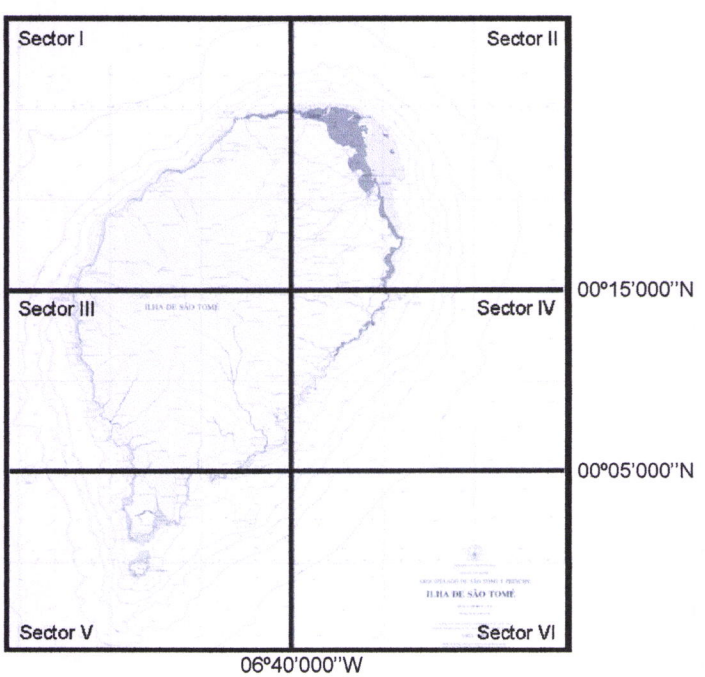

Figure 2 – Map showed the study area subdivided in six sectors according to latitude and longitude coordinates.

Back on land, photographs were analyzed to confirm species identification, GPS positions plotted into the laptop, as well as all the ecological recordings made during each day survey. Depth at each cetacean sighting was derived from bathymetric charts. Four classes of bathymetry were considered ([0-20[, [20-100[, [100-1000[and [1000-2000[m). The data from sea surface temperature were downloaded from servers of IRI/LDEO (International Research Institute for Climate and Society Library).

Due to the existence of few samplings, the division of the observed species was carried out in order to remove the biggest number of any existing zeros. Two groups were considered: mysticetes and odontocetes. Whenever necessary, the groups were analysed bearing in mind the species involved. For the same reason, three or six sectors were considered for statistical analysis. To statistical analysis, non-parametric tests were used. The Mann-Whitney U test was used to check for any relationship between the distribution of the species and SST and depth. Later on, a G test was carried out so that we could test differences in the category distribution pattern of each study parameter: sectors, depth and SST. In order to accomplish the G test, the respective values were obtained bearing in mind the time spent and the temperature in each sector. In the case of depth, since it was not possible to recover the time spent in each class, the respective values are estimates of the total amounts, supposing that the observed groups do not have a specific standard distribution directly related with depth.

All species observed were considered to statistical procedures, followed Siegel & Castellan (2000) and Zar (1996); the analyses were performed with the software *Statistica 5.0*. The map of sightings was constructed with the software *ArcGIS 9.1*.

RESULTS

Survey effort

During the four years of study we conducted 201 dedicated boat surveys with a sampling total effort of 35212 minutes, of which 5094 minutes were of real cetacean observations (Table I).

Table I – Summary of sampling effort, cetacean's direct observation and number of surveys conducted in each of the four years of field data collection.

Years	Time at Sea (min)	Observation Time (min)	Surveys	Survey Mean Duration (min)
2002	11749	1964	87	135,046
2003	7775	1203	60	129,583
2004	6873	697	22	312,409
2005	8815	1230	32	275,469
TOTAL	**35212**	**5094**	**201**	**175,184**

Occurrence and distribution of cetaceans

Since 2002 to 2005 we encountered different groups of cetaceans. All cetaceans' were identified, corresponding to six different species (Table II): sperm whale (*Physeter macrocephalus*), killer whales (*Orcinus orca*), humpback whales (*Megaptera novaeangliae*), pan-tropical spotted dolphins (*Stenella attenuata*), bottlenose dolphins (*Tursiops truncatus*) and pilot whale (*Globicephala spp.*). Short-finned and long-finned pilot whales cannot easily be distinguished at sea, but based on known distributions (Reeves *et al.*, 2002; Rice, 1998), it seems most likely that pilot whales sightings were short-finned (*Globicephala macrorhynchus*). The humpback whale was the most sighted, registering the highest sighting rate (50,39%). The sighting rate of bottlenose dolphin, pan-tropical spotted dolphin and killer whale was of, respectively 32,56%, 10,85% and 4,66%. Pilot and sperm whales were only seen on one occasion each (0,77% each). The totals of 129 encounters with the referred cetacean's species are mapped in Figure 3.

Table II – Summary of number of surveys and number of different species sighted in the study area between 2002 and 2005.

Year	2002	2003	2004	2005	TOTAL
Survey	87	60	22	32	**201**
Pantropical spotted dolphin (Sa)	1	0	4	9	**14**
Humpback Whales (Mn)	24	23	7	11	**65**
Bottlenose dolphins (Tt)	22	12	2	6	**42**
Pilot whales (Gsp)	0	1	0	0	**1**
Killer whales (Oo)	4	1	1	0	**6**
Sperm whales (Pm)	0	0	0	1	**1**
Total	**51**	**37**	**14**	**27**	**129**

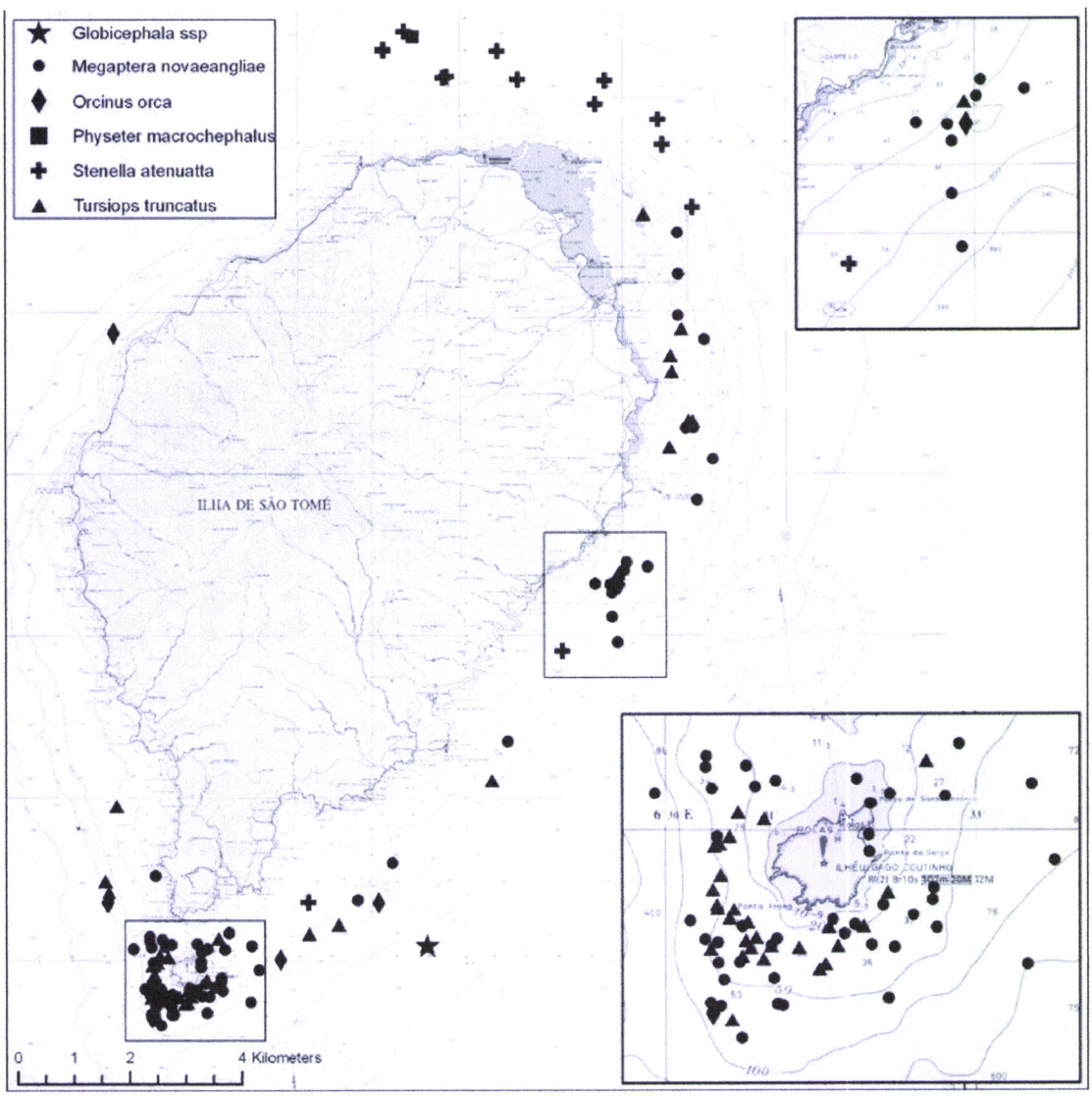

Figure 3 – A total of 129 GPS positions of individual cetaceans groups are mapped around the island of S.Tome; enlarged areas show larger concentrations of cetaceans. The start position for each encounter is indicated by a symbol: (★) *Globicephala ssp*, (•) *Megaptera novaeangliae*, (♦) *Orcinus orca*, (■) *Physeter macrocephalus*, (✚) *Stenella attenuata* and (▲) *Tursiops truncatus*.

Cetaceans were sighted throughout the surveyed area; distribution of effort was not equal between sectors, with greaten effort spent in sectors II, IV and V than in the other sectors. Because of that, geographical differences in the distribution of all cetaceans' species were examined by comparing the number of sightings of each species among the sectors with G test. There was a significant difference in the distribution category pattern of cetaceans between the sectors (I to VI) around Sao Tome Island as far as humpback whales, pan-tropical spotted dolphins and bottlenose dolphins are concerned; the referred species have different distributions (Table III).

Table III – G values for the G test to check the relationship of cetaceans among the sectors. To remove the biggest number of existing zeros, the sectors and species were grouped. The values with * are significant.

Sectors	Groups	df	G value, p<0,05
I+II; III+V; IV+VI	Mysticetes	2	15,5447 *
	Odontocetes	2	2,9743
I; II; III; IV; V; VI	Mysticetes	5	21,2611 *
	Odontocetes	5	11,0818 *
I; II; III; IV; V; VI	Humpback whale	5	21,2611 *
	Bottlenose dolphin	5	15,9721 *
	Pan-tropical spotted dolphin	5	22,3657 *
	Other odontocetes	5	9,7285

Relation of cetaceans' occurrence with environmental variables

There is a wide variation in the cetacean species' use of the Sao Tome waters in relation to area, depth and SST. Cetaceans were found throughout a range of temperatures between 24 and 29 ºC and a wide range of depths (see figure 4).

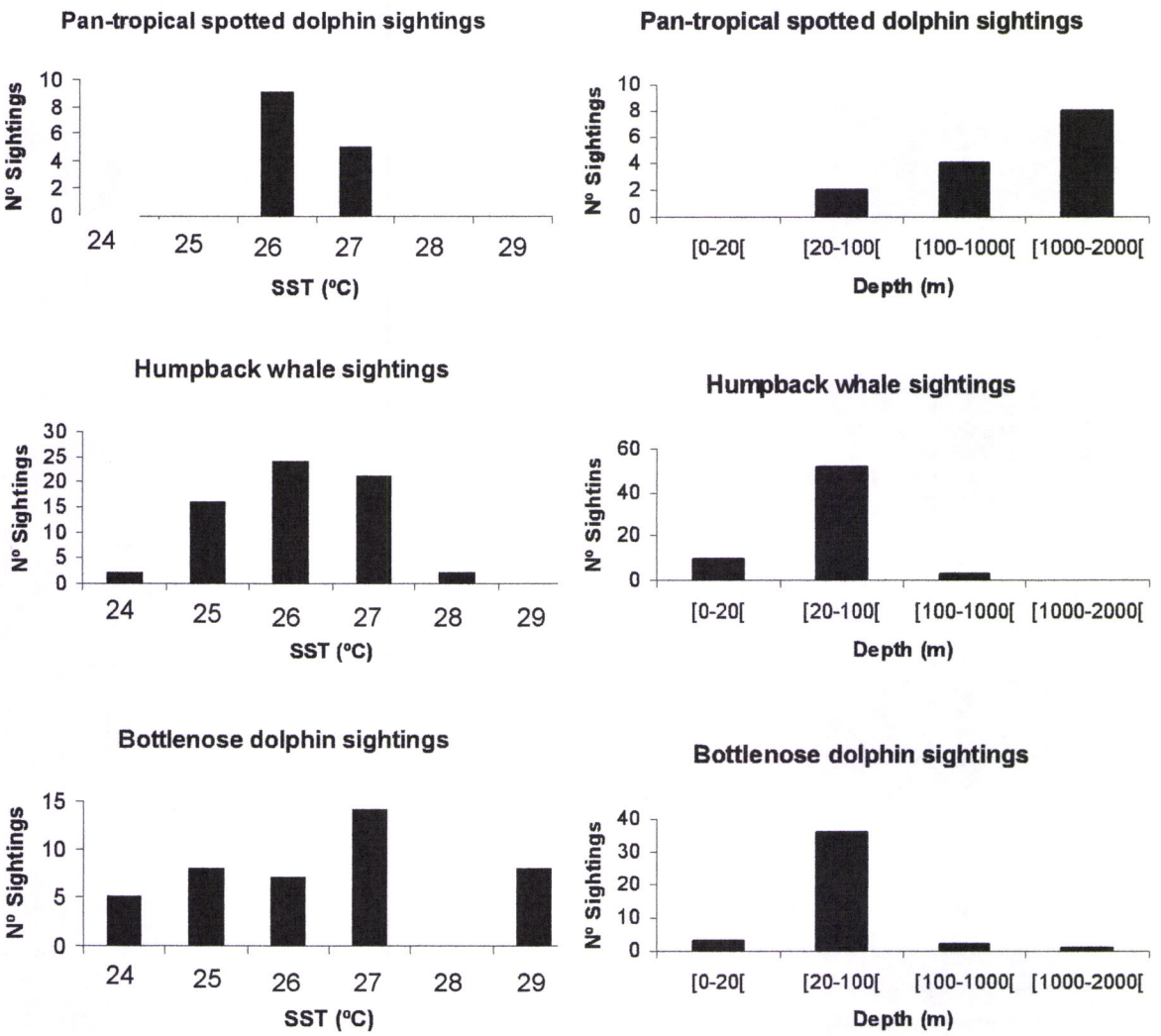

Figure 4 – Comparative distribution of the tree more sighted species, pan-topical spotted dolphin, humpback whale and bottlenose dolphin for the SST values (ºC) and depth classes (m).

When we compare the general pattern of the spatial distribution of the mysticetes and odontocetes bearing in mind these two variables we found significant differences ($U=1605$; $N=129$; $p<0,05$ for SST and $U=1327,5$; $N=129$; $p<0,05$ for depth). In figures 5 and 6, we notice that the odontocetes occur at higher SST and at a wider interval than the mysticetes. The same pattern applies to depth.

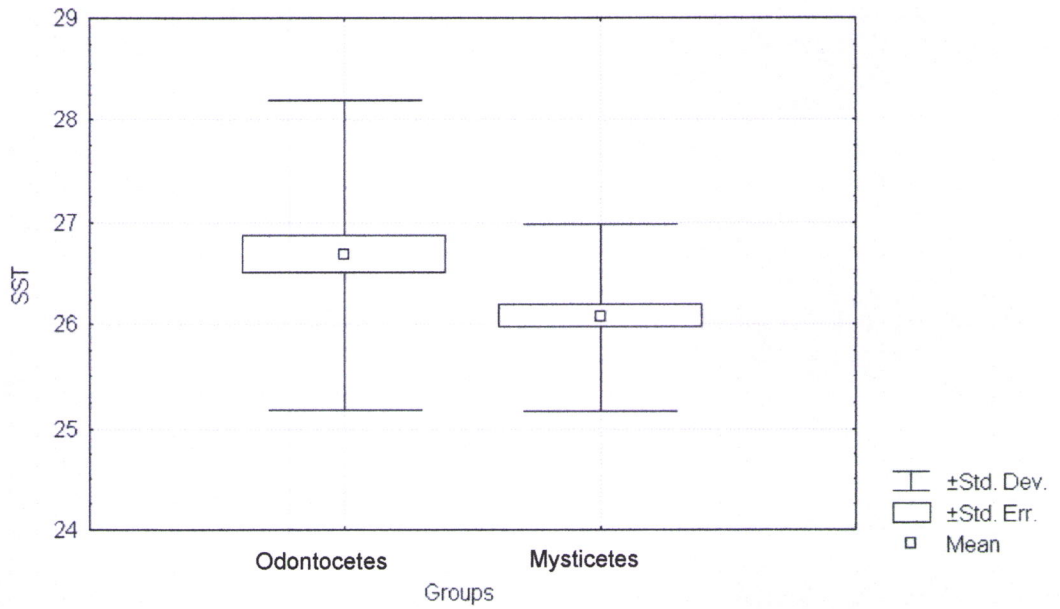

Figure 5 – Mean values of SST for mysticetes and odontocetes distribution (N=129).

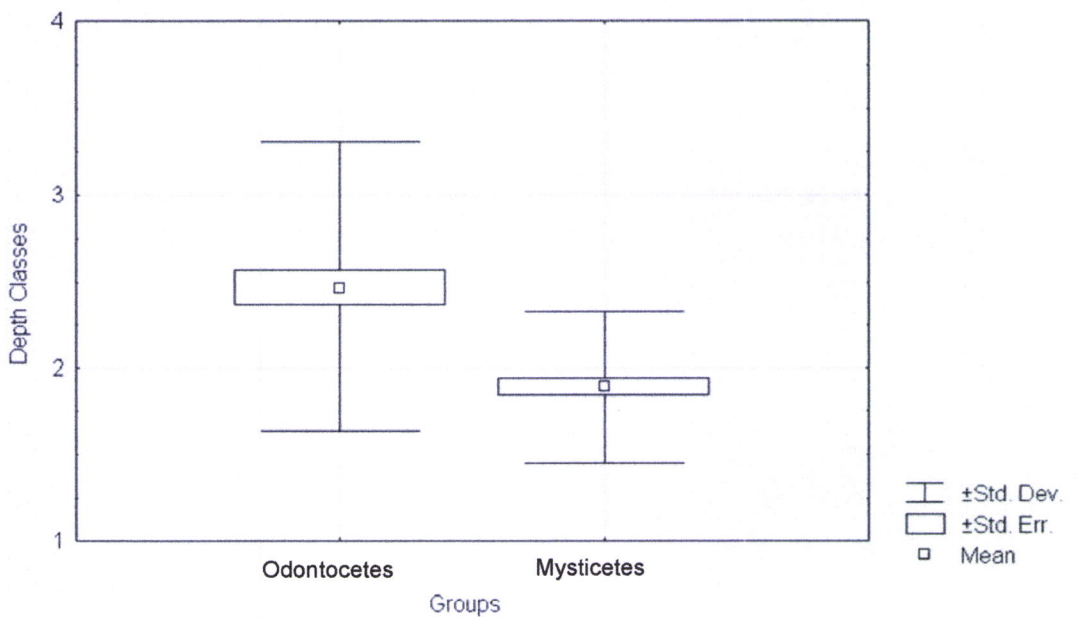

Figure 6 – Classes of bathymetry (1= [0-20[m; 2= [20-100[m; 3= [100-1000[m; 4= [1000-2000[m) for mysticetes and odontocetes ditribution (N=129).

To understand the differences that occur in relation to SST and depth in each species, a G test was conducted. There was a significant difference in the distribution pattern of the three most sighted species around Sao Tome Island in relation to the SST (Table IV). According to this variable, each of them follows a distinctive distribution pattern as observed in figure 4.

Table IV - G values for the G test to check the relationship between cetaceans and the SST. To remove the biggest number of existing zeros the species were grouped. The values with * are significant.

SST	Groups	G value, df= 5, p<0,05
24 to 29	Mysticetes	30,5240 *
	Odontocetes	11,8802
24 to 29	Humpback whale	30,5240 *
	Bottlenose dolphin	11,4330 *
	Pan-tropical spotted dolphin	16,7488 *
	Other odontocetes	16,3823 *

There was a significant difference in the distribution pattern of humpback whales and pan-tropical spotted dolphins around Sao Tome Island in relation to depth (Table V). Pan-tropical spotted dolphins occur in bigger number at depths above 1000 meters as humpback whales and bottlenose dolphins occur at middle depths between 20 and 100 meters (Figure 4).

Table V - G values for the G test to check the relationship between cetaceans and the depth. The depth classes are: 1= [0-20[m; 2= [20-100[m; 3= [100-1000[m and 4= [1000-2000[m.To remove the biggest number of existing zeros the species were grouped. The values with * are significant.

Depth Classes	Groups	G value, df= 3, p<0,05
1, 2, 3, 4	Mysticetes	14,8004 *
	Odontocetes	11,0441 *
1, 2, 3, 4	Humpback whale	14,8004 *
	Bottlenose dolphin	5,85589
	Pan-tropical spotted dolphin	32,7999 *
	Other odontocetes	15,6481 *

DISCUSION

Six different species of cetaceans were seen during the surveys conducted around the Sao Tome Island, in Sao Tome and Principe Archipelago, between 2002 and 2005. Humpback whales, pan-tropical spotted dolphins and bottlenose dolphins were the most sighted species, comprising more than 93% of the sightings. Pilot and sperm whales were only seen once during the surveys, in 2003 and 2005 respectively. For these two species'

sightings occurred on shore waters, between 1000 and 2000 m, which is typical for these species' (Macleod *et al.*, 2003).

As a whole, the species of cetaceans that were sighted during this study were considered to be occurring in this region. Humpback whales are probably migrating from the Antarctic were they feed to these warm waters to breed (Carvalho, 2004) and the smaller dolphins found in numerous groups are typical on coastal areas of oceanic islands such as Sao Tome (e.g. MacLeod & Bennet, 2007). The distribution of the species around the Sao Tome Island seems uneven, but weather and sea conditions may have caused a bias on the observation effort and on the detection of cetaceans. Such as in other studies, winds cause rough seas and often make navigation around the Sao Tome Island difficult and hazardous. This explains, in part, the lack of information about cetaceans occurring in this archipelago as in other parts of the world (Reiner *et al.*, 1996). Nevertheless, in spite of the short number of samplings and of the fact that several zeros were eliminated, three patterns seem to emerge from our data: a higher concentration of humpback whales in the south, of bottlenose dolphins in the southeast, and of pan-tropical spotted dolphins in the northeast of S. Tome Island. For bottlenose dolphins, a total of 49 individuals were identified photographically in 2004 and 2005 and 10,2% of that were re-sighting in 2005. In this year, the researchers observed the same individuals in different days in the same area. This data suggest a certain degree of residency of, at least, some individuals in this region (Pimentel *et al.*, 2007).

Differences of some species distribution among the sectors of the study area could be related to differences in the abundance or diversity of food resources (Selzer & Payne, 1988), although the absence of data on prey species in the waters around this island prevented the examination of this hypothesis. The fluctuation of SST may affect cetaceans' distribution primarily by influencing the availability of their preys too (Selzer & Payne, 1988). Habitat preference is subsequently driven by a complex interaction among behavioural patterns, biological requirements and environmental conditions (Ersts & Rosenbaum, 2003). It is difficult, therefore, to discriminate between the effects of climate change and other factors affecting cetaceans' preys, such as overfishing (Bearzi *et al*, 2005). We

should also add that the SST values in use were daily average ones which were not measured in real time. Therefore, they do not reflect the variation of this parameter between the areas, which may somehow influence the results we have obtained.

Bathymetric features may provide a means of predicting important foraging habitats for cetaceans. Hooker *et al.* (1999) described cetacean distribution using different variables and found that depth was the most informative variable. Many studies have shown that the distribution of cetaceans can be closely linked to habitat, but the underlying function of the preferred habitats often remains unclear (Norris & Dohl, 1980; Wells *et al.*, 1980; Hastie *et al.*, 2004). There were considerable differences in spatial distribution between some species, whereas bottlenose dolphins and humpback whales occurred preferentially in coastal waters, pan-tropical spotted dolphins exhibited the reverse tendency, with greater sightings recorded in the offshore zones. Humpback whales showed a preference for shallower waters between 20 and 100 meters. For humpback whales on their breeding grounds, females with calves preferred shallower waters, also heavily used by humans for coastal trade, commercial and subsistence fishing, whale watching and recreation (Ersts & Rosenbaum, 2003). Humpback whales sighted in the region were the only baleen whales observed and are probably migrating from the Antarctic were they feed to these warm waters to breed (Carvalho, 2004). Bottlenose dolphins occurred most commonly along the continental shelf (20 to 100 m). Pan-tropical spotted dolphin occurred in deep slope waters (> 1000 m) and for SST of 26 and 27 °C, like in the other studies in other regions of world (Maze-Foley & Mullin, 2006; MacLeod & Bennett, 2007). Differences in habitat selection among delphinid species may be reflect distinct feeding habits and foraging strategies, and also could contribute to reduce ecological competition among species that occur in the same geographic area (Silva *et al.*, 2003).

Hooker *et al.* (1999), find that both depth and SST had a significant effect on species distributions, but when interactive effects are considered, the effect of depth appears to be more significant than that of SST, which suggests that species distribution are better defined by fixed features of the physical environment than by variable aspects of environment. SST, hydrographic features and other variables derived from satellite data

have recently been used as predictors of cetacean habitat and distribution (Hooker *et at.*, 1999). Our positional data only represent the location of the initial contact with groups, thus not accounting for variations in depth and SST during the period of observation. These results require more detailed and dedicated studies in the future. We need to understand the real influence of this features on dolphins and whales occurrence and distribution, as well as to consider the biological parameters associated with these physical conditions. In general, assessing species distribution across their habitat in relation to environmental variables is essential to obtain a more completed understanding of the dispersion of upper-trophic marine predators and the nature and location of habitat hot-spots (Yen *et al.*, 2004).

This study represents the first attempt to document occurrence and distribution of cetaceans in Sao Tome and Principe Archipelago. Care should be taken, however, because results presented here only pertain to some months of the year, and may not reflect accurately what happens in the area during the remaining period. The rest of the year represents a more difficult season to survey and to the present date, despite the need of better understanding of seasonal trends to implement appropriate management strategies in this region, no result based on continuous sampling are available for the area. Thus, future cetacean survey studies are necessary to clarify seasonality, maybe using other methods such as aerial surveys and linear transects.

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CETACEANS AND HUMAN MARITIME ACTIVITIES IN SAO TOME AND PRINCIPE ARCHIPELAGO, GULF OF GUINEA: HISTORICAL REVIEW, PRESENT STATUS AND FUTURE APPROACHES

Picanço, C.[1,2], Carvalho, I.[2,3,4] & Brito, C.[5]

[1] UBC – Unidade de Biologia da Conservação, Universidade de Évora, Pólo da Mitra, Valverde, 7002-554 Évora, Portugal. [2] Projecto Delfim – Centro Português de Estudos dos Mamíferos Marinhos, Apartado 23051 1147-601 Lisboa, Portugal. [3] Faculdade de Ciências do Mar e Ambiente – Universidade do Algarve, Campus Gambelas, 8000-139 Faro, Portugal. [4] Centre for Biodiversity and Conservation - American Museum of Natural History 79 th Street and Central Park West, New York, NY, 10024, USA. [5] Escola de Mar, Rua Actriz Virgínia, 17 C, 1900-026 Lisboa, Portugal.

ABSTRACT

Sao Tome and Principe is an archipelago located in the Gulf of Guinea. This archipelago seems to be an important area for cetaceans, probably due to large concentrations of prey, as well as the existence of several small bays and shallow water that constitute preferred rest areas. In comparison to other areas of the world, little is know about cetacean communities in this archipelago. Historically, this archipelago has been reported as a possible breeding ground of humpback whales in the Gulf of Guinea region since the whaling period. Sao Tome and Principe don't have any legislation regarding marine mammals or the marine environment. It is also important to refer that a significant nature tourism and whale watching industry is presently beginning in the archipelago. A biological research to study cetacean's occurrence was conducted between 2002 and 2005. Our research allowed obtaining new data on these cetacean's populations and efforts are being made to create a legal background to regulate human activities that may affect directly or indirectly whales and dolphins' populations.

INTRODUCTION

Humans and cetaceans are both part of the complex marine ecosystems. For an ecosystem approach to the management of the marine environment it is essential to know the role of all components and the consequences of the human impacts. The state of the global oceans is rapidly deteriorating, with dire consequences for marine species (Jackson *et al.*, 2001). Several marine mammals' species or significant populations are currently threatened by a variety of anthropogenic factors, ranging from bycatch and ship-strikes to pollution, global warming, and potential food competition. Cetaceans, as a guild of abundant, large organisms that are relatively sensitive to such threats, provide a reliable means to determine the boundaries for a conservation area in a certain region (Hooker *et al.*, 1999).

Marine mammals are not only top predators and indicators of the quality of their ecosystems, but also relatively vulnerable to extinction. Of the approximately 120 currently recognized marine mammal species, four have become extinct, eleven are thought to be in imminent peril of extinction, seventeen to be of significant concern with respect to extinction, and eight were once thought to be at risk of extinction but are now recovering (VanBlaricom *et al.*, 2000; Hooker & Gerber, 2004). Historically, most conservation efforts have focused on terrestrial systems, but it is becoming increasingly apparent that conservation efforts are urgently required for the oceans as well (Casey & Myers, 1998). Recently, significant attention has been given to the establishment of marine reserves, because marine and freshwater habitats are less well known than terrestrial areas (Boersma & Parrish, 1999; Mangel, 2000; Hooker & Gerber, 2004; Mace, 2005). In recent years, many studies of distribution have aimed to identify critical habitats for cetaceans (Greg & Trites, 2001; Harwood, 2001) and, in several cases, such data have been used to support the establishment of Marine Protected Areas (MPA) (Dawson & Slooten, 1993; Hooker *et al.*, 1999; Hastie *et al.*, 2003). In spite of the lack of a solid theoretical foundation, large ocean megafauna, such as marine mammals and birds, are often used to direct conservation efforts. Marine predators attract significant attention in ocean conservation

policy and planning and are therefore often used to promote reserve designation (Hooker & Gerber, 2004).

The World Conservation Union has defined a Marine Protected Area as "*any area of inter-tidal or sub-tidal terrain, together with its overlying waters and associated flora, fauna, and historical and cultural features, which has been reserved by legislation to manage or protect part or all of the enclosed environment*" (Kelleher & Kenchington, 1992; Hooker *et al.*, 1999). The prime objective in the establishment of many MPA is the conservation of biodiversity (Jones, 1994; Hooker *et al.*, 1999). In general, we find that reserves can benefit marine megafauna, and that megafauna can help establish target areas and boundaries for ecosystem reserves. However, the spatial nature of the interplay between potential threats and predator life histories requires careful consideration for the establishment of effective reserves (Hooker & Gerber, 2004; Giuseppe Notarbartolo di Sciara, personal communication). An alternative to this approach is to examine which human activities might affect top predators and regulating those activities to achieve conservation aims (Tasker, 2007). The development and implementation of effective conservation measures requires, however, detailed knowledge about the geographic occurrence of a species (Kaschner *et al.*, 2006).

Sao Tome and Principe, an African equatorial archipelago situated in the Gulf of Guinea, seems to be a relevant marine area of cetacean's concentration, which may be due to prey abundance or the existence of shallow and protected bays. Information on cetacean distribution plays an important role in the identification of suitable boundaries for marine protected areas, but is also crucial for developing management and monitoring programmes. Even though data on habitual use by pelagic cetaceans is generally difficult to collect, such information is beneficial to most conservation and management purposes (Kiszka *et al.*, ND) and this is what is intended for Sao Tome and Principe archipelago. Our objectives in this study were (1) to determine the presence of cetaceans along the coast of the Sao Tome island, (2) to understand which human activities could affect the presence of cetaceans in coastal waters, (3) to review historical and recent legislation related to

cetaceans and (4) to give some preliminary indications to the conservation of coastal whales and dolphins.

METHODS

Between 2002 and 2005 a pilot study was conducted which allowed a preliminary assessment of which species of cetaceans regularly occur around Sao Tome island (Sao Tome and Principe archipelago, Gulf of Guinea). A total of 201 dedicated boat-based surveys were conducted in order to evaluate cetaceans' presence, distribution and habitat use. The survey route was not pre-determined with fixed waypoints but rather was selected to cover a area as wide as possible.

Also, an exploratory historic and socio-cultural research was carried out. This investigation was conducted in national archives and libraries, especially the Sao Tome and Principe National Archive, as well as in local environmental and historical associations, to obtain some information on the maritime and coastal human activities existing in the archipelago. A careful and detailed review of more recent literature, regarding cetacean occurrence, fishing and conservation of marine environment in the Gulf of Guinea, was conducted during all the period of this study.

RESULTS

Occurrence of cetaceans

Literature review

The marine mammal fauna of the West African coasts, as well as of the oceanic islands in the Gulf of Guinea, is not well known and, despite the existence of a great diversity, there is very little information about the ecology of the species occurring in that region (Hoyt, 2005). The bibliographical information available for the cetacean occurring in the Gulf of Guinea is summarized on Table I.

Table I- Cetacean species that may occur in Sao Tome and Principe.

Cetacean Specie	Geographic localization in West Africa	References
Steno bredanensis	Ivory Coast, Gulf of Guinea off Ghana, Entire West African coast and Gulf of Guinea	Jefferson *et al.*, 1997; Reeves *et al.*, 2002
Sousa teuszii	Cameroon, Nigeria, Gabon	Jefferson *et al.*, 1997; Reeves *et al.*, 2002
Tursiops truncatus	Entire West African coast, Ivory Coast, Cameroon, Gabon, Gulf of Guinea	Jefferson *et al.*, 1997; Reeves *et al.*, 2002
Stenella attenuata	Ghana, Ivory Coast, Gulf of Guinea	Jefferson *et al.*, 1997; Reeves *et al.*, 2002
Stenella frontalis	Gulf of Guinea, Gabon, Ivory Coast	Jefferson *et al.*, 1997; Reeves *et al.*, 2002
Stenella longirostris	Ivory Coast, Gulf of Guinea, Equatorial Guinea, Gabon	Jefferson *et al.*, 1997; Reeves *et al.*, 2002
Stenella clymene	Gulf of Guinea, Equatorial Guinea	Jefferson *et al.*, 1997; Reeves *et al.*, 2002
Stenella coeruleoalba	Ivory Coast, Entire West African coast, Gulf of Guinea	Jefferson *et al.*, 1997; Reeves *et al.*, 2002
Lagenodelphis hosei	Gulf of Guinea, West African coast	Reeves *et al.*, 2002
Delphinus sp	Gabon, Ivory Coast, Cameroon, Congo	Jefferson *et al.*, 1997; Reeves *et al.*, 2002
Megaptera novaeangliae	Entire West African coast and Gulf of Guinea	Reeves *et al.*, 2002
Balaenoptera acutorostrata	Ivory Coast, Ghana, Cameroon, Nigeria, Gabon	Reeves *et al.*, 2002
Balaenoptera bonaerensis	Entire Gulf of Guinea	Reeves *et al.*, 2002
Balaenoptera edeni	Entire West African coast, Gulf of Guinea	Reeves *et al.*, 2002
Balaenoptera borealis	Entire West African coast, Gulf of Guinea	Reeves *et al.*, 2002
Balaenoptera physalus	Entire West African coast, Gulf of Guinea	Reeves *et al.*, 2002
Balaenoptera musculus	Entire West African coast, Gulf of Guinea	Reeves *et al.*, 2002
Physeter macrocephalus	Entire West African coast, Gulf of Guinea	Reeves *et al.*, 2002
Kogia sp	Entire West African coast, Gulf of Guinea	Reeves *et al.*, 2002
Feresa attenuata	Annobon Island, Gulf of Guinea	Jefferson *et al.*, 1997; Reeves *et al.*, 2002
Pseudorca crassidens	Ivory Coast, Ghana, Gabon, Coastal waters of West Africa	Jefferson *et al.*, 1997; Waerebeek & De Smet, 1996; Reeves *et al.*, 2002
Orcinus orca	Ghana, Gabon, Annobon Island, Ivory Coast	Jefferson *et al.*, 1997
Mesoplodon densirostris	Entire West African coast, Gulf of Guinea	Reeves *et al.*, 2002
Globicephala macrorhynchus	Ivory Coast, Entire West African coast	Jefferson *et al.*, 1997; Reeves *et al.*, 2002
Ziphius cavirostris	Entire West African coast, Gulf of Guinea	Reeves *et al.*, 2002
Mesoplodon europaeus	Possible range in Equatorial Guinea	Reeves *et al.*, 2002
Grampus griseus	Entire West African coast, Gulf of Guinea	Jefferson *et al.*, 1997; Reeves *et al.*, 2002
Peponocephala electra	Guinea Bissau, Central equatorial Atlantic, Gulf of Guinea	Jefferson *et al.*, 1997; Reeves *et al.*, 2002

Sao Tome and Principe, in particular, have been reported as a breeding ground for humpback whales since the 19th and 20th century whaling period (Figueiredo, 1958). Between 1913 and 1959 a great number of whales were captured in the coastal waters of Sao Tome and Principe. This activity also took place between 1925 and 1934, but there are no data on the captures, and between 1937 and 1948 (Figure 1). Between 13 July and 25 October 1951, different species of great whales were captured in waters around Sao Tome and Principe: sperm (*Physeter macrocephalus*), fin (*Balaenoptera physalus*), Bryde's (*Balaenoptera edeni*) and humpback whales (*Megaptera novaeangliae*) (Figure 2) (Figueiredo, 1958; Brito & Carvalho, 2007).

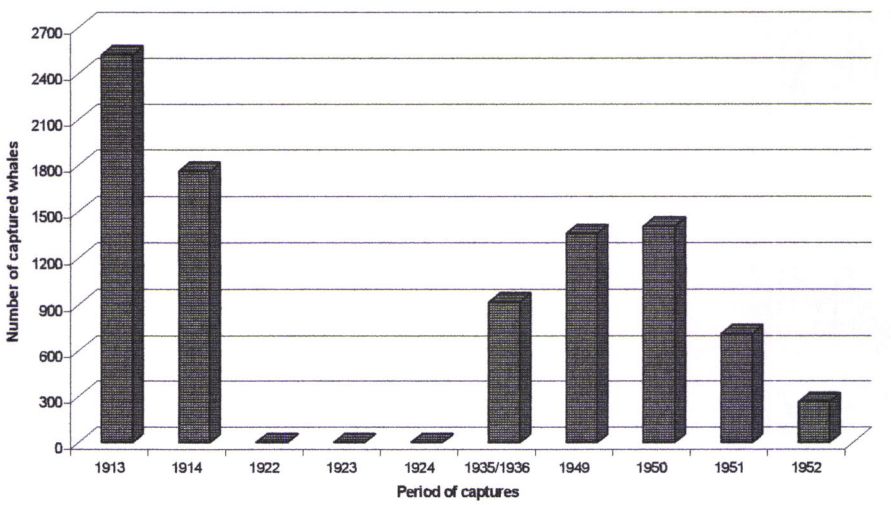

Figure 1 – Number of captured whales during all whaling period in the coastal waters of Sao Tome and Principe, between 1913 and 1952.

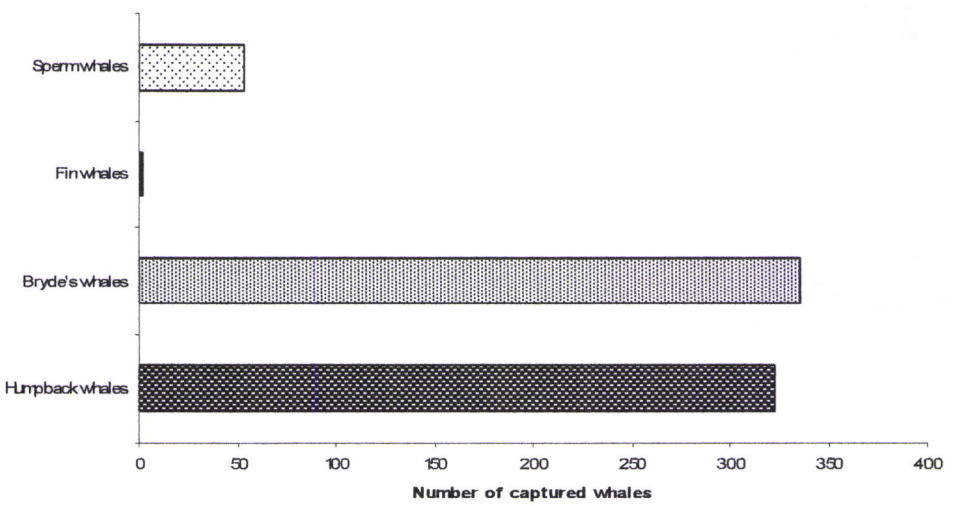

Figure 2 – Number of captured whales of different species between 13 of July and 25 of October of 1951 in Sao Tome and Principe waters.

The poor catch of only 323 humpback whales resulted in the just established whaling company closing operations after this first season. The reduced number of available whales was evident, also showed by a striking decrease of the captures off Cape Lopez (Gabon, West African Coast) from 1356 in 1949 to only 264 in 1952 (Aguilar, 1985). More recently, however, the sightings of humpback whales have become more frequent off the Sao Tome Island (Francisco Reiner, personal communication) which may indicate a recovery of the populations or the whales returning to a former concentration area of the Southern Hemisphere population. In the scientific literature from several decades ago there are also data on coastal populations of bottlenose (*Tursiops truncatus*) and common dolphins (*Delphinus* sp); pilot, sperm (*Physeter macrocephalus*) and killer whales (*Orcinus orca*); and several species of great whales; and there was reference to the possible occurrence of twenty-eight different species of cetaceans for Sao Tome and Principe (Table I).

Field Study

The results from our biological surveys showed, from a total of 129 encounters, the occurrence of six cetacean species: pilot whale, *Globicephala spp.*; humpback whale, *Megaptera novaeangliae*; killer whale, *Orcinus orca*; sperm whale, *Physeter macrocephalus*; pan-tropical spotted dolphin, *Stenella attenuata* and bottlenose dolphin, *Tursiops truncatus*.

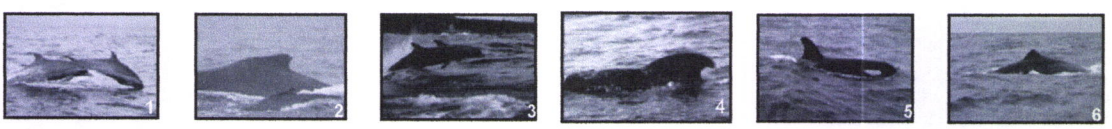

Figure 3 – Cetaceans' species sighted in study area between 2002 and 2005: (1) Pan-tropical spotted dolphins (*Stenella attenuata*), (2) Humpback whales (*Megaptera novaeangliae*), (3) Bottlenose dolphins (*Tursiops truncatus)*, (4) Pilot whales (*Globichephala spp*), (5) Killer whales (*Orcinus orca*) and (6) Sperm whale (*Physeter macrochephalus*).

We mapped the occurrence of the species sighted in order to understand their geographical distribution. Even though the sampling effort was not homogeneously distributed along the Sao Tome Island coast, as during the 2004 and 2005 field season

(Figure 4), we can observe particular areas of cetaceans' concentration. This is particularly true for the humpback whales occurring mainly in the southern part of the Island and the pan-tropical spotted dolphins occurring mostly in the northeast part (Figure 5).

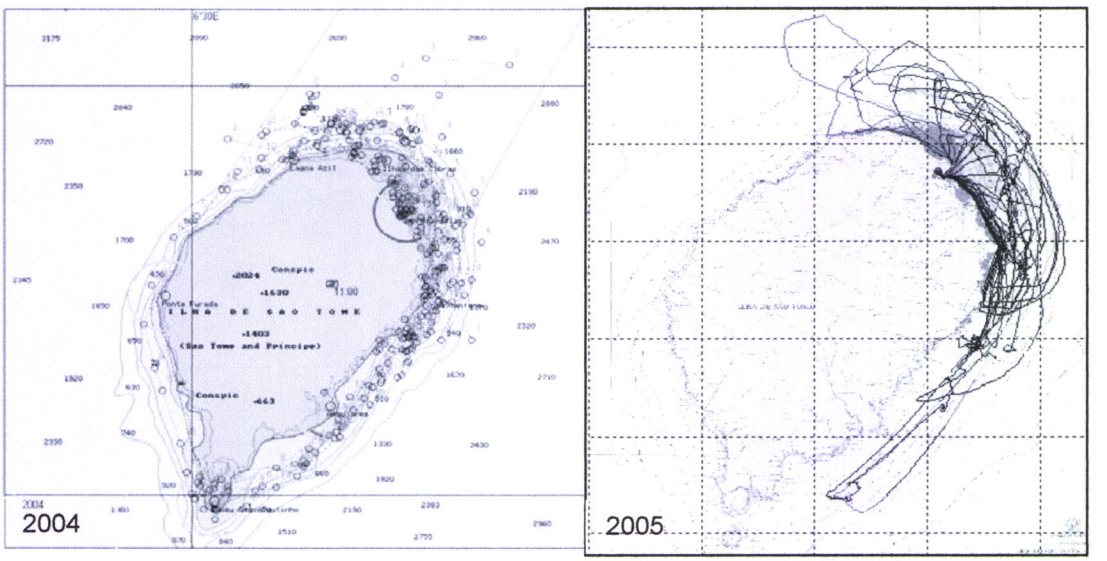

Figure 4 – Survey effort carried out in 2004 (6873 minutes) and 2005 (8815 minutes) around the Sao Tome Island.

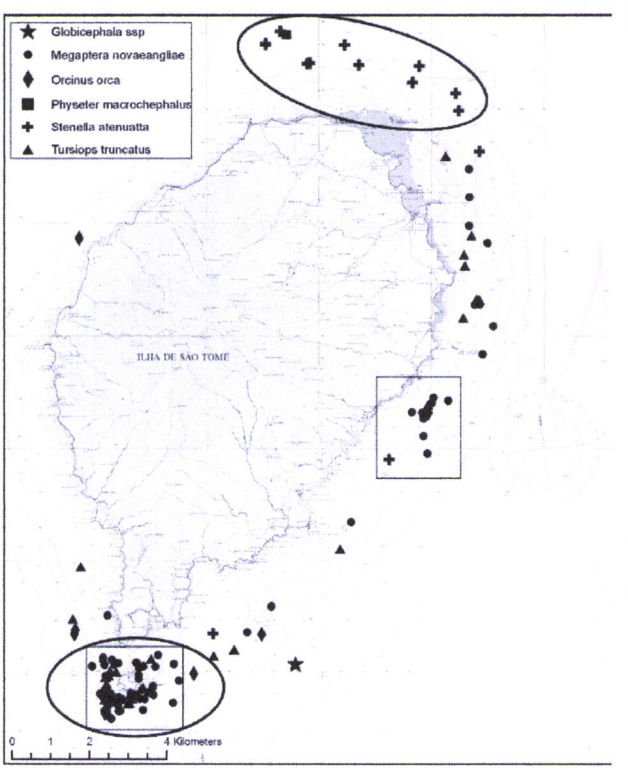

Figure 5 – Map showing particular areas of cetaceans' concentration with humpback whales occurring mainly in the south part of the Island and the pan-tropical spotted dolphins occurring mostly in the northeast part (sightings between 2002 and 2005).

Human activities and related legislation

Human activities

We found five human activities related to the marine environment and with possible strong, direct or indirect, impacts on natural populations of cetaceans occurring in the area: (1) historic whaling and by-catches; (2) fishing; (3) tourism; (4) debris and pollution; (5) oil exploration.

Whaling for great whales occurred during most of the 19th and 20th centuries but no longer exits, except for occasional and sporadic catches of small dolphins nowadays (fishermen direct information, 2004). Artisanal fishing is an important resource to locals of S. Tome Island, and captured fishes are 60 a 70 per cent of the animal protein in human feeding habits (Afonso *et al.*, 1999). Fishing takes places in small wooden canoes, moved by paddles or small outboard motors. In this activity, the opportunistic catches by fishermen are probably by-catches of some traditional fishing gears. An expedition by the Department of Oceanography and Fisheries of the University of Azores 1993 (Santos *et al.*, 1995) showed an occurrence total of 127 species of fishes. The same authors considered ichthyodiversity of Sao Tome Island high when compared to other Eastern Atlantic Islands, mainly due to its biogeographic influences. This abundance and biodiversity is reflected in the marine resources exploitation, both traditional and industrial fishing, which are an every day activity in the archipelago.

Also directly regarding the whales, a new activity is now developing as part of a tourist increase in Sao Tome and Principe: whale watching and related maritime activities. Scuba diving, snorkelling and small boat tours are also flourishing in the coastal waters of S. Tome. There is also a problem of pollutant discharges in the maritime areas. The main sources of coastal and marine environment pollution are: industrial and domestic sewage; solid wastes, detritus, plastics and marine debris; physical modifications of the shoreline, including the degradation of the critical habitats and coastal erosion; oil residue wastes and other hydrocarbons, most often due to uncontrolled shipping operations off the coast of the archipelago (UNEP, 1999).

The Gulf of Guinea is one of the most prolific hydrocarbon provinces of the world. An intensive exploration effort over the last 35 years in and around the Niger Delta in particular has led to a succession of significant discoveries. However, the full potential of the continental slope and rise seaward of the shelf break is only recently becoming apparent, with a number of exploration programs having resulted in world-class discoveries being made in recent years (Gerhard Seibert, personal communication). The *Nigeria – Sao Tome and Principe Joint Development Zone* (JDZ) is between latitudes 1 and 3 degrees north and longitudes 4 and 8 degrees east in the Gulf of Guinea. It covers an area of 34,548 km^2 with water depths ranging from about 1500m in the northern part of the JDZ to over 4000m at its south-western sector (Figure 6).

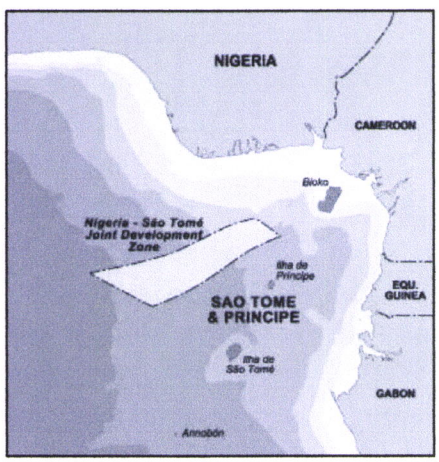

Figure 6 – Localization of the Nigeria–Sao Tome and Principe Join Development Zone (Image obtained from *www.nigeriasaotomejda.com*).

Legislation for the marine environment

Regarding the legislation of human activities on the marine environment we found several 20th century laws, especially in relation to whaling. From a total of eleven different laws, six considered whaling or related aspects and the others (all post whaling) are related to general aspects of environment protection (see Table II).

Table II- Legislation related with marine environment and cetaceans since 1913 until nowadays.

Year	Legislation	Theme	Reference
1913	Regulates the whaling in S. Tome and Principe (STP) waters	Whaling	Lei n.º 58 (1913)
1914	Approves whaling in STP waters	Whaling	Portaria n.º 102 (1914)
1932	Changes to the previous rules on whaling in STP waters	Whaling	Portaria n.º 7 (1932)
1936	General information about whaling activities in STP islands	Whaling	Portaria n.º 102 (1936)
1938	Establish a payment for captured whales in STP waters	Whaling	Portaria n.º 181 (1938)
1951	Gives the exclusive of whaling hunting and industrialization for the STP territorial waters to a specific company	Whaling	Portaria n.º 1:537 (1951)
1955	Establishes rules to protect the soil, animals and vegetation of the overseas Portuguese territories	Environment	Decreto n.º 40:040 (1955)
1999	Environmental laws	Environment	Lei n.º10/99 (1999)
1999	Law for the conservation of fauna, flora as protected areas	Conservation	Lei n.º11/99 (1999)
2001	Fishing and marine resources law	Fishing	Lei n.º09/2001 (2001)
2003	Petroleum regulations	Oil exploration	Nigeria-Sao tome and Principe joint development authority (2003)

An important difference between these laws is that whaling legislation until mid-20th century was rather precise in terms of hunting seasons, number of whales to be captured and to be discarded on shore, on the place to establish land-based operations and factories, as well as approved whaling licenses. Once this activity ended we could not find any other legislation referring in particular to whales or dolphins occurring in the region. Most of the legal attention is, in fact, given to land and forest protected areas and species.

DISCUSSION

Conserving cetaceans (and other wildlife) is an ongoing process that can never be considered complete (Jones, 1994). Conservation measures need to be evaluated and re-evaluated, and new approaches need to be developed to address threats that were unrecognized or non-existent until recently (Reeves *et al.*, 2003). To moderate anthropogenic pressures and protect the abundance of the species it is necessary to understand which management measures should be applied (Moulins *et al.*, 2007).

In Sao Tome and Principe, in order to protect whales and dolphins it was necessary to first understand which species occurred and in which coastal areas. We found three areas of special concentration of cetacean's sightings (humpback whales, bottlenose and pan-tropical spotted dolphins) and these may be taken into consideration when establishing protected marine areas or when developing coastal activities, such as industries. In this study we identified five human activities with very different possible impacts on cetaceans.

The seasonality in relative abundance of cetacean species is relevant to the development of effective mitigation measures against anthropogenic threats. In particular, understanding of the temporal and spatial distribution of cetaceans is essential to determine when animals might come into contact with particular fisheries and to mitigate against potential by-catch (Weir *et al.*, 2007). The efficacy of any management in this area is though also dependent on the degree of adherence to any regulations by fishermen.

Whale watching activities are rapidly increasing but are unregulated and conducted without any information by several tourist operators. At the present moment, specific legislation is most definitely required in this domain in order to protect the more commonly observed cetacean species. Particular attention should be given to humpback whales coming to these protected shores to give birth to their calves (Carvalho, 2004).

Sao Tome e Principe has an extensive marine ZEE, which is rich not only in biological resources but also in oil resources. Oil exploration is the most recent industry in the archipelago and probably the one with the most negative impact and with a direct influence on ecosystems and marine animals. Still at its beginning and kilometres off S. Tome Island, it is now the moment to obtain baseline information on cetaceans' occurrence to prevent future destruction of these internationally protected natural populations. Before large-scale exploration and development of oil and gas resources is to take place in deep Gulf waters, an assessment of cetacean abundances and distributions is needed so that changes possibility associated with future development could be detected (Mullin & Hoggard, 2004).

Regarding specific legislation, since the end of the whaling period there has been an effort to give a legal background to several activities related with whales and dolphins.

Nowadays, even though there are laws for the local protection of fauna, where cetaceans are generically included, more detailed legislation is necessary. Besides that it is urgent that along with the establishment of such laws rises a system of fiscalization.

Conservation measures to be accounted for in the future, regarding the natural populations of cetaceans are: (1) a more detailed study of cetaceans occurrence and distribution, including both Sao Tome and Principe islands; (2) establishment of geographical marine and coastal areas of protection or interdiction to some human activities, like fishing; (3) create a legal background on fishing activities, tourism (especially whale watching) and conservation and management measures; (3) create and keep a policing brigade in order to guarantee that existent legislation is in fact being implemented; (4) environmental studies considering the new tourist and industrial activities to be implemented in coastal areas and in open sea; (5) civic and environmental education, people training and awareness-raising campaigns. Every one of these points must be taken into consideration and applied in the field according to the culture of the local people and the country but, of course, the creation of a marine protected area for the direct conservation of marine life is the most important measure.

For effective conservation, the first step is a change in public sentiment, so that ocean users become more effective at policing themselves. Ultimately, conservation benefits in the ocean are likely to depend on greater vision on the part of scientists – and, most critically, of policymakers and the people using the ocean resources – in realizing the benefits of favouring long-term sustainability over short-term economic profit (Hooker & Gerber, 2004). At this point, in S. Tome and Principe, a change from a consumptive attitude to a more conservation-oriented perspective is growing to begin. Scientific research, environmental education plans and whale watching programs totally replaced past destructive whaling activities. This is the moment to move towards the creation of a specific legal background to the conservation of cetaceans based on scientific results.

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4 – CONSIDERAÇÕES FINAIS

O estudo de cetáceos em meio selvagem apresenta uma série de dificuldades e constrangimentos. São animais que, pelas suas características, são difíceis de seguir continuamente, pois deslocam-se rapidamente e passam a maior parte do seu tempo submersos. A obtenção dos registos, nomeadamente os fotográficos, está fortemente dependente de condições meteorológicas favoráveis, no que respeita ao estado do mar, vento e precipitação, assim como dos meios náuticos utilizados nas saídas. Em estudos similares, as saídas terminam quando existe vento considerado moderado a forte (escala de Beaufort > 4). No nosso caso, e em particular no ano 2005, devido à época das chuvas não se ter iniciado, o vento existia quase diariamente numa escala igual ou superior a 5. As saídas decorriam durante algum tempo, no entanto a probabilidade de detecção de cetáceos diminuía. Tendo em consideração os resultados obtidos nos estudos preliminares, bem como as características oceanográficas especiais desta região, presume-se que este ecossistema suporte uma grande diversidade de espécies de cetáceos pelo facto de fornecer potencialmente um grande número de nichos ecológicos. Apesar de a partir deste estudo se terem algumas noções da ocorrência e distribuição de determinadas espécies de cetáceos no arquipélago de S. Tomé e Príncipe, tem de se ter em atenção que o estudo abrange apenas alguns meses do ano, não reflectindo o que ocorre na área no restante período. Para colmatar esta falha, são necessários outros estudos que permitam clarificar a sazonalidade de ocorrência de cetáceos neste arquipélago, como acontece noutras regiões do mundo. Torna-se muito importante avaliar que processos afectam a distribuição dos cetáceos e a que escalas espaciais e temporais operam estes processos. Apesar de ser muito exigente, é, sem dúvida, um trabalho necessário para compreender de que modo as condições oceanográficas afectam a ecologia dos cetáceos nesta zona oceânica tropical. Estas informações são tão mais importantes numa altura em que a exploração petrolífera se inicia em S. Tomé e Príncipe, de uma forma que se prevê contínua e intensa. Esta é também uma região cada vez mais escolhida como destino turístico e os operadores turísticos vêm no *whale watching* mais

uma forma de cativar turistas. Estes dois motivos são suficientemente importantes para um esforço no sentido de conhecer as espécies de cetáceos que existem nas águas destas ilhas e para que se implemente legislação que regule as actividades humanas, com continuada monitorização, fiscalização e posterior estabelecimento de áreas prioritárias para conservação destes animais.

Este estudo representa o primeiro esforço no sentido de documentar a ocorrência e distribuição de cetáceos no arquipélago de S. Tomé e Príncipe, mais concretamente na ilha de S. Tomé, sendo de todo o interesse a sua continuidade. Assim, passámos da caça à baleia à sua observação e investigação, num espaço de poucas décadas, desde meados do século XX até ao início do século XXI. Estamos perante um caso de ajuste e mudança de mentalidades, o primeiro passo para o sucesso da conservação dos ecossistemas marinhos neste arquipélago equatorial.

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6 – ANEXO

- As tabelas seguintes contêm os dados utilizados para a realização dos testes estatísticos no tratamento dos dados recolhidos entre 2002 e 2005 em São Tomé e Príncipe.

Tabela I – Número de avistamentos de cada espécie em cada sector amostrado e tempo (em minutos) passado em cada um dos sectores da área de estudo (ver divisão da área de estudo na página 15).

		Odontocetes					Mysticetes	
Sector	Minutes	*Stenella attenuata*	*Tursiops truncatus*	*Globichephala sp*	*Orcinus orca*	*Physeter macrochephalus*	*Megaptera novaeangliae*	**TOTAL**
I	1235	4	0	0	1	1	0	**6**
II	10570	8	7	0	0	0	8	**23**
III	606	0	0	0	0	0	0	**0**
IV	3469	1	1	0	1	0	9	**12**
V	19146	1	34	1	4	0	48	**88**
VI	186	0	0	0	0	0	0	**0**
TOTAL	**35212**	**14**	**42**	**1**	**6**	**1**	**65**	**129**

Tabela II – Número de avistamentos de cada espécie por cada valor de temperatura da superfície do mar (SST) em °C.

	Odontocetes					Mysticetes	
SST	*Stenella attenuata*	*Tursiops truncatus*	*Globichephala sp*	*Orcinus orca*	*Physeter macrochephalus*	*Megaptera novaeangliae*	**TOTAL**
24	0	5	0	0	0	2	**7**
25	0	8	0	0	0	16	**24**
26	9	7	0	0	1	24	**41**
27	5	14	0	1	0	21	**41**
28	0	0	0	0	0	2	**2**
29	0	8	1	5	0	0	**14**
TOTAL	**14**	**42**	**1**	**6**	**1**	**65**	**129**

Tabela III – Número de avistamentos de cada espécie por cada classe de profundidade (em metros).

	Odontocetes					Mysticetes	
DEPTH	*Stenella attenuata*	*Tursiops truncatus*	*Globichephala sp*	*Orcinus orca*	*Physeter macrochephalus*	*Megaptera novaeangliae*	**TOTAL**
[0-20[	0	3	0	0	0	10	**13**
[20-100[	2	36	0	1	0	52	**91**
[100-1000[	4	2	0	5	0	3	**14**
[1000-2000[	8	1	1	0	1	0	**11**
TOTAL	**14**	**42**	**1**	**6**	**1**	**65**	**129**