



Universidade do Algarve
Faculdade de Ciências e Tecnologia

Relatório de Actividade Profissional

José Nuno David e Silva Gomes Pereira

Mestrado em Biologia Marinha

Janeiro 2012



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Relatório orientado por Jorge M. S. Gonçalves

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Resumo:

Sendo diplomado em Biologia Marinha e Pescas no plano curricular “pré-bolonha” desde 2006 (15 Dezembro), serve o presente relatório para demonstrar que possui “experiência profissional relevante na área científica dominante deste curso, superior a 5 anos”, de forma a “requerer a substituição das unidades curriculares Projeto de Tese e Dissertação pela apresentação de um Relatório de Atividade Profissional”, ao abrigo do Despacho Reitoral 033/2011.

Neste sentido destaco o percurso académico com uma formação continuada (incluindo duas disciplinas do Mestrado em Estudos Integrados dos Oceanos na UAç), e uma experiência profissional diversificada no âmbito da Ecologia Marinha. Tendo como principal área de investigação actual a ecologia bentónica do mar profundo e o mapeamento de comunidades marinhas, no âmbito de diversos **projectos internacionais** (CORAZON, CoralFISH, Hermione, MeshAtlantic) mantenho um interesse paralelo por interacções tróficas de grandes predadores. Como tal a minha experiência estende-se da taxonomia de bicos de cefalópodes, a ferramentas de geo-especialização e modelação. Tendo participado em diversos congressos internacionais, com posters e apresentações orais, sou ainda **co-editor** da revista Arquipélago, Life and Marine Sciences e **revisor** da revista peer reviewed Aquatic Mammals (desde 2008). Para além de ser **membro fundador** da SCIAENA – Associação de Ciências Marinhas e Cooperação (2006), formada na Universidade do Algarve, sou também membro da direcção (vice-presidente) do Observatório do Mar dos Açores (2008), e sócio da Sociedade Portuguesa de Ecologia (2009). No campo da divulgação das ciências contribuo assiduamente com artigos de divulgação na imprensa local, websites (ex. www.intradop.info) tendo sido responsável pela rubrica “Mar-Ciência”, do programa de televisão “Águas Vivas” desenvolvido para a RTP Açores (2011). Por fim destaco a dedicação às ciências naturais, através de pequenos empregos que antecederem a entrada no “mercado” académico, assim como a continuidade no estudo e na escrita de artigos mesmo nos períodos de desemprego. No período entre 2006 e 2012, publiquei **5 artigos** em revistas com arbitragem científica (em anexo), **1 livro**, **1 capítulo** de livro, **6 posters**, e **9 palestras** como orador (sendo co-autor de outras 20 só entre 2010-2011), para audiências internacionais em encontros científicos.

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II - Exposição Técnica e Científica

De forma a facilitar a leitura e apreciação das competências adquiridas e actividades realizadas ao longo dos cinco anos decorridos desde o término da obtenção do grau de licenciado em Biologia Marinha e Pescas e a submissão do presente Relatório de Actividade Profissional, estas serão apresentadas de forma cronológica. Todas as formações e actividades mencionadas, incluindo cursos de pós-graduação não indicados nesta secção, encontram-se listadas por categorias na secção III) *Curriculum vitae*.

No que respeita às actividades, é indicado sempre que possível, e de forma crítica, o seu contributo nas áreas de biodiversidade, estrutura e funcionamento dos ecossistemas aquáticos; desenvolvimento, melhoria e/ou implementação de aplicações inovadoras para a exploração, conservação e gestão de recursos ou ecossistemas marinhos. De igual modo, é feita uma apreciação da relevância e impacto da experiência profissional adquirida, recorrendo a indicadores considerados pertinentes.

2006

2006 Janeiro. Fundação da Sciaena – Associação de Ciências Marinhas e Cooperação

Em Janeiro de 2006, com os colegas da Universidade do Algarve Bárbara Costa e Jorge Assis criámos a Sciaena – Associação de Ciências Marinhas e Cooperação (J. Assis viria a renunciar ao cargo ao fim de dois anos para formar a Gobius, Comunicação e Ciência).

A sua missão consiste a) Conceber, executar e apoiar projectos de cariz ambiental, para a cooperação e desenvolvimento humano integrado no meio marinho; b) Fomentar formas de exploração sustentável dos recursos costeiros e marinhos, em prol do desenvolvimento integrado das comunidades associadas; e c) Promover de estudos de carácter científico e educativo, de inovação e resolução de problemas sócio-ambientais.

Responsável pela introdução do BIOBLITZ em Portugal, tem sido na frente da PONG-Pesca, a plataforma das ONGs portuguesas para os assuntos Pescas, que integra a LPN, Quercus, SPEA, etc., que o seu trabalho se tem evidenciado mais. www.sciaena.org

2007

**2007 Janeiro-Junho. Estagiar L em ecologia trófica (poster, workshop e palestra)
Universidade dos Açores**

Desenvolvi um programa “Estagiar L”, entitulado “Identificação de cefalópodes a partir de mandíbulas “bicos”, na dieta de alfonsinos (*Beryx splendens*) e Imperadores (*Beryx decadactylus*) nos Açores”. No Centro do IMAR da Universidade dos Açores (Horta).

Este estudo permitiu-me ganhar competências na identificação taxonómica de cefalópodes a partir das mandíbulas, ou “bicos”. O principal objectivo deste trabalho prendeu-se com a identificação e o conhecimento da ecologia trófica de predadores, assim como alguns aspectos da ecologia dos próprios cefalópodes, cuja captura com redes e armadilhas é em muitos casos impossível.

A integração da componente de cefalópodes com os restantes dados da dieta ainda não foi submetida a publicação. Deste trabalho resultou um relatório interno e mais tarde um poster em que avalei a proveniência alimentar de duas espécies de Teleósteos de montes submarinos com interesse comercial, identificando uma origem pelágica. Este estudo tem interesse no âmbito da discussão em curso sobre o funcionamento dos montes submarinos, e como sustentam grandes quantidades de biomassa em ambientes oligotróficos.

Pereira, JN, T Morato, G Menezes, Malcolm Clarke, Luís Barcelos & F Porteiro. 2010 Cephalopods in the diet of two seamount aggregating fish species: alfonsino, *Beryx splendens* and orange roughy, *Hoplostethus mediterraneus*. Presented at Project HERMIONE – 2nd Annual Science Meeting, 12-16 April, Málaga, Spain (Poster).

Neste sentido, colaborei na logística do Cephalopod Beak Training Course e III International Workshop, organizado pelo Dr. José Xavier e pela Dra. Maria Carvalho, e leccionado pelo Dr. Malcom Clarke, no Departamento de Oceanografia e Pescas, Universidade dos Açores, 31-3 a 12 de Abril, 2007. Ainda no âmbito deste curso foi realizada a palestra em baixo descrita:

Pereira, JN 2007. “Cephalopods in the diet of Alfonsinos (*Beryx splendens*) off Azores”. III International Workshop on Cephalopod Beaks. Malcom Clarke, Department of Oceanography and Fisheries, University of Azores, 31 de March e 12 de April, 2007. (palestra)

2007 Abril. Dados de Whale-watching para a cetologia (Poster e Artigo)

Desenvolvi durante este ano a minha segunda hipótese de tese, que prescindira em deterimento da defendida em 2006, acabando por submeter também este estudo a publicação.

Consiste numa tentativa de aproveitamento de dados provenientes de operações turísticas de observação de cetáceos para a ciência. Através deste estudo foi realizado um poster para conferência anual da Sociedade Europeia de Cetáceos e uma publicação na revista indexada Journal of Marine Biological Association:

Pereira, JNG 2007. “Daily species check-list from whale-watching. Studying the research potential with an Azorean case study.” 21st Annual Conference of the European Cetacean Society, Donostia-San Sebastian, Spain, from April 23rd – 25th, 2007. (Poster)

Pereira, JNG 2008. “Daily species check-list from whale-watching. Studying the research potential with an Azorean case study”. Journal of Marine Biological Association 88: 1283-1288. DOI: 10.1017/S0025315408001070 (citado por 2 artigos) (anexo)

Pereira (2008) é um artigo descritivo que pretende revelar padrões de ocorrência de cetáceos na região, recorrendo a valores de temperatura de superfície do mar (SST). Os Açores são um local de ocorrência de mais de 25 espécies de cetáceos, incluindo residentes, residentes-temporárias, migratórias, e outras de estatuto desconhecido. Este artigo apresenta a primeira associação dos seus padrões de ocorrência com a temperatura a nível regional. Desenvolvi ainda um exercício não paramétrico simples, na procura de relações entre observações/ocorrências de diferentes espécies, suscitando novas linhas de pesquisa, nomeadamente a nível co-ocorrência de delfínídeos. Ultrapassada a polémica questão da utilização de dados recolhidos sem método *a priori*, a informação tem de facto pouca relevância científica, na medida em que existem já observações de programas de monitorização de pesca que podem fornecer mais detalhe (apesar de continuarem por publicar), assim como a definição dos valores de SST utilizados, contudo, valorizam-se entanto o baixo custo dos dados ea diversidade de espécies cobertas (+19).

2007 Junho – Literatura científica sobre cetáceos nos Açores (palestra e publicação)

Palestra em workshop sobre história da ciência, entitulado “História dos Mamíferos Marinhos”, tendo apresentado a primeira revisão de literatura científica sobre cetáceos no Arquipélago dos Açores. Com principal importância do ponto de vista histórico, permitindo ainda suportar uma revisão mais extensa no futuro, foram reunidas 166 referências cobrindo cerca de 150 anos de pesquisas sobre cetáceos no arquipélago.

Pereira, JN & J Gonçalves. 2007. “Scientific Literature on Cetaceans in the Azores region: numbers and general trends” II Workshop “History of Marine Mammals”. European Cetacean Society, Escola de Mar, Lisbon, 8 June, 2007.

O workshop decorreu em Lisboa, e o conteúdo foi editado dois anos mais tarde nos proceedings do encontro da Sociedade Europeia de Cetáceos em 2007 (de onde fora cancelado o workshop).

Pereira, J.N. & J.M. Gonçalves 2009. “Scientific literature on cetaceans in the Azores region: an historical overview.” Proceedings of the European Cetacean Society, Workshop on Marine Mammal History, Lisbon, 8 June, 2007, (Eds.) Brito, C. & P. Evans, 2009, San Sebastian, Spain. (anexo)

2007 Outubro (2007)- Fevereiro(2008)

Frequentei duas disciplinas do Mestrado Integrado em Estudos dos Oceanos (2007/2008), leccionadas no Departamento de Oceanografia e Pescas, Universidade dos Açores. Nomeadamente, Instrumentos de Disseminação Científica com o Prof. Dr. João Gonçalves, e a disciplina Delineamento Experimental e Tratamento de Dados, com o Prof. Dr. Gui Menezes (os respectivos planos curriculares encontram-se detalhados na secção III).

A disciplina Instrumentos de Disseminação Científica, na qual obtive a classificação final de 18 valores, teve como trabalhos práticos a revisão de um artigo científico; a criação de um blog, tendo criado o “secretivitaeinmare.blogspot.com”; e a publicação um artigo na imprensa local, tendo escrito “Apontamentos sobre baleias na história açoriana”, que acabou por ser dividido, saindo em duas edições (também disponível no blog).

A disciplina de Delineamento Experimental e Tratamento de Dados, para a qual obtive a classificação de 16 valores (média das frequências 18). Dos exercícios de análise de dados realizados no decorrer das aulas, levei a publicação dados recolhidos pelo Departamento.

Pereira, J.N., A. Simas, A. Rosa, A. Aranha, S. Lino, E. Constantino, V. Monteiro, O. Tariche, G. Menezes 2012. **“Weight-length relationships for 27 demersal fish species caught off the Cape Verde archipelago (eastern North Atlantic)”**. Journal of Applied Ichthyology, Volume 28, Issue 1, pages 156–159. Online a 28 Dezembro de 2011 (anexo)

O artigo apresenta regressões peso - comprimento para 27 espécies de peixes e tubarões demersais capturados principalmente na cota dos 600 metros, das quais 10 não existia qualquer registo publicado. Apresenta ainda, a primeira revisão dedicada ao histórico de estudos de biometrias na região, com enorme utilidade na avaliação de condições sazonais de populações, comparações taxonómicas, conversões idade-comprimento, etc.

2008

2008 *Membro do Secretariado Editorial da Arquipélago - Life and Marine Sciences*

Em 2008 integrei a equipe editorial da revista científica editada na Universidade dos Açores, a “Arquipélago - Life and Marine Sciences”. A revista é uma referência na investigação em ciências naturais terrestres e marinhas de ambientes insulares do Atlântico norte, com 257 artigos e pequenas comunicações publicadas e mais de 200 revisores de 27 países. Encontra-se em franco crescimento, com pretensões de se alargar ao Atlântico sul e a outras regiões. Editor técnico dos volumes 24 ao 27 e de dois suplementos, contribuí para a renovação da revista, melhoramento de layout, surgimento da capa a cores e edição online de artigos *in press*, estando a desenvolver esforços no sentido da indexação na Thompson Reuters. A revista está disponível em www.arquipelago.info

Para a edição dos 30 anos da revista preparei uma pequena resenha histórica:

Martins, H., **J.N.Pereira** & F.M. Porteiro 2010. Thirty years of natural sciences in the Atlantic Ocean. 2010. Editorial Notes, *Arquipelago*. Life and Marine Sciences. no.27, 77 pp.

2008 *Março. Membro do Observatório do Mar dos Açores*

Integrei a direcção do OMA – Observatório do Mar dos Açores (ONG), (2008-2009), sendo actualmente vice-presidente(2010-2013). O OMA tem como objectivos a divulgação da cultura científica e tecnológica e a promoção de actividades de interpretação e educação ambiental, no âmbito das Ciências do Mar. Enquanto Centro de Ciência, o OMA actua junto da sociedade Açoriana, promovendo a inclusão na sociedade global da informação e do conhecimento. Sendo uma ONG de utilidade pública actualmente enraizada na sociedade, grande parte da minha actividade nesta organização passa pela divulgação científica, coordenação de equipas e desenvolvimento de projetos. www.oma.pt

2008 *Maio-Junho. Trabalho como biólogo pescueiro no projecto ARQDAÇ008*

Membro da equipe científica no projecto ARQDAÇO P08, a bordo do RV Arquipélago. Um programa de monitorização de recursos demersais da responsabilidade do DOP/UAç. Programa anual de avaliação de stocks demersais em todo o Arquipélago dos Açores, recorrendo a long-line de fundo, a arte mais utilizada pelas pescarias regionais. A amostragem incluía a recolha de peso, comprimento, extração de otólitos e amostras para genética. Os trabalhos incluían ainda apoio nas operações do navio relativas à colocação e alagem de aparelho.

2008 *Junho-Agosto. Trabalho como skipper de embarcações de investigação*

Skipper de embarcações para o Departamento de Oceanografia e Pescas da Universidade dos Açores. Tendo participado em diversos projectos relacionados com mergulho, destaco a monitorização de recursos costeiros, aquacultura de cracas, erradicação da alga invasora *Caulerpa webbiana*.

2008 *Setembro-Dezembro. Consultoria para museu sobre Campos Hidrotermais dos Açores*

Consultoria sobre Campos hidrotermais dos Açores, para o Museu “Aquário Virtual”. Os conteúdos foram requisitados pela Secretaria Regional do Ambiente e do Mar, ao Observatório do Mar dos Açores, Fábrica da Baleia de Porto Pim, 9900 Horta, Azores – Portugal. A tarefa incluía a reunião de todos os conteúdos informativos sobre as áreas hidrotermais, a preparação dos cadernos de encargos, relativos ao equipamento multimédia. O concurso acabou por ser cancelado, já depois de aberto, não se chegando a equipar o novo museu por motivos de ordem financeira.

2008 *Dezembro. Publicação de tese de licenciatura: Notas sobre Golfinhos de Risso*

No final do ano foi aceite a publicação com a informação recolhida e analisada no âmbito da tese de licenciatura em Biologia Marinha e Pescas, submetida em 2007.

Pereira, J.N.G. 2008a. "Field Notes on Risso's dolphins (*Grampus griseus*) distribution, social ecology, behaviour and occurrence in the Azores." Aquatic Mammals, Volume 34, Number 4, pp. 426-435(10). DOI 10.1578/AM.34.4.2008.426 (citado por 5 artigos) (anexo)

Três meses de observações de golfinhos de risso a sul da ilha do Pico (2003), nomeadamente distribuição e comportamento, permitiram descrever a utilização do habitat na região, tamanhos de grupos, assim como relatar novas interações agonísticas com outros cetáceos. Os "rissos", são teutófagos mergulhadores de profundidade, distribuindo-se geralmente sobre a batimétrica dos 600 m, no declive das plataformas, apenas de fácil estudo em regiões insulares. O seu papel como predadores de topo mantém-se uma incógnita, assim como qualquer informação relativa à sua abundância na região. O artigo revela ainda a residência deste cetáceo, recorrendo às comunicações (observações) pessoais de um vigia ligado à baleação que operava há 50 anos na região, relatando a ocorrência durante todo o ano na área de estudo pelo menos durante os últimos 15 anos.

2009

2009 Março – Agosto. Edição de Livro: Darwin nos Açores.

Edição de um livro sobre a passagem de Darwin nos Açores. No âmbito dos 200 anos do seu nascimento e dos 150 anos da publicação da Origem das Espécies. Revisitou-se o diário de Darwin ao passar nos Açores, traduzindo para português, e interpretando “os seus comentários” sobre o que vira e sentira. Participaram ainda uma historiadora, Susana Serpa Silva, um Vulcanólogo João Carlos Nunes e Paulo Barcelos, um conhecedor de trilhas da Ilha Terceira, por onde Darwin passou. Um contributo para o enquadramento do Arquipélago na história Ciências Naturais, um diário de interesse para muitos que visitam a região, ilustrado com imagens da época. Estamos neste momento a preparar a 2ª edição, em formato bilingue.

Pereira, J.N.G. & V. Neves 2009. “Darwin nos Açores. Diário pessoal com comentários.” Observatório do Mar dos Açores, Horta, Portugal. [new edition in 2012, UK & PT].



2009 Outubro–Dezembro. Mergulhador chefe em projecto INVASORAS – Caulerpa webbiana

Mergulhador chefe no projecto INVASORAS - *Caulerpa webbiana* nos Açores. IMAR-DOP/UAç, Faial, Azores. A *C. webbiana* é uma alga invasora, registada em 2002 na ilha do Faial. O projecto visa controlar a expansão desta espécie de cariz invasor na região, localizada principalmente no porto da Horta, através de uma erradicação de novas colónias em desenvolvimento nas extremidades da sua distribuição.

2010& 2011

Os trabalhos desenvolvidos entre Janeiro de 2010 e Junho de 2012, têm uma continuidade, pelo que serão apresentados de forma integrada. Durante este período estive contratado como bolseiro em dois projectos distintos com objectivos semelhantes. As tarefas desenvolvidas prendem-se com a utilização de imagens do mar profundo para descrição e mapeamento de habitats, nomeadamente corais de água fria e suas interacções com peixes e pescarias, em montes submarinos da Região dos Açores.

A obtenção destas bolsas deveu-se ao meu conhecimento de diferentes ecossistemas da região, e à minha experiência com vídeo, obtida através de trabalhos de filmagem de mergulhadores lúdicos em empresas de turismo (ver secção III).

De Janeiro a Junho de 2011 estive contratado como bolseiro no projecto Corazon “Comunidades bentónicas dos Açores: com importância para a conservação: corais de águas frias” CORAZON/PTDC/MAR/72169/2006//IMAR/UAÇ/001/2010. IMAR – Institute of the Sea, Coimbra, Portugal.

De Novembro de 2011 a Junho de 2012 estou contratado como bolseiro no projecto CoralFISH - Ecosystem based management of corals, fish and fisheries in the deep waters of Europe and beyond”, financiado pelo 7º Programa Quadro da Comissão Europeia (FP7), dando continuação aos trabalhos em curso.

As tarefas consistiram na inventariação de todo o material de vídeo de mar profundo do DOP/UAÇ, criação e implementação de uma base de dados, implementação de software de análise sistemática de vídeo e georeferênciação de imagens. Tarefas de base sobretudo técnica, mas que requerem conhecimentos de ecologia, biodiversidade e mapeamento de habitats, no que respeita à definição de metodologias de estudo de diferentes comunidades.

Foram catalogados um total de 146 mergulhos, de 35 projectos diferentes, totalizando 345 horas de fundo. Criei códigos individuais e desenvolvi uma base de dados em excel com 75 campos, actualmente com 665 entradas. Em seguida, adquiriram-se softwares de anotação de vídeo e iniciou-se a análise de vídeo relativa aos projectos em curso, como se verifica pelas publicações indicadas em seguida. Está neste momento a decorrer a integração da base de

dados do vídeo na base de dados central do departamento de forma a integrar toda a informação existente sobre ocorrências de espécies.

Os dados recolhidos a partir do vídeo, cujos métodos de análise foram na maioria das vezes por mim delineados, contribuíram para diversos estudos em curso ao longo deste período. Estes são em seguida apresentados de forma agrupada, permitindo obter uma melhor ideia dos temas e da minha contribuição: questões técnicas de análise de vídeo, descrição e mapeamento de habitats, descrição de comunidades de corais, estudos de ictiofauna e interações com pescas.

Apesar de temer ser demasiado exaustivo, pretendo sobretudo com esta listagem de contribuições orais, actas de congressos e posters apresentados, demonstrar a minha contribuição para os trabalhos em curso, notando que em grande parte dos quais sou segundo autor. Publicações em revistas internacionais de grande relevo, estão em curso pelo que não estão ainda aqui descritas. Em cada grupo temático é feita uma breve nota aos temas abordados e qual a minha contribuição no seu estudo, contudo, tendo em conta a variedade de temas abordados, é difícil mencionar com clareza a contribuição individual de cada estudo em particular, no plano de conhecimento internacional.



Análise de Vídeo em curso no IMAR-DOP/UAç (2011)

2010 & 2011 *Questões técnicas de análise de vídeo (palestras, resumos e posters)*

Actualmente o DOP-IMAR/UAç é grupo de investigação em Portugal com maiores competências em termos de mapeamento de habitats através do uso de plataformas vídeo, em parte a) pelo histórico de prospecção de mar profundo do próprio departamento, e b) fruto do investimento que foi feito no desenvolvimento dos trabalhos por mim efectuados acima descritos, de inventariação de histórico e de implementação de software de análise. Dos progressos técnicos desenvolvidos, foram apresentados em eventos internacionais os seguintes progressos:

Pereira, JN & FN Tempera. “**Video analysis stage point at DOP/UAç.**” CoralFISH video workshop. 2010, Attard, Malta, 10 April 2010. (Palestra)

Pereira, J.N., F. Tempera, H. Schone, A. Henriques, R. Medeiros, F. Porteiro, T. Morato, G. Menezes & R. Santos. 2011. “**ROV and Tow-cam imagery at Condor Seamount: overview**”. CONDOR final workshop. Horta, Portugal, 16 February 2011. (Palestra)

Pereira, J.N., F. Tempera, H. Schone, A. Henriques, R. Medeiros, F. Porteiro, T. Morato, G. Menezes & R. Santos. 2011. “**Submarinos no Condor: revelações maravilhosas e utilidade. Workshop dos utilizadores do Condor.**” Horta, Portugal, 29 Março 2011. (Palestra)

Tempera, F., **J.N. Pereira**, A. Braga-Henriques, C. Pham, D. Cuvelier & J. Fontes (2011). “**Video Surveying Techniques for Seafloor Habitat Mapping.**” Presented at MeshAtlantic Video Survey Techniques Workshop, Faro (Portugal). (Palestra)

Pereira, JN & FN Tempera. 2011. “**Practicalities of implementing video annotation.**” Mesh Atlantic Workshop, Faro, Portugal, 20-22 July, 2011. (Palestra)

Apresentação (1 hora) sobre questões práticas relativas à implementação de um sistema de anotação e análise de vídeo, no workshop internacional organizado pelo projecto MeshAtlantic. Com a crescente acessibilidade de aparelhos de prospecção remota com recurso a vídeo, diversos institutos começam a acumular Terabytes de imagens de vídeo, requerendo de orientações para o seu armazenamento, recolha e análise.

2010 & 2011 *Descrição e mapeamento de habitats (palestras, resumos e posters)*

Os dados recolhidos da distribuição vertical de fauna permitiram contribuir na identificação de 35 habitats, apresentados ao longo deste período. Extendendo-se dos jardins de corais negros a menos de 50 metros, aos 3000 m dos campos hidrotermais do Rainbow, muitos destes habitats, definidos por comunidades conspícuas de invertebrados sésseis ou de reduzida mobilidade (corais, esponjas, echinoides, etc), são novos para a região, incluindo vários desconhecidos para a ciência. Estes continuam a ser levantados de forma exaustiva, através da função que desempenho, com o objectivo de integrar modelos de distribuição predictiva para áreas não exploradas. Este trabalho tem contribuído para a classificação de habitats EUNIS, assim como no apoio à decisão no âmbito da Directiva Habitats e da convenção de OSPAR, através da identificação de Vulnerable Marine Ecosystems. Uma das mais recentes apresentações de resultados decorreu em Setembro de 2011 no World Marine Biodiversity Congress, em Aberdeen, através de um Poster em formato vídeo (ver em baixo).

Tempera, F., A. Braga-Henriques, A. Colaço, **J.N. Pereira**, G. Menezes & F. Porteiro. **“Geomorphological characterization of the Condor de Terra seamount in preparation of deep-sea habitat predictive modeling.”** Lamarche, G. (Editor), 2010. Programme and abstracts, GeoHab 2010, Wellington, New Zealand, 157 p. (Palestra)

Tempera, F., **J.N. Pereira**, A. Braga Henriques, F. Porteiro, T. Morato, V. Matos, D. Cuvelier, M. Souto, A. Colaço & R.S. Santos. 2011. **“Deep-sea biotope diversity: an illustrated catalogue for the Azores (NE Atlantic).”** The GeoHab 2011 Conference Marine Geological and Biological Habitat Mapping. 3–6 May, 2011. Geological Survey of Finland, Espoo. Bulletin of the Geological Society of Finland, Special Issue, 1: 91. (Poster).

F. Tempera, A. Braga Henriques, **JN Pereira**, AS Campos, J. Luís, A. Colaço, T. Morato, G. Menezes, FM Porteiro & RS Santos. 2011. **“Terrain characterization of the Condor seamount in preparation of deep-sea habitat predictive Modelling.”** Presented at 3rd CoralFish Science Meeting, 31 October - 04 November, Heraklion, Crete, Greece. (Poster)

Tempera, F., **J.N. Pereira**, A.B. Henriques, F. Porteiro, T. Morato, V. Matos, D. Cuvelier, M. Souto, A. Colaço & R.S. Santos (2011). **“Deep-sea biotope diversity: Illustrated catalogue**

for the Azores (NE Atlantic)." Presented at the "Project HERMIONE: 2nd Science Meeting", Estepona (Spain).(Palestra)

Porteiro, F.M., T. Morato, F. Tempera, A. Henriques, Í. Sampaio, V. Matos, M. Carreiro-Silva, T. Bento, **J.N. Pereira**, C. Pham, R. Bettencourt & R.S. Santos (2011). "**Deep sea Biodiversity: Benthic communities of corals (in Portuguese).**" Presented by Filipe Porteiro at Fórum Científico de Apoio à Decisão "Conhecer o Mar dos Açores", 19-20 January 2011. Horta (Azores, Portugal).(Palestra)

Tempera, F., **J.N. Pereira**, A. Braga Henriques, F. Porteiro, T. Morato, V. Matos, D. Cuvelier, M. Souto, A. Colaço & R.S. Santos (2011). "**Deep-sea biotope diversity: an illustrated catalogue for the Azores (NE Atlantic).**" Digital object presented at World Marine Biodiversity Congress. (Poster emVÍdeo)ONde??

2010 & 2011 *Estudos de comunidades de corais (palestras, resumos e posters)*

Os estudos detalhados das comunidades de corais têm se centrado no banco submarino Condor, e no canal Faial-Pico, no âmbito dos projectos CORAZON e Condor. São estudos sobretudo descritivos e semi-quantitativos da biodiversidade das diferentes comunidades, assim como, da fauna de invertebrados associada da responsabilidade da estudante de doutoramento A. Braga-Henriques da Universidade dos Açores. A minha contribuição prende-se com a identificação e mapeamento das comunidades descritas, assim como recolha de informação sobre dimensões e abundâncias das comunidades. Destaca-se a descoberta da primeira comunidade exuberante de coral negro *A. subpinnata* na região, uma nova espécie de coral para os Açores (Matos et al. 2011).

Braga-Henriques, A., J.N. **Pereira**, F. Tempera, F.M. Porteiro, C. Pham, T. Morato & R.S. Santos. 2011. **“Preliminary anaelysis of the distribution and structure of the cold-water coral communities on Condor Seamount.”** Presented at Project HERMIONE – 2nd Annual Science Meeting, 12-16 April, Málaga, Spain (Poster).

Braga-Henriques, A, **Pereira JN**, Porteiro FM, Tempera F, Pham C, Morato T, J & K Jacobson, Santos RS (2011). **“Cold-water coral communities of the Azores: Condor seamount and southern slope of Faial-Pico Channel.”** Seminar held on board RV Pourquoi Pas? during the BobEco cruise (IFREMER) to the Bay of Biscay and western coast of Ireland. (Palestra)

Braga-Henriques A, **Pereira JN**, Tempera F, Porteiro FM, Pham C, Morato T, Santos RS (2011). **“Cold-water coral communities on Condor Seamount: initial interpretations.”** Project Condor: final workshop (16-17 Feb 2011), Horta (Azores, Portugal).(Palestra)

Braga-Henriques A, **Pereira JN**, Porteiro FM, Tempera F, Jakobsen J, Pham C, Morato T, Santos RS. 2011. **“Invertebrate megafaunal diversity of upper-bathyal cold-water coral assemblages from two locations in the Azores (NE Atlantic).”** World Conference on Marine Biodiversity, 26 to 30 of September. Aberdeen (Scotland). (Palestra)

Matos V., J.N. **Pereira**, A. Braga-Henriques, F. Tempera & F. Porteiro (2011). **“Twilight coral gardens: First record of *Antipathella subpinnata* in the Azores.”** Presented at 3rd CoralFish Science Meeting, 01-04 November, Crete, Greece. (Poster)

2010 & 2011 *Ictiofauna (palestra, artigo in prep)*

Os trabalhos de estudos de ictiofauna decorridos centram-se principalmente no monte submarino Condor. Consistem na inventariação de ictiofauna dos 185 aos 1100 metros, o estudo da sua associação com os biótopos descritos, assim como o estudo dos seus comportamentos. A minha contribuição consistiu na escolha dos métodos de amostragem, e recolha de dados. Este estudo revela dados inéditos, como um comunidade não inventariada pelos métodos clássicos de prospecção pesqueira, uma menor associação ao habitat com a profundidade, assim como comportamentos de ictiofauna em relação a corais e novas ocorrências para a região. Apresentado pelo ictiólogo Filipe Porteiro, os resultados destes estudos estão em fase de preparação para submissão no special issue da Deep-sea research dedicado ao Monte Submarino Condor.

Porteiro, F., **J.N. Pereira**, Tempera, F., T. Morato, C. Pham, A.B. Henriques, R.S. Santos & G.Menezes (2011). “**Deep-sea benthic fish from bathyal biotopes in northeast Atlantic shallow seamounts, observed by ROV surveys.**” Presented by F. Porteiro at the “Project HERMIONE: 2nd Science Meeting”, Estepona (Spain).(Palestra)

Porteiro, F.M., J. **Nuno**, C. Pham, F. Tempera, T. Morato & G. Menezes. (In prep) “**Fish habitats and communities from Condor seamount as depicted from ROV surveys.**”Deep-sea Research I. Special Issue on Condor seamount.

No âmbito do estudo da comunidade ictiológica preparei durante 2011 uma pequena nota sobre observações de ictiofauna numa estrutura artificial a 200 metros de profundidade.

Nuno, J., F. Tempera & F. Porteiro. (In press) “**Note on an opportunistic artificial reef near cold-water corals**”. Arquipelago. Life and Marine Sciences 29: 11-18.

2010 & 2011 *Pescas (palestras, proceedings e posters)*

No âmbito do CoralFISH, efectuei uma análise das comunidades de corais dos 200 aos 1000 metros de profundidade no banco Condor, de forma a identificar a presença sinais de pesca (linhas, bóias, pedras, etc.), e o estado das comunidades de invetebrados sésseis nesses

locais. Estes dados integraram os estudos em curso sobre a relação entre pescas e corais, coordenados pelo Doutor Telmo Morato, e da responsabilidade do estudante de doutoramento C. Pham.

Morato, T., T. Bento, V. Matos, **J.N. Pereira**, C. Pham, F. Porteiro, I. Sampaio, R.S. Santos & F. Tempera. (2011). **“Impact of fishing on CWC in the Azores.”** Presented by Telmo Morato at: Project Condor: final workshop (16-17 Feb 2011). Horta (Azores, Portugal); Project Condor: seamount stakeholder workshop (29th March 2011). Horta (Azores, Portugal). (Palestra)

Santos, R.S., A. B. Henriques, V. Matos, T. Morato, **JN Pereira**, C. Pham, F. M. Porteiro, I. Sampaio, M. C. Silva, F. Tempera. 2011. **“Surrounded by High-Seas: Cold Water Corals and Line Fisheries in the Azores.”** In: Workshop “Understanding Deep-Water Biodiversity in the South Atlantic: Options for Conservation and Sustainable Use of Resources in the High-Seas² UNESCO-IOC 7-8 April 2011, Paris (Palestra)

Pham, C. K., T., Morato; T. Bento; V. Matos; **J.N. Pereira**; F. Porteiro; I. Sampaio; R.S. Santos; F. Tempera. 2011. **“The Impact of Fishing on CWC Communities in the Azores.”** HERMIONE Annual Meeting 2011, Malaga, 11 – 15 April. (Palestra)

Pham, C.K., T. Morato, T. Bento, A.B. Henriques, V. Matos, **J.N. Pereira**, F. Porteiro, Í. Sampaio, R.S. Santos & F. Tempera (2011). **“Evaluating the impact of bottom longline on cold-water corals and sponges in the Azores.”** 3rd CoralFISH Science Meeting 31st October – 4th November 2011, Crete. (Palestra)

2011 Agosto. Artigo de ecologia trófica: dieta de baleias de bico do Atlântico central.

Este trabalho surge no seguimento dos trabalhos paralelos que mantenho em ecologia trófica de grandes predadores. Sabe-se ainda muito pouco sobre a dieta de mamíferos marinhos do Atlântico Norte central e estas baleias em particular continuam a ser dos mamíferos menos conhecidos em todo o planeta. Com base em análises de conteúdos estomacais recolhidos entre 2002 e 2009, verificou-se que estas baleias de bico se alimentam dos peixes de meia-água (meso e batipelágicos) mais abundantes na região até aos 750 metros. Um caso de plasticidade comportamental no que respeita à alimentação, divergindo das presas bentopelágicas preferidas pelos seus conspecíficos de águas continentais.

Pereira, J.N., V.C. Neves, R. Prieto, M.A. Silva, I. Cascão, C. Oliveira, M.J. Cruz, J.V. Medeiros, J.P. Barreiros, F.M. Porteiro, D. Clarke. 2011. “Diet of mid-Atlantic Sowerby's beaked whales *Mesoplodon bidens*.” Deep Sea Research Part I: Oceanographic Research Papers, 58(11): 1084-1090. DOI: 10.1016/j.dsr.2011.08.004

2011 Dezembro. Responsável por conteúdos do Museu do Parque Marinho dos Açores

Desenvolvi uma proposta de conteúdos para o Museu do Parque Marinho dos Açores (PMA), submetida via Observatório do Mar dos Açores, tendo a proposta e o caderno de encargos sido aceites pela Direcção Regional do Ambiente, e o contrato de prestação de serviços assinados ainda em Dezembro de 2011. Durante 2012, serei responsável pelos conteúdos informativos e implementação tecnológica do museu que dará a conhecer o PMA através de cinco painéis expositores informativo-didáticos apresentando as suas 11 áreas com estatuto de conservação, agrupadas em quatro módulos: 1) informação geral sobre o PMA; 2) montes submarinos profundos (Sedlo, Crista Média Atlântica Norte dos Açores, Altair e Antialtair); 3) montes submarinos de baixa profundidade (D. João de Castro e Banco das Formigas; 4) zonas pelágicas offshore (Important Bird Areas); e 5) campos hidrotermais de profundidade (Menez Gwen, Lucky Strike e Rainbow). Irá dispor ainda de equipamentos multimédia e de um website, tudo em formato bilingue.

2012

2012 Janeiro. Investigador convidado para Workshop “Practicalities of implementing video annotation” pelo Coastal Fisheries Research Group, CCMAR-UAlg

Durante os dias 09 a 13 de Janeiro, estive presente na Universidade do Algarve a convite do Coastal Fisheries Research Group do Centro de Ciências do Mar da Universidade do Algarve para realizar um Workshop relativo à recolha e implementação de um sistema de análise de vídeo, com principal foco na utilização e personalização do software de catalogação e processamento de imagens científicas de vídeo COVER.

2012 Janeiro. Artigo para enciclopédia Biomes and Ecosystems

Artigo submetido a 13 de Janeiro sobre o maior banco submarino do mundo, o Banco Saya de Malha, no Oceano Índico. A enciclopédia é uma produção da Golson Media, a ser editada em 2012, e consiste numa revisão de classificações biológicas e geográficas.

Nuno, J. & G. Dionísio. *In press*. Saya de Malha Bank. Biomes and Ecosystems: An Encyclopedia. Ed. Howarth, Robert Warren. Salem Press.

III - *Curriculum Vitae* detalhado

i) Percurso académico

Curso em Biologia Marinha e Pescas. Faculdade de Ciências do Mar e do Ambiente, Universidade do Algarve, Faro 2000-2006, concluído a 15 de Dezembro de 2006.

Estágio de Licenciatura no Departamento de Biologia, Universidade dos Açores, São Miguel, Setembro-Dezembro de 2005.

2 Disciplinas de pós graduação, Departamento de Oceanografia e Pescas, Universidade dos Açores, Faial (2007)

Duas disciplinas do Mestrado Integrado em Estudos dos Oceanos, leccionado no Departamento de Oceanografia e Pescas, Universidade dos Açores. Nomeadamente, Instrumentos de Disseminação Científica (18) com o Prof. Dr. João Gonçalves, e Desenho Experimental e Tratamento de Dados (16), com o Prof. Dr. Gui Menezes.

Na disciplina Instrumentos de Disseminação Científica, com uma carga horária de 125 horas, constava no seu plano curricular a disseminação resultados científicos: método científico, projectos de investigação, entidades financiadoras; concursos; elaboração de propostas; métodos de selecção (painéis de avaliadores); execução técnica e financeira; Formas de suporte da escrita para a comunidade científica: bases de dados bibliográficas, publicações online e citações revistas; Escrita de artigos, livros, relatórios técnicos; Revisão de artigos – sistema “peer review”; “Posters” e comunicações orais; Monografias e emissão de Pareceres; Divulgação científica, educação e sensibilização ambiental; Propriedade intelectual e ética científica; Organização de eventos e reuniões científicas de participação pública.

Na disciplina de Delineamento Experimental e Tratamento de Dados, com uma carga horária superior a 100 horas, incluía a Descrição de Dados; Resumo Numérico dos Dados; Resumo de Dados Bivariados; Probabilidade e Distribuições; Distribuições da Amostra; Estimativa de Intervalos para uma Amostra; Teste de Hipóteses de uma Amostra; Inferências para Duas Amostras Independentes; Inferências de Dados Emparelhados; Regressão Linear Simples e Correlação; Análise de Variância e Análise de Dados Categóricos.

ii) Formação complementar (pós graduação)

Formação avançada em “Bioacoustics and Marine Telemetry”, leccionado por Magnus Wahlberg, IMAR/Departamento de Oceanografia e Pescas, Univ. dos Açores, Horta 18-25 Junho, 2006.

Magnus Walnberg é prof. Honorário do Instituto de Biologia da Universidade de Southern Denmark. O curso introduziu as bases de bioacústica e telemetria marinha, incluindo a recolha, processamento e análise de dados. O workshop pretendia apoiar na implementação de técnicas acústicas de telemetria passiva na investigação a decorrer no DOP/UAç. A acústica é a forma de comunicação mais efectiva na maior parte do oceano, assim como em longas distâncias, pelo que do seu domínio é essencial no estudo de ambientes marinhos. No âmbito do workshop apresentei uma palestra intitulada “Do Cephalopods Hear?” Bioacoustics and Marine Telemetry (Workshop), Horta, Faial, 18-25 June, 2006. Uma pequena revisão sobre os aparelhos auditivos e a recepção de estímulos vibratórios nos cefalópodes.

Formação avançada em “Biogeografia, Teoria e Análise”, leccionado por Jorge Crisci e Liliana Katinas, no Departamento de Biologia (São Miguel), Universidade dos Açores, 15-19 Outubro de 2007.

Jorge Víctor Crisci é um botânico argentino, uma “autoridade” científica ao nível da biogeografia histórica. Com mais de 24 identificações e nomeações de novas spp., é editor associado da Cladistics, Plant Systematics and Evolution e presidente da "Sociedade Argentina de Botânica". Sua esposa Liliana Katinas é Professora de Botanica e Biogeografia da Universidad Nacional de La Plata. O curso percorreu a história e os princípios da Biogeografia Histórica, Biogeografia Filogenética e Cladística, desde a escolha de métodos, até ao tratamento computacional dos dados.

Formação avançada no “Cephalopod Beak Training Course” lectured and hosted by Dr. Malcom Clarke, Department of Oceanography and Fisheries, University of Azores, 31-3 to 12 of April, 2007.. Malcolm clarke é uma autoridade científica nesta abordagem, dispondo de uma das maiores colecções de bicos a nível mundial, tendo sido posteriormente ao Museu de História Natural de Londres.

Formação avançada em “Geographic Information Systems applied to Marine Sciences”, leccionado por Pedro Bordalo-Machado (IPIMAR), no DOP/UAç, 14-18 Abril, 2008.

Participação (sem contribuições) no GeoHab Meeting, em Trondheim, Noruega. June 2009. Um colectivo mundial que reúne biólogos e geólogos, no sentido de desenvolver contactos e me introduzir no meio académico do Mapeamento de Habitats

Formação avançada em ArcGIS 3D Analyst e ArcGIS Spatial Analyst, leccionados pela própria ESRI, via Cybermap, Faial, Julho de 2009.

Formação avançada em “Practical ecological modelling and analysis for coastal and marine management”. Centro de Ciências do Mar do Algarve. 11-13 July 2011. Lectured by Jason Roberts, Marine Geospatial Ecology Lab, University of North Carolina.

Jason Roberts, ex-funcionário da Microsoft, trabalha actualmente para o Marine Geospatial Lab, na Duke University, Carolina do Norte. Um dos melhores grupos no mapeamento de ecosystemas de larga escala, tendo como outputs os Aquamaps da Fishbase, ou o OBIS-Seamap. Neste curso abordaram-se desde a manipulação de dados oceanográficos obtidos remotamente, identificação e mapeamento de eventos oceanográficos, recolha de observações de espécies a partir de bases de dados informáticas, mapeamento de biodiversidade, modelação e mapeamento de esforço de pesca, ou a conectividade da dispersão de larvas.

iii) Actividade profissional

2006 (May). Univ. of the Azores. Skipper during Limped monitoring program, from the Univ. of Azores, to Graciosa Island, Azores.

2006 (July-September). Biologist & Underwater cameraman. Norberto Diver. Horta, Faial.

2007 (January-June): Identification of Cephalopods from remaining beaks, in the diet of Alfonsinos (*Beryx splendens*) off Azores. Institute of the Sea - Department of Oceanography and Fisheries, University of Azores. 9901-862 Faial, Azores.

2007 (September-December): Consulting on Hydrothermal Vents for the “Aquário Virtual” Museum, Faial. OMA – Marine Observatory of the Azores, Fábrica da Baleia de Porto Pim, 9900 Horta, Azores – Portugal.

2008 (April-May) Horta Cetáceos – Actividades Marítimo Turísticas, Lda. R. Vasco Gama, Horta 9901-017, Açores - Portugal. Biologist, Second Skipper and Field Guide (Whale-watching)

2008 (May-June): Scientific crew of ARQDAÇO P08, onboard RV Arquipélago. (demersal fisheries monitoring program, in the Azores). Institute of the Sea - Department of Oceanography and Fisheries, University of Azores. 9901-862 Faial, Azores, Portugal.

2008–2012: Editorial Secretariat (peer-reviewed journal). Arquipélago – Life and Marine Sciences. University of the Azores. 9501-801, Ponta Delgada, Azores, Portugal.

2009 (October-December). Chief diver at Caulerpa webbiana eradication project in the Azores. Institute of the Sea - Department of Oceanography and Fisheries, University of Azores. 9901-862 Faial, Azores.

2010 (Jan) –2011 (June). IMAR – Institute of the Sea, Coimbra, Portugal. Deep-sea video annotator & video based analysis, Project Corazon CORAZON/PTDC/MAR/72169/2006//IMAR/UAC/001/2010

2011 (November) – 2012 (June). Video analysis of deep-sea benthic communities Project CoralFish. IMAR – Institute of the Sea, Coimbra, Portugal.

iv) Participação em projetos científicos e de desenvolvimento,

2010-2011 – Projecto CORAZON “Mid-depth benthic communities of conservation importance: cold-water coral ecosystems” (FCT PTDC/MAR/72169/2006). Responsável pela extracção de dados de vídeo para a descrição das comunidades, servindo os modelos de mapeamento. Contratado pelo IMAR – Institute of Marine Research.

2011-2012 Projecto CORALFISH “Assessment of the interaction between corals, fish and fisheries, in order to develop monitoring and predictive modelling tools for ecosystem based management in the deep waters of Europe and beyond” (EC/FP7:ENV/2007/1/213144). Responsável pela análise de vídeo, caracterização da comunidade ictiológica e integração com os estudos em curso. Contratado pelo IMAR – Institute of Marine Research

2010-2011 – Projecto CONDOR “Observatory for Long-Term Study and Monitoring of Azorean Seamount Ecosystems” (EEA grants PT0040). Responsável por inventariação exaustiva da fauna no monte submarino Condor.

2010–2011 Projecto HERMIONE "Hotspot Ecosystem Research and Man's Impact On European Seas" (EC/FP7-226354). Contribuições várias com dados de comunidades.

2010–2011 Projecto MeshAtlantic "Mapping Atlantic Area Seabed Habitats". (Atlantic Area 2009-1/110). Contribuições com dados de comunidades, e recomendações para standards e protocolos de operação.

2008. ARQDAÇO08, Monitorização de Recursos demersais dos Açores

v) Publicações Científicas

Porteiro, F.M., J. **Nuno**, C. Pham, F. Tempera, T. Morato & G. Menezes. (In prep) Fish habitats and communities from Condor seamount as depicted from ROV surveys. Deep-sea Research I. Special Issue on Condor seamount.

Pereira, J., M.J. Carvalho, R. Marques & A. Martins. First record of Fraser's dolphin *Lagenodelphis hosei* in the Azores and Madeira archipelagos, with a review for the North Atlantic. Marine Mammal Science. (In Prep).

Nuno, J., F. Tempera & F. Porteiro. (In press) Note on an opportunistic artificial reef near cold-water corals. Arquipelago. Life and Marine Sciences 29: 11-18.

Pereira, J.N., A. Simas, A. Rosa, A. Aranha, S. Lino, E. Constantino, V. Monteiro, O. Tariche, G. Menezes 2012. Weight-length relationships for 27 demersal fish species caught off the Cape Verde archipelago (eastern North Atlantic), Journal of Applied Ichthyology, Volume 28, Issue 1, pages 156–159.

Pereira, J.N., V.C. Neves, R. Prieto, M.A. Silva, I. Cascão, C. Oliveira, M.J. Cruz, J.V. Medeiros, J.P. Barreiros, F.M. Porteiro, D. Clarke. 2011. Diet of mid-Atlantic Sowerby's beaked whales *Mesoplodon bidens*, Deep Sea Research Part I: Oceanographic Research Papers, 58(11): 1084-1090. DOI: 10.1016/j.dsr.2011.08.004

Martins, H., J.N. **Pereira** & F.M. Porteiro 2010. Thirty years of natural sciences in the Atlantic Ocean. 2010. Editorial Notes, Arquipelago. Life and Marine Sciences. no.27, 77 pp. link

Pereira, J. N.G. 2008. Daily species check-list from whale-watching. Studying the research potential with an Azorean case study. Journal of Marine Biological Association 88: 1283-1288. DOI: 10.1017/S0025315408001070

Pereira, J.N.G. 2008. Field Notes on Risso's dolphins (*Grampus griseus*) distribution, social ecology, behaviour and occurrence in the Azores. Aquatic Mammals, Volume 34, Number 4, pp. 426-435(10). DOI 10.1578/AM.34.4.2008.426

vi) Outras publicações

Livro como autor

Pereira, J.N.G. & V. Neves 2009. Darwin in the Azores. Personal diary with commentaries. Observatório do Mar dos Açores, Horta, Portugal. [new edition in 2012, UK & PT]. [link](#)

Capítulo de Livro

Nuno, J. & G. Dionísio. In press. Saya de Malha Bank. Biomes and Ecosystems: An Encyclopedia. Ed. Howarth, Robert Warren. Salem Press

Jornal como co-Editor

Arquipelago – Life and Marine Sciences, Vol. 25-29 (2007-2012).

Arquipelago – Life and Marine Sciences Special Vol. 6 and 7.

Publicações sem revisão arbitrária

Pereira, JN, F. Porteiro, C. Pham, F. Tempera & T. Morato. 2011. Regional comparison of differences in fish assemblages recorded from analysis of in situ video. Hermione Report D50. December 2011.

Pereira, JN, F Tempera, A Braga-Henriques & FM Porteiro. Check-list of megafauna from underwater video analysis at the Condor seamount – current status. Final Report of project Condor (EEA), 20 March 2011.

Braga-Henriques, A., ZN **Pereira**, F Tempera, FM Porteiro, C Pham, T Morato and RS Santos. Cold-water coral communities on Condor Seamount: initial interpretations. Final Report of project Condor (EEA), 20 March 2011.

Tempera, F., A. Braga-Henriques, A. Colaço, JN **Pereira**, G. Menezes & F. Porteiro. Geomorphological characterization of the Condor de Terra seamount in preparation of deep-sea habitat predictive modeling. Lamarche, G. (Editor), 2010. Programme and abstracts, GeoHab 2010, Wellington, New Zealand, 157 p.

vii) comunicações em encontros científicos e de divulgação científica;

Pereira, JN & FN Tempera. 2011. Practicalities of implementing video annotation. Mesh Atlantic Workshop, Faro, Portugal, 20-22 July, 2011. (Talk)

Pereira, J.N., F. Tempera, H. Schone, A. Henriques, R. Medeiros, F. Porteiro, T. Morato, G. Menezes & R. Santos. 2011. Submarinos no Condor: revelações maravilhosas e utilidade. Workshop dos utilizadores do Condor. Horta, Portugal, 29 Março 2011. (Talk)

Pereira, J.N., F. Tempera, H. Schone, A. Henriques, R. Medeiros, F. Porteiro, T. Morato, G. Menezes & R. Santos. 2011. "ROV and Tow-cam imagery at Condor Seamount: overview". CONDOR final workshop. Horta, Portugal, 16 February 2011. (Talk)

Pereira, JN 2010. Underwater cleaning: yes or no? "Limpeza a fundo: sim ou sopas?" Horta, Faial. 4 Setembro 2010.

Pereira, JN & FN Tempera. 2010. Video analysis stage point at DOP/UAç. CoralFISH video workshop. 2010, Attard, Malta, 10 April 2010. (Talk)

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Posters

F Tempera, A Braga Henriques, **JN Pereira**, AS Campos, J Luís, A Colaço, T Morato, G Menezes, FM Porteiro & RS Santos. 2011. Terrain characterization of the Condor seamount in preparation of deep-sea habitat predictive Modelling. Presented at 3rd CoralFish Science Meeting, 31 October - 04 November, Heraklion, Crete, Greece. (Poster)

Matos V., **J.N. Pereira**, A. Braga-Henriques, F. Tempera & F. Porteiro (2011). Twilight coral gardens: First record of *Antipathella subpinnata* in the Azores Presented at 3rd CoralFish Science Meeting, 01-04 November, Crete (Greece).

Tempera, F., **J.N. Pereira**, A. Braga Henriques, F. Porteiro, T. Morato, V. Matos, D. Cuvelier, M. Souto, A. Colaço & R.S. Santos. 2011. Deep-sea biotope diversity: an illustrated catalogue for the Azores (NE Atlantic). Bulletin of the Geological Society of Finland, Special Issue, 1: 91. (Poster).

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Pereira, JN, T Morato, G Menezes, Malcolm Clarke, Luís Barcelos & F Porteiro. 2010 Cephalopods in the diet of two seamount aggregating fish species: alfonsino, *Beryx splendens* and orange roughy, *Hoplostethus mediterraneus*. Presented at Project HERMIONE – 2nd Annual Science Meeting, 12-16 April, Málaga, Spain (Poster).

Pereira, JNG 2007. Daily species check-list from whale-watching. Studying the research potential with an Azorean case study. 21st Annual Conference of the European Cetacean Society, Donostia-San Sebastian, Spain, from April 23rd – 25th, 2007. (Poster)

viii) Participação em sociedades profissionais e científicas;

Sciaena – Associação de Ciências Marinhas e Cooperação. Membro Fundador (2006)

GEO – Grupo de Estudos Oceânicos. (2007 -)

SPECO – Sociedade Portuguesa de Ecologia. Sócio (2009 -)

ix) Indicadores de inovação e empreendedorismo

Criação da Sciaena – Associação de Ciências Marinhas e Cooperação (2006)

Criação do próprio emprego: Cameraman subaquático em empresas de turismo de mergulho (2006)

x) Divulgação de ciência (vídeos)

Responsável pela rubrica “Mar-Ciência” do programa televisivo “Águas Vivas”, para a RTP Açores, 2011 (250.000 espectadores). March-July 2011. MarImages, Lda

GoogleOcean - Youtube link: <http://www.youtube.com/user/ImagDOP#p/u/0/qADlhgCclac> (4000 visualizações)

xi) Outras competências relevantes

Software

OS: Windows, Mac, Linux

Image: Adobe Phostoshop, ACDSee, ImageJ

Video: Adobe Premier, Encore & After Effects; Final Cut Pro

Audio: Adobe Audition; Audacity

Virtual Mapping: GMT (basic), Surfer, ArcGIS

Ecological: Phlex, Phinex, Mathematica

Statistic: Statistica

Useful Others: Mendley Desktop, Procite, EndNote, Microsoft Access, Excel, Dreamweaver

Licenças técnicas

>First Aid Basic Course - Red Cross, Faro (2001).

>Driver License nº 186048774 (2003)

>Scubadiving: Open water diver, by PADI Europe (St. nº0212E75899; 2002).

>Local Skipper, Licence nº 101324 (2003), allows navigation to 5 miles from the coast and 10 miles from a safe harbour.

>Marine Radio Operator Class A, License nº05032104 (2003).

Web-Design

>www.nebua.aualg.pt - Homepage of Academic Group of Students of Biology, University of Algarve (2005)

>www.geo-oasis.info - Homepage of GEO-Oasis, the GEO (Group of Oceanic Studies, to the Gorringe Bank (2007)

ANEXOS

Field Notes on Risso's Dolphin (*Grampus griseus*) Distribution, Social Ecology, Behaviour, and Occurrence in the Azores

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Abstract

This study reports new information on *Grampus griseus* (G. Cuvier, 1812) distribution with depth and slope, group size, general and interspecific behaviour, and calving intervals for the Azorean archipelago. Observations are in agreement with scarce previous work and most other regions in the North Atlantic and Mediterranean. Data were collected on 107 sightings south of Pico Island that took place between 17 May and 29 August 2003 from opportunistic research platforms. Information on occurrence, provided by an observer with 50 y of land-based cetacean experience, was included for comparison. Risso's dolphins preferred areas between 497 and 1,233 m depth (modal class 600 to 650 m; N = 69), with slopes between 27 and 35%, although these data require validation. The majority of groups were composed of up to 20 individuals (modal 6 to 10), averaging 12.3 (1 to 55; N = 74). Large socializing aggregations observed during July and August (55 to ~175 individuals) were similar to land-based observations between 1992 and 2005. *G. griseus*'s diurnal activities in this study were mostly traveling (77%) and socializing (13%), with feeding (5%) and resting (3.7%) occurring less frequently. The first newborn calves are reported. Two-species groups and interactions with six cetacean species are described. Harassment behaviours with *Globicephala* spp. and *Physeter macrocephalus* suggest competitive interference. Year-round observations between 1992 and 2005 near Pico Island, together with birth reports and recent data on site fidelity, suggest population residency.

Key Words: Risso's dolphin, *Grampus griseus*, ecology, behaviour, aggregations, newborn, mixed-species groups, harassment

Introduction

Risso's dolphin (*Grampus griseus*) (G. Cuvier, 1812) is the smallest member of the subfamily Globicephalinae (Delphinidae) and is distributed

in tropical and temperate oceans worldwide (Leatherwood et al., 1980; Le Duc et al., 1999). In the North Atlantic, it is known from New Foundland to the Caribbean Sea (Fritts & Reynolds, 1981; Leatherwood et al., 1982; Ward et al., 2001), occurring off most European coasts from Norway to Greece (Raga et al., 1985; Gannier, 1989; Evans, 1998; Pollock et al., 2000; Frantziis & Herzog, 2002) and around all Macaronesian Islands (Chaves, 1924; Vonk & Martín, 1988; Reiner et al., 1996; Freitas et al., 2002).

These mainly teuthophagous delphinids (Clarke, 1966; Blanco et al., 2006) prefer habitats over steep slopes between 400 and 1,200 m depth, recurrently near the slope edge (Dohl et al., 1983; Hain et al., 1985; Kenney & Winn, 1986; Gannier, 1989; Fabbri et al., 1992; Baumgartner, 1997; Evans, 1998; Cañadas et al., 2002) or near strong bathymetric features such as submarine canyons and seamounts (CeTAP, 1982; Kenney & Winn, 1987; Evans, 1992; Waring, 1993). Shallower occurrences are less frequent, and the Risso's dolphins apparently favour areas where the slope is close to the coastline, such as in the proximity of islands, where they become more accessible for observation (Notarbartolo di Sciara et al., 1993; Shane, 1995a; Pálacios, 2002). Feeding mostly at night, *G. griseus* travels during the day (Shane, 1995a) in groups of 3 to 30 individuals (Kruse et al., 1999), apparently forming longer, stable clusters than the "fusion-fission" societies in a recently proposed "stratified social organization" (Hartman et al., 2008). Large aggregations of several hundred individuals have been observed in the Pacific (Kruse et al., 1999), and mixed-species groups and interactions with other cetaceans have been registered in different areas (Würsig & Würsig, 1980; Frantziis & Herzog, 2002).

G. griseus occurs in the Azores region along with 25 other cetacean species (see Pereira, 2008, for a recent review). The Azores consist of nine volcanic islands and several seamounts that rise east of the Mid-Atlantic Ridge between 36° 55' to 39° 43' N and 24° 46' to 31° 16' W from a theoretical 2,000-m depth micro-plate limit (Needham

& Francheteau, 1972). Regional scientific registries consist mostly of faunal listings since the early 20th century (Chaves, 1924; Ferreira, 1935; Clarke, 1981; Reiner, 1988) and a short report by Arnbom et al. (1988) near the Azores. The first regional ecological information was reported by Silva et al. (2003), placing Risso's dolphin among the five cetacean species with higher sighting rates and reporting an even distribution throughout the whole Archipelago. Silva et al. (2003) also reported a preferential distribution over depths below 500 m and an average group size of 5.8. This requires further validation as it was based only on 16 sightings. Near the study area, the species has been observed via whale-watching since 1992 and throughout the whole season between 2001 and 2004 (April to October; Pereira, 2008). Hartman et al. (2008) found strong fidelity within this area through photo-identification work between 2004 and 2006, estimating a population size exceeding 904 individuals. The present study adds to the poor knowledge on *G. griseus* distribution with depth, group size, general and interspecific behaviour, and calving intervals for the Azorean archipelago. Data were collected through opportunistic research platforms and are compared with previous studies and other regions, mostly from the North Atlantic and the Mediterranean. Information from local unreported multi-decadal observations on the Risso's dolphin was included for comparison.

Materials and Methods

Sampling and Study Area

Sampling was carried out from 17 May to 29 August 2003 onboard whale-watching rubber inflatable boats (RIBs) of 4.7 and 7.35 m, with 70 and 140 hp, respectively. Platforms departed from Lajes on the south coast of Pico (Figure 1) and were directed to cetaceans through VHF radio by lookouts at advantage points on land, using Carl Zeiss magnifying lens (15 × 60). Pico is located in the central group of islands, with a WNW-ESE orientation, surrounded by steep bathymetric slopes.

The main land lookout (called Queimada: 38° 23' 094" N, 28° 14' 498" W; Figure 1) is situated near the departing harbour 75 m above sea level (Silva et al., 1994). Used since 19th-century whaling, it can cover approximately 733 nmi², based on 210° of a circle centred on the observation point on land and a 20 nmi visibility. Due to the sporadic use of alternative lookouts from Pico, the surrounding areas were included (Figure 1).

Observation effort took place from this land-based lookout and was not quantified. Searches were both random and directed, based on previous

knowledge of species distribution and favouring proximity of the departing harbour. The number of daily boat trips, location, and duration of sightings were determined by a series of uncontrolled factors related to weather conditions and the tourism observational activity (see Pereira, 2008, for a review). Sampling occurred during surface or underwater observation trips, averaging 3 h. With the tourism activity favouring the observation of different species (Pereira, 2008), *G. griseus* group resighting was minimized within each 3-h period through radio communications at sea and daily data analysis.

Data Collection

Data on 107 sightings of *G. griseus* were collected between 0950 and 1830 h. These were recorded on 65 of the 105 d of field work, totalling 21:02 h of observation. On each sighting, date, time, group activity (see below), position (GPS Garmin), duration, group size (including single individuals and all individuals in close proximity, moving in the same direction, and often engaged in similar behaviour; Shane, 1990) were recorded. The presence of juveniles (brownish), calves, and newborn calves (approximately 1 to 1.5 m with birth marks, flaccid dorsal fin, and asynchronous swimming; Tayler & Saayman, 1973; Jefferson et al., 1993) was also registered.

The natural behaviour of *G. griseus* was recorded cautiously based on activity noted at a distance of more than 50 m from the boat and comparing information with the lookout on land. The following activities were considered: traveling (unidirectional movement), resting (floating at surface, stationary, or moving forward very slowly), socializing (frequent corporeal contact, usually accompanied by surface displays and no apparent movement), feeding (group moving in a line abreast formation with the animals at similar distances, or group diving in the same location and surfacing facing in varying directions), and unidentified behaviours (Shane, 1995a; Heithaus & Dill, 2002). Combinations of activities were not considered, and the generalized group behaviour was recorded as the main activity. As the employed platforms tend to approach progressively closer, behaviour was registered only once per sighting as the ongoing behaviour before boat arrival. Behaviour of mixed-species groups and interspecific behavior were registered separately, independent of boat proximity, consisting of general descriptions of the events.

Depths and slopes were calculated from bathymetric data made available by the Portuguese Hydrographic Institute through *Generic Mapping Tools (GMT)* software with *Mirone*, Version 5.0,

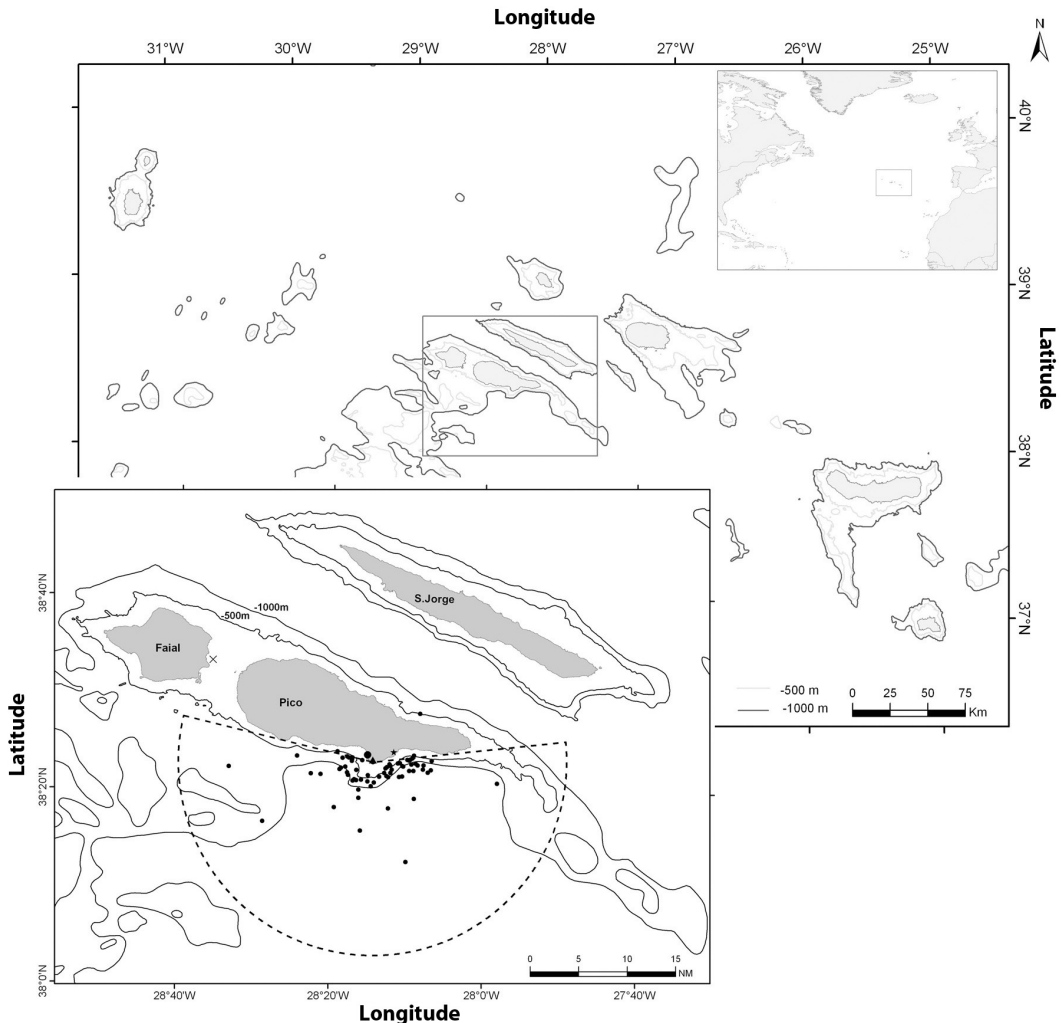


Figure 1. Azores archipelago in the North Atlantic context and map of the main area covered in the central group of islands, showing main lookout (▲) and respective area of coverage (---), departing harbour (●), home location of long-time cetacean observer (★), geo-referenced sighting locations (●), and location of the largest aggregation observed (x)

interface. Depths were grouped on 50- and 500-m depth classes.

Empiric information on the local occurrence of *G. griseus* was collected through tape recording conversations with João José Gonçalves, a lifetime professional cetacean observer who worked for 50 y as a lookout, first for whale boats beginning age 15 (1947 to 1984), and later for the first tourism company from 1992 to 2005. Whale watching officially began in the Azores in 1993 (Silva et al., 2003), although the first company, for which this lookout was operating, had already been running in the previous year (Espaço Talassa). Observations were made mainly from south of Pico Island, and year-round information between 1992 and 2005 were based on sporadic winter surveys performed

from his house, a vantage point on land (covering the same area) where he frequently worked from until ceasing activity in 2005 (Figure 1; see, also, Pereira, 2008). Personal communications were recorded in 2003 and were repeated in 2005 to verify possible inconsistencies; these are included in the “Results” section.

Results

Distribution with Bottom Features

Relative depths of 69 geo-referenced surface sightings ranged from 46 to 1,812 m, with a modal distribution over the 600- to 650-m depth class (Figure 2). The distribution of Risso’s dolphins was unequal over depths and slopes (Pearson’s

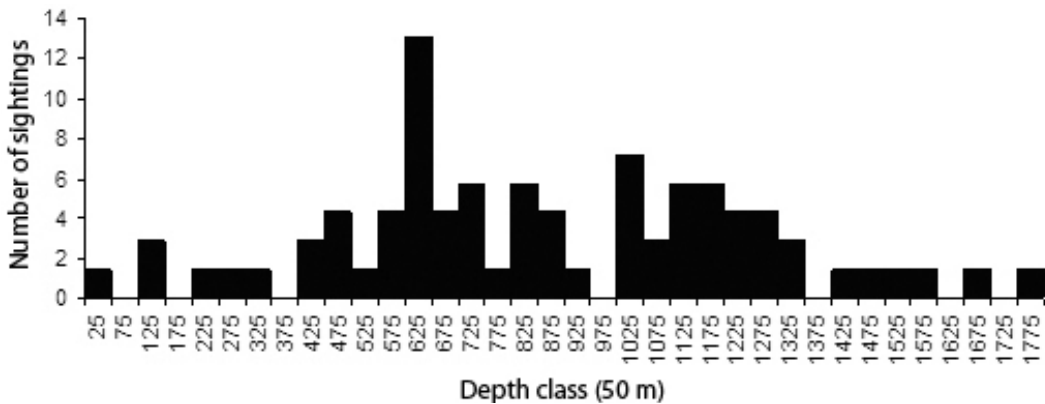


Figure 2. Risso's dolphin sightings distribution over 50-m depth classes (mid-class values are indicated; $N = 69$)

chi-square $\alpha = 0.05$), occurring preferentially over 497- and 1,288-m depth areas ($Z\alpha = 0.05$ assuming normality), averaging 893 m ($SD = 461.1$). Considering the larger depth classes, most sightings occurred over areas below 500 m (500 to 1,000 m, 41%; 1,000 to 1,500 m, 36%). Bottom slopes oscillated between 9 and 622 m/km, with an average of 308 m/km ($SD \pm 182$), or 30.8%, between 265 and 351 m/km ($\alpha = 0.05$). Due to the inclusion of directed search, distribution data will require future validation.

Group Size

The number of Risso's dolphins was registered on 74 encounters and varied between 1 and 170 to 180 individuals. During four events, the number greatly exceeded the typical 3 to 30 (Kruse et al., 1999), namely 55, 63, 87, and ~175 individuals, respectively, with intraspecific socialization as the generalized behaviour. These aggregations were

excluded from the estimated average group size of 12.3 ($SD = 9.9$).

Groups were mostly composed of 6 to 10 individuals ($n = 26$; Figure 3), followed by groups of 1 to 5 individuals ($n = 17$) and groups of 16 to 20 individuals ($n = 11$), accounting for 77% of the overall sightings. The class of 31 to 35 individuals was the most frequent among larger groups. Aggregations of over 50 individuals (09, 17, 25 July, and 2 August) represent less than 5% of the overall sightings. These were registered during four events separated by 6 to 8 d (55, 175, 63, and 87 individuals, respectively) at different locations within the Pico-Faial-São Jorge Islands "triangle"—a central group of islands (Figure 1). During these sightings, intraspecific socialization was the ongoing activity, and a diversity of energetic behaviours were registered such as chasing; biting; distinct aerial behaviours; lob-tailing; dorsal fin, pectoral, and head slapping; inverted and lateral swimming; and vertical diving, among

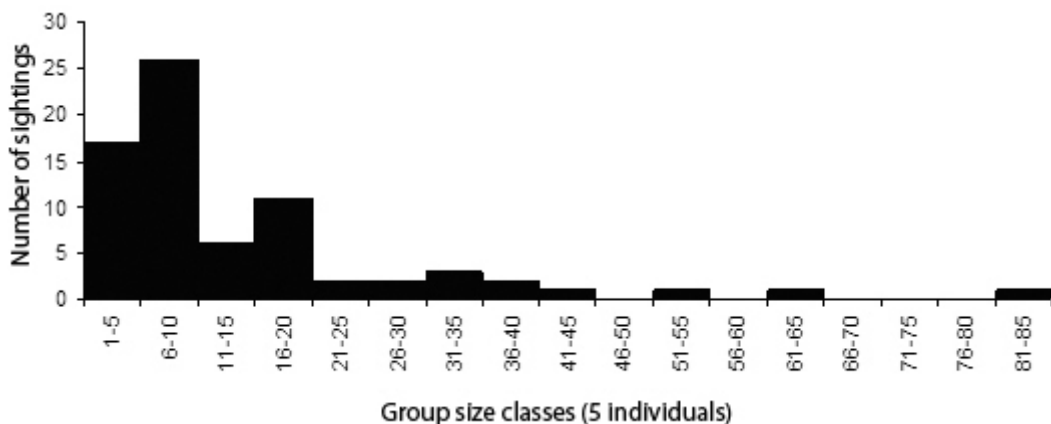


Figure 3. Group size sighting distribution over size classes of 5 individuals (1 to 85); the aggregation with 170 to 180 individuals is not represented ($N = 73$).

others. The largest aggregation was registered west of Faial Island over depths of 50 to 55 m and a 270 m/km slope (Figure 1). Contrary to the other stationary events, a generalized southward movement of the aggregated *G. griseus* was noted.

Calves

Calves were observed on 11 different sightings between 17 July and 25 August. The research method did not allow differentiating all the groups where calves were observed and, subsequently, the total number of calves. Based on the author's unpublished photo-identification data, one very young calf and two newborns were identified in two distinct groups. On 13 August, a group of ~36 individuals (including 6 juveniles) had two calves, one slightly smaller, showing a flaccid dorsal fin. The other group with a newborn was observed on 25 August, being composed of 11 individuals reaching 30 to 32 individuals on the following day (adults and juveniles). The newborn in this group showed all newborn features (see "Materials and Methods"), including asynchronous swimming. This last was accompanied by a juvenile, photo-identified at the study area the previous May.

General Behaviour

Behaviour was identified on 79 sightings, with traveling as the most frequent activity (77%; $n = 61$). *G. griseus* socialized 13% of the time recorded (11) and rested in 3.7% of the sightings. (3). Feeding behaviour was observed during 5% of the sightings (4 events): once at the end of June and three times in August. The parallel formation, with animals moving in the same direction side by side at similar distances, was observed only on 15 August at 1219 h. Four fragments of small gelatinous opaque red-coloured octopods (suborder Incirrata) were observed floating on different locations within the area of this event. The fragments consisted mainly of arm remains, lacking the beak mass region and most of the mantle, which made positive identification difficult.

Interspecific Behaviour

Sympatric occurrences with six cetacean species south of Pico Island were recorded in 10 of the 107 sightings. Six mixed-species groups, with Atlantic spotted dolphins (*Stenella frontalis*) (1), short-beaked common dolphins (*Delphinus delphis*) (1), pilot whales (*Globicephala* spp.) (2), and bottlenose dolphins (*Tursiops truncatus*) (2); and four interactions without the formation of mixed-species groups, with bottlenose dolphins plus fin whales (*Balaenoptera physalus*) (1) and with sperm whales (*Physeter macrocephalus*) (3). The events are described below.

Atlantic Spotted Dolphins and Short-Beaked Common Dolphins—Two traveling mixed-species groups were observed, one with each species. Interactions were not clear in either event, the number of individuals was not registered, and the species separated just after the boat's arrival.

Pilot Whales—In the two mixed-species groups with pilot whales, interactions initiated by Risso's dolphins were observed. On 2 July, four Risso's dolphins moved into a large stationary group of pilot whales of 46 to 54 individuals (ratio 1:16), which was formed by subgroups of adults and juveniles spread over ~800 m². On several occasions, the Risso's dolphins positioned in front of adults, head to head, initiating the interaction, with pilot whales reacting energetically, sometimes speeding towards *G. griseus*. During another event (15 July), six Risso's dolphins were circulating calmly in a stationary group of over 75 to 100 pilot whales (ratio 1:14), which was composed of several subgroups of adults, juveniles, and calves. Sporadic moments of interaction were observed, again initiated by *G. griseus*.

Bottlenose Dolphins—On 25 July 2003, an interaction with bottlenose dolphins was registered within an aggregation of 75 to 100 socializing Risso's dolphins. A chase was observed, involving ~30 to 50 bottlenose dolphins, with larger individuals ahead of the group, breaching out in speed after 10 to 15 adult *G. griseus*, also breaching completely out of the water. The interaction initiated in the area of the Risso's dolphins' aggregation and terminated with the bottlenose dolphins leaving this area. On 16 August 2003, a mixed-species group with over 50 bottlenose dolphins and eight Risso's dolphins (ratio 1:12) was observed. The dolphins were traveling, spread out over a wide area, distancing the outermost individuals ~130 m. The bottlenose dolphins were dispersed, and the Risso's dolphins were traveling more closely packed, maintaining the "borders" of their single-species group with only three active individuals 20 to 30 m ahead of their conspecifics. No interaction between the species was observed.

Three Species Interaction—During a sighting with fin whales and bottlenose dolphins, an interaction was registered between the three species (20 June 2003). A group of four fin whales was traveling at an average speed of 6 nmi/h, with 3 to 4 breathing surfaces, spaced by 3 to 5 min of submersion. Suddenly, during the breathing sequence, these fin whales dove rapidly, with one of the individuals "showing" the inferior of the caudal fin (an uncommon behaviour for the species), surfacing over 200 m further in the same direction after no more than 30 s. Before being resighted, another fin whale surfaced, moving in

the same direction accompanied by bottlenose dolphins (7 to 12) at 20 m distance. This last whale also plunged and disappeared, leaving the bottlenose dolphins behind. Eighteen seconds later, four *G. griseus* arrived, moving at high speed with short surface breaths in the same direction as the fin whales, slowing down and ending the chase while crossing the RIBs that were stopped since the first fin whales submerged rapidly.

Sperm Whales—During the three sightings with sperm whales (2, 6, and 17 August), Risso's dolphins engaged in energetic behaviours surrounding the physeterids. These responded by agitating vigorously in the water, spinning, and sometimes defecating, terminating all sightings with the sperm whales diving. On 6 August, three sperm whales from a large group of females were resting tightly at surface. Around 20 Risso's dolphins were observed at a distance, breaching and moving at a high velocity towards them. The sperm whales plunged vertically and clearly precipitously, while the Risso's dolphins were still at a distance of 70 m. These dolphins came from an unregistered aggregation of 50 to 60 individuals at a distance of more than 400 m. After arriving at the area, the Risso's dolphins slowed down and dispersed.

Notes on Occurrence

A resident cetacean observer from Pico Island reports the occurrence of *G. griseus* around Pico since 1947, and also year-round sightings were made from 1992 to 2005 in this particular area (João Gonçalves, see "Materials and Methods"). Large aggregations were also reported to occur in the area, at least from 1992 to 2005 (not every year), "during the summer months (months not discriminated), sometimes at a distance further than usual from the coast" (J. Gonçalves, pers. comm.).

Discussion

Distribution with Bottom Features

A clear prevalence between 497 and 1,288 m was shown for the first time in the Azores (Silva et al., 2003), although these results require further validation as the method includes directed search, and effort was not quantified. Nevertheless, relative depths of main occurrence were broadly similar to most European regions (400 to 1,200 m; Evans, 1998), corresponding also to the distribution reported in the Mediterranean (Fabbri et al., 1992; Cañadas & Sagarminaga, 1996; Airoidi et al., 2000; Azzellino et al., 2001) and in the northern Gulf of Mexico (Baumgartner, 1997). The characteristic preference for steep slopes was also observed in this study (Baumgartner, 1997; Cañadas et al., 2002; Palácios, 2002).

Group Size and Reproduction

Knowledge on the reproductive seasonality of *G. griseus* is still limited in the North Atlantic. There are birth reports year-round, occurring mostly from April to September (Evans, 1987). This study reports for the first time the birth of *G. griseus* in the Azores through three recently born calves with estimated birth dates between June and August 2003 (summer months). Assuming a 12- to 14-mo gestation period (Kasuya, 1985; Evans & Raga, 2001), reproductive activity must have occurred between March and August 2002.

The present study reveals group sizes in the Azores usually below 20 individuals (more often below 10), which is in general agreement with the typical 3 to 30 described by Kruse et al. (1999). Risso's dolphin group sizes were similar to Arnborn et al.'s (1988) observations in the proximities of the Archipelago and by Silva et al. (2003) (5.9; 1 to 15; $n = 16$), considering sightings within the same range (6.4; $n = 49$ in this study). Values also agree with Hartman et al.'s (2008) long-term clusters of 3 to 12 individuals in this area ($n < 62$). Off the United Kingdom, the modal class of 6 to 12 is identical to this study (Reid et al., 2003, and references therein). Average group sizes in the Azores (this study; Hartman et al., 2008) are larger than those in the Ligurian Sea (Mediterranean), averaging 12 for groups between 1 to 70 (Airoidi et al., 2000), while strikingly inferior to the Alboran Sea (17.2 from 1 to 55) (Cañadas & Sagarminaga, 1996). In the Northeast Pacific, average values vary between 11 and 45 (Leatherwood et al., 1980; Kruse, 1989), with groups from the Galápagos volcanic islands having generally similar average sizes (13) (Smith & Whitehead, 1999) to the Azorean archipelago.

Large aggregations of *G. griseus* observed here between July and August 2003 have been reported elsewhere, such as the Northeast Pacific, where they can reach several hundred individuals (Kruse et al., 1999). In the Azores, as these "large aggregations" were not observed every year south of Pico by J. Gonçalves's land-based surveys, it suggests they occur in other areas within their home range, which is confirmed by the observation of a large aggregation west of Faial in the present study, supporting its multiyear occurrence (Figure 1).

Considering the bathymetric reality of south Pico Island (Figure 1), the formation of large aggregations further from the coast "than usual" (J. Gonçalves, pers. comm., 2005) suggests that these events are not necessarily related to seafloor depth. Risso's dolphin groups' fusion in large aggregations has been related to the local abundance of food resources (Norris & Dohl, 1980). The aggregations reported here, with intense intraspecific

socialization, might be related with reproductive activities based on the limited available evidence. Similar surface behaviours have been observed in large aggregations called “copulation gatherings” of *Globicephala melas* (a *G. griseus* sister genera) in the Mediterranean (Cañadas & Sagarminaga, 2000). Sexual behaviours were confirmed from underwater observations, and the events were registered in a variable way between July and September 1992 to 1997, a period analogous to the Azores. Also, the apparent independence of these social events with depth and the correspondence with the estimated breeding season of the previous year in this study are relevant arguments which cannot be ignored. Furthermore, the results from several winters of surveying near Santa Catalina Island, California, reveal a much lower intraspecific socializing behaviour (Shane, 1995a) (see “General and Interspecific Behaviour” below). Only one large aggregation was reported in the proximity of commercial squid (*Loligo opalescens*) jigging boats. Full descriptions of these events, including underwater observations, knowledge of main preys, and more birth reports will promote further understanding.

General and Interspecific Behaviour

The general behaviour of Risso’s dolphins was similar to winter observations off Santa Catalina Island, California (Shane, 1995a), with traveling as the most frequent diurnal activity, although a different method was used. A slightly higher percentage of resting *G. griseus* were observed, possibly related to the land-based search method used in this study. Also intraspecific socialization was slightly higher than Shane’s (1995a) observations (8%).

Several records of mixed-species groups and interactions of *G. griseus* with other cetacean species such as reported in this study have been published (e.g., Shane, 1994; Kruse et al., 1999). *G. griseus*’s propensity for “intense interactions” is an expected characteristic mentioned in grey literature and suggested by the increasingly scarred dermal patterns throughout their lives. Harassing behaviours by *G. griseus* with different cetaceans are known, even when resource sharing should be nonexistent or very small such as chasing gray whales (*Eschrichtius robustus*) (Shelden et al., 1993) or fin whales (this study). For instance, a recent study reported that in two three-species groups, interactions always occurred between Risso’s dolphins and one of the other species (Frantzis & Herzing, 2002). These behaviours, such as chasing, can be considered potentially playful or aggressive and might vary between species and ecological contexts.

Interactions reported here reveal harassment behaviour in every sighting with the pilot whales and sperm whales. These are likewise teuthophagous delphinids, which favour depths greater than 500 m (Clarke et al., 1993; Cañadas & Sagarminaga, 2000; Davis et al., 2002; Silva et al., 2003). Aggressive behaviour between sympatric species of the family Delphinidae have been observed only occasionally (Bearzi, 2005). Near the Island of Santa Catalina, California, Shane (1995b) reported interactions with *G. macrorhynchus* generally similar to this study, always with *G. griseus* approaching the pilot whales and not the opposite. These closely related genera are medium-sized delphinids, which feed mostly on cephalopods, with overlapping ubiquitous distributions in temperate and tropical seas. Polacheck (1987) classified them as main competitors, and Shane (1995b) argues that competitive exclusion is a rule on a local scale. There is very limited knowledge in regards to the ecology of pilot whales in the Azores (*G. macrorhynchus* and the less often sighted *G. melas*). From opportunistic sightings between April and September 2000 to 2004, *Globicephala* spp. were more frequent in surface waters over 18° C (early June to September) (Pereira, 2008). The mixing of these species has been observed in this area from 1999 to 2007, always with “the presence of Risso’s dolphins ‘conditioning’ the behaviour of pilot whales,” with one underwater photographer witnessing Risso’s dolphins biting pilot whales’ pectoral fins (J. Quaresma, pers. comm., 2008; João Quaresma has been a professional whale-watching skipper since 1996). Risso’s dolphins’ harassment behaviours in the same area towards pilot whales, sperm whales, and false killer whales were observed in the following 3 y after this study (K. L. Hartman, unpub. data; see Hartman et al., 2008). As these were done generally by males, Hartman et al. (2008) hypothesised that males benefit in regards to access to females and foraging grounds, using a mechanism termed *habitat defence*, based on their tendency to form large groups and remain within the population, constantly sharing the same area. Do the behaviours of Risso’s dolphins keep pilot whales out or make them spend less time in the studied area? The existing data points towards Shane’s (1995b) local exclusion hypothesis. While historical regional references to pilot whales’ “blackfish” during the whaling period are abundant (e.g., Drouët, 1876), the lack of quantitative data does not allow for further conclusions at the moment.

The first interactions of Risso’s dolphins with sperm whales are reported here. Observations during the interaction and approach indicate recognition of some type of harassment behaviours developed by the delphinids, with evident stress

demonstrations such as rushed diving by the sperm whales. The momentary shift of forage area induced by the arrival of *G. griseus* was obvious in the three events, which is interpreted as a competitive interference (May, 1981). Niche overlap studies between these three species should be carried out.

Final Remarks

The *quasi* historical land-based observations from João Gonçalves suggest the existence of a resident population of *G. griseus* in the Azores that have been frequenting the area south of Pico year-round during at least a 13-y period (1992 to 2005). Their geographic isolation, wide regional distribution (Silva et al., 2003), and birth reports (this study) fall within this context. Resident populations of *G. griseus* are known from other locations (e.g., Fraser Island, Australia) (Bannister et al., 1996), and residency has been found for bottlenose dolphins in the Azores (Silva, 2007). Validation is usually based on photo-identification data, which was recently made available by Hartman et al. (2008), revealing the high frequency of the studied area during spring/summer 2004 to 2006 and strong site fidelity for over 40% of an estimated population of more than 904 individuals. Further studies are bound to support this assertion.

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Daily species checklist from whale-watching—studying the research potential with an Azorean case study

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*The present work uses daily checklist data from whale-watching to study basic aspects of cetacean ecology. Data in the Azores consists of a simple daily list of all species sighted by boats, with no additional information. The Azorean whale-watching activity is described and sources of variation related to data collection are debated. A data-set from one whale-watching company is analysed from 2001 to 2006, from April to October (tourism season). The first four years were used to describe frequencies in the area, and maximum and minimum regional sea surface temperatures for nineteen cetacean species, based on remote sensed data. Several species were present throughout the season, while for others, results indicate transient habits in the study area (*Balaenopterids*, *Globicephala* sp., *Pseudorca crassidens*, *Orcinus orca* and *Hyperoodon ampullatus*). Reservations were made relative to small size and evasive species. Sighting frequencies on temperature classes in 2005 and 2006 were used successfully in an experimental approach to study delphinid sympatry. The simplicity of data was overcome by the diversity of sighted species and the dimension of the time scale. Daily checklist is a low cost useful source of information mainly for large cetaceans that should keep being registered.*

Keywords: whale-watching; checklist; Azores; cetacean; ecology; sea surface temperature.

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INTRODUCTION

Whale-watching (WW) is a prosperous activity around the world (Hoyt, 2001), a reflection of a paradigm shift that now supports the daily efforts of the 'new whalers', and the resulting unprecedented number of cetacean sightings. While most studies related to WW focus on the impact of this growing activity (e.g. Bass & Duffus, 1999; Magalhães *et al.*, 2002), this type of ecotourism can and has been used as a source of valuable data and funding for cetacean research, mainly throughout the work of biologists or dedicated naturalists (e.g. Gordon *et al.*, 1995; Leaper *et al.*, 1997).

There are two main visual observation points related to WW that retrieve two different sources of data: observations on board and data from lookouts, when they operate. Both have in common the fact that they can be economically supported by tourism therefore data collection just needs to follow a determined experimental design, by experienced observers. They have been used successfully and one can have advantages and disadvantages over the other, or be complementary, according to the specific research in question (see Evans & Hammond, 2004). Problems and opportunities of the data from WW boats, concerning scientific purposes, have been analysed by Gordon *et al.* (1994). The daily species checklist is the most basic type of data, and usually refers to observations made on board. This information is simply a daily list of the species sighted by the company's

boat(s), with no additional information. So could there be any interest in this data for cetacean research? The following work attempts to outline its limitations and explore potentialities for research, based on Azorean WW data and present knowledge.

The Azores archipelago consists of nine volcanic islands, rising with several seamounts from a 2000 m depth delimited micro-plate (Needham & Francheteau, 1972) in the North Atlantic (NA). It is located between 36°55'–39°43'N and 24°46'–31°16'W, on the east side near the Mid-Atlantic Ridge (Figure 1). The absence of a continental shelf on its coastal geomorphology provides the possibility to observe coastal and oceanic cetacean species, from land or boat. It represents the latitudinal distribution limit known for certain cetacean species in the north-east Atlantic (e.g. *Hyperoodon ampullatus*). In addition the occurrence of several migrating balaenopterids (e.g. fin whales: Chaves, 1924), resident delphinid species (Silva, 2007) and others of unknown patterns of frequency (e.g. pilot whales, *Globicephala macrorhynchus*), make it an ecologically important observation point for cetaceans in the NA.

Whale-watching first approaches data back to 1989, with 'experimental' trips using hydrophones, five years after the end of an important whaling tradition. It started officially in 1992 with one of the vigias from the whaling era, and a company based in Lajes on Pico. Currently it still uses many of the old observation points from land, to find the species and direct the boats, through binoculars and VHF radio. Most WW companies in the Azores, like in other places (e.g. Monterey Bay, CA), record the daily cetacean boat sightings to promote their activity, to present and future clients.

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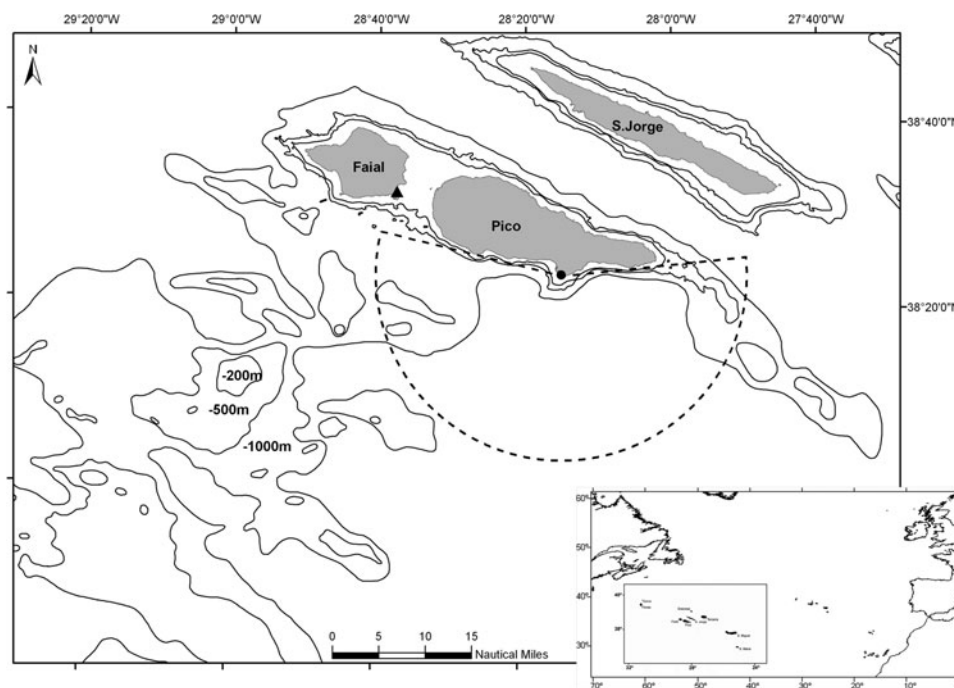


Fig. 1. Azores archipelago in the North Atlantic context (northernmost islands on the bottom right of the image), and map of the main area covered, central group of islands, south Pico (inside dashed line - - -); (●) lookout location and (▲) Horta harbour.

Some are methodical and serious, accounting for several years of records.

Daily species checklist is a record of each species sighted daily, whenever observed, in the Azorean case, by the WW company boats. These data are recorded in a yes/no format for each species, in reference to a date. Although called 'daily', in the Azores most companies include reference to which part of the day (morning/afternoon) the sighting was made. The total number of boats operating during each part of the day is sometimes also recorded. These data are marked by discontinuities, as the boats do not go out to sea every day. Whale-watching companies operating with lookouts depend primarily on favourable weather conditions for species sighting, namely cloud cover (including rain and fog), wind velocity (Beaufort scale), glare and swell height; but also on clients' presence. Both these factors can cancel a WW trip and have actually determined the seasonal dimension of most companies operating in the Azores until now, and the resulting 'environmental window' available from these data (predominantly from April to October).

Once the conditions are reasonable for the lookouts and there are clients, other important factors come into play. Species behaviour and distance from the boat/departing harbour, taking into account the sea conditions (in this case wind speed and swell height) and least often, the age of the passengers, are possible sources of bias, specially for small size cetaceans, and species travelling on small pods. The type of boats, their size, number and engine power, vary per company and can change from year to year. Also, re-sighting of the same species/groups is a common event for regionally close companies, and should be taken in account if multiple data-sets are integrated from different sources. Nevertheless operators share a common goal of seeing as many different species as possible during each WW trip, providing some coherence in the *modus operandi* and increasing the checklist interest.

The following work develops the first approach to daily species checklist data, using Azorean WW to attain basic aspects of cetacean ecology, through comparison with sea surface temperature (SST).

MATERIALS AND METHODS

Daily checklist records from 2001 to 2006 were analysed, from the first WW company to record this type of data methodically in the region, 'Espaço Talassa'. The study area corresponds to the main area covered by the lookout, with a maximum visibility of 12 miles from near Lajes do Pico, on the south coast of Pico Island, but also neighbouring areas (Figure 1). The area covered is over 698 Mn², over depths of more than 1500 m. One to four semi-rigid boats performed 3-h trips, directed by one main lookout on land, between 0900 to 1300 and 1400 to 1800, from April to October.

A general sighting frequency for the years 2001 to 2004 was calculated using each morning and afternoon that at least one boat went to sea. The species recorded were: *Hyperoodon ampullatus*, *Ziphius cavirostris*, *Mesoplodon bidens*, *M. europaeus*, *Balaenoptera musculus*, *B. physalus*, *B. borealis*, *B. acutorostrata*, *Megaptera novaeanglia*, *Delphinus delphis*, *Tursiops truncatus*, *Stenella frontalis*, *S. coerulealba*, *Grampus griseus*, *Globicephala macrorhynchus*, *Pseudorca crassidens*, *Orcinus orca*, *Physeter macrocephalus* and *Kogia breviceps*. Fifteen day average SST values, from an area between 34°65'–42°67'N and 23°73'–33°51'W were used to describe maximum and minimum temperature for each of the above mentioned species. Processed satellite data from 16 April to 12 October in 2001–2003, and from 15 April to 11 October in 2004, was used on this analysis (provided by DOP-UAÇ/IMAR and DRP/SRAPA).

The second approach performed was to assign morning and afternoon trips that at least one boat went to sea, to

Table 1. Sighting frequencies and sea surface temperature ranges (°C) based on regionally remote sensed data (15 d averages; available by DOP/UAç), for 19 cetacean species sighted by a whale-watching company and recorded on a daily checklist, South Pico Island, Azores.

Sampled period				<i>Hyperoodon ampullatus</i>				<i>Zifius cavirostris</i>				<i>Mesoplodon</i> sp. (1)				<i>Mesoplodon</i> sp. (2)				
Year	N	Time scale	Min	Max	S	%	Min	Max	S	%	Min	Max	S	%	Min	Max	S	%	Min	Max
2001	251	16 April–12 October	16.3	24.4	6	2.4	20.4	24.4*	1	0.4	24.0 ⁺	24.0 ⁺	16	6.4	18.6 ⁺	24.4	0	0	–	–
2002	238	16 April–12 October	16.0	24.6	3	1.3	21.1	23.8 ⁺	0	0.0	–	–	26	10.9	20.0	24.6*	0	0	–	–
2003	255	16 April–12 October	16.1	24.1	8	3.1	23.5	23.8	2	0.8	22.5	23.5	29	11.4	23.1	23.8	0	0	–	–
2004	223	15 April–11 October	16.5	23.5	6	2.7	23.2	23.3	0	0.0	23.3 ⁺	23.3 ⁺	21	9.4	20.0	23.2	1	0.4	23.0 ⁺	23.0 ⁺
<i>Balaenoptera musculus</i>				<i>Balaenoptera physalus</i>				<i>Balaenoptera borealis</i>				<i>Balaenoptera acutorostrata</i>				<i>Megaptera novaeanglia</i>				
Year	S	%	Min	Max	S	%	Min	Max	S	%	Min	Max	S	%	Min	Max	S	%	Min	Max
2001	8	3.2	16.3*	16.6	12	4.8	16.3*	17.8	18	7.2	17.8	22.6	1	0.4	16.3* ⁺	16.3 ⁺	5	2.0	16.6 ⁺	16.6 ⁺
2002	11	4.6	17.4	19.4	9	3.8	17.1	19.4	15	6.3	17.1	24.4 ⁺	2	0.8	19.4 ⁺	21.1 ⁺	1	0.4	17.1 ⁺	17.1 ⁺
2003	25	9.8	16.1*	23.5 ⁺	50	19.6	16.1*	24.1 ⁺	23	9.0	16.2	19.9	0	0	–	–	10	3.9	18.2	19.9
2004	10	4.5	16.5*	20.0	33	14.8	16.5*	23.3 ⁺	13	5.8	16.5*	23.3 ⁺	0	0	–	–	8	3.6	16.5*	20.0
<i>Delphinus delphis</i>				<i>Tursiops truncatus</i>				<i>Stenella frontalis</i>				<i>Stenella coerulealba</i>				<i>Grampus griseus</i>				
Year	S	%	Min	Max	S	%	Min	Max	S	%	Min	Max	S	%	Min	Max	S	%	Min	Max
2001	178	70.9	16.3*	24.4*	94	37.5	16.3*	24.4*	63	25.1	20.4	24.4*	37	14.7	16.3*	24.4*	158	62.9	16.3*	24.4*
2002	139	58.4	16.0*	24.6*	104	43.7	16.0*	24.6*	109	45.8	19.4	24.6*	42	17.6	17.1	24.6*	142	59.7	16.0*	24.6*
2003	146	57.3	16.1*	24.1*	91	35.7	16.1*	24.1*	92	36.1	19.0	24.1*	65	25.5	16.1*	24.1*	170	66.7	16.1*	24.1*
2004	102	45.7	16.5*	23.5*	77	34.5	16.5*	23.5*	91	40.8	20.3	23.5*	71	31.8	16.5*	23.5*	139	62.3	16.5*	23.5*
<i>Globicephala</i> sp.				<i>Pseudorca crassidens</i>				<i>Orcinus orca</i>				<i>Physeter macrocephalus</i>				<i>Kogia breviceps</i>				
Year	S	%	Min	Max	S	%	Min	Max	S	%	Min	Max	S	%	Min	Max	S	%	Min	Max
2001	28	11.2	16.3* ⁺	24.4*	6	2.4	16.6 ⁺	24.0 ⁺	1	0.4	16.3* ⁺	16.3 ⁺	105	41.8	16.3*	24.4*	0	0.0	–	–
2002	44	18.5	18.9	24.6*	3	1.3	21.1 ⁺	23.8 ⁺	4	1.7	20.0 ⁺	24.6*	126	52.9	16.0*	24.6*	0	0.0	–	–
2003	19	7.5	18.2	23.8	2	0.8	23.1 ⁺	23.1 ⁺	0	0.0	–	–	162	63.5	16.1*	24.1*	2	0.8	23.1 ⁺	24.1* ⁺
2004	34	15.2	17.4	23.3	1	0.4	23.3 ⁺	23.3 ⁺	0	0.0	–	–	147	65.9	16.5*	23.5*	0	0.0	–	–

N, number of mornings and afternoons that at least one boat went to sea; S, number of sightings in mornings and afternoons; %, percentage of sightings; Min and Max, minimum and maximum sea surface temperature in degrees Celsius (°C); *Mesoplodon* sp. (1) is most probably *M. bidens*, and (2) *M. europaeus*. * indicates values that coincide with the extreme average temperature registered during sample period. ⁺ indicates sightings isolated at least 15 d from others.

1°C temperature classes from 16 May to 30 September 2005 and in 2006. For this set of data, daily 30 cm depth hand measurements made inside Horta harbour, were used (Figure 1; provided by the IMAR/DOP-UAç and DRP/SRAPA). Sighting frequencies of *S. frontalis*, *S. coeruleualba*, *T. truncatus*, *G. griseus* and *D. delphis* were used for comparison. Number of boats, type and engine power remained the same in this period. A Spearman correlation coefficient (R_s ; $P < 0.05$; Siegel, 1956) was applied between sighting frequencies in the same temperature class using STATISTICA (StatSoft, Inc.), for each species between different years, and between all species in the same year.

RESULTS

The number, sighting frequency and SST ranges for 19 cetacean species, from 3167 sightings between 2001 and 2004 are presented (Table 1; $N = 967$; corresponding to morning and afternoon trips that at least one boat went to sea). The potential for misidentification of small species of *Mesoplodon* based on morphological features is considerable even for experienced observers; they are here reported as *Mesoplodon* sp. (1) for *M. bidens* and *Mesoplodon* sp. (2) for *M. europaeus*. In the case of *Globicephala* it is known that most sightings are relative to the regionally referenced *G. macrorhynchus*, however, the author is aware of unreported sightings of *G. melas* based on underwater photographs, urging some caution on data interpretation. The Kogiidae were excluded from similar treatment since the author was onboard during both sightings.

Species with sighting frequencies below 1% were *Kogia breviceps*, *Balaenoptera acutorostrata*, *Orcinus orca* and *Ziphius cavirostris*. *Pseudorca crassidens*, all beaked and baleen whales were nearly below 10%. The exception was *B. physalus*, which together with *Globicephala* sp. and other delphinids stayed below 50% of sighting frequency. The species most observed during this period were *Delphinus delphis*, *Grampus griseus* and *Physeter macrocephalus*.

Sea surface average temperatures ranged between 16.0 and 24.6°C (Table 1), reflecting the end of the cold season and almost the entire warm season, that peaks in August with the highest values, and lasts until November (when the 18°C isotherm starts retrieving southward from north of the Archipelago; see Bashmachnikov *et al.*, 2004).

Ziphiidae sightings occurred always above 20.0°C, mostly between July and September, except for one isolated sighting of *Mesoplodon* sp. (1) in 18.6°C. Baleen whales were generally sighted from April to June–July. The *B. musculus*, *B. physalus* and *Megaptera novaeanglia* were not sighted frequently with average SST values above 20.0°C, while *B. borealis* sightings extended into higher SST values. *Balaenoptera acutorostrata* were only sighted rarely and, with all baleen whales except them, occurrences were registered in warmer waters, later in the season in 2003 and 2004. The Bryde's whale (*B. edeni*) although not present in these records, was sighted by the company for the first time in July 2004 (Steiner *et al.*, 2007).

Delphinus delphis, *Tursiops truncatus*, *Stenella coeruleualba* and *G. griseus* were sighted in general from April to October in the four years, occurring in the whole range of temperatures covered. *Stenella frontalis* were only sighted with average surface temperatures equal or above 18.95°C, usually appearing in mid-June, and present until the end of the sampling

period. The other Delphinidae members include *Globicephala* sp. which were most sighted with temperatures above 17.4°C, appearing in early warm season. False killer whales (*Pseudorca crassidens*) were only sighted infrequently and temperatures were usually above 21.0°C. *Orcinus orca* specimens were sighted in high regional surface temperature values in 2003, and only once in 2002 but in temperatures between 16–17°C. The Physeteridae family members were observed during the entire period sampled, while on the other hand pigmy sperm-whales (*Kogia breviceps*) were sighted only in high SST values.

Within and between year Spearman correlation coefficients using sighting frequencies from temperature classes are given (Tables 2 & 3). Results reveal positive correlations between 2005 and 2006 for *S. coeruleualba* (R_s 0.89; $P = 0.02$) and marginally significant for *S. frontalis* (R_s 0.77; $P = 0.07$; Table 2). No significant correlations were found for the rest of the within species analysis between years. Inter-specific comparisons in the same year, revealed inverse correlation between sightings of *S. frontalis* and *D. delphis* (R_s -0.83; $P = 0.04$), as well as with *S. coeruleualba* (R_s -0.83; $P = 0.04$) in 2006. The last two species also revealed a positive correlation of sighting frequencies in temperature values, in both years (R_s 0.77; $P = 0.07$: identical values), which was nearly significant. A similar positive correlation between *T. truncatus* and *G. griseus* in 2006 was also found (R_s 0.77; $P = 0.07$).

DISCUSSION

The daily checklist registries from 2001 to 2004 included at least 20 of the 27 cetacean species sighted so far in the archipelago. Species not present have been observed only once, have not been sighted for more than 30 years or have been only positively identified from strandings or photographs (Chaves, 1924; Clarke, 1981; Reiner, 1981, 1986; Reiner *et al.*, 1993; Gonçalves *et al.*, 1996; Steiner, 1995; Simas *et al.*, 1999; Barreiros *et al.*, 2006; Steiner *et al.*, 2007; plus *G. melas* and two beaked whales, Rui Prieto, personal communication).

The time scale was long enough to reveal six month multi-year occurrence for some species, and sighting frequency patterns for others, even though seasonally limited. Application to a wider regional data should be pursued in further works. As previously mentioned, there is not a pure systematic method of collecting these data, which might be behind possible failures in future validation for some species. Nevertheless sightings indicate the presence of species during this period, mainly for large cetaceans. One example is the species with sighting frequencies below 1%, which can be considered as rare to sight. In the case of *Balaenoptera acutorostrata* and *Orcinus orca* it is obvious that they were actually less frequent

Table 2. Comparison of sighting frequencies on 1°C temperature classes (16 May to 30 September; range 17–23°C), between 2005 and 2006, for five cetacean species (Spearman R_s , $P < 0.05$).

Sfo		Sco		Dde		Ttr		Ggr	
R_s	P	R_s	P	R_s	P	R_s	P	R_s	P
0.77	0.072	0.89	0.02	0.66	0.156	-0.37	0.47	-0.26	0.62

Sfo, *Stenella frontalis*; Sco, *Stenella coeruleualba*; Dde, *Delphinus delphis*; Ttr, *Tursiops truncatus*; Ggr, *Grampus griseus*; R_s , Spearman correlation coefficient; P , P -value.

Table 3. Comparison of sighting frequencies on 1 °C temperature classes (16 May to 30 September; range 17–23 °C), between five cetacean species within 2005 (upper right values), and 2006 (lower left) (Spearman R_s , $P < 0.05$).

2006 N(s)		Sfo		Sco		Dde		Ttr		Ggr		N(s) 2005	
		R_s	P	R_s	P	R_s	P	R_s	P	R_s	P		
Sfo	47			-0.66	0.156	-0.60	0.208	-0.60	0.21	-0.03	0.96	63	Sfo
Sco	43	-0.83	0.042			0.77	0.07	0.09	0.87	-0.14	0.79	36	Sco
Dde	48	-0.83	0.042	0.77	0.07			0.03	0.96	-0.60	0.21	55	Dde
TTr	55	0.14	0.79	0.09	0.70	0.14	0.79			0.60	0.21	71	TTr
Ggr	78	-0.09	0.87	0.09	0.87	0.14	0.79	0.77	0.07			108	Ggr
N	120	R_s	P	R_s	P	R_s	P	R_s	P			136	N
		Sfo		Sco		Dde		Ttr					

N(s), sightings per species; Sfo, *Stenella frontalis*; Sco, *Stenella coeruleualba*; Dde, *Delphinus delphis*; Ttr, *Tursiops truncatus*; Ggr, *Grampus griseus*; N, total of mornings or afternoons with available temperature data; R_s , Spearman correlation coefficient; P , P -value.

due to their size and sighting interest. In the case of *Kogia breviceps* and most beaked whales the method might be shadowing the real presence of these species that mix smaller sizes and evasiveness. *Hyperoodon ampullatus*, *Pseudorca crassidens* and baleen whales, were not frequently sighted (generally below 10%). *Mesoplodons*, *Balaenoptera physalus* together with *Globicephala* sp. were sighted more often (mainly below 15%). Excluding the scarcely sighted species data indicates that Balaenopterids, pilot whales, false killer whales, orcas and *Hyperoodon ampullatus* were not present during the whole season from 2001 to 2004, having a transient profile in the area during the sampled period.

The smaller delphinids (*Stenella frontalis*, *S. coeruleualba*, *Delphinus delphis*, *Grampus griseus*, *Tursiops truncatus*) and *Physeter macrocephalus*, were registered during six months (in all temperature ranges), on four consecutive years in the study area. Some authors have been reporting these species seasonally (e.g. Matthews *et al.*, 2001; Silva *et al.*, 2003; Pereira, 2006), and *G. griseus* have been sighted year-round in this area from 1992 to 2005 (João Gonçalves, personal communication). Photo-identification of *P. macrocephalus* indicates a year-round presence of the species, but only time-limited patterns of individual occurrence have been reported (Magalhães *et al.*, 2005). Only for *Tursiops truncatus* individual year-round residency has been proved (Silva, 2007).

Stenella frontalis are an exception in this group, which might be considered as a seasonal-resident population. The arrival of this species in large numbers in the early warm season to the northernmost distribution known, for the north-east Atlantic, also showed an inverse sighting frequency correlation with *D. delphis* and *S. coeruleualba*. These were sighted during the whole period in all years, suggesting some sort of niche partitioning which is already under investigation with *D. delphis* (Querouil *et al.*, in press), and should be extended to *S. coeruleualba*.

The reference of the company's first sighting of *Balaenoptera edeni*, was actually among the sources of data for the first article mentioning the species in the Azores (Steiner *et al.*, 2007). It is a clear indication of how important data becomes with any additional information, reiterating the urgent need to motivate biologists and skippers working on/with WW to publish their observations. In general, the simplicity of data was overcome by the diversity of sighted species and the dimension of the time scale. Data should keep being recorded and combined in the future with other areas as

well as with higher SST definition, for increased robustness. Daily species checklist from WW is a low cost important source of information on cetaceans, which combined with other data-sets, can be a potential tool for assessment of long term changes.

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Deep-Sea Research I

journal homepage: www.elsevier.com/locate/dsriDiet of mid-Atlantic Sowerby's beaked whales *Mesoplodon bidens*J.N. Pereira^{a,*}, V.C. Neves^a, R. Prieto^a, M.A. Silva^{a,c}, I. Cascão^a, C. Oliveira^a, M.J. Cruz^a, J.V. Medeiros^a, J.P. Barreiros^d, F.M. Porteiro^a, D. Clarke^b^a Departamento de Oceanografia e Pescas, Centro do IMAR da Universidade dos Açores, Rua Frederico Machado no. 4, 9901-862 Horta, Faial, Açores, Portugal^b Rua do Porto 18, 9930-430 São João, Pico, Açores, Portugal^c Biology Department, MS#33, Woods Hole Oceanographic Institution, Woods Hole MA02543, USA^d Departamento de Ciências Agrárias, Universidade dos Açores and Azores Biodiversity Group, CITA-A, PT-9700-042 Angra do Heroísmo, Portugal

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ABSTRACT

The first mid-Atlantic diet of *Mesoplodon* beaked whales is presented, from ten Sowerby's *Mesoplodon bidens* stranded in the Azores region between 2002 and 2009. This doubles the worldwide number of stomachs sampled, and reveals new feeding habits for this species. The mean number of prey items per stomach was 85 ± 89 (range: 12–238), with fish accounting for 99.3% and cephalopods contributing less than 1% of total prey. Fish otoliths from 15 families and cephalopod lower mandibles from three families were identified, representing 22 taxa. The diet consisted mainly of small mid-water fish, the most numerous being *Diaphus* sp., *Lampanyctus* sp. and Melamphidae species. Myctophids were present in all stranded individuals, followed by Diretmidae, Melamphidae and *Opisthoproctus soleatus*, while the remaining fish species were scarce or single occurrences. Consistency of diet in four different years reveals a divergence from all previous records in continental areas, where mainly neritic and shelf-break benthopelagic fish species have been reported. Mid-Atlantic Sowerby's beaked whales' showed dietary plasticity, feeding on the most abundant mid-water groups occurring between 0 and 750 m. Trophic level from prey numerical frequency was estimated at 4.4 ± 0.46 .

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1. Introduction

The unveiling of beaked whales' trophic role is still in its early days, mostly due to the scarcity of available data leading to few studies published on the diet of this group. Knowledge grows at the pace of stranding events and the lack of published material is particularly evident for *Mesoplodon* species, for which very low numbers of prey individuals are often found per stomach (e.g. Mead et al., 1982). Fish and cephalopods are the main diet components of the 14 species of *Mesoplodon* (MacLeod et al., 2003), with some species relying primarily on cephalopods (e.g. *M. carlhubsi* and *M. layardii*) and others on bony fishes (e.g. *M. mirus* and *M. bidens*).

The Sowerby's beaked whale *Mesoplodon bidens* (Sowerby, 1804) is exclusive to the North Atlantic and is the northernmost *Mesoplodon* in this ocean. Distribution extends from Massachusetts (USA) to Labrador (Canada) in the west, from Iceland and Norway in the north, along the European coasts down to Madeira Islands and along the Mid-Atlantic ridge to the Azores (MacLeod, 2000). The species appears to be common in some parts of its range, with higher stranding reports from the British coasts and neighboring

countries (Klinowska, 1991), but there is no information on its global or regional abundance. Present knowledge on the feeding habits of Sowerby's beaked whales is limited to thirteen stomachs from stranded and by-catch individuals from North America and European coasts, revealing a primarily piscivorous whale with preference for benthopelagic species (Dix et al., 1986; Santos et al., 1994, 1995; Gannon et al., 1998; Spitz et al., 2011).

The Azores archipelago and its surrounding seamounts rise east of the Mid-Atlantic Ridge, approximately at 36–39°N and 25–29°W, representing a residence or passage point for more than 25 cetacean species (Prieto and Silva, 2010). The steep topography of the region provides deep-water and slope habitats where most *Mesoplodon* species are commonly observed in continental areas, over the slope and beyond (e.g. Waring et al., 2001; MacLeod et al., 2004). *Mesoplodon* beaked whales frequent the mid-Atlantic ridge (Mar-Eco, 2004; Doksæter et al., 2008) and are common during summer in the Azores (Reiner, 1986; Leal, 2003; ICES, 2010 unpublished data), but little is known about their distribution and habitat preferences as elsewhere. There are scattered reports of Sowerby's beaked whales over slopes (Waring et al., 2001), canyons (Hooker and Baird, 1999) and deep oceanic waters (MacLeod et al., 2007).

This study provides the first insight on Sowerby's beaked whales' diet in the mid-Atlantic, based on ten specimens stranded

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in the month of July of 2002, 2004, 2005 and 2009. Dietary samples are compared between different years and with available information from other areas of its distribution. Prey choice and foraging strategy of Sowerby's beaked whales in the Azores is interpreted in light of the main preys' local abundance and habitat and current knowledge on the species.

2. Materials and methods

2.1. Sample collection

Researchers involved in the Azorean Stranding Network (RACA) carried out the necropsies and collected whole stomachs from ten Sowerby's beaked whales stranded between 2002 and

2009 (Table 1). All strandings occurred in the month of July in the central group of islands, four of which, of two and three individuals considered here as mass strandings (2002, 2005, 2009 Terceira and 2009 Faial; Table 1, Fig. 1). Stomachs were frozen and contents were subsequently sorted in the laboratory and preserved for later identification.

2.2. Prey identification

Full stomach samples were examined and sorted under a binocular microscope: otoliths were dry kept; all the other remains were stored in 70% ethanol. Fish otoliths and cephalopod lower beaks were identified using available keys for fish (Schmidt, 1968; Hecht and Hecht, 1981; Nolf, 1985; Smale et al., 1995;

Table 1

General information on stranded beaked whales in the Azores islands, between 2002 and 2009, with collection of stomach contents reported in this study; ^f indicates individuals found floating and towed to shore.

Code	Sex	Total length (cm)	Maturity ^a	Stranding			Stomach contents	
				Date	Location	Condition ^b	Fish otoliths	Cephalopod beaks
Mbi 02I	Female	432	M	27 July 2002	Pico ^f	3	Yes	No
Mbi 02II	Male	> 340 ^c	–	29 July 2002	Pico	4	Yes	Yes
Mbi 04I	Female	413	M	19 July 2004	Pico	1	Yes	Yes
Mbi 05IA	Male	409	M	21 July 2005	Terceira	3	Yes	No
Mbi 05IB	Male	435	M	22 July 2005	Terceira	3	Yes	No
Mbi 09IA	Female	388	I	28 July 2009	Terceira	1	Yes	No
Mbi 09IB	Male	361	I	29 July 2009	Terceira	1	Yes	No
Mbi 09IIA	Female	410	M	30 July 2009	Faial	1	Yes	Yes
Mbi 09IIB	Female	414	M	30 July 2009	Faial	1	Yes	Yes
Mbi 09IIC	Female	384	I	31 July 2009	Faial	1	Yes	No

^a Maturity established through external observation of the gonads: M—Mature; I—Immature.

^b Condition: 1—Alive; 2—Freshly dead; 3—Moderately decomposed; 4—Decomposed.

^c Minimum length. Total length could not be measured because the individual had a fractured beak.

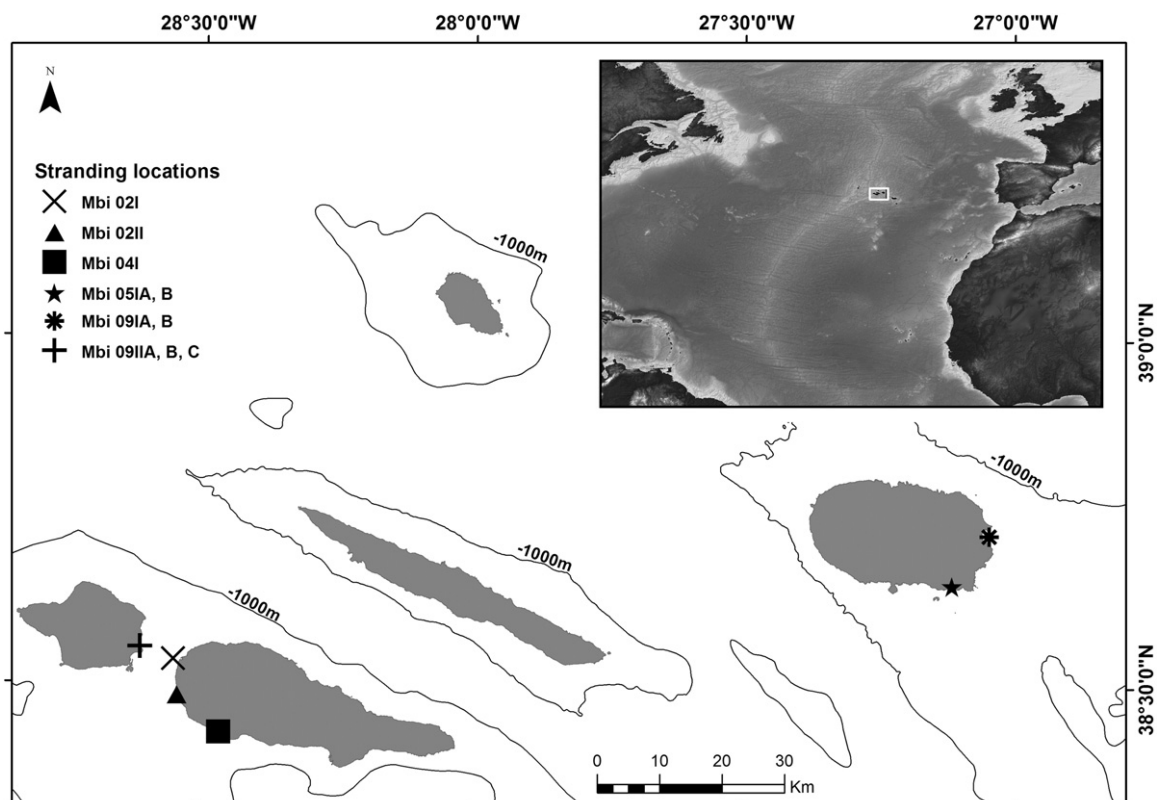


Fig. 1. Map of the Azores archipelago, with indication of stranding locations.

Tuset et al., 2008) and for squid beaks (Clarke, 1986), and reference collections of otoliths at the University of the Azores and Malcolm Clarke's personal cephalopod beak collection. Minimum number of individual prey was estimated from remains, as total upper/lower cephalopod beaks and right/left fish otoliths.

2.3. Data analysis

The importance of individual prey species is shown through their frequency in number (individual numbers of each prey). Frequency of occurrence was calculated for most frequent items only (percentage of samples containing each prey type). Diet overlap was assessed using Schoener (1968) overlap index. Pair wise comparisons were made between different years (with yearly samples clustered together) and between different samples individually. Sample size prevented investigation of dietary differences associated with sex, maturity class and season. The ecology of main prey is used to infer the predators' foraging strategies in the region.

Sowerby's trophic level (TL) was estimated as follows:

$$TL = 1 + \sum_{i=1}^G DC_i TL_i$$

where DC_i represents the numerical frequency of prey (i), TL_i the trophic level of prey (i), and G the total number of prey. Trophic level of prey species was extracted from Cherel et al. (2009) and Froese and Pauly (2010). For items identified to genus, the regionally most abundant species were used based on the work of Sutton et al. (2008); for items identified to family, the trophic level from other species found in this study within the taxon were used.

3. Results

Information on the stranding events and specimens is summarized in Table 1. The mean number of prey items per stomach was 85 ± 89.1 (range: 12–238), with fish occurring in 100% of the stomachs and cephalopods in 30%. Fish numerical frequency was 99.3% ($N=885$) (Table 2) and cephalopods comprised less than one percent of the total number of prey items ($N=8$) (Table 2). Fish otoliths from 15 families and cephalopod lower beaks from three families were identified, representing 22 taxa in total. Fish otoliths ranged from 22 to 235 otoliths (corresponding to 12–214 fish) per whale stomach. Cephalopods reached a maximum numerical frequency of 6.5% in a single individual (Mbi 09IIB). The high degree of erosion of the mandibles in this case suggests a long period of time since ingestion.

Fish eye lenses were present in most of the samples from 2009, namely Mbi 09IB (15), Mbi 09IIA (200–300), Mbi 09IIB (3) and Mbi 09IIC (73). Two eroded fish vertebrae and one scale were collected from Mbi 09IB. Cephalopod eye lenses were present in Mbi 09IIA (1) and Mbi 09IIB (1). Only one out of the four cephalopod beaks was considered fresh (*Taonius pavo*, Mbi 09IIA; Piatkowsky and Putz, 1994). No other soft tissue remains were collected and there was no record of artificial elements such as plastic or any other debris. All samples are stored and available at the Department of Oceanography and Fisheries, University of the Azores.

Table 3 summarizes information on prey indexes and ecology, including frequency of occurrence for prey with high numerical frequency. Myctophids were the most represented family, always above 30% in number, reaching 100% in stomachs with few contents. These occurred in all stranded individuals, followed by families Diretmidae and Opisthoproctidae, while the remaining fish families were represented by scarce or single occurrences. Demersal (benthopelagic) species such as *Galeichtyes* sp.?, *Guttigadus latifrons*, *Gadaculus argenteus* or *Epigonus telescopus*

were rare ($\leq 1\%N$; Table 2). Main prey maximum sizes are below 15 cm (Froese and Pauly, 2010), and average prey size found in this study should be lower (*D. argenteus* common size around 9 cm). One exception is *Galeichthys* sp. (probably *feliceps*), which is normally around 35 cm (Froese and Pauly, 2010).

Schoener (1968) overlap index indicated significant overlap in the diet of whales stranded in different years, with the lowest values occurring when we compare the years 2005 and 2009, possibly due to the small sample sizes (small number of contents in 2005). Individual stomach comparisons revealed significant overlap for all samples, except for the 2005 samples. Trophic level compensated for all prey items was estimated at 4.4 ± 0.46 , a value common to most of the myctophid prey.

4. Discussion

All prey species and genera identified in this study are known to occur in the Azores (Santos et al., 1997), except the demersal *Merluccius* sp. and *Galeichthys* sp. The occurrence of *Merluccius* sp., probably *M. merluccius* (Linnaeus, 1758) in the region, is known from only one unpublished recent record. The species is distributed along the European coast down to Mauritania, with records extending to the Meteor seamount, south of the stranding area (Froese and Pauly, 2010). *Galeichthys* sp. is a more unexpected record. There are only four recognized species for this genus and only two occur in the Atlantic, more specifically on the coastal waters of SW Africa. So far, there are no valid records for this genus on the central or northeast Atlantic (Froese and Pauly, 2010). The record of Lampe (1914) of this species in the Azores waters was considered not valid by Santos et al. (1997), suggesting a possible "mislabelling of the specimens or jars".

It has been argued that stomach contents of stranded animals may not be truly representative of the feeding habits of healthy animals, revealing unusually high percentages of empty stomachs and differences in prey composition and relative abundance (Clarke, 1986; Selzer et al., 1986). None of the stomachs examined in this study were empty and our results indicate recent feeding activity in two cases. Most samples also come from mass stranding events, which reflect feeding habits more reliably than other strandings (Santos et al., 2007). Finally, the consistency of stomach contents over an 8-year period indicates this study reflects Sowerby's beaked whales' summer diet in the Azores and possibly a previous region of provenance.

The seasonal coincidence of the five stranding events, four of which are mass stranding events, gives little evidence on natural death. The pathological study of some of these strandings was still underway at the time of writing of this work and none of the possible agents could be ruled out (e.g. bio-toxins, seasonal diseases, acoustic traumas).

4.1. Diet composition

A restricted group of meso and bathypelagic fish formed the bulk of Sowerby's diet in the Azores from 2002 to 2009. The myctophids *Diaphus* sp., *Lampanyctus* sp., together with *Opisthoproctus soleatus*, *Diretmus argenteus* and *Melamphidae* spp. (10 spp. are known in the Azores; Santos et al., 1997) are present in all years sampled (except for the small samples from 2005), representing 62% of all contents by number, with a frequency of occurrence averaging approximately 70% in all samples.

The relatively wide range of sizes among most of the prey species in this study (3–15 cm) makes it difficult to analyze the emphasis given by numerical frequencies to small prey in the diet (Table 3). In this sense, the numerical contribution of the two largest species should be noted, namely *D. argenteus* and

Table 2

Numerical frequency (%N) of the fish and cephalopod identified in the stomachs of Sowerby's beaked whales (*Mesoplodon bidens*) stranded in the Azores islands from 2002 to 2009; N indicates minimum number of individual prey estimated from otoliths and lower beaks; family taxa organized by decreasing %N and cephalopods grouped together.

Prey list of lower taxa	Mbi 02I		Mbi 02II		Mbi 04I		Mbi 05IA		Mbi 05IB		Mbi 09IA		Mbi 09IB		Mbi 09IIA		Mbi 09IIB		Mbi 09IIC		Totals		
	27.07.2002		29.07.2002		19.07.2004		21.07.2005		22.07.2005		28.07.2009		29.07.2009		30.07.2009		30.07.2009		31.07.2009				
	N	%N	N	%N	N	%N	N	%N	N	%N	N	%N	N	%N	N	%N	N	%N	N	%N	N	%N	
Myctophidae																							
<i>Myctophidae</i> spp.			27	15.25											18	8.41	2	6.25	1	1.18	48	5.38	
<i>Diaphus</i> sp.	8	14.04	15	8.47	25	10.50	13	100.00	11	91.67	36	73.47	10	66.67	36	16.82	13	40.63	10	11.76	177	19.82	
<i>Electrona risso</i>					3	1.26					3	6.12	3	20.00	12	5.61					21	2.35	
<i>Lampanyctus</i> sp.	20	35.09	32	18.08	47	19.75					1	2.04							30	35.29	130	14.56	
<i>Bolinichthys</i> sp.?											2	4.08	1	6.67	58	27.10					61	6.83	
Diretmidae																							
<i>Diretmus argenteus</i>	3	5.26	14	7.91	21	8.82					3	6.12			3	1.40	1	3.13	1	1.18	46	5.15	
Melamphidae																							
<i>Melamphidae</i> spp.	8	14.04	27	15.25	56	23.53									13	6.07	4	12.50	10	11.76	118	13.21	
<i>Poromitra capito</i>											2	4.08									2	0.22	
<i>Melamphaes typhlops?</i>											1	2.04									1	0.11	
Opisthoproctidae																							
<i>O. soleatus</i>	1	1.75	15	8.47	8	3.36									44	20.56	6	18.75	14	16.47	88	9.85	
Ariidae																							
<i>Galeichthys</i> sp.?			3	1.69	6	2.52															9	1.01	
Microstomatidae																							
<i>Nansenia</i> sp. ?															2	0.93			6	7.06	8	0.90	
Scopelarchidae																							
<i>Scopelarchus</i> sp.	3	5.26																			3	0.34	
Gadidae																							
<i>Gadiculus argenteus</i>					1	0.42													1	1.18	2	0.22	
Melanonidae																							
<i>Melanonus zugmayeri</i>					2	0.84															2	0.22	
Epigonidae																							
<i>Epigonus telescopus</i>																				1	1.18	1	0.11
Gonostomatidae																							
<i>Gonostoma denudatum</i>																				1	1.18	1	0.11
Moridae																							
<i>Guttigadus latifrons</i>					1	0.42															1	0.11	
Macrouridae																							
<i>Odontomacrus murrayi</i>															1	0.47					1	0.11	
Merlucciidae																							
<i>Merluccius</i> sp.					1	0.42															1	0.11	
Paralepididae																							
<i>Paralepis</i> sp.					1	0.42															1	0.11	
Cranchiidae																							
<i>Taonius pavo</i>															1	0.47					1	0.11	
Cycloteuthidae																							
<i>Discoteuthis laciniosa</i>			1	0.56																	1	0.11	
Histioteuthidae																							
<i>H. meleagroteuthis</i>															1	0.47	1	3.13			2	0.22	
Unidentified ceph			1	0.56	2	0.84											2	6.25			5	0.56	
Unidentified fish	14	24.56	43	24.29	64	26.89			1	8.33	1	2.04	1	6.67	25	11.68	3	9.38	10	11.76	162	18.84	
Total	57	-	177	-	238	-	13	-	12	-	49	-	15	-	214	-	31	-	85	-	893	100	

Galeichthys sp., which average 27 cm and 55 cm, respectively. Prey size or weight estimations based on mesopelagic fish otoliths were not possible, due to the lack of biometric regression equations. This information seems absent from current literature, and it is of major relevance as it assists further analysis of these results, such as for biomass estimates. Nevertheless, prey preference studies based on numerical occurrence is a useful approach when combined with *in situ* abundances as developed below (e.g. Hansson, 1998).

4.2. Feeding activity and prey ecology

The meso and bathypelagic fish communities just north of the stranding area were described during one of the stranding periods (27 June to 01 July 2004; 42.81–41.24°N; Sutton et al., 2008). A large vertical migrating mesopelagic fish assemblage occupies the upper 0–750 m, termed the “Lanternfish group”. Characterized by

high diversity and low abundance, compared with the more productive areas to the north of the Mid-Atlantic Ridge, it is dominated by the Myctophidae family (29 spp., 50.8%N, 26.9% in biomass; Sutton et al., 2008).

Myctophids represent 49% by number of the Sowerby's beaked whale diet in this study. The most important prey, *Diaphus* sp. and *Lampanyctus* sp., are amongst the most abundant species in the Azores region, ranking in the top 10 at these depths (Sutton et al., 2008). It seems relevant to note they account for 34% in our study while reaching only 5.6% in net surveys. This could indicate possible prey or habitat preference, once *Diaphus* spp. may be preferentially associated to bottom structures (F.M. Porteiro personal communication).

Between 750 and 1500 m there is a decrease in abundance and increase in biomass, with two discrete deep-meso/upper-bathypelagic assemblages, both co-dominated by *Cyclothone microdon*: one with three large melamphaid species and the second

Table 3
Most frequent prey items with indication of frequency in number (%N), frequency of occurrence (%O), number of possible species (spp.), Adult Max Lengths of all possible species in the region (AML, cm; source: www.fishbase.org) and vertical migration (M) and non-migration (NM).

Family	Lower taxon	N	%N	%O	2002	2004	2005	2009	spp.	AML	Migrate
Myctophidae	<i>Diaphus</i> sp.	177	19.8	100	x	x	x	x	7	6–15	M
Myctophidae	<i>Lampanyctus</i> sp.	130	14.6	50	x	x		x	2	8.5–13.8	M
Melamphaidae	Melamphaidae spp.	118	13.2	60	x	x		x	10	2.9–13.1	M and NM
Opisthopterae	<i>O. soleatus</i>	88	9.9	60	x	x		x	1	10.5	NM
Myctophidae	<i>Bolinichthys</i> sp.?	61	6.8	30				x	4	4.5–15.3	M
Myctophidae	Myctophidae spp.	48	5.4	40				x	25	2.9–14.3	M
Dirtemidae	<i>Dirtemus argenteus</i>	46	5.2	70	x	x		x	1	27.6	NM
Myctophidae	<i>Electrona risso</i>	21	2.4	40		x		x	1	8.2	M
Ariidae	<i>Galeichthys</i> sp.?	9	1.0	20	x	x			1	55	NM
–	Cephalopods (all)	9	1.0	40	x	x		x	3 ^b	–	M and NM
–	Fish spp. (< 1%N) ^a	24	2.7	–	x	x		x	–	–	–
–	Non identified fish	162	18.1	90	x	x	x	x	–	–	–
Total		893	100%								

^a Includes 12 different species.

^b Three unidentified items not included.

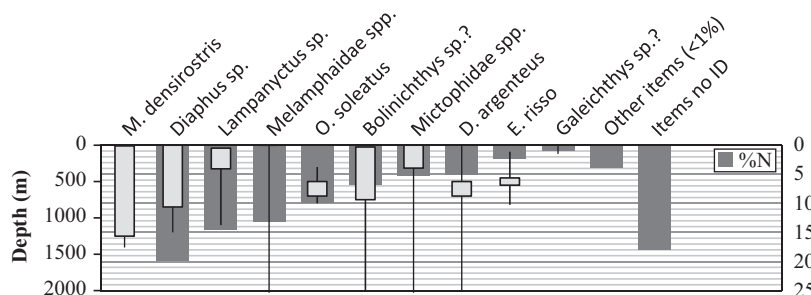


Fig. 2. Frequency in number (%N) of main prey, predator foraging depths (from *M. densirostris* off Canary Islands, Tyack et al., 2009; max depth given by Baird et al., 2008) and night-time distribution for vertical migrating prey: main depths for *O. soleatus* and *D. argenteus* (non migrators); Myctophidae (25 spp.) average values for night-time maximum depths are given; Melamphaidae (10 spp.) wide distribution depths not represented (source: Fishbase (Froese and Pauly, 2010)).

with the myctophid *Benthosema glaciale* (Sutton et al., 2008). Considering the numerical importance of the Melamphaidae species in our study, Sowerby's beaked whale foraging depths likely extends beyond 750 m, where this group of species becomes more abundant, though these could be also benefiting from night-time vertical ascension not contemplated on Sutton et al. (2008). According to Sutton et al. (2008) *D. argenteus* and one melamphaid (*S. mizolepis*) have important biomass contributions both in the upper and lower community, whereas the absence of *C. microdon* in any of our samples may indicate prey selectivity.

Main prey in the mid-Atlantic Azores region migrate to shallower depths at night aggregating in horizontal layers, becoming shallower than the maximum foraging depths (Baird et al., 2008; Tyack et al., 2009; Fig. 2). Diel patterns of vertical movements have been reported for several odontocetes, reflecting shifts in prey vertical availability (Benoit-Bird and Au, 2003) or predator avoidance (Baird et al., 2008). Recent studies on *Mesoplodon densirostris* off Hawaii revealed similar diving rates during day and night, leading Baird et al. (2008) to postulate that either prey do not exhibit diel vertical migrations, or that the whales switch prey species at night. Considering the importance of mesopelagic prey for *M. bidens* in this study, shallower foraging depths should occur during night-time.

4.3. Sowerby's beaked whale diet

Sowerby's beaked whales in the Azores are primarily fish eaters, as in other regions of its range (MacLeod et al., 2003; Spitz et al., 2011). Diet in the Azores contrasts to the mostly benthopelagic prey records from the few studies conducted

elsewhere. Dix et al. (1986) reported a single Gadidae spp. from a stranded male in Newfoundland, on one of the first western Atlantic records. From Scotland, Santos et al. (1994, 1995) (see also MacLeod et al., 2003) reported 3 specimens, totaling 17 items, with *Merluccidae* spp. (52.9%) and *Gadidae* spp. (41.3%) being the most frequent prey. Gannon et al. (1998) reported on six freshly killed Sowerby's in the NE Atlantic, but 4106 food items were referred only as bottom-dwelling deep-water fish (deeper than 400 m) between 10 and 20 cm length. From the Bay of Biscay Siptz et al. (2011) reported three Sowerby's containing four *Gadidae* species (51.6%N), one *M. merluccius* and one Myctophidae, together with *Sepia* sp. and several swimming crab *Polybius* spp. (33%M).

According to these reports, Sowerby's near continental areas forage for neritic benthopelagic prey, probably in the lower shelf and shelf-break where these prey commonly occur (e.g., Mahon and Smith, 1989; Cartes et al., 2009). In the Azores, Sowerby's are feeding mostly on mid-water numerically abundant prey. Their advection through lateral currents and vertical entrapment over seamounts and island slopes are a long considered phenomena (Isaacs and Schwartzlose, 1965; Koslow, 1997), and foraging does occur near the bottom where these prey might also become available (Porteiro and Sutton, 2007). Many bottom dwelling fish reported as prey in other areas, such as *Merluccidae* spp. (Gannon et al., 1998) and *Gadidae* spp. (e.g. Spitz et al., 2011), achieve larger sizes than the main prey here reported, except for some of the scarce demersal and benthopelagics from this study. Sowerby's depredation on longline fishing gear has been recently suggested (Spitz et al., 2011), and although an artisanal bottom longline fishery extracts about 6000 tons per year of demersal fish species in this area (INE, 2009), mostly between 200 and 600 m

depth (Morato et al., 2001), no prey with commercial value was found in our study, and there are no records of interactions of these whales with the Azorean bottom fisheries. The geomorphology of this insular and mid-Atlantic region and/or the actual scarcity of gadids and merluccids should provide explanatory variables for the regional differences in the feeding ecology. The regional prevalence of mid-water prey reveals dietary plasticity, which has been proposed by MacLeod et al. (2003) for all beaked whales, and is here revealed for Sowerby's beaked whales for the first time. Population level responses are expected when predators become subject to geographic variations in prey resources (e.g. Rutz and Bijlsma, 2006), and this should be taken into consideration in future population assessments.

There is as few data on Sowerby's diet as in its trophic level (TL). Early estimates by Ostrom et al. (1993) pointed to a TL of 3.7 based on stable isotope ratios (data corrected considering herbivores TL=2 following Pauly and Christensen, 1995). Pauly et al. (1998) calculated a 4.3 level for *M. bidens*, weighting grouped prey items from scarce existing records. Even though cephalopods were estimated to contribute 50%, which is not supported by any record to our knowledge, their values were very close to our estimate. The trophic level of 4.4 in this study reflects the predominance of myctophids and melamphids and higher values are expected for other regions where larger species are being taken.

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Technical contribution

Weight–length relationships for 27 demersal fish species caught off the Cape Verde archipelago (eastern North Atlantic)

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Summary

Weight–length relationships were estimated for 27 demersal fish species of the Cape Verde archipelago. Samples were collected in October and November 2000 using longline gear in the depths up to 600 m, and occasionally to 1200 m. The b values were within expected ranges, varying between 2.406 and 3.761, except for *Syacium micrurum* (1.574) and *Paraconger notialis* (4.476), which presented strong allometries instigated through further analysis. This work revises previous literature in the archipelago and provides the first reference on weight–length parameters for 10 fish species worldwide and for 21 species of the Cape Verde archipelago.

Introduction

Fishery scientists have been analyzing weight–length relationships (WLR) since the 1920s through extensions of the ‘cube-law’ (Järvi, 1920; Tyurin, 1927; Keys, 1928). WLRs have several applications, namely in fish biology, physiology, ecology and fisheries assessment. WLRs can be useful for the estimation of weight-at-age and can provide morphological and life history comparisons between different fish species or between different fish populations from different habitats (e.g. Petrakis and Stergiou, 1995; Gonçalves et al., 1997; Morato et al., 2001; Rosa et al., 2006).

Many expeditions to the Cape Verde archipelago from the mid-twentieth century, especially in the final quarter, included demersal fish species in their surveys (Reiner, 1996 in review). During this period, cooperative studies from the Cape Verdean INDP (National Institute for Fisheries Development) with the Icelandic International Development Agency (ICEIDA) and the Marine Research Institute in Reykjavik produced the vast majority of current knowledge on demersal fish species in the region. Bottom trawl surveys in 1984 and 1985 provided abundance estimates, distribution, maturity and weight–length data for 53 demersal species (Magnússon and Magnússon, 1984, 1985, 1987a,b). Pálsson (1989) reported WL parameters for 13 species, together with stock size and length distributions from 1988 bottom-trawl surveys. Later, Thorteinsson et al. (1995) reported rough estimates on biomass, sustainable yield and total allowable catches of commercial species, stressing the need for further knowledge on biological parameters of these species.

From 1995 to 1997, further joint handline surveys by INDP and ICEIDA reported weight–length relationships for several fish species (Oddsson et al., 1996; Oddsson and Monteiro, 1997,

1998a), and allowed the construction of the first assessment models on small-scale demersal resources in the region (Oddsson and Monteiro, 1998b). Oddsson and Monteiro (1998a) took the opportunity to compare all WL parameters with those of the Magnússon and Magnússon (1987b) study.

The present study provides an important contribution to the available weight–length relationships of 27 demersal fish species of the Cape Verde archipelago. Data were collected under the CABOFISH project, a research cruise on the demersal and deep-water fishing resources of Cape Verde, a joint initiative between the governments of the Azores and Cape Verde, the University of the Azores and the Instituto Nacional de Desenvolvimento das Pescas (INDP) of Cape Verde. The main aims of the project were to identify the demersal and deep-water ichthyofauna and their main distribution patterns to a depth of 1200 m, and to prospect for fish species potentially interesting for the development of a bottom longline fishery in the archipelago of Cape Verde (Menezes et al., 2004).

Materials and Methods

Data analyzed in this study were collected in October and November 2000 during the longline survey conducted off Cape Verde archipelago, onboard R/V ‘Arquipélago’. The longline gear used in all fishing operations was similar to that used by the commercial demersal fishery in Azores, and locally known as ‘stone/buoy longline’. Samples were obtained from depths to 600 m, and occasionally down to 1200 m. Details on the survey sampling protocol, areas, depth limits and relative abundance of species can be found in Menezes (2003) and Menezes et al. (2004). All individuals were measured onboard (either total or fork length) to the nearest cm, weighed to the nearest gram and the sex determined, when possible.

The weight–length relationship was analyzed through the most common approach (Hayes et al., 1995) using the log form of the expression: $W = aL^b$, where W is the weight (g), L is the length (cm), a is the intercept of the regression and b is the regression coefficient. All outliers were excluded prior to regression analysis. For species with small length ranges, or represented by < 12 individuals, the intercept value a was calculated using the above expression, and assuming $b = 3$ (Froese, 2006). Species with more than 12 individuals per sex type were tested for independence between sexes; WLRs were estimated for males and females and for the entire species, including immature specimens.

Results and discussion

Length and weight parameters of 27 demersal fish species are shown in Table 1, along with the coefficient of determination (r^2) and the length characteristics. Two size records were noted, namely for *Bodianus scrofa* (male, 56 cm TL, 3356 g), and *Paraconger notialis* (82 cm TL, 1070 g, sex undetermined). In these two cases, extremely small or large individuals were not included on the WLR estimates to avoid distortions (Froese, 2006). No significant differences in weight–length regression slopes were observed between sexes ($P < 0.05$) for the nine species analyzed.

The relationships estimated in this study should be used with caution, and considered as representative of the study period. Also, the selective characteristics of longline do not include all range of length distributions. As suggested by Petrakis and Stergiou (1995), the use of these weight–length relationships should be strictly limited to the observed length ranges. Lower regression strengths also reflect the smaller ranges covered, such as with the *Laemonema laureysi*. Additionally, factors such as habitat, seasonal effects, stomach fullness, preservation techniques, maturity stage and age, which are known to affect weight–length relationships (Carlander, 1969; Ricker, 1975;

Table 1
Length and weight parameters of 27 demersal fish species along with coefficient of determination (r^2) and length characteristics

Species	Sex	Size (cm)				Regression parameters ¹							
		n	Min.	Max.	Type	<i>a</i>	CL		<i>b</i>	CL		SE (<i>b</i>)	r^2
							Lower 95%	Upper 95%		Lower 95%	Upper 95%		
<i>Beryx decadactylus</i>	B	15	25.0	47.0	FL	0.0077	0.0012	0.0495	3.325	2.814	3.836	0.237	0.938
<i>Beryx splendens</i> ²	B	32	26.0	36.5	FL	0.0230	–	–	3.000 ²	–	–	–	–
<i>Bodianus scrofa</i> ³	B	12	39.0	51.0	TL	0.0100	0.0013	0.0791	3.133	2.589	3.677	0.244	0.943
<i>Centrophorus granulosus</i> ³	B	173	33.5	107.0	TL	0.0015	0.0007	0.0033	3.293	3.117	3.469	0.089	0.889
	M	150	64.0	94.0	TL	0.0043	0.0015	0.0123	3.057	2.822	3.292	0.119	0.820
	F	22	82.0	107.0	TL	0.0010	0.0001	0.0170	3.395	2.774	4.015	0.297	0.870
<i>Cephalopholis taeniops</i>	H	65	24.0	44.0	TL	0.0082	0.0049	0.0139	3.147	2.996	3.298	0.075	0.965
<i>Coloconger cadenati</i> ³	N	44	45.0	71.0	TL	0.0003	0.0001	0.0019	3.673	3.240	4.107	0.215	0.874
<i>Dentex macropthalmus</i>	B	61	17.0	32.0	FL	0.0167	0.0105	0.0266	3.041	2.897	3.184	0.072	0.968
	M	30	18.0	29.0	FL	0.0161	0.0076	0.0340	3.055	2.821	3.289	0.114	0.962
	F	27	17.0	32.0	FL	0.0193	0.0109	0.0341	2.989	2.811	3.166	0.086	0.980
<i>Etmopterus pusillus</i>	B	12	29.5	47.0	TL	0.0033	0.0009	0.0122	3.033	2.670	3.395	0.163	0.972
<i>Gephyroberyx darwini</i>	B	18	19.5	49.5	TL	0.0080	0.0034	0.0190	3.297	3.057	3.536	0.113	0.982
<i>Gymnothorax polygonius</i> ³	N	56	49.5	98.0	TL	0.0003	9.28E-5	0.0007	3.421	3.176	3.667	0.122	0.935
<i>Helicolenus dactylopterus</i>	B	138	24.0	50.0	TL	0.0210	0.0153	0.0288	2.960	2.874	3.046	0.043	0.971
	M	54	27.0	50.0	TL	0.0219	0.0131	0.0368	2.947	2.808	3.085	0.069	0.972
	F	83	24.0	45.0	TL	0.0173	0.0107	0.0278	3.016	2.885	3.147	0.066	0.963
<i>Laemonema laureysi</i> ³	B	42	27.0	38.0	TL	0.0062	0.0017	0.0224	3.053	2.684	3.422	0.183	0.875
	M	14	27.0	36.0	TL	0.0047	0.0007	0.0326	3.134	2.578	3.690	0.255	0.926
	F	14	29.0	36.0	TL	0.0023	2.6E-05	0.1978	3.346	2.061	4.630	0.590	0.729
<i>Mustelus mustelus</i>	B	46	47.0	132.0	TL	0.0017	0.0009	0.0030	3.174	3.046	3.302	0.064	0.983
	M	21	47.0	111.0	TL	0.0022	0.0009	0.0052	3.110	2.921	3.299	0.090	0.984
	F	25	83.0	132.0	TL	0.0012	0.0005	0.0029	3.248	3.061	3.435	0.090	0.983
<i>Neomerinthe folgori</i> ³	B	49	34.0	59.0	TL	0.0080	0.0048	0.0134	3.176	3.041	3.311	0.067	0.980
	M	22	34.0	57.0	TL	0.0066	0.0036	0.0121	3.225	3.065	3.385	0.077	0.988
	F	27	34.0	59.0	TL	0.0096	0.0041	0.0228	3.131	2.905	3.358	0.110	0.970
<i>Pagellus acarne</i>	H	39	16.0	29.0	FL	0.0062	0.0037	0.0102	3.381	3.223	3.539	0.078	0.981
<i>Paraconger notialis</i> ³	N	12	48.5	72.0	TL	0.0012	4.6E-05	0.0310	3.144	2.353	3.935	0.350	0.900
<i>Parapristipoma humile</i>	B	18	27.0	37.5	TL	0.0193	0.0091	0.0410	2.945	2.727	3.163	0.103	0.981
<i>Polymixia nobilis</i> ³	B	152	19.0	47.0	FL	0.0184	0.0141	0.0241	3.062	2.982	3.142	0.040	0.975
	M	42	19.0	36.0	FL	0.0390	0.0211	0.0720	2.841	2.655	3.027	0.092	0.960
	F	72	20.0	47.0	FL	0.0191	0.0141	0.0260	3.059	2.969	3.149	0.045	0.985
<i>Pontinus kuhlii</i>	B	286	16.0	46.0	TL	0.0163	0.0132	0.0200	2.956	2.896	3.016	0.030	0.971
	M	188	16.0	46.0	TL	0.0150	0.0113	0.0198	2.980	2.900	3.060	0.041	0.967
	F	63	18.0	36.0	TL	0.0194	0.0102	0.0370	2.935	2.703	3.101	0.126	0.899
<i>Priacanthus arenatus</i> ²	B	14	26.0	35.0	TL	0.0133	–	–	3.000 ²	–	–	–	–
<i>Promethichthys prometheus</i>	B	32	29.0	48.5	FL	0.0041	0.0015	0.0110	3.053	2.789	3.317	0.129	0.949
<i>Sargocentron hastatum</i>	B	13	19.0	25.0	FL	0.0247	0.0042	0.1468	2.910	2.332	3.489	0.263	0.918
<i>Serranus atricauda</i>	H	86	19.0	32.0	TL	0.0198	0.0101	0.0387	2.870	2.667	3.074	0.102	0.904
<i>Squalus uyato</i> ³	B	40	46.0	99.5	TL	0.0017	0.0009	0.0031	3.261	3.124	3.398	0.068	0.980
	M	20	56.0	90.0	TL	0.0029	0.0008	0.0105	3.138	2.845	3.430	0.139	0.970
	F	20	46.0	99.5	TL	0.0015	0.0007	0.0030	3.292	3.128	3.454	0.078	0.990
<i>Syacium micrurum</i> ²	B	12	25.0	29.5	TL	0.0082	–	–	3.000 ²	–	–	–	–
<i>Synphobranchus kaupii</i>	N	54	31.5	72.0	TL	0.0003	0.0001	0.0008	3.355	3.100	3.609	0.127	0.931
<i>Synodus synodus</i>	B	23	20.0	43.0	TL	0.0084	0.0047	0.0151	3.067	2.893	3.240	0.084	0.985

¹All regressions are highly significant (ANOVA for $H_0: \beta = 0$ against $H_A: \beta \neq 0$; $P < 0.001$) (Zar, 1984). Sex B includes species H, simultaneous hermaphrodites, and N, when sex was not recorded; n is the sample size, min. and max. total (TL) or fork (FL) length in centimeter are presented; *a* and *b* are the parameters of the weight–length relationship: $W = aL^b$, where W is the total weight (g) and L is the length (cm), 95% Confidence Limits are indicated, and SE is the standard error of *b* and r^2 is the coefficient of determination.

²Indicates species with small number of species or small size range, where *a* was estimated assuming $b = 3$ (Froese, 2006).

³Indicates species WLR reported for the first time in literature; species in bold are first reports for Cape Verde.

Table 2

Comparison of weight–length relationships parameters for species considered in this study with previously published by several authors (see footnote)

Species	Year of data	Regression parameters				Ref.
		n	a	b	r ²	
<i>Cephalopholis taeniops</i>	1985	162	0.0073	3.200		A
	1995	76	6E(-6)	3.240	0.990	C
	1996	71	7E(-6)	3.210	0.987	D
	1997	133	0.007	3.213	0.985	E
	2000	65	0.0082	3.147	0.965	F
<i>Dentex macrophthalmus</i>	1984	101	0.0233	2.800		A
	1985	110	0.0134	2.950		A
	2000	61	0.0167	3.041	0.968	F
<i>Pagellus acarne</i>	1984	108	0.0137	3.090		A
	1985	86	0.0109	3.170		A
	1988	30	0.051	3.060	0.910	B
	2000	39	0.0062	3.381	0.981	F
<i>Parapristipoma humile</i>	1984	38	0.0898	2.520		A
	1985	136	0.0224	2.920		A
	1988	43	0.0244	2.870	0.930	B
	1996	64	0.0119	3.093	0.994	D
	1997	228	0.0794	2.521	0.845	E
	2000	18	0.0193	2.945	0.981	F
	1996	52	0.0443	2.644	0.996	D
<i>Priacanthus arenatus</i>	1988	80	0.0207	2.870	0.970	B
	1996	52	0.0443	2.644	0.996	D
	2000	14	0.0133	3.000		F

The 'year of data' refers to the year when the samples were collected; n is the sample size; a and b are the weight–length parameters; r² the coefficient of determination and Ref. is the reference for the different authors: A – Magnússon and Magnússon (1987b); B – Pálsson (1989); C – Oddsson et al. (1996); D – Oddsson and Monteiro (1997); E – Oddsson and Monteiro (1998a); F – present study.

Ozaydin et al., 2007), particularly a, were not considered in the present study. These might provide explanations for regression coefficients below optimum, such as in the *Centrophorus granulosus* and *Pontinus kuhlii* females. To avoid distortion in the WLRs of *Mustelus mustelus* and considering that the females mature at about 80 cm (Compagno, 1984), any females under 84 cm were not included in the analysis.

Nevertheless, the intersection values obtained corresponded to the body shape of each species (Froese, 2006). The same for WLR slopes (b) in species all falling within expected ranges (2.5 < b < 3.5; Carlander, 1969). The b parameter usually does not vary significantly throughout the year (Bagenal and Tesch, 1978), and together with a can be considered mean annual values, as suggested by several authors (Gonçalves et al., 1997; Santos et al., 2002; Borges et al., 2003; Andreu-Soler et al., 2006).

For the Cape Verde archipelago, the only information available for weight–length relationships refers to the authors Magnússon and Magnússon (1987b), Pálsson (1989), Oddsson et al. (1996) and Oddsson and Monteiro (1997, 1998a). These parameters were published only in technical reports (grey literature); those species are also reported and compared in Table 2. Due to the lack of basic data accompanying the regression equations, namely, sample size and standard error, it was not possible to make a statistical comparison with those previous works. Nevertheless, this data can be used to estimate the mean condition factor for given lengths (K_{mean} as given by Clark, 1928). Oddsson and Monteiro (1998a) compared weight–length parameters with previous work by Magnússon and Magnússon (1987b) and found that weight–length data for *Cephalopholis taeniops* from 1985 (Magnússon and Magnússon, 1987b), differed from 1995 and 1996, particularly a, while it was not different from 1997; however, the statistical procedure for the comparison was not indicated. Accordingly, no further comparisons were made at this stage.

In conclusion, the authors' focus in this study provides important information on weight–length relationships of demersal fish species in Cape Verde waters, being the first parameter estimates for 21 species from this archipelago (Table 1, species in bold) and for 9 species worldwide (Table 1, with *; Froese and Pauly, 2010).

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SHORT COMMUNICATION

Note on an opportunistic artificial reef near cold-water corals

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INTRODUCTION

Artificial reefs (AR) of many different shapes and materials have been widely used, serving different purposes from habitat protection and enhancement to recreational diving (Polovina 1991). With more than 250 ARs covered by scientific literature world-wide (Baine 2001), very few studies concern areas deeper than 60 meters, reflecting the majority of deployment depths and the vertical limits for SCUBA operations.

In parallel, the importance of reef-forming cold water corals (CWC) for deep-sea fish communities with commercial interest is the focus of many recent large research programs, following the deepening of fisheries and the advent of video and submersible technology. These “habitat building species”, alter sediment deposition and provide complex structural habitat (Roberts et al. 2006), considered essential for diverse fish and invertebrate communities (Reed 2002; Costello *et al.* 2005; Ross & Quattrini 2007).

On top of the Condor Seamount (Azores, NE Atlantic), a CWC community dominated by plexaurid gorgonians cf. *Dentomuricea*, with *Viminella flagellum* and hydroids cf. *Polyplumaria flabellata*, thrives on areas of hardbottom and mixed hardground-unconsolidated sediments down to circa 300 meters (Tempera et al. 2010). These slow-growing species are classified as Vulnerable Marine Ecosystems under EUNIS classification system (Connor 2005), remaining

susceptible to local bottom long-line fisheries.

Fish opportunistic attitude towards habitat, is a relatively well known response from habitat complexity studies on shallow natural (Harding & Mann 2001), and artificial reefs (Gratwicke & Speight 2005). Besides the importance of CWC reefs such as *Lophelia pertusa* for some fishes (Mortensen *et al.* 1995; Costello *et al.* 2005), opportunism towards either geological or biological reefs has been recently noted in some CWC areas (Auster 2005; Tissot et al. 2006). Observations of deep-water AR have also demonstrated that local fish populations tend to utilize artificial structures similarly to other biological or geological reef available (e.g. Koenig et al. 2004; Husebø et al. 2002), even though differences might be found in the fish community from natural reefs (Clarke & Edwards 1994). Therefore, ARs can contribute to a better understanding on the use and importance of available habitats (Hixon & Beets 1989). Simplified structures can also facilitate the observation of juvenile fish (Gorham & Alvizon 1989), usually difficult to observe when larger fish are present on natural reefs (Ross & Quattrini 2007), as in aquaria.

This note provides a sporadic insight on the importance of hard three-dimensional structures for deep-water fish near cold-water corals. Fish associations to the structure and surrounding area are described, including size and behavior. Additionally a list of biofouling epifauna growing on the structure is provided.

MATERIAL AND METHODS

The Condor is a ridge seamount located east of the Mid-Atlantic Ridge, at about 17 km from Faial Island in the Azores archipelago (Portugal, Northeast Atlantic; Fig. 1). The seamount has an elongated shape, with a relatively flat summit from 184 to 300 meters, with large areas of unconsolidated sediment and gravels, intermixed with shallow rocky outcrops, and small and medium boulder areas (Tempera et al. 2010).

The structure consisted of a stainless steel framework, attached to a 1.20 m cement square base/weight, with a flat top holding an Acoustic Doppler Current Profiler. It remained deployed on top of the Condor Seamount at 230 meters depth for 375 days (between 29 July 2009 and 08 August 2010; 38°31.87816 N, 29°01.94419 W; Fig. 1 to 3). It was a one meter high pyramidal frame, with a diameter varying from 170 cm at the base to 113 cm at the top. At mid-height it was 176 cm wide, due to four extruding floaters.

In view of the divergence between the structure utilized in this study and the most common definition of artificial reef - a submerged structure placed on the substratum (seabed) deliberately, to mimic some characteristics of a natural reef (Jensen 1998), this was therefore considered an "opportunistic Artificial Reef".

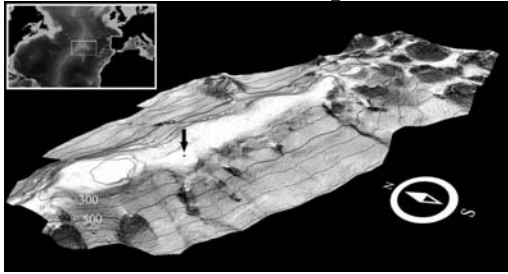


Fig. 1. Condor Seamount within the Mid-Atlantic Ridge, with location of the opportunistic artificial reef.

The opportunistic AR was located over unconsolidated sediment, mostly sand with a gravel component (~70% of the surface) and bioclastic sediments (~20%). The area was in close proximity (~2 m) of a coral garden growing on mixed unconsolidated-consolidated hardground, dominated by gorgonian plexaurid cf. *Dento-muricea*,

together with sparse *Viminella flagellum*, and hydroids cf. *Polyplumaria*, mostly below 0.5 meters high.

The structure and associated fish fauna were carefully inspected for 38:08 minutes by a remote operated vehicle "Luso", recording full HD digital video (Calado et al. 2008). Removal of the top component occurred 17:01 minutes after the beginning of inspection, by physically releasing the framework from the cement base, allowing the four floaters to invert it and surface it immediately, remaining only the cement base.

Fish presence and relation to the opportunistic AR were post-analyzed from video images using video annotation software COVER (v0.7.0 beta; Ifremer). A transition zone including 3 meters outward from the sand-reef interface was considered. All visible species were identified to the lowest feasible taxon, counted and measured when possible. Each fish was considered a separate event, except for juvenile *Anthias anthias* due to size and schooling behaviour. Annotated categories included species, 'observed response to ROV' and 'response timing'. Behaviour was annotated conservatively (Pascal & Trenkel 2006; Stoeck 2008), including 'Response to ROV' (escape/hide/slow escape/no reaction) and 'Response timing' (before detection/far from ROV/close to ROV/no reaction). All fish that reacted 'before detection' or 'not clear' were excluded from posterior analysis. Other behaviour included 'Locomotion' (no locomotion/slow forward movements/station holding), 'position in the water' (sitting on bottom/less than one body length/< 0.5m /0.5-1m off bottom) and 'position to AR' (below AR/next to/sitting on/within AR), 'distance to AR' (in contact/<1 body length/<1 AR length(1.20m)). Fish size estimations and distances from the AR were calculated using known measures from the AR with "ImageJ" (v.1.43u, Abramoff et al. 2004). Twelve measurements were made per each individual to minimize measurement errors. Individual sizes are presented as average values.

After retrieval of the structure onboard, invertebrate fauna was measured and largest sizes of main taxa were recorded. Total number of individuals per species was not quantified once out of the scope of this work. Samples of representative taxa were preserved on ethanol 96% and kept on

the reference collection “COLETA” at the Department of Oceanography and Fisheries of the University of the Azores.

RESULTS

Seven fish species, in a total of 18 individuals, were attracted to the opportunistic AR, with *Anthias anthias* juveniles standing out numerically (Fig. 2). Fish size and behavior, such as position in the water, relation and distance to the

structure are presented in Table 1. Species occurring near the artificial structure with reaction times previous to detection or unclear (not included in Table 1), were the high mobility *Pagellus bogaraveo* (2) and *Trachurus picturatus* (2), together with one benthic *Helicolenus dactylopterus*, and three adult *A. anthias*.

The adult *A. anthias* observed near the ROV (Table 1) was positioned on the current side, facing the current, while the juvenile were opposite to current provenance possibly benefiting from interference from the AR (Fig. 2).

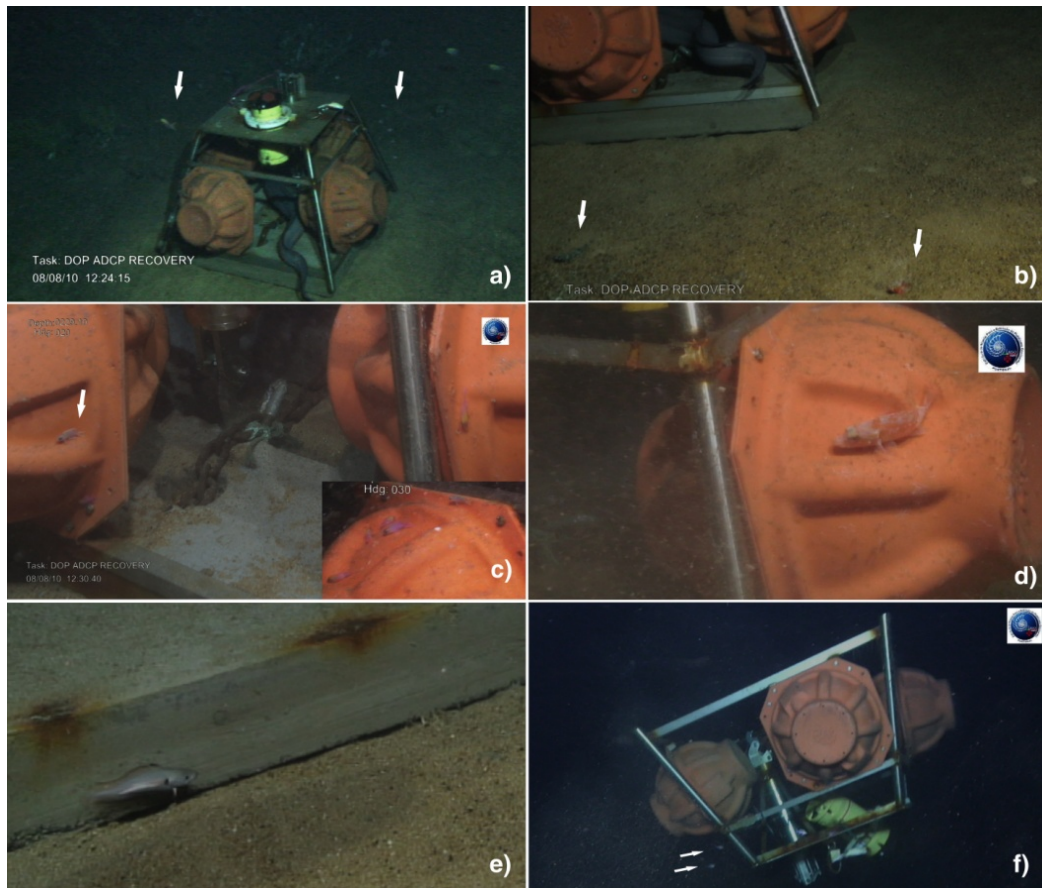


Fig. 2. Illustrative plate of fishes associated with the artificial structure: a) general view of opportunistic AR with *A. anthias* and *C. conger*; b) *S. saurus* and *H. Dactylopterus* ; c) juvenile *C. ruber*, and picture insert of juvenile *A. anthias* aggregations; d) young *P. kuhlii* sitting on floaters; e) Undet. *Macrouridae* circling cement base after structure removal; f) opportunistic AR inverted and surfacing, with juvenile *A. anthias* accompanying the structure.

Table 1. Fish size and behavior: position in the water and relation to the artificial reef; **Callanthias ruber* position is not indicated once it was not identifiable at distance.

Lower taxon	N°	Size (cm)	Position in the water	Position rel to AR	Distance to AR	Locomotion	Response to tumbling	Response to ROV
<i>A. anthias</i>	1	11.52	Less than 0.5 meter off bottom	next to AR	<1 body length	Station holding	Far from ROV	Slow escape
<i>A. anthias</i>	1	3.29	0.5-1 meter off bottom	within AR	-	No locomotion	Far from ROV	Hide
<i>A. anthias</i>	7	3.53 - 4.49	1 body length to 1 meter off bottom	next to AR	<50 cm	Slow forward mov.	Far from ROV	Hide
<i>A. anthias</i>	2	3.27 - 3.58	Sitting on AR	below AR	In contact	No locomotion	Far from ROV	Slow escape
<i>C. ruber</i> *	1	4.23	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
<i>C. conger</i>	1	135 - 160	Sitting on bottom	within AR	in contact	No locomotion	Close to ROV	Escape
<i>H. dactylopterus</i>	1	n.a.	Sitting on bottom	next to AR	<120 cm	No locomotion	No reaction	No reaction
<i>S. saurus</i>	1	n.a.	Sitting on bottom	next to AR	<120 cm	No locomotion	No reaction	No reaction
<i>P. kuhlii</i>	1	22.05	Sitting on bottom	Sitting on bottom	in contact	No locomotion	Close to ROV	Slow escape
Macrouridae sp.1	1	9.58	Less than 1 body length off bottom	within AR	Not clear	Not clear	After AR removal	No reaction

Table 2. List of sessile invertebrate fauna from the artificial reef; Maximum size in cm from visual inspection,^h for height, ^w for width (in *C. longispinus* concerns the shell); measures are from *in situ* data, and do not correspond to the repository samples indicated (repository COLETA, from the Department of Oceanography and Fisheries, University of the Azores)

PHYLUM	CLASS	ORDER	FAMILY	Lower taxon	N°	Size max (cm)	Average (cm)	Repository Code
BRYOZOA	Stenolaemata	Cyclostomatida	Tubuliporidae	Tubuliporidae undet.1	>10	3.85 ^w	1.77	DOP-7440
BRYOZOA	Stenolaemata	Cyclostomatida	Tubuliporidae	Tubuliporidae undet.2	?	-	-	-
CNIDARIA	Hydrozoa	Leptothecata	Aglaopheniidae	<i>Aglaophenia</i> sp.	>10	2.90 ^h	-	DOP-7441
CNIDARIA	Hydrozoa	Leptothecata	Lafoeidae	<i>Acryptolaria</i> sp.	>10	6.25 ^h	-	DOP-7442
CNIDARIA	Hydrozoa	Leptothecata	Campanulariidae	<i>Obelia</i> sp.	>10	1.85 ^h	-	-
MOLLUSCA	Gastropoda	Trochoidea	Calliostomatidae	<i>Calliostoma</i> sp.	1	0.91 ^h /0.84 ^w	-	DOP-7443
MOLLUSCA	Gastropoda	Trochoidea	Calliostomatidae	<i>Calliostoma</i> sp.	1	0.77 ^h /0.58 ^w	-	DOP-7444
ECHINODERMATA	Echinoidea	Diadematoida	Diadematidae	<i>Centrostephanus longispinus</i>	1	0.91 ^w	-	-
ANNELIDA	Polychaeta	Sabellida	Serpulidae	Filograniinae undet.	>10	-	-	-

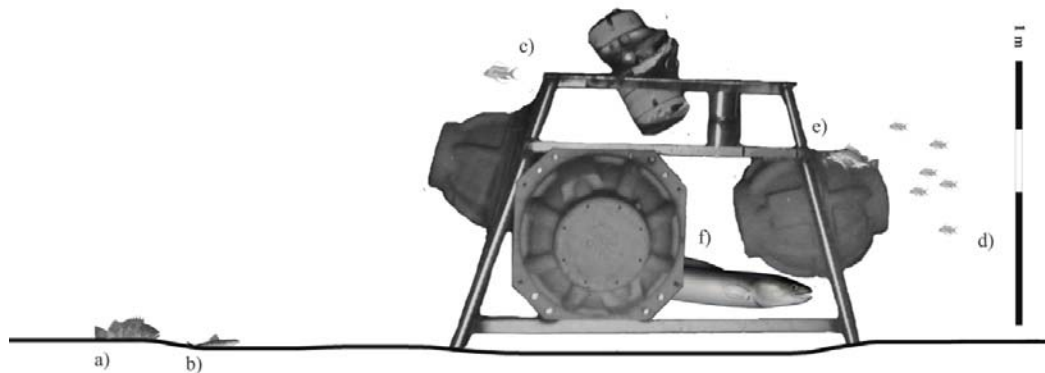


Fig. 3. Infographic resume of fish relation to artificial structure has observed on a sporadic event, in the vicinity of a cold water coral garden: a) *H. dactylopterus*, b) *S. saurus*, c) adult *A. anthias*, d) juvenile *A. anthias*, e) *P. kuhlii*, f) *C. conger*; fish size and positions are up to scale (fish illustrations are courtesy of Fishpics®).

All species remained in their location in relation to the artificial structure for 17 minutes, as depicted in Figure 3. Exceptions were one large *A. anthias* that left the area, and most juvenile *A. anthias* that swam towards the artificial structure, hiding and holding position, to overcome the strong current generated by the thrusters. Juvenile *A. anthias* and one *Callanthias ruber* were within similar size ranges (Table 1), namely 2.27 and 4.55 cm (TL, average 3.8, STD 0.65, $n=9$), while *C. ruber* measured 4.23 cm (TL).

Biofouling epifaunal species and sizes are listed in Table 2 and Figure 4. Organisms from five different Phyla were attached to the opportunistic structure, including rapid growth sessile bryozoa and hydrozoa, a juvenile echinoderm and juvenile gastropods. No exact quantification was accomplished, and species with a large number of individuals are indicated as >10 in Table 2.

DISCUSSION

The opportunistic artificial reef was utilized by a diverse group of benthic fish species that maintained their behavioral relation to the artificial habitat throughout the observations. Considering the sporadic conditions of these observations, in the case of benthopelagic species, such as *A. anthias*, the exploratory or casual swimming near the structure cannot be neglected. These include

several adults that reacted before detection, such as *Pagellus bogaraveo* and *Trachurus picturatus* swimming actively in the vicinity of the AR. From fishing surveys on this Seamount (Menezes pers. comm.) *P. bogaraveo*, *T. picturatus*, *P. kuhlii* and *H. dactylopterus* are within the top five species at these depths, with *C. conger* being more abundant below 300 meters. These are commercially important species exploited throughout the region (Silva & Pinho 2008). Most specimens observed near the opportunistic AR were small sized individuals. With the exception of the *C. conger*, one adult *A. anthias*, *H. dactylopterus* and *S. saurus*, one *C. ruber* and 10 *A. anthias* were all juveniles. The undetermined Macrouridae was also likely a young stage (Fig. 2), and *Pontinus kuhlii* aged between 7-8 years old (Isidro 1996; Krug et al. 1998), which is most probably an immature individual (L50 22.6cm; Estácio et al. 2001). The number of juveniles is not especially interesting, but rather the diversity of species reported. Much larger numbers of antheids have been observed over *Oculina* reefs on Florida waters (Reed 2002; *Hemanthias vivanus*), darting into the branches for protection and feeding on the invertebrates.

The reef mediating processes of predation and competition by providing refuges for settling recruits is a concept known both from tropical natural (Hixon 1991) and artificial reefs (Hixon & Beets 1989). These juvenile *A. anthias* reacted to

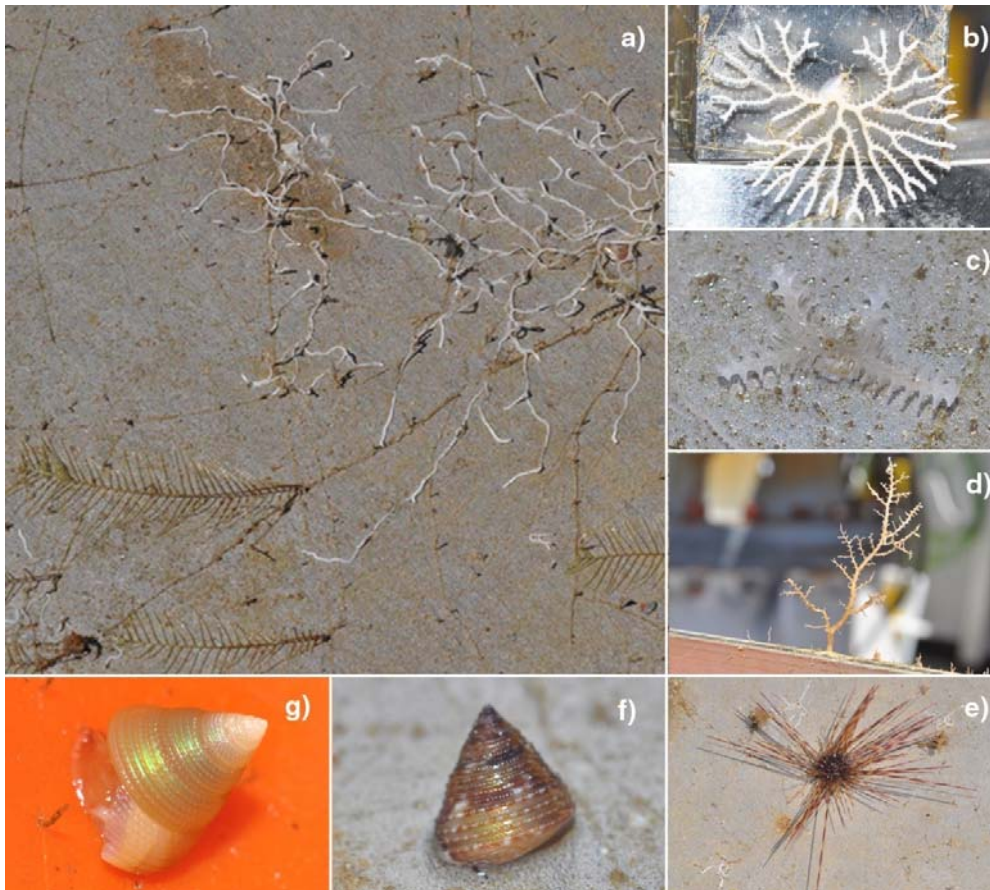


Fig. 4. Invertebrate fauna collected from a one year deployed artificial structure: a) Filigraninae tubeworms and *Aglaophenia* sp., b) undet. Tubuliporidae 1, c) undet. Tubuliporidae 2, d) *Acryptolaria* sp., e) *Centrostephanus longispinus*, f) and g) *Calliostoma* sp.

the ROV hiding and placing themselves on the floaters depressions, remaining aggregated (not in contact), and resisting the current streams generated by the thrusters. Higher diversities of juvenile fish are often associated with increased habitat complexity (Gorham & Alevizon 1989; Hixon 1991), and the defensive behavioral response, here reported for the first time for this species, should directly benefit from it. The opportunistic AR provided a more complex habitat than the surrounding corals, even though these coral communities can cover large areas on this seamount, and be much taller than this structure (Tempera et al. 2010). On a superficial compari-

son neither the fan shaped Plexaurid cf. *Dentomuricea*, nor the whip coral *V. flagellum*, certainly provide the number of cavities for sheltering *C. conger*, or juvenile *A. anthias* as the opportunistic AR in this study, or other more “bush” shaped corals (Reed 2002).

The solitary macro-carnivores *C. conger* (dominating biomass) and *P. kuhlii* inhabited the structure, while *H. dactylopterus* and *S. saurus* occupied the surrounding area, sitting on unconsolidated sediments. The young Macrouridae was sheltered on the shadowed fraction of the opportunistic AR. *S. saurus* is an opportunistic carnivore, feeding on benthic and gregarious pelagic

fishes (35% smaller), including juveniles of others predators, which the species favors at shallower depths in the Azores (Soares et al. 2003; Esposito et al. 2009). Their presence near shallow AR has been associated with a reduction in the number of juvenile fish species in Canary Islands (Herrera et al. 2002).

Sessile epibiota increase habitat complexity, having an important role on the survival of juvenile fish (Bradshaw et al, 2003 in review), as on settling mobile invertebrate (e.g. Isaksson et al. 1994), which become prey for large fish. The invertebrate biofouling fauna collected in the AR comprised a considerable variety of Phyla commonly observed. Results presented here aim solely to provide clues on settlement season and growth of these species (Svane & Peterson 2001). Settlement of sessile invertebrate Tubuliporidae, *Aglaophenia* sp. and *Acryptolaria* sp. transported by currents, can have occurred from August 2009 onwards, hence maximum sizes should consider at least 12 months of growth. Even though AR may develop fouling assemblages different from epibioses on natural substrata (Carr & Hixon 1997; Glasby & Connell 1999), any opportunities should be seized, considering the remarkable lack of taxonomic and ecological information of most of the species recruiting to CWC habitats. Samples are available for future studies (Table 2). Results outline the need for further research on substrate types, settlement plans and seasonality of benthic invertebrate megafauna near CWC habitats.

The opportunistic AR revealed very useful on providing preliminary insights on behavior and habitat association of some bottom fish from CWC areas. Future research should include (non opportunistic) reef design, orientated to study the importance of CWC 3D structures versus coral and rocky reefs (Carr & Hixon 1997; Auster 2005; Tissot et al. 2006), including temporal observation from visual inspection and/or automatic releases.

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