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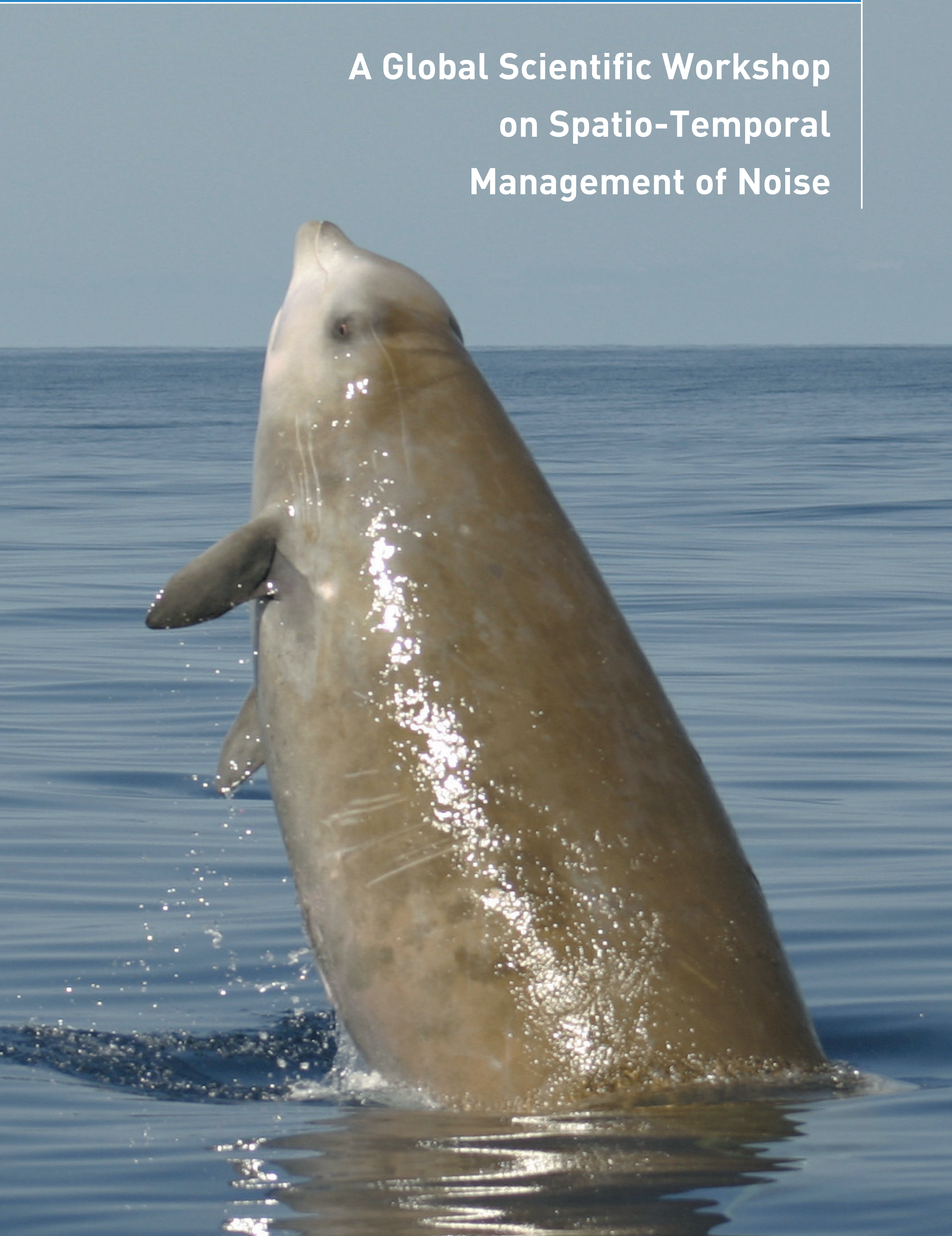
A Global Scientific Workshop on Spatio-Temporal Management of Noise



A Global Scientific Workshop on Spatio-Temporal Management of Noise

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EXECUTIVE SUMMARY

Marine fauna, especially cetaceans, rely on sound for a range of biological functions and are susceptible to the effects of marine noise pollution (e.g. Richardson *et al*., 1995). However noise, despite its implicit classification as a pollutant by the United Nations Convention on the Law of the Sea (UNCLOS), is not subject to the same level of regulation as other pollutants.

Spatio-temporal restrictions (STRs), including marine protected areas (MPAs), offer one of the most effective means to protect cetaceans and their habitats from the cumulative and synergistic effects of noise as well as from other anthropogenic stressors (Weilgart, 2006), as the various threats confronting cetaceans do not occur in isolation. For example, there is evidence that anthropogenic noise could interact with cetacean by-catch or ship collisions, preventing animals from sensing fishing gear or oncoming vessels and making them more vulnerable to injury or death (Todd *et al*., 1996; Andre *et al*., 1997). However, despite great potential, at present very few MPAs are large enough to reduce ensonification (i.e. exposure) of cetaceans to noise from human activities in the ocean (Hoyt, this report). This consensus report creates a conceptual foundation for utilising marine protected areas and other STRs to help improve this situation.

EXISTING MPAS AND SANCTUARIES

The efficient transmission of sound underwater (as compared to transmission in air) increases the geographical scale of the potential effects of anthropogenic noise pollution, which may interfere with biological processes at considerable geographical scales. Therefore, some reduced ensonification may be conferred if predetermined levels of intense mid-frequency sounds are excluded from areas tens of kilometres away from critical habitats (implying an STR on the order of 100 km^2 to 1,000 km^2). However, protection from intense low-frequency sounds might require larger distances of hundreds of kilometres from sound sources and areas of STR on the order of at least 10,000 km^2 to 100,000 km^2.

There have been various strategies aimed at increasing the size of MPAs and their level of protection. The United Nations (UN) and other initiatives and congresses have suggested protecting 20-30 per cent of the oceans in some way (Roberts *et al*., 2006) and regional treaties such as The Agreement on the Conservation of Cetaceans in the Black Sea, Mediterranean Sea and contiguous Atlantic area (ACCOBAMS) are cooperating in the implementation of these goals. However, less than 1 per cent of the surface of the world ocean currently has any protected status, with only 0.01 per cent assigned highly protected status (IUCN Category I) (Hoyt, 2005).

Spatio-temporal marine management has the potential to contribute substantially to cetacean conservation through the mitigation of various kinds of noise and associated threats. Participants considered several types of potentially useful areas (from Hoyt *et al*., in prep):

1. A marine protected area, or MPA, is a generic term commonly used to describe a marine-based area to conserve species or habitats, backed by local, national or regional legislation. Of the more than 350 MPAs that include some cetacean habitat, only 20 MPAs with cetacean habitat are greater than 10,000 km^2 and could function to provide superior mitigation of some noise sources.

2. A spatio-temporal noise-threat buffer zone is a marine zone set up around an MPA to provide adequate or precautionary distance between noise sources and known or suspected cetacean habitat (e.g. the Abrolhos Bank, Brazil - Engel, this report).

3. An international cetacean sanctuary is a marine area in international waters (high seas) established by an international body or group of countries typically to protect whales and dolphins from hunting (e.g. International Whaling Commission sanctuaries for the Southern and Indian Oceans). These areas have no management plans, with the exception of the PELAGOS Sanctuary for Mediterranean Marine Mammals (87,492 km^2).

4. A national cetacean sanctuary is a marine area occupying the entirety (or most) of the exclusive economic zone (EEZ) of a country or overseas territory. Some 20 countries have declared their national waters as marine mammal sanctuaries, ranging from 120,000 to 16,000,000 km^2. These areas have no management plans but are subject to the laws of a country insofar as they can apply to the EEZ.

5. STRs of noise sources have been applied in several places to help mitigate noise sources of particular concern (e.g. the restriction on naval mid-frequency active sonar within 50 nm (92 km) of the Canary Islands).

Participants of the Workshop strongly agreed that STRs of noise pollution would benefit cetacean species and commended the efforts of those countries that have employed substantial measures to protect cetaceans from the impacts of anthropogenic noise pollution in their national waters. Specifically, they recommended that:

- Coastal states should seek scientific and conservation organisation input to review national (EEZ) and international cetacean sanctuaries and suggest incorporating noise-related STRs.
- Long-term visual and acoustic monitoring of species and acoustic monitoring of noise levels should be undertaken in existing cetacean-related MPAs and sanctuaries.
- Coastal states and MPA regional and national management authorities should explore options/tools for designing spatio-temporal buffer zones around existing and proposed spatio-temporal marine management areas (such as MPAs) that include cetacean habitat.
- In the interest of cetacean conservation, coastal states should develop noise STRs independent of existing formally protected areas.
- MPA management authorities and other stakeholders should review existing MPA management plans and evaluate their effectiveness with regard to protecting cetaceans from predetermined levels of intense noise sources.
- Identification of gaps between existing MPAs and areas subject to extensive noise-producing activities is required.

FRAMEWORK

Historically, conservation planning has been largely ad-hoc and opportunistic, based around a reserve system biased towards areas of low production value and sites perceived as 'charismatic' (Pressey *et al*., 1993). Cetacean conservation is somewhat emblematic in this regard. This has led to an unrepresentative reserve network that, in isolation, is unlikely to adequately conserve biodiversity. To redress the situation, systematic conservation planning has evolved as the process of prioritising sites for conservation by optimising decisions across species and other values. The advantages of these now proven (e.g. Pressey, 1998; Myers *et al*., 2000; Cowling and Pressey, 2003; Fernandes *et al*., 2005) tools include efficiency (both in the use of available resources and the avoidance of other societal costs), transparency and the ability to incorporate the best scientific knowledge into planning processes, while enabling an adaptive management system.

Workshop Participants agreed that there is a need to develop a systematic protocol for identifying and prioritising noise mitigation actions. To this end, the report sets forth a six-step Framework that draws heavily on the general principles identified in the conservation planning and adaptive management literature, while being tailored to the context of noise mitigation for cetaceans.

This Framework, like much modern conservation planning, is guided by general principles from ecological theory such as: (a) larger areas of habitat are generally better than smaller areas; (b) more connected landscapes are more likely to maintain population processes than more fragmented ones; and (c) diverse habitat will generally support more species than uniform habitat. Given the current state of our knowledge with regards to cetacean distribution, abundance and habitat uses, as well as anthropogenic noise production and propagation, the Participants acknowledged the need to take a precautionary approach on the regulation of noise. This may suggest excluding areas as data become available and shifting the onus onto sound producers to prove that an area does not contain high-value habitat.

1. Define the goal(s), constraints and geographic scope of the planning process

The first step in a site/action prioritisation model is to define a clear goal. A statement of goal should be explicit about where the plan applies the measures that will be used to assess its success and the constraints that apply. The goal itself is measurable and progress towards the goal can be monitored. Defining the goal is crucial to the transparency of the project and helps engage all stakeholders at the initial step of the model process.

2. Identify relevant data and data gaps

The second step in a site prioritisation model is to identify, compile and assess relevant data. At the heart of a site/action prioritisation model is spatial information on species habitat distributions, threats and socio-economic information. Such data are seldom available for all species and all social aspects of a conservation planning problem. Where substantial data gaps exist, research and data collection priorities are identified. In some instances, there may be a need for urgent collection of data before a prioritisation process can commence, but it is usually preferable to move forward with the data that are available and utilise expertise and expert models to make decisions that might be modified at a later stage when new data become available. It is extremely rare that better conservation outcomes arise by postponing decisions until more data are available. Consequently, the role of expert opinion is central to most conservation planning processes.

3. Synthesise habitat and threat data to generate exposure ranking maps

The third step in the site prioritisation model is the synthesis of exposure maps from threats and biological data to identify areas of overlap between biodiversity values and threats to those values. Where sufficiently detailed knowledge exists, particular weights may be assigned to particular species/threat combinations to delineate between different magnitudes of impact for that combination of species and threat. However, in the absence of such knowledge, it may be reasonable to assume equal impact to all species from particular types of threats.

4. Generate map of mitigation priority areas

Step four in the site prioritisation model integrates the exposure maps from step three with spatial data on existing opportunities and impediments, opportunity costs and any other spatial information on constraints and preferences that can be systematically incorporated in an objective statement. Existing opportunities and impediments include current MPAs that may provide opportunities for economic savings in implementation and increased connectivity of 'secure' habitats, and jurisdictional and social impediments such as areas of high oil value, multilateral regulation or important recreational zones.

5. Identify and prioritise actions for priority conservation zones

Prioritisation should incorporate the concepts of conservation benefit, feasibility and cost efficiency. *Conservation benefit* reflects the amount of conservation value that is predicted to arise from implementing an action. *Feasibility* reflects the probability that an action will bring the desired biodiversity benefit. Finally, because conservation operates on finite budgets, the cost of one action implies a loss of opportunity to invest in other actions. Cheap, feasible, high-benefit actions are preferred to expensive, low-value actions with little probability of success.

6. Implement and monitor

A surprising number of conservation planning initiatives simply do not get implemented (Knight *et al*., 2006). Without an effective monitoring strategy, the success of management actions cannot be assessed, meaning the state of knowledge and therefore the efficiency of future management will not improve. Monitoring and the incorporation of the resulting data into the adaptive management process should be considered an integral component of management and designed and budgeted accordingly.

This Framework represents an open, systematic process that the Workshop Participants recommend be adopted by managers and scientists working to conserve cetaceans in the face of a potential threat from noise. However, it does not represent a completely new process, rather a formalisation (and standardisation) of existing efforts. For example, when efforts were made to introduce protection across the Abrolhos Bank for breeding humpback whales from seismic survey noise (see Engel, this report), a similar process was followed.

Adopting a systematic approach to prioritisation helps identify priorities efficiently and transparently, highlights the areas of data deficiency that most impact on the reliability of decisions and provides a sound basis for discussing and comparing competing conservation strategies. Many additional recommendations for the effective use of the Framework are made in this report.

CASE STUDIES

The next section of the report provides case studies of geographic areas where noise mitigation could be coupled to ongoing MPA efforts to reduce the effects of noise on cetaceans, in what could be considered pilot or demonstration projects. The Workshop focused on a) the Mediterranean region, encompassed by ACCOBAMS, where much scientific attention is focused, MPAs for cetaceans are being proposed, and policy mechanisms for noise management are under development; and b) parts of South and East Asia, a highly productive region where less is known about the status of cetaceans, yet pressures for development from industry and commerce are high and likely to continue to grow.

In the Mediterranean, Participants recommended the establishment of STRs for noise-producing activities in the Alborán Sea to protect a diverse range of cetacean species and in the Southwest Crete-Hellenic Trench to protect populations of sperm whales (*Physeter macrocephalus*) and Cuvier's beaked whales (*Ziphius cavirostris*). In these areas, as well as the existing PELAGOS Sanctuary for Mediterranean Marine Mammals, Participants made a number of recommendations for implementing and/or strengthening noise-related protections, specifically related to the use of military sonar and seismic surveys, and re-routing shipping lanes around the habitats of cetaceans sensitive to this source type as well as vulnerable to ship strikes. As a further priority, Participants also recommended that ACCOBAMS should apply the Framework to investigate the options for establishing a network of noise-related sanctuaries within the Mediterranean.

In Asia, threats to cetaceans in the Bay of Bengal and East Asian waters were considered. Participants recommended that data on the distribution of cetaceans and noise sources, as well as the effects of noise on the species present be collected and existing data be compiled in these areas to determine how STRs could be useful. The public should be engaged, especially in areas identified as priorities, and appropriate consideration given to the locations of noise-producing activities at the planning stage. Participants also recommended that monitoring for cetacean strandings be improved.

CONTENTS

INTRODUCTION

Marine fauna, especially cetaceans, rely on sound for a range of biological functions and are susceptible to the effects of marine noise pollution (Richardson *et al.*, 1995). In particular, concerns have surrounded the high-amplitude sound produced by the mid- and low-frequency active sonars emitted by naval vessels and airguns towed from seismic survey vessels during geophysical exploration, as well as the increase in noise associated with commercial shipping and transport. Noise, as a form of energy, is implicitly considered a pollutant under Article 1(1)(4) of the United Nations Convention on the Law of the Sea (UNCLOS). However, noise is not subject to the same level of regulation as other pollutants, at national or international levels, although such efforts are currently underway in the Mediterranean (Pavan, 2006; 2007).

Participants of the Workshop strongly agreed that spatio-temporal restrictions (STRs)[1] of noise pollution would benefit cetacean species. The efficient transmission of sound underwater (as compared to transmission in air) increases the geographical scale of the potential effects of anthropogenic noise pollution, which may therefore interfere with biological processes at considerable geographical scales. The protection of key cetacean habitat via the implementation of spatio-temporal management has been frequently identified as one of the most effective currently available means of mitigating the impacts of noise on cetaceans (for example, Barlow and Gisiner, 2006; Weilgart, 2006) and has been implemented in a handful of locations worldwide (e.g. Australia and the Canary Islands). Workshop Participants commended the efforts of those countries that have employed strong measures to protect cetaceans from the impacts of anthropogenic noise pollution in their national waters. To date, however, efforts have not been standardised at regional or national levels.

Despite indisputable merits, geographical limitation and the use of STRs may also present some limitations in the light of the current lack of data regarding cetacean distribution and/or areas of special importance, such as feeding and breeding grounds. STRs, indeed, tend to be biased towards well-studied areas where there are sufficient survey efforts and sightings data, while ignoring areas that have not been sufficiently surveyed or for which there are no available data. Of course, no sightings in an area does not necessarily mean that there are no cetaceans. Timely data on anthropogenic noise production and the species of animals present coincidentally would help in the management of noise. However, due to the paucity of regulation on anthropogenic marine noise pollution, most noise producers are not required to gather data on the potential effects of their activities on the marine environment. Given the current state of our knowledge, the Participants acknowledged the need to take a precautionary approach on the regulation of noise. This may suggest excluding areas as data become available and shifting the onus onto sound producers to prove that an area does not contain high-value habitat.

This consensus report aims to create a conceptual foundation for utilising marine protected areas (MPAs) and other STRs to help improve this situation. Section A provides recommendations on ways to implement and adapt MPAs so that they will be more effective in preserving areas of important cetacean habitat from noise pollution. Section B details a systematic Framework for identifying the most efficient mitigation efforts, including the most suitable locations for STRs, which can be applied at local and global levels and any scale in between. Associated recommendations include the implementation of legal instruments to regulate noise pollution and increasing the availability of data on noise-producing activities to allow scientific and public input and to further our understanding of the effects of noise on cetaceans.

Section C of the report provides case studies of geographic areas where noise mitigation could be coupled to ongoing MPA efforts to reduce the effects of noise on cetaceans, in what could be considered pilot or demonstration projects. The Workshop focused on a) the Mediterranean region, encompassed by the Agreement on the Conservation of Cetaceans in the Black Sea, Mediterranean Sea and contiguous Atlantic Area (ACCOBAMS), where much scientific attention is focused, MPAs for cetaceans are being proposed, and policy mechanisms for noise management are under development; and b) parts of South and East Asia, highly productive regions where less is known about the status of cetaceans, yet pressures for development from industry and commerce are high and likely to continue to grow.

[1] In referring to spatial temporal restrictions (STRs), we include conventional marine protected areas (running the gamut from strictly protected nature reserves to large-scale multiple-use sanctuaries and parks). However, we have also chosen to consider non-conventional area-based marine management measures, such as temporary closures with migration corridors during certain seasons, or special geographically-referenced regulations aimed at marine mammal protection, such as national or international whale sanctuaries, that exist outside the context of true marine protected areas (MPAs).

A EXISTING MPAS AND SANCTUARIES

Existing spatio-temporal marine management areas (such as MPAs and sanctuaries) for cetaceans with respect to anthropogenic noise sources

Spatio-temporal restrictions (STRs), including marine protected areas (MPAs), offer one of the most effective means to protect cetaceans and their habitat from the cumulative and synergistic effects of noise as well as from other anthropogenic stressors (Weilgart, 2006). It is important to understand that the various threats confronting cetaceans, such as fisheries by-catch, habitat degradation, chemical pollution, whaling, vessel strikes and global warming do not occur in isolation. For example, human impacts on marine ecosystems such as over-fishing, eutrophication and climate change can interact to produce a magnified effect (Lotze and Worm, 2002; Worm *et al.*, 2002). There is evidence that anthropogenic noise could similarly interact with cetacean by-catch or ship collisions, preventing animals from sensing fishing gear or oncoming vessels, making them more vulnerable to injury or death (Todd *et al.*, 1996; Andre *et al.*, 1997). MPAs that effectively protect cetaceans may well be the only way to address these sorts of impacts.

However, despite great potential, at present very few MPAs are large enough to reduce ensonification of cetacean species by various impulsive sounds or increasing levels of ambient noise due to human activities in the ocean (Hoyt, this report). The size of the MPA needed depends on the species' sensitivity (to the extent this is known), the species' mobility, the location (bathymetry and bottom topography), and noise source (dB, directionality, frequency, duration and repetition rate). Still, it can be said in general terms that some reduced ensonification may be conferred if predetermined levels of intense mid-frequency sounds are excluded from areas tens of kilometres away from critical habitats (implying an STR on the order of 100 km^2 to ideally closer to 1,000 km^2), while protection from intense low-frequency sounds might require distances of hundreds of kilometres from sound sources and areas of STR on the order of at least 10,000 km^2 to 100,000 km^2.

There have been various strategies aimed at increasing the size of MPAs and their level of protection. At the World Summit on Sustainable Development (Johannesburg, 2002) and at the V World Parks Congress (Durban, 2003) a target was set for a global system of MPA networks by 2012, including strictly protected areas that amount to at least 20-30 per cent of each habitat (Hoyt, 2005). Regional treaties such as ACCOBAMS are cooperating in the implementation of these goals. Other initiatives include the United Nations (UN) Millennium Project that aims initially to have 10 per cent of the oceans set aside in marine reserves, with a long-term goal of 30 per cent (Roberts *et al.*, 2006). Currently, less than one per cent of the surface of the world ocean has any protected status, and highly protected status (IUCN Category I) applies to only 0.01 per cent of the world ocean (Hoyt, 2005).

Various types of spatio-temporal marine management areas have the potential to contribute substantially to cetacean conservation through the mitigation of various kinds of noise and associated threats. Participants considered several types of potentially useful areas (from Hoyt *et al.*, in prep):

1. A marine protected area, or MPA, is a generic term commonly used to describe a marine-based area to conserve species or habitats, backed by local or national legislation. In some areas of the world, MPAs are variously called "national marine sanctuaries", "marine parks" or "marine reserves". More than 350 MPAs include some cetacean habitat but only 64 of these are at least 1000 km^2, at a size that could better provide some noise mitigation if noise regulations were in place. Only 20 MPAs with cetacean habitat are greater than 10,000 km^2, and could function to provide superior mitigation of some noise sources. However, even the six largest MPAs that include cetacean habitat (ranging in size from 100,000-350,000 km^2) are probably too small to thoroughly protect cetaceans from high intensity low-frequency sounds such as low-frequency active sonar, acknowledging that some protection from the most intense levels (closest to the noise source) is better than nothing at all.

2. A spatio-temporal noise-threat buffer zone is a marine zone set up around an MPA to provide adequate or precautionary distance between noise sources and known or suspected cetacean habitat. An example of this is at the Abrolhos Bank, Brazil, where a 95,000 km^2 buffer zone was set up in 2003 around the 913 km^2 Abrolhos Marine National Park to protect humpback whales (*Megaptera novaeangliae*) and other marine species from seismic surveys associated with oil and gas exploration, as well as associated noise from potential oil development (Engel, this report). This buffer zone was withdrawn by court order in mid-June 2007, although legal challenges within Brazil are now underway to restore the buffer zone or to create a much larger MPA.

3. An international cetacean sanctuary is a marine area in international waters (high seas) established by an international body or group of countries typically to protect whales and dolphins from hunting. Examples are the International Whaling Commission (IWC) sanctuaries for the Southern Ocean (50 million km^2) and the Indian Ocean (103.6 million km^2) and the Eastern Tropical Pacific Seascape (2.1 million km^2). These areas have no management plans, with the exception of the PELAGOS Sanctuary for Mediterranean Marine Mammals (87,492 km^2), which is sometimes considered an MPA as it lies partly in national and partly in international waters and has a management plan in process. At present none of these areas function as noise restriction zones, but the PELAGOS Sanctuary is the subject of recommendations in Section C of this report.

4. A national cetacean sanctuary is a marine area occupying the entirety (or most) of the exclusive economic zone (EEZ) of a country or overseas territory. Some 20 countries and overseas territories have declared their national waters as whale, cetacean or marine mammal sanctuaries (sometimes including marine turtles as well). These areas have no management plans but are subject to the laws of a country insofar as they can apply to the EEZ. The sizes of national cetacean sanctuaries vary from 120,000 to 16,000,000 km^2. Most are on the order of 1 million km^2.

5. STRs of noise sources have been applied in several places to help mitigate noise sources of particular concern. An example of this is a noise mitigation area for naval mid-frequency active sonar that was established to the limit of 50 nm (92 km) around the Canary Islands. Whilst setting a good example, this moratorium may not be sufficient to protect against all mid-frequency sonar noise sources as some anthropogenic noise-related beaked whale (*Ziphiidae*) mortalities around the Canary Islands have since been reported at some 120 nm (222 km) from the noise source (and the dead animals subsequently floated towards the Islands).

EXISTING MPAS AND SANCTUARIES: RECOMMENDATIONS

- Coastal states should seek scientific and conservation organisation input to review national (EEZ) and international cetacean sanctuaries and suggest incorporating noise-related STRs. At present, there are no management plans in these areas and no restrictions on noise, but it might be possible to introduce noise restriction zones to reduce the ensonification of cetaceans known or suspected to be sensitive to certain noise sources. In most cases these areas are large enough to offer significant protection from predetermined exposure levels of mid-frequency noise to coastal or near-shore cetaceans.

- Long-term visual and acoustic monitoring of species and acoustic monitoring of noise levels should be undertaken in existing cetacean-related MPAs and sanctuaries.

- Coastal states and MPA regional and national management authorities should explore options/tools for designing spatio-temporal buffer zones around existing and proposed spatio-temporal marine management areas (such as MPAs) that include cetacean habitat. Buffer zone distances would vary depending on species characteristics (i.e. seasonality, distribution, sensitivity, where fully known) and sound source characteristics (i.e. distribution, incidence, intensity, frequency, etc.). Many spatio-temporal marine management areas will require buffer zones if they are to most effectively reduce levels of ensonification to seasonally and/or permanently resident cetacean populations by human activities in surrounding waters. For example, special areas of conservation (SACs) under the EU Habitats and Species Directive are all (except one) less than 1,000 km^2 in size, while high-intensity low-frequency (and some mid-frequency) sources are likely to propagate at levels well above ambient/background throughout these areas even if the sound sources are well outside the SAC. Some areas may only need to be protected on a temporal basis, such as buffer zones for baleen whales which could be implemented only during feeding or breeding times when whales are present in an area.

- In the interest of cetacean conservation, coastal states should develop noise STRs independent of existing formally protected areas. For instance, a handful of countries have already designated their entire EEZs as cetacean protection areas. As noted above, these countries could be persuaded to prohibit the most invasive noise-producing operations (e.g. active sonar and seismic surveys using air gun arrays) from their waters, on an appropriate spatio-temporal scale, in areas or seasons of particular concern. Such action will, on occasion, be impossible (e.g. preventing shipping traffic from accessing an existing port), in which case effective mitigation measures should be imposed and rigorously enforced. Similarly, areas that serve as migration corridors but which do not enjoy MPA protection could have noise STRs instituted only during periods of use by cetaceans - akin to the fishing restrictions established in the U.S. when migrating leatherback sea turtles move though continental shelf waters offshore of the mid-Atlantic states.

- MPA management authorities and other stakeholders should review existing MPA management plans and evaluate their effectiveness with regard to protecting cetaceans from predetermined levels of intense noise sources. It would be valuable to identify potential quick-fixes related to noise, for example, maintaining quiet zones where noise sources don't currently exist (e.g. in the Marine Mammal Protection Zone of the Great Australian Bight Marine Park, which offers protection for southern right whales (*Eubalaena australis*) and Australian fur seals (*Arctocephalus pusillus*) from seismic surveys by regulatory exclusion). Conservation non-governmental organisations (NGOs), in particular, should try to raise public awareness and education about paper sanctuaries and the lack of inclusion of provisions to protect cetaceans from anthropogenic noise. NGOs, working with researchers, should set up a schedule for commenting on management plans for MPAs with cetaceans (existing and proposed MPAs), with the goal of inserting or enhancing relevant provisions.

- Identification of gaps between existing MPAs and areas subject to extensive noise-producing activities is required. Many MPAs are established opportunistically, not necessarily to address imminent threats to cetacean species. The conceptual Framework described below could easily be applied at the global level to look at known cetacean distributions, existing noise-related threats and the efficacy of existing MPAs (including national sanctuaries such as the cetacean protection EEZs mentioned above). This global analysis should lead to identification of priority areas where MPAs either do not exist or are not effective at addressing noise-related threats.

B FRAMEWORK

A systematic framework for designing noise mitigation zones and protected areas for the conservation of cetaceans

Summary

There is substantial uncertainty about the best way to mitigate geographically against the impacts of noise on cetaceans. Which places, for example, would be the most appropriate for the successful implementation of mitigation measures? It is important that approaches to identifying priority areas come with a plan for monitoring and learning about the efficacy of conservation strategies. There is a solid history and extensive literature on systematic conservation planning to provide guidance on efficient ways to design STRs and deal with uncertainty in an adaptive manner. Participants include a brief review of the literature and present a general Framework for spatial prioritisation of noise mitigation and cetacean conservation zones. The Framework is based on six general steps:

1. Setting measurable objectives and thresholds of acceptable performance and defining the geographic scope of the problem.

2. Identifying relevant expertise and available spatial and biological data to develop maps of key cetacean habitat.

3. Overlaying habitat maps with current and likely future threats to generate biodiversity threat map.

4. Identifying candidate priority mitigation zones by integrating threat surfaces and other relevant spatial information (including jurisdictional, industrial and other constraints and opportunity costs).

5. Identifying priority actions appropriate to each candidate mitigation zone on the basis of conservation efficiency from a set of potential candidate actions.

6. Implementing priority actions and monitoring their effectiveness. The importance of maintaining flexibility in the spatial prioritisation process is also discussed. In this way, management may adapt in light of new information that arises from monitoring the performance of conservation strategies.

Systematic conservation principles and tools

Historically, conservation planning has been largely ad-hoc and opportunistic, based around a reserve system biased towards areas of low production value and sites perceived as 'charismatic' (Pressey *et al*., 1993). Cetacean conservation is somewhat emblematic in this regard. This has led to an unrepresentative reserve network that, in isolation, is unlikely to adequately conserve biodiversity. Systematic conservation planning has evolved to redress this situation, presenting a framework for incorporating the best scientific information to help prioritise conservation action.

Systematic conservation planning is therefore the process of prioritising sites for conservation by optimising decisions across species and other values. The advantages of these tools include efficiency (both in the use of available resources and the avoidance of other societal costs), transparency and the ability to incorporate scientific knowledge into planning processes, while enabling an adaptive management system. The technique has proven to be useful in many settings, including identifying biodiversity hotspots (Myers *et al*., 2000), allocating land to a reserve system (Pressey, 1998), prioritising fishing exclusion zones (Fernandes *et al*., 2005) and identifying areas within the urban fringe that require special conservation attention (Cowling and Pressey, 2003).

Much modern conservation planning is guided by general principles from ecological theory. Principles drawn from island biogeography (MacArthur and Wilson, 1967), meta-population theory (Hanski, 1998) and niche theory (Connell, 1975) have been used to generate general rules such as: (a) larger areas of habitat are generally better than smaller areas; (b) more connected landscapes are more likely to maintain population processes than more fragmented ones (Lambeck and Hobbs, 2002); and (c) diverse habitat will generally support more species than uniform habitat. Such general ecological principles have been applied in conservation planning to attempt to maintain the highest possible range of biodiversity in the absence of specific data on individual species requirements.

Numerous methods exist for prioritising sites for conservation and optimising across species and other values. The simplest method is to rank sites according to a set of criteria: e.g. species richness, presence of threatened species, shape, proximity to roads, or acquisition cost (Margules *et al*., 1991). The chosen criteria should be able to be compared across the landscape and should ideally be numerical and independent (Root *et al*., 2003).

Reserve design algorithms take this simple approach further by ranking sites according to minimum specified targets. These tools allow managers to determine a network of conservation reserves that meets specified targets for reservation (e.g. 15% of all forest types) while minimising the economic cost (e.g. lost revenue from fisheries) (Possingham *et al*., 2000). Several software packages are available to assist with this process, including C-Plan (e.g. Kerley *et al*., 2003), MARXAN (Ball and Possingham, 1999) and ZONATION (Moilanen *et al*., 2005). The United States GAP analysis method (Jennings, 2000) is another example of this approach, whereby additional conservation reserves are selected and managed on the basis that they accommodate under-represented species or vegetation types.

Targets for the amount of habitat protection and its spatial configuration can be obtained from population viability models (e.g. Burgman *et al*., 2001) or empirically based conservation planning approaches (e.g. Lambeck, 2003). These optimisation packages can be used to optimise the economic value of the site (e.g. value of the fishery) subject to the biodiversity constraints. Similarly, the biodiversity values can be maximised, subject to economic and other constraints. In a marine setting, these two approaches to the problem allow the examination of tradeoffs between fisheries (and other values) and biodiversity conservation.

Margules and Pressey (2000) summarised the six stages of systematic conservation planning as:

1. Compile data on the biodiversity of the planning region
2. Identify conservation objectives for the planning region
3. Review existing conservation areas
4. Select additional conservation areas
5. Implement conservation actions
6. Maintain the required values of conservation areas

Margules and Pressey (2000) further stated that systematic conservation planning has several distinctive characteristics. "First, it requires clear choices about the features to be used as surrogates for overall biodiversity in the planning process. Second, it is based on explicit objectives, preferably translated into quantitative, operational targets. Third, it recognises the extent to which conservation objectives have been met in existing reserves. Fourth, it uses simple, explicit methods for locating and designing new reserves to complement existing ones in achieving goals. Fifth, it applies explicit criteria for implementing conservation action on the ground, especially with respect to the scheduling of protective management when not all candidate areas can be secured at once (usually). Sixth and finally, it adopts explicit goals and mechanisms for maintaining the conditions within reserves that are required to foster the persistence of key natural features, together with monitoring of those features and adaptive management as required. The effectiveness of systematic conservation planning comes from its efficiency in using limited resources to achieve conservation goals, its defensibility and flexibility in the face of competing land uses, and its accountability in allowing decisions to be critically reviewed. This is an idealised description of a process that is difficult to achieve in practice. Nevertheless, substantial parts have now been implemented around the world."
The many uncertainties in systematic conservation planning have led some to question the relevance of optimisation tools, particularly in rapidly changing landscapes (Meir *et al*., 2004).

Meir *et al*. (2004) argue that in these situations, it may well be more effective to use simple decision rules, such as protecting the available site with the highest irreplaceability or with the highest species richness, particularly when implementation occurs over many years. Few approaches have been developed that attempt to deal explicitly with the many uncertainties inherent in conservation planning (but see Moilanen & Wintle, 2006). The most coherent strategy for dealing with severe uncertainties in conservation planning is to take an adaptive approach (Walters & Holling, 1990) with a strategy for learning about the efficacy of conservation actions, though few examples of genuine application of adaptive management exist (Stankey *et al*., 2003).

Conservation planning has two key goals: representativeness and adequacy (also known as persistence) (Margules and Pressey, 2000). General ecological principles suggest possible mechanisms to improve the persistence of biota in the landscape, but do not adequately identify the relative costs and benefits or risks posed to individual species by alternative conservation plans (Lambeck and Hobbs, 2002). Few attempts have been made to optimise landscapes for both representativeness and persistence (e.g. Haight *et al*., 2002) and developing methods that integrate the two goals has been identified as an important area of needed research (Opdam *et al*., 2002). However, the primary value of a systematic framework for conservation planning is in the standardisation of approaches and introduction of transparency about the process that was used to arrive at final recommendations. In the remainder of this section, Participants provide such a framework that could be used in concert with spatial optimisation tools or using heuristic process (e.g. Delphi methods) to arrive at final recommendations.

A framework for identifying priorities for cetacean noise threat mitigation

During the Workshop, Participants agreed that there is a need to develop a systematic protocol for identifying and prioritising noise mitigation actions. Given that most mitigation strategies involve the identification of particular areas for protection or noise reduction, it can be argued that spatial prioritisation approaches are appropriate. The following paragraphs describe six steps proposed as a Framework for systematic prioritisation of noise mitigation. The Framework draws heavily on the general principles identified in the conservation planning and adaptive management literature, while being tailored to the context of noise mitigation for cetaceans. The description of the Framework (Figure 1 and text below) is followed by a general discussion about its features and the challenges likely to arise when implementing it.

1. Define the goal(s), constraints and geographic scope of the planning process

The first step in a site prioritisation model is to define a clear goal. A statement of goal should be explicit about where the plan applies the measures that will be used to assess its success and the constraints that apply. For example, a reasonable planning goal may be to: *"Identify noise exclusion zones within the Mediterranean sea that ensure at least 80% of suitable breeding habitat of all cetacean species is maintained free of noise impacts greater than X decibels with 95% confidence, while minimising the loss of oil exploration opportunities in the region"*. While this statement is provided as a hypothetical example, it provides the key requirements on which prioritisation could be structured: the geographic scope (*Mediterranean*), a measurable conservation target (*80% of breeding habitat maintained below X decibels*), the desired degree of confidence (*95%*), and a measure of social opportunity costs (economic opportunities lost). The goal itself is measurable and progress towards the goal can be monitored. Defining the goal is crucial to the transparency of the project and helps engage all stakeholders at the initial step of the model process. More sophisticated goals pertaining to probabilities of persistence may be specified but require substantially more technical expertise to assess and monitor.

2. Identify relevant data and data gaps

The second step in a site prioritisation model is to identify, compile and assess relevant data. At the heart of a site/action prioritisation model is spatial information on species habitat distributions, threats and socio-economic information. Such data are seldom available for all species and all social aspects of a conservation planning problem. Where substantial data gaps exist, research and data collection priorities are identified. In some instances, there may be a need for urgent collection of data before a prioritisation process can commence, but it is usually preferable to move forward with the data that are available and utilise expertise and expert models to make decisions that might be modified at a later stage when new data become available. It is extremely rare that better conservation outcomes arise by postponing decisions until more data are available. Consequently, the role of expert opinion is central to most conservation planning processes.It is important, however, for the sake of community trust that expert opinion is

recorded and used in a formal and transparent manner. Guidance on systematic approaches to developing expert models of species habitat, threats and social and economic values are sparse, though some advice does exist (USFWS, 1980; Crance, 1997; Rand & Newman, 1998; Burgman *et al*., 2001; Wintle *et al*., 2005; Burgman 2005).

Where appropriate data are available, species' habitat distributions may be predicted using statistical models (Wintle *et al*., 2005; Elith *et al*., 2006; and many others). If little or no biological survey data are available, expert knowledge may be used to construct habitat suitability indices (HSIs): using multiple experts for this purpose can improve their robustness and credibility. Presence-only data (also known as 'ad-hoc' data), which, by their nature, contain associated effort data, may be used to develop statistical methods using a variety of methods (Elith *et al*., 2006). Although slightly more robust than expert opinion models, presence-only models lack accepted methods for evaluating model performance (Wintle *et al*., 2005). Presence-absence data are used in a variety of regression models including generalised linear models (GLMs) (McCullagh and Nelder, 1989) and generalised additive models (GAMs) (Hastie and Tibshirani, 1990). Count data may also be used to construct biological models, though reliable count data are seldom available. For an overview of statistical methods for building species habitat maps, see Guissan & Zimmerman, 2000; Wintle *et al*., 2005; Elith *et al*., 2006; and abstracts by LaBreque, Kaschner, Cañadas, Wintle, in this report).

Threat data include any type of spatial data on anthropogenic threats to a species of concern. Examples include, but are not limited to: interpolated sound fields, areas of high shipping, areas of known seismic exploration, future areas of seismic exploration, and model outputs of predicted directions of oil spills. Socio-economic data include maps on current jurisdictional boundaries, current MPAs, and spatial information on the opportunity costs of implementing the MPAs and other representations of social preferences for biological conservation and competing activities.

3. Synthesise habitat and threat data to generate exposure ranking maps

The third step in the site prioritisation model is the synthesis of exposure maps from threat and biological data. The primary aim of this step is to identify areas of overlap between biodiversity values and threats to those values. The simplest way to synthesise these data would be identify a threshold of threat (in our case, noise levels) and thresholds of biological value (e.g. habitat quality) to develop a binary map of threatened and unthreatened biodiversity values. Depending on the availability of suitable data, a more sophisticated approach could produce a continuous map of exposure risk using a metric such as:

$$exposure_{ijk} = \sum_{j}\sum_{k} [pr(biovalue)_i * pr(threat)_k],$$

where $exposure_{ijk}$ represents the level of exposure to species j at site i from a given threat k. Threat maps may be species specific or general, depending on the level of detailed knowledge about how individual threats affect particular species. Where sufficiently detailed knowledge exists, particular weights may be assigned to particular species/threat combinations to delineate between different magnitudes of impact for that combination of species and threat. However, in the absence of such knowledge, it may be reasonable to assume equal impact to all species from particular types of threats.

In some situations, conservation planners may wish to weight species according to some social or scientific criteria. Traditionally, conservation effort is allocated according to the perceived endangerment of the species so that highly endangered species receive more immediate and substantial resources for conservation than less endangered species. However, this is just one priority-weighting approach among the many that can be utilised. It is seldom acknowledged that current approaches to conservation planning implicitly give more weight to species for which population status and threats are well studied and understood. Such species tend to be charismatic species or species of high economic interest due to their commodity value or indirectly through their tourism value. The default option in most situations would be to use equal weights (equivalent to not introducing weights) in the exposure mapping process, but weights are trivial to implement as long as a coherent process for determining them can be agreed.

4. Generate map of mitigation priority areas

Step four in the site prioritisation model integrates the exposure maps from step three with spatial data on existing opportunities and impediments, opportunity costs and any other spatial information on constraints and preferences that can be systematically incorporated in an objective statement. Existing opportunities and impediments include current MPAs that may provide opportunities for economic savings in implementation and increased connectivity of 'secure' habitats, and jurisdictional and social impediments such as areas of high oil value, multilateral regulation or important recreational zones.

Step four is the step commonly associated with systematic conservation planning 'algorithms' (e.g. MARXAN, C-Plan, ZONATION) that may be used to produce an '*optimal*' arrangement of potential conservation areas. Optimality has traditionally been defined as the solution that provides the most effective protection for a species or habitat for the least cost. Cost may be measured in terms of area, the lost opportunities for economic gain, the financial cost of not protecting (e.g. fish stock crashes or tourism failure) and potential financial rewards for protecting too (e.g. increasing fish stocks or thriving tourism in near-by areas) or some combination of the above. However, it is not necessary that systematic conservation planning algorithms be used in this step. Committee processes (e.g. Delphi methods) may be used to identify priority zones at the cost of forgoing optimality in the design. This may not be a problem in situations where the number of possible priorities and the number of decision variables are few; more complicated problems, however, may be difficult to implement using committee processes.

Whichever approach is used to identify spatial priority zones, the most important and difficult step is the development of a statement of objectives (or objective function in automated algorithms) that adequately reflects the preferences of the stakeholders. Specifying the objective function is critical because it determines the types of trade-offs that are considered 'acceptable' in the prioritisation process. For example, suppose that area 1 is the last known breeding ground of an endangered marine mammal population, but occurs on a potentially lucrative oil field; whilst area 2, which contains lower oil value, has average conservation value. Depending on how the objective function is specified (e.g. a simple division of bio-value by cost), it is possible that area 1 might receive a lower spatial priority value than area 2. If this is unacceptable to some or all of the stakeholders, then the objective function does not adequately reflect the true goal of the conservation planning exercise and must be modified. Careful specification of an objective function will provide a map of suitable sites that fit the criteria specified though the mapping of suitable habitat, the weighting of species importance, the sensitivity of species to threats, the uncertainty in the data and the infrastructural and social costs of implementing an MPA.

5. Identify and prioritise actions for priority conservation zones

If conservation actions were undertaken on an infinite budget, there would be no need to prioritise individual conservation actions according to economic efficiency because all actions could ultimately be implemented. However, conservation budgets are finite and some form of action prioritisation is necessary. Ad-hoc prioritisations can be wasteful and ultimately lead to sub-optimal conservation outcomes and loss of community trust. It is desirable therefore that a coherent and transparent approach is taken to prioritise actions. Numerous prioritisation protocols exist (Possingham *et al*., 2002).

Irrespective of the exact protocol used, some general prioritisation principles hold. Prioritisation should incorporate the concepts of conservation benefit, feasibility and cost efficiency. *Conservation benefit* reflects the amount of conservation value that is predicted to arise from implementing an action. If the action is preventative or ameliorative, the benefit may be measured in terms of the loss that has thereby been avoided: alternatively, if the action is restorative, the conservation benefit may be measured in terms of the predicted increase in biological value that will result from the restoration. Metrics can be defined in terms of expected increase in population sizes (or avoided decreases), changes in the probability of persistence of a species (or multiple species) in a region or any other coherent metric for benefit. Measures that directly reflect values of interest (e.g. population sizes or probabilities) are better than indirect or arbitrary indices of benefit. *Feasibility* reflects the probability that an action will bring the desired biodiversity benefit. There is no point investing in something that has little or no probability of succeeding. One may favour actions that have a high probability of bringing some benefit than actions with a very low probability of bringing a windfall. Finally, because conservation operates on finite budgets, the *cost* of one action implies a loss of opportunity to invest in other actions. Cheap, feasible, high-benefit actions are preferred to expensive, low-value actions with little probability of success.

Making this trade-off explicit enables conservation planners to explore trade-offs between competing actions and to point out exactly which options were not funded because of current budgetary constraints. This is also a very powerful way to communicate a case for increasing funding. One candidate model for combining benefit, feasibility and cost is presented in Figure 1; however, the exact manner in which these (and potentially other variables) are combined must reflect the specific goal of the conservation plan and the preferences of all stakeholders. Weightings for particular species may also be implemented at this point.

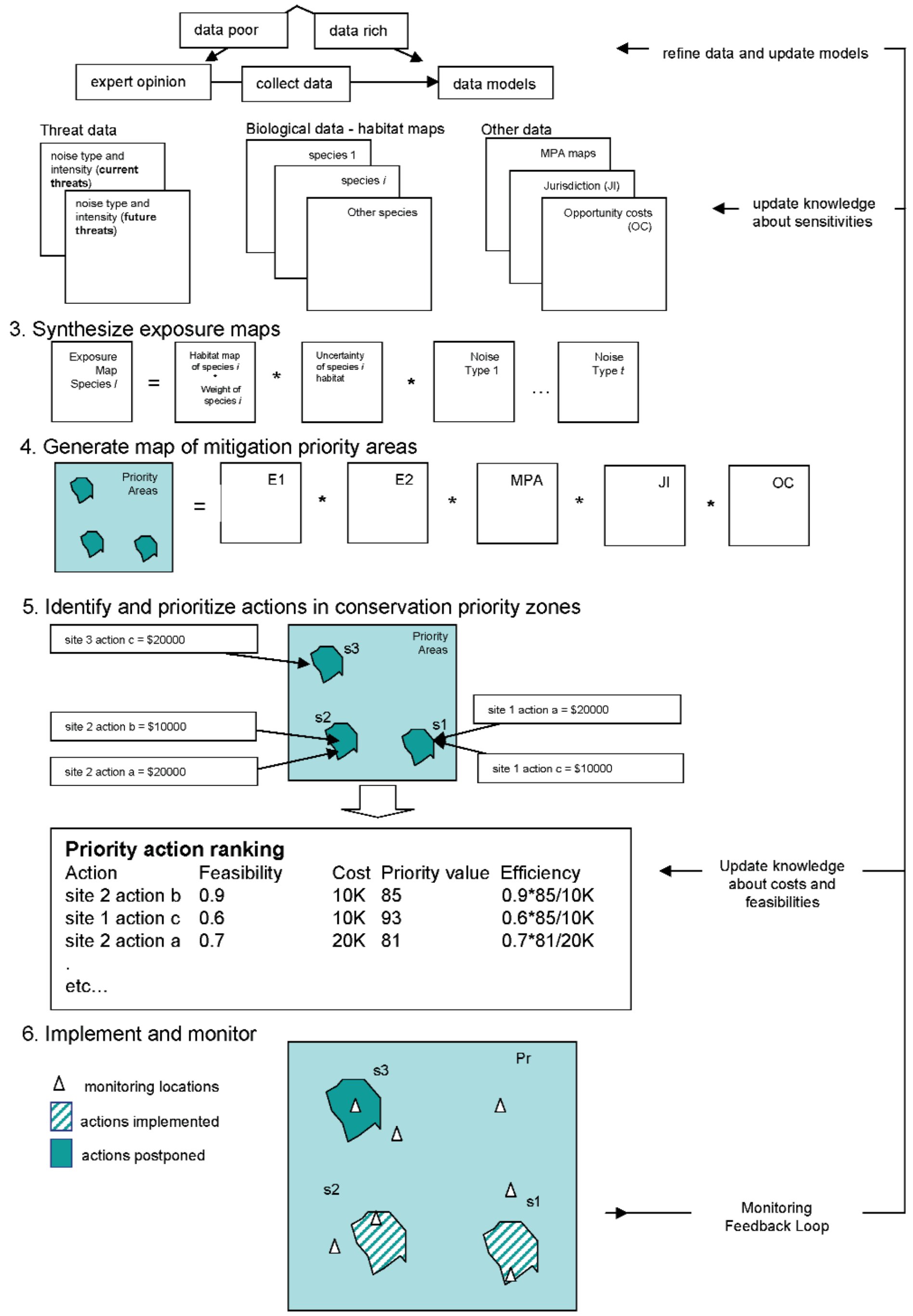


Figure 1.
Site Prioritisation and Adaptive Management Model

Step 1: Define the objectives of the conservation prioritisation

Step 2: Identify and compile relevant data

6. Implement and monitor

Implementation and monitoring are critical steps in conservation planning that are commonly overlooked. A surprising number of conservation planning initiatives simply do not get implemented (Knight *et al*., 2006). Sadly, monitoring the performance of conservation action is the exception rather than the rule, ensuring that adaptive management is almost never successfully adopted. Monitoring, or integration of monitoring data that is collected back into the decision-making process, is the missing link that makes adaptive management more than a 'nice idea'. Coordination between managers and scientists is essential to ensure the best possible implementation of priority actions and the monitoring of their success. The plan for monitoring is central to the success of the adaptive prioritisation framework because, without an effective monitoring strategy, the success of management actions cannot be assessed, meaning the state of knowledge and therefore the efficiency of future management will not improve. Implementation and monitoring should be closely integrated. Monitoring and the incorporation of the resulting data into the adaptive management process should be considered an integral component of management and designed and budgeted accordingly. The plan for monitoring should be designed well in advance of the implementation stage because it is usually apparent that some monitoring is needed prior to implementation.

Other issues

Non-spatial actions

This report deals with spatial prioritisation of conservation actions, primarily the identification of STRs. However, due to the current gaps in knowledge, spatial prioritisation may also have limitations and, in some circumstances, may not be the most effective option. Non-spatial mitigation and conservation actions include engineering or mechanical modifications, training and capacity building, social/tourism developments, community monitoring (integrated with strategic monitoring), independent observers on military, seismic or other vessels and assessment of required survey efforts to ensure that no cetaceans are present in observable impact zones. Many additional important non-spatial factors exist that are beyond the remit of this workshop report.

Dealing with uncertainty and data paucity

Uncertainty is often used as an excuse for inaction, resulting in deleterious environmental and biodiversity outcomes (Stern, 2006). Large uncertainties surround the impacts of noise on cetaceans, and are prevalent in cetacean distribution information as well as local patterns of sound propagation underwater. But failure to act on available evidence/expert opinion is in itself a decision with specific consequences that must be weighed against the costs and benefits of acting.

The Framework, as described above and in Figure 1, represents an example of passive adaptive management. It explicitly allows for the possibility that as conservation strategies are implemented, managers may learn (via monitoring) that previously preferred strategies are, in fact, sub-optimal and that alternative strategies should be explored. A systematic exploration of competing strategies, with a plan for learning about how those strategies work is known as *active* adaptive management. Active adaptive management is a coherent approach to dealing with uncertainty in situations where the optimal management strategy can't be known before actions are implemented. An adaptive approach to managing threats posed by noise would provide a sufficiently flexible and precautionary strategy that allows managers to adapt actions in light of improved information, changes in knowledge, and temporal and spatial variability in the distribution of cetaceans and threats. However, this represents a major bureaucratic challenge that must be addressed by policy makers.

Adopting a systematic framework for conservation prioritisation also helps to identify where existing knowledge limits the reliability of management decisions. For example, it may be insufficient for accurate conservation prioritisation decisions or it may preclude from making sensible ranking of competing strategies. A standard output of undertaking a systematic conservation prioritisation is a targeted research strategy aimed at filling critical knowledge gaps. To a large degree, the application of a systematic framework will precipitate the collection of baseline data to identify critical habitats of cetaceans and noise occurrence and encourage ground-truthing in areas predicted (either by models or experts) as being potential high-value habitats for sensitive species.

The use of experts

The Framework relies on both expert opinion and appropriate data being available to allow identification of the areas of likely overlap between significant noise threat and areas of high importance and to identify the biodiversity benefit of individual actions. A common criticism of systematic planning processes is that they require "sophisticated models that we don't have". This is not a reasonable criticism. In fact, conservation planning can be (and often is) undertaken solely with the use of experts. The value of our Framework is that it encourages experts to work transparently and in a common currency, justifying each of their choices and weightings with whatever evidence is relevant. For example, in the absence of systematic survey data it is reasonable (and indeed desirable) to develop habitat suitability indices (Burgman *et al.*, 1994) that can be used to develop maps of suitable habitat for the species of interest. Using experts in a structured way to develop maps for use in conservation planning introduces transparency to the process. Participants recommend that expert knowledge should be used in a structured way where empirical data is not available or is inadequate.

The Framework can be applied with or without the use of computer models and optimisation algorithms. Where insufficient computer skills exist, the process may be implemented with available maps and expertise. However, undertaking the process in such a way necessarily reduces the economic and biodiversity efficiency of the process, especially when the problem is multidimensional and involves numerous constraints and trade-offs that cannot easily be handled by the human mind. Furthermore, computer models may produce unexpected or counter-intuitive results that, by definition, would not be involved in decisions based on expert opinion alone.

Prospective assessment of the efficacy of conservation strategies

For the sake of clarity and simplicity, the current discussion of the prioritisation framework has deliberately avoided the topic of risk assessment and population viability analysis (Burgman *et al.*, 1993). Population viability analysis (PVA) is a specific form of risk assessment commonly used to quantify the probability that a species will decline to an unacceptably low population size within a particular timeframe. PVA has been used to prioritize investment in species conservation (IUCN, 1994), identify research priorities (Possingham & Lindenmayer, 1994) and rank management options (Wintle *et al.*, 2005). It is plausible that PVA could be used to determine the likely population consequences or benefits predicted to arise from a given spatial prioritisation proposal or option and to compare conservation options against the option of doing nothing (*status quo*). Options would usually be compared on the basis of the relative risks of extinction or the minimum population size expected over a given period into the future (McCarthy & Thompson, 2003). When competing management options (including doing nothing, as this is still a management decision) may drive listed endangered species to extinction, it is reasonable to expect that those with the jurisdiction to manage threatened species would undertake an assessment of the population consequences of actions. Given that the technology and expertise to undertake such assessments has existed for 20 years, undertaking PVA to assess the fate of threatened species would seem to be a minimum demonstration of due diligence. However, PVA is not widely used to assess the relative merits of competing management strategies. Participants recommend that efforts be made to assess the population viability of threatened cetacean populations under a range of management scenarios, although account must be taken of the substantial difficulty of applying PVA techniques to assessing the extinction risk of a cetacean population due to noise, alone and in combination with other factors.

Is this new?

The Framework described above represents an open, systematic process that the Workshop Participants recommend be adopted by managers and scientists working to conserve cetaceans in the face of a potential threat from noise. However, it does not represent a completely new process, rather a formalisation (and standardisation) of existing efforts. For example, when efforts were made to introduce protection across the Abrolhos Bank for breeding humpback whales from seismic survey noise (see Engel, this report) a similar process was followed. With that goal (Step 1) in mind, available data on the distribution of the various species in the area as well as the locations of planned oil and gas licenses were gathered (Step 2). The various potential exposures to noise and oil spills were compared (Step 3) and managers assigned to humpbacks and coral reefs (Step 4). This produced an indication of the protected buffer area required (Step 5), which was largely accepted by the Brazilian Environmental Agency (IBAMA) through implementation (Step 6). The current annulment (at time of printing) reflects a judge's conclusion that buffer zones must be created by a presidential decree or by a resolution from CONAMA (the Brazilian Environmental Council), rather than IBAMA action or rejection of the original declaration. Neither the size of the buffer zone nor its limitations were mentioned as problematic by the judge.

Conclusions

Conservation resources are finite and the designation and management of marine protected areas (including STRs) incur costs of management and social opportunity costs, although it should be noted that there could also be economic benefits arising from protective measures. Explicitly incorporating efficiency in prioritisation of mitigation measures reduces social opportunity costs while determining the most appropriate management actions that can be undertaken given available resources. An additional benefit to using a systematic prioritisation process is that the approach to identifying priorities is transparent and defensible. Once a systematic prioritisation protocol is instituted, it is a relatively straightforward matter for individual stakeholders to test the relative efficiency of alternative prioritisations or mitigation strategies that they favour and compare them to existing policies. Participants believe that adopting a systematic approach to prioritisation helps identify priorities efficiently and transparently, highlights the areas of data deficiency that most impact on the reliability of decisions and provides a sound basis for discussing and comparing competing conservation strategies.

OVERARCHING FRAMEWORK RECOMMENDATION

- Managers should apply the Framework described in this Report. As a priority, for example, ACCOBAMS should apply the Framework to investigate the options for establishing a network of noise-related sanctuaries within the Mediterranean.

DATA RECOMMENDATIONS

- Generate appropriate baseline data to identify important habitats for cetaceans and levels of noise occurrence. Survey (ground-truth) those areas modelled as being potential critical habitats for sensitive species.

- Noise producers should use detectability curves (a graph describing how the probability of detecting a species changes with increasing survey effort) to determine how long and under what circumstances they should survey an area for cetaceans (especially long-diving and cryptic species such as beaked whales and pygmy and dwarf sperm whales (*Kogia* spp.) to assure themselves with statistical confidence whether or not it is occupied and, if so, at what density, rather than concluding few animals are there simply as the result of inadequate survey effort.

- Managers and the public should have timely access to data on noise source characteristics, spatio-temporal distribution of use and mitigation protocols for noise-producing activities. Noise producers need to provide sufficient lead-time and notice (e.g. at least a year for significant projects) for planned timing of activities, to allow appropriate mitigation and scientific assessment of impacts ('before, during and after' studies; IWC, 2006).

- Expert bodies and extramural scientists should have a role in discussions surrounding site determination for intense anthropogenic sound-producing activities.

- Government agencies, research groups, industries and developers should allow open public comments to their activities and mitigation protocols when they involve sound sources with potential impacts to marine fauna including, but not limited to, active sonar, seismic surveying and/or the use of explosives.

- Expert reports should be required from independent sources, such as local research bodies, conservation organisations and federal environmental agencies.

- Complete information on past noise events, such as naval manoeuvres involving sonar, should be released in a timely and transparent manner by noise producers to allow for the independent analysis of potential correlations between biological and noise events, such as strandings with active sonar.

- In some areas (e.g. many parts of Asia and Africa), empirical data on the distribution, abundance and structure of cetacean populations exists but has not been compiled. Compilation of such data is essential for spatio-temporal mitigation of anthropogenic noise in these areas and increased emphasis on researching cetaceans in areas where such data do not exist, but where noise-producing activities are expected to occur, should be a priority for management funding. However, management should not be delayed during this process: the opinion of recognised experts can be used to supplement the limited data that is available.

SPECIES PRIORITISATION RECOMMENDATIONS

- CRITERIA FOR PRIORITISATION. Although it is likely that all cetaceans are impacted by anthropogenic noise to some degree, populations of certain species (such as beaked whales) have been identified as particularly sensitive, especially to some noise sources (e.g. mid-frequency military sonar). Moreover, some cetacean species are highly resident and occur in small isolated units (e.g. river dolphins, vaquita, *Phocoena sinus*, probably some beaked whales), have seasonal concentrations for biologically important activities such as feeding and breeding (e.g. humpback whales) and/or communicate using frequency bandwidths that overlap particularly strongly with anthropogenic sources (e.g. fin, *Balaenoptera physalus*, and blue whales, *B. musculus*, and commercial shipping). These characteristics may make these populations especially good candidates for spatio-temporal management. Another criterion for prioritisation must be conservation status of species and populations or, where this is unknown or data deficient, the likelihood of long-term irreversible harm.

- Stranding data worldwide, together with information on any concurrent noise events, if available, should be consolidated, both for the analysis of species distribution data and to detect possible correlation of particular species with anthropogenic acoustic events.

MONITORING FOR ADAPTIVE MANAGEMENT RECOMMENDATIONS

- Effective, timely and transparent stranding networks should be established to improve the probability of detecting strandings and of obtaining fresh samples. Priority should be placed on those areas subject to high noise disturbance and where such networks do not already exist or need improvement, such as the South China Sea and the PELAGOS Sanctuary in the western Mediterranean.

- Long-term monitoring, including passive acoustic monitoring, should be initiated in areas known to have ongoing high-risk acoustic activities (e.g. East Asia and Africa) and in existing cetacean-related spatio-temporal management areas and areas identified as possible candidates for future spatio-temporal management.

HABITAT PRIORITISATION AND MANAGEMENT RECOMMENDATIONS

Shipping noise

- The International Maritime Organization (IMO) should adjust routes, merge existing routes and/or create new routing measures or speed restrictions to minimise exposure of sensitive cetaceans to noise from commercial shipping and other large ocean-going vessel traffic. This approach has been utilised in the U.S. EEZ (shifting of traffic separation schemes in Massachusetts Bay relative to distributions of several endangered western North Atlantic baleen whale populations), the Canadian EEZ (shifting of traffic separation schemes and associated measures relative to North Atlantic right whale, *Eubalaena glacialis*, population in the Bay of Fundy) and within the Straits of Gibraltar and neighbouring Spanish Alborán Sea (shifting of traffic separation schemes and slowing of speeds relative to sperm whale, *Physeter macrocephalus*, population west of the Strait). National and/or regional regulatory authorities, cetacean scientists, shipping industry representatives and conservation organisations should initiate dialogues in areas with high traffic and sensitive cetacean populations in order to identify possible re-routings and/or consolidations that would balance the needs of species (protection from noise and collisions) and transport industries. Resulting proposals should be submitted to the IMO and coastal states for approval.

- To address the problem of low-frequency ambient noise, governments and stakeholders should promote the introduction within the IMO of ship-quieting technologies, such as those recently reviewed in the 2007 international symposium sponsored by the US National Oceanic and Atmospheric Administration (NOAA)[2].

Oil and gas exploration

- Oil and gas companies should identify new sites of interest before committing resources and communicate this interest to relevant conservation authorities (e.g. Environment Ministries of concerned countries and relevant international treaties, agreements or conventions in the high seas), to enable programmatic assessment, including spatio-temporal mitigation. A structure for programmatic planning is required; companies should avoid areas of concern, whether permanently or seasonally; and, initiate independent data collection, including long-term passive acoustic monitoring, in areas with limited information on cetacean distribution and abundance.

[2] For an overview of existing and proposed vessel quieting technology discussed at the symposium see: http://www.nmfs.noaa.gov/pr/acoustics/presentations.htm

Naval sonar

- Navies should commit to ongoing independent monitoring in all existing naval exercise areas to understand possible long-term population and individual impacts on marine biota. In addition, information about military exercises should be made available if presently unavailable, particularly in areas undergoing high-risk acoustic activities (e.g. East Asia). Precautionary spatial-temporal mitigation should be undertaken for both on-range and off-range naval activities and should also be used in the siting of ranges.

- North Atlantic Treaty Organisation (NATO) should make public its operational guidelines for mitigation of high-intensity active sonar.

Data access

- Navies, oil and gas companies and other noise producers must honestly and fairly balance the needs for transparency with security and/or industry competition. Formalised processes should determine what information on noisy activities can be made available to the public and/or regulators, keeping in mind the need for informed decision-making on mitigation. Where full public disclosure is impossible, processes to allow limited data sharing (e.g. through national security clearances of representative regulators and members of the public) should be established.

Research and management funding

- Maintaining the principle of 'polluter pays', the funding of research on baseline surveys for cetaceans in areas proposed to be ensonified, and the investigation of potential noise effects, should be managed and controlled independently so that scientists are not placed in conflict-of-interest situations with their noise-producing funders.

- States and regional bodies should continue to fund existing sanctuaries and MPAs to maintain current levels of protection from noise and other impacts, to prevent them from becoming paper sanctuaries and to inform future decisions surrounding effective management requirements.

Legal instruments for management

- Members of the IMO should initiate an amendment to MARPOL (the International Convention for the Prevention of Pollution from Ships) to include "energy" in its definition of pollution, consistent with Article 1(1)(4) of the U.N. Convention on the Law of the Sea (UNCLOS). More immediately, the IMO, as the only organisation competent to regulate international shipping, should consider possible options to reduce the impact of ship-source noise on marine life, such as building upon the IMO's Guidelines for the Identification and Designation of Particularly Sensitive Sea Areas (PSSAs), (Para 2.2 of Resolution A. 982(24)), which identify shipping noise as a marine pollutant. This could be done by using existing navigational measures (e.g. traffic separation schemes or areas to be avoided) or developing new ship quieting requirements. The IMO should consider the possibility of including ocean noise, together with ship strikes, as a new agenda item for its Marine Environmental Protection Committee (MEPC).

- Regional agreements can be an effective means of identifying and designating noise-related exclusion areas at a biologically appropriate scale. Existing agreements should extend their competence over noise, including OSPAR (the Convention for the Protection of the Marine Environment of the North-East Atlantic), ACCOBAMS (the Agreement on the Conservation of Cetaceans in the Black Sea, Mediterranean Sea and Contiguous Atlantic Area), the SPA (Specially Protected Areas) Protocol of the Barcelona Convention for the protection of the Mediterranean Sea and the SPAW (Protocol concerning Specially Protected Areas and Wildlife of the wider Caribbean region). In areas not currently covered by appropriate legal frameworks (e.g. east and south Asia, Africa), multilateral regional instruments with clear, enforceable mandates should be established.

- In general, underwater noise should be expressly classified as a pollutant (where not already so defined) by States and managed accordingly. Participants noted approvingly that the current proposal for an EU Maritime Strategy Directive includes underwater noise in the definition of pollution; once adopted, the Directive will require that EU Member States manage noise in European waters and will provide a model for analogous legislation outside the EU.

C CASE STUDIES

1. MEDITERRANEAN

i. PELAGOS Sanctuary

The PELAGOS Sanctuary is a large marine protected area, extending over 87,500 km^2 of sea surface in the north-western Mediterranean Sea, between south-eastern France, Monaco, north-western Italy and northern Sardinia, and surrounding Corsica and the Tuscan Archipelago (Figure 2). Sanctuary waters include the Ligurian Sea and parts of the Corsican and Tyrrhenian Seas, and comprise the internal (15% of its extent) and territorial waters (32%) of France, Monaco and Italy, as well as the adjacent high seas (53%).

The PELAGOS Sanctuary contains habitat suitable for the breeding and feeding needs of the entire complement of cetacean species regularly found in the Mediterranean Sea (Notarbartolo di Sciara *et al*. 2007). The two most abundant species in the Sanctuary, the fin whales and striped dolphins (*Stenella coeruleoalba*), accounted for over 80% of all cetacean sightings made during summer cruises conducted in the area between 1986 and 1989 (Notarbartolo di Sciara, 1994). About 3,500 fin whales are found in the western Mediterranean, most of which concentrate in the Corsican-Ligurian-Provençal Basin in summer to feed on krill (Forcada *et al*., 1996), although whales can be observed there year-round (Notarbartolo di Sciara *et al*., 2003). Striped dolphins are the most abundant cetaceans throughout the Mediterranean offshore waters (Aguilar, 2000); in the Sanctuary their numbers are 20,000-30,000 (Forcada *et al*., 1995) and accounted for 60% of all cetacean sightings in 1986-89 (Notarbartolo di Sciara, 1994). The remaining species are also regular components of the Sanctuary's cetacean fauna; these include deep-diving teutophagous odontocetes such as sperm whales, long-finned pilot whales (*Globicephala melas*) and Risso's dolphins (*Grampus griseus*), frequenting both offshore and slope waters (Di-Méglio *et al*., 1999; Gordon *et al*., 2000), and Cuvier's beaked whales (*Ziphius cavirostris*), favouring specific slope areas overlying submarine canyons (Nani *et al*., 1999); now rare and endangered short-beaked common dolphins (*Delphinus delphis*), found both in coastal and offshore waters particularly in the southern part of the Sanctuary (Bearzi *et al*., 2003); and predominantly coastal bottlenose dolphins (*Tursiops truncatus*), frequenting mostly the shelf areas surrounding Corsica, northern Sardinia, the Tuscan Archipelago, and continental France (Nuti *et al*., 2004).

The PELAGOS Sanctuary came into existence as a tri-national effort involving the countries of Italy, Monaco and France. In addition to being the first high seas MPA for cetaceans, it was designated a SPAMI (Specially Protected Area of Mediterranean Importance) under the Barcelona Convention in 2001. As such, its fate is of concern not only to the three countries but also to all the countries that have ratified the Barcelona Convention SPA Protocol (Notarbartolo di Sciara *et al*., 2007). In addition, permitting the development of new industries requires Environmental Impact Statements (EISs) above and beyond the requirements of any of the three participating countries.

The Secretariat for the protected area is housed in Genoa. A PELAGOS Marine Sanctuary management plan has been developed and amended, but has not yet been implemented. Very limited restrictions on noise currently exist in the management plan. There is extensive shipping traffic (Figure 3). However, unilaterally, Italy has proclaimed that it will not practice use of military sonar within the limits of the MPA.

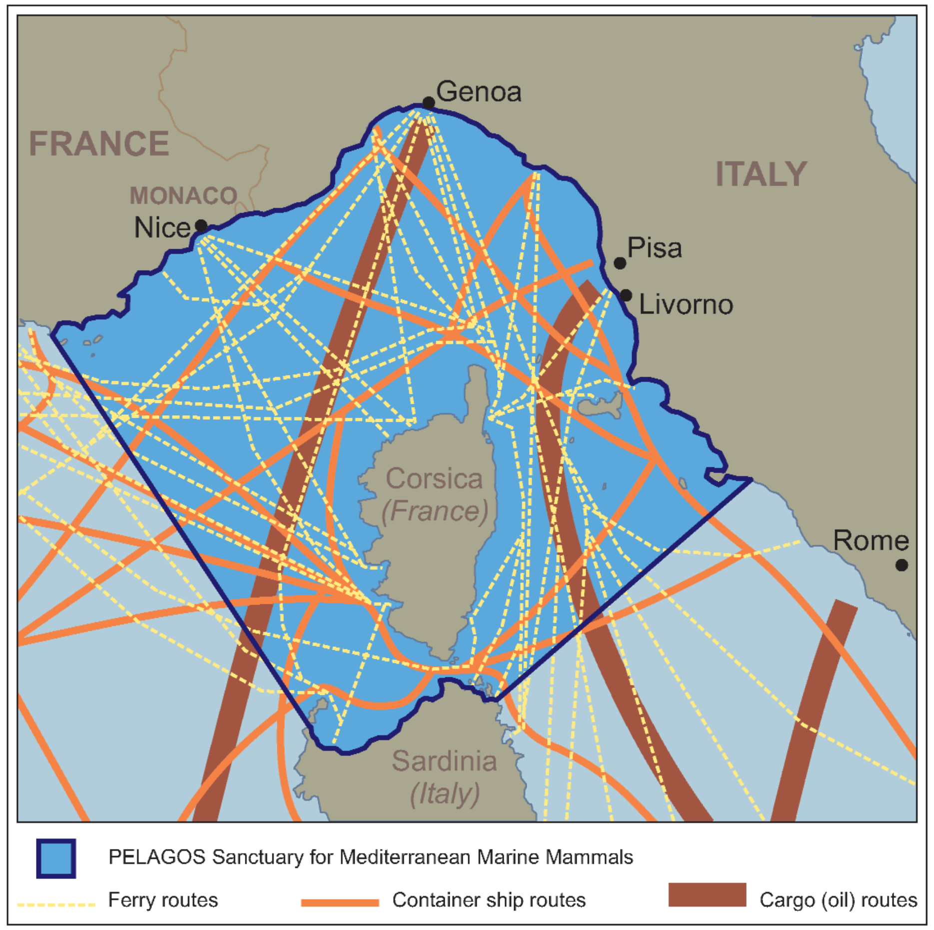
Because many of the cetacean species for which the sanctuary was created are threatened by unmitigated anthropogenic noise, the Workshop Participants **recommend** the establishment of the following supplemental management measures:

- Banning of all military sonar within the existing Sanctuary boundaries to protect the concentration of Cuvier's beaked whales.

- Banning of seismic surveys within the existing Sanctuary boundaries to protect the year around concentration of vulnerable cetacean species. Protection should be designed around important habitat for fin whales, known to be sensitive to this source type (Clark and Gagnon, 2006), but also to provide protection for other species.

Figure 2.
A map of the PELAGOS Sanctuary

Figure 3.
A map of the PELAGOS Sanctuary including shipping lanes



- Creation of a seismic noise threat buffer zone to extend from the western boundary of the Sanctuary (and paralleling it) to provide additional protection to fin whales and striped dolphins. The dimensions of this buffer should be based on isopleths estimated by modeling (and ultimately measuring) acoustic propagation in the local marine environment and distribution and avoidance information for fin whales and other local marine animals with documented acoustic responses to seismic activity. Where documented response to seismic is absent but the species is known to be acoustically active and/or responsive to other acoustic source types, precaution should dictate inclusion of protection for these species in buffer zone development.

- Engagement with the IMO, shipping industry and fast-ferry community to reroute a limited number of shipping lanes (including ferry routes, cargo and tanker traffic) away from species sensitive to this source type (and vulnerable to ship strikes), possibly using an additional PSSA designation.

- Undertaking of further research into the appropriate placement of shipping routes. Compliance of ship movements should be undertaken using vessel-monitoring systems (VMS), such as AIS (Automatic Identification Systems), and other noise activities should be monitored for compliance using strategically positioned passive acoustic buoys.

- Encouraging the PELAGOS Sanctuary Permanent Secretariat to initiate dialogue with commercial shipping companies using the area to employ ship-quietening mechanisms such as those recently reviewed in an international symposium sponsored by the US National Oceanic and Atmospheric Administration (NOAA).

- Strengthening of the existing stranding network, with increased capacity to conduct appropriate and timely necropsies aimed at detecting gas and fat embolic syndrome, ship-strike trauma, etc. (and to include training and the establishment of tissue banks).

ii. Proposed MPA in the Alborán Sea

The Participants noted that the Alborán Sea-Strait of Gibraltar is the most cetacean diverse area in the Mediterranean with year-round populations of bottlenose, striped, common and Risso's dolphins, fin whales, sperm whales, long finned pilot whales, killer whales (*Orcinus orca*), and Cuvier's beaked whales (Cañadas *et al.*, 2002). The Alborán Sea-Strait of Gibraltar has recently been proposed by the ACCOBAMS Scientific Committee for consideration as an MPA by the ACCOBAMS Parties and is now in the very early stages of being considered by Spain and Morocco for the "creation of a shared Management Plan to ensure the conservation of its biodiversity and sustainable use of its prioritisation"; it is hoped that Algeria will be included in due course. The Participants agreed that the boundaries proposed for the Alborán Sea (Figure 4) by the ACCOBAMS Scientific Committee were currently sufficient to give protection from mid-frequency sonar and seismic surveys in areas of high probability of occurrence of sensitive species. The Participants considered various noise issues for cetacean populations in the Alborán Sea. Specifically, the group was very concerned about military manoeuvres (including ordnance explosions and sonar) throughout the region, particularly given the associated strandings of several Cuvier's beaked whales in January 2006 (Fernández, 2006).

The following **recommendations** were therefore considered imperative:

- Considering the available knowledge of the high density of cetaceans in the Strait of Gibraltar, Participants recommend navies employ effective mitigation in the use of sonar in the Strait of Gibraltar and avoid all use of sonar in the Alborán Sea, where important Cuvier's beaked whale habitat has been identified.

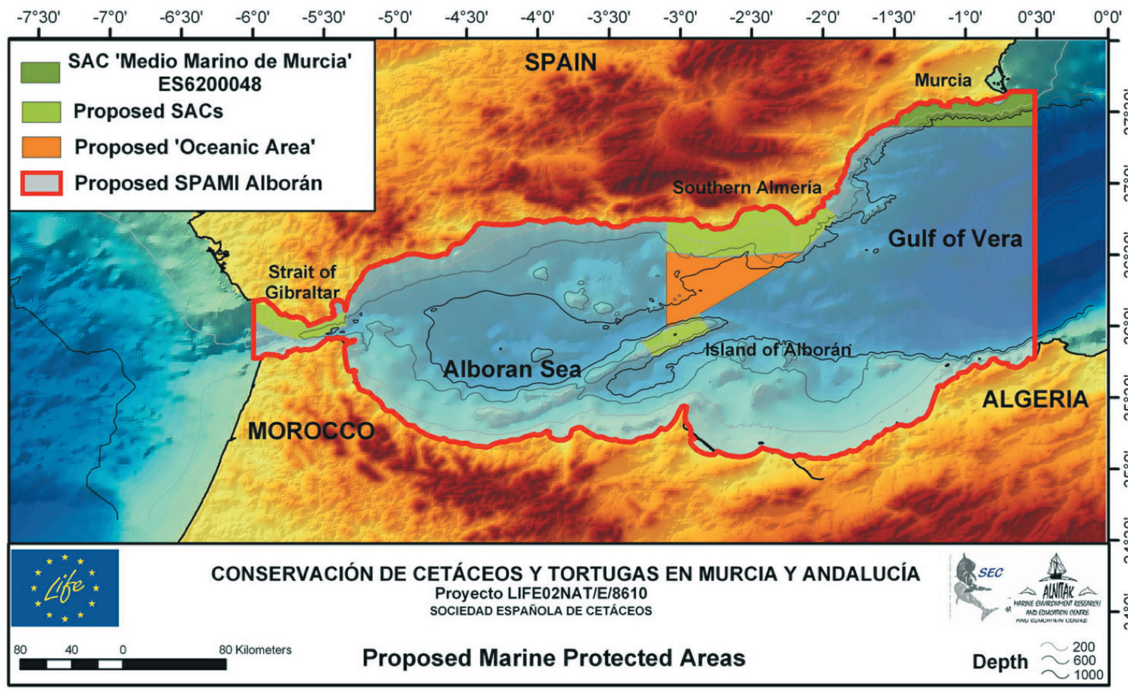
- Seismic surveys should be avoided throughout the proposed area until appropriate regulations or guidelines for mitigation are set in place by national governments.

- Shipping lanes should be established after appropriate research to determine their best location to minimise the exposure of sensitive cetaceans to the cumulative high intensity noise generated by maritime traffic.

- Encouraging the PELAGOS Sanctuary Secretariat to initiate dialogue with commercial shipping companies using the area to employ ship-quietening mechanisms.

- The European Commission should be urged to designate the north-eastern section of the Alborán Sea as a SAC under the EU Habitats and Species Directive and to exercise its monitoring/enforcement functions to ensure that Spain fully implements the proposed SAC and that all EU Member States comply with their obligations to avoid any deliberate disturbance of cetaceans in the area (EU Habitats and Species Directive, Article 12; see Cañadas *et al*., 2005).
- An appropriate stranding network should be created on the North African coast, and improvement of that on the Spanish coast, with capacity to conduct appropriate and timely necropsies (and to include training and tissue banks).

Figure 4. Proposed MPA in the Alborán Sea



iii. Proposed MPA in the Hellenic Trench

The Participants commended the ACCOBAMS proposal for an MPA covering the Southwest Crete-Hellenic Trench that would protect populations of sperm whales and Cuvier's beaked whales in the eastern Mediterranean Sea. The proposal lies mainly within the national waters of Greece, which is a party to the ACCOBAMS agreement, and also extends offshore into international waters.

In 2002, the ACCOBAMS Parties adopted the Southwest Crete-Hellenic Trench as a potential pilot MPA, following the proposal of the ACCOBAMS Scientific Committee. Although this MPA has yet to be designated, the ACCOBAMS Scientific Committee re-asserted the urgency to create this MPA at a one-day MPA Workshop in November 2006 and, in early 2007, refined the proposed boundaries (Figure 5).

Recognising that:

1. Sperm whales may be particularly sensitive to noise directly and indirectly (through collisions) and that the Mediterranean population of this species is likely to be very small and has suffered the removal of a significant number of individuals (from pelagic driftnets and collisions) in past decades;
2. In 2006 an IUCN-ACCOBAMS meeting of experts formally proposed the listing of the Mediterranean sperm whale population as Endangered;

3. Cuvier's beaked whales have been subject to mass strandings from sonar events in the Eastern Mediterranean and the species is generally known to be susceptible to sonar and other noise sources; and
4. Sperm whales and Cuvier's beaked whales inhabiting the Hellenic Trench are subjected to substantial noise level pollution from shipping traffic, military sonar, illegal dynamite fishing and increasing seismic survey activity,

the Workshop Participants **recommend**:

- The immediate cessation of all seismic and military sonar activities in this area and the introduction of caution to shipping when crossing the area until appropriate noise protection zones, mitigation measures and shipping lane regulations can be put into place, as part of the structure of an MPA.
- The enforcement of national legislation by the Greek authorities, so that all illegal activities related to dynamite fishing along the Hellenic Trench (and in all Greek Seas) are stopped.
- The designation by Greece of the SW Crete-Hellenic Trench MPA with a follow-up management plan to address threats to the species and the ecosystem.
- Shipping lanes should be established after appropriate research to determine their best location to minimise the exposure of sensitive cetacean species, such as the deep divers, to the cumulative high-intensity noise generated by maritime traffic.
- An appropriate stranding network should be created all along the Hellenic Trench and the Greek coastline, with capacity to conduct appropriate and timely necropsies.

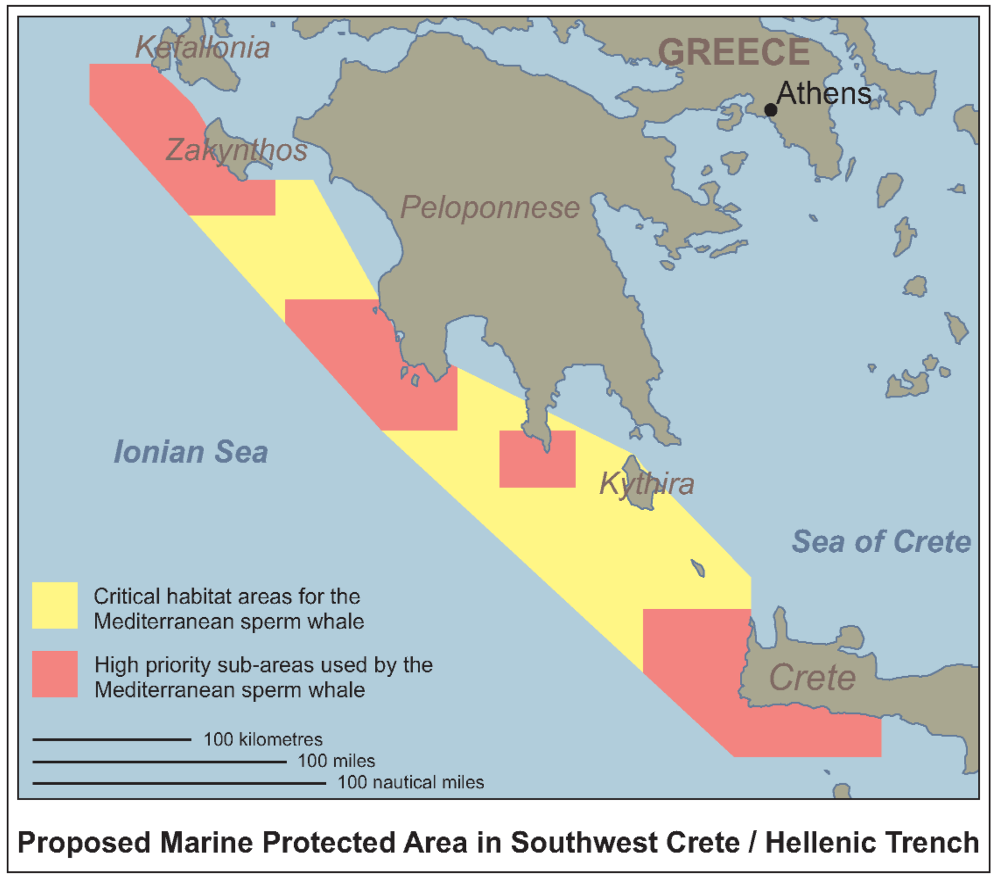


Figure 5. Proposed MPA in Southwest Crete/Hellenic Trench

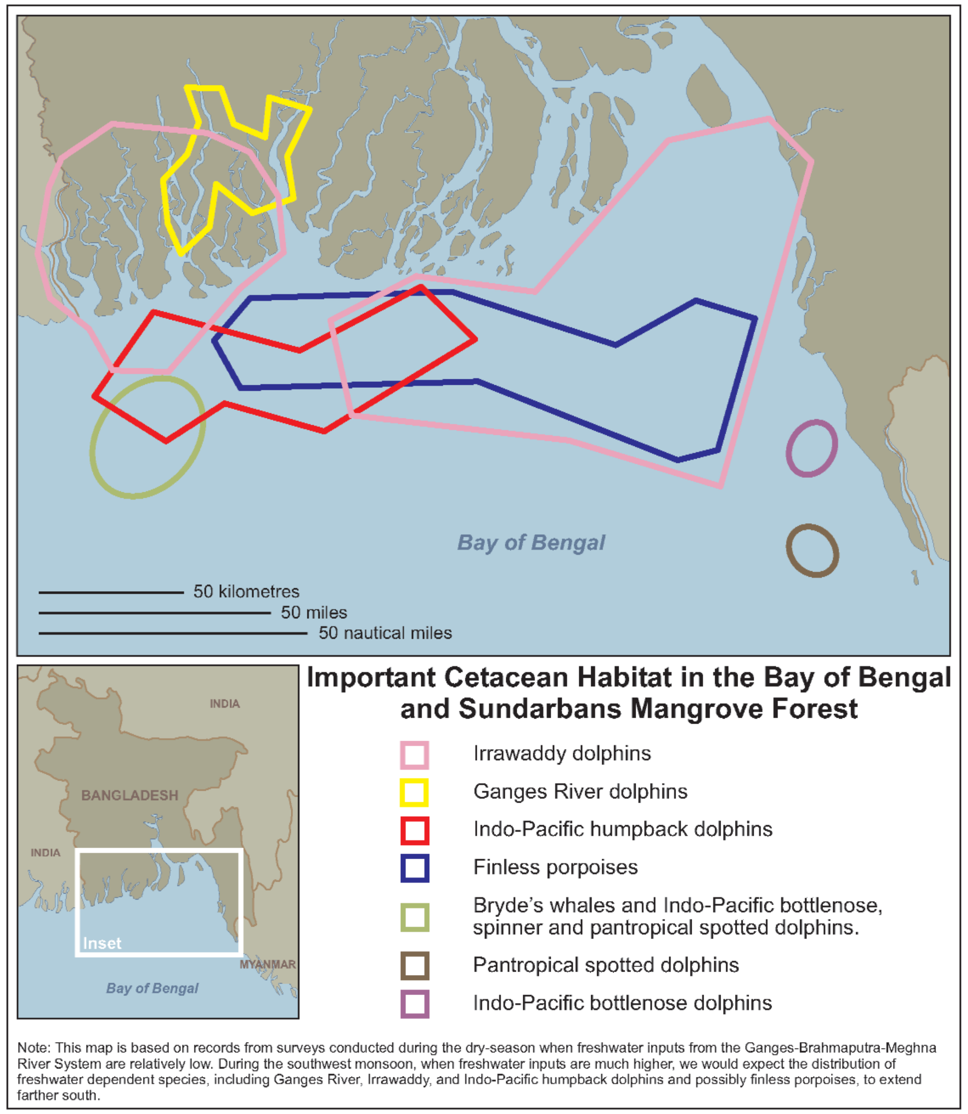
2. SOUTH AND EAST ASIA

i. Bay of Bengal

A 120-km wide belt of mangrove forest, open estuarine and deep-sea canyon waters in the northern portion of the Bay of Bengal in Bangladesh has been identified as an important region of cetacean diversity and abundance, supporting globally significant populations of several species at risk (Figure 6). Waterways of the Sundarbans mangrove forest in the northern portion of this belt encompass the farthest downstream range of the endangered Ganges River dolphins (*Platanista gangetica*). In a generally narrow geographic band occurring within the same habitat is the farthest upstream distribution of a seasonally mobile population of Irrawaddy dolphins (*Orcaella brevirostris*). Farther offshore but still occurring in habitat influenced by freshwater inputs are Indo-Pacific humpback dolphins (*Sousa chinensis*) and finless porpoises (Neophocaena phocaenoides). Then, a relatively short distance from the rim of the mangrove forest is the Swatch-of-No-Ground, a 900+ m submarine canyon where upwelling currents support large groups of Indo-Pacific bottlenose (*Tursiops aduncus*), spinner (*Stenella longirostris*) and pan-tropical spotted dolphins (*S. attenuata*), as well as a probable resident population of Bryde's whales (*Balaenoptera edeni/brydei*).

The diversity of cetaceans occupying this relatively small area is remarkable, and rigorous abundance estimates of Ganges River, Irrawaddy, and Indo-Pacific bottlenose dolphins, as well as finless porpoises, indicate that large populations of these species remain. However, optimism about the long-term survivability of cetaceans in these waters is tempered by increasing threats from incidental killing in gillnet and trawl fisheries as well as habitat loss and degradation through development and other commercial and industrial activities.

Figure 6. Important cetacean habitat in the Bay of Bengal



Although these waters are relatively quiet, especially compared to other areas in Asia (e.g. Taiwan Strait), looming threats to cetaceans from noise include a dramatic increase in commercial shipping traffic and port construction, as well as offshore gas exploration and development. With a successful effort to address the realised threat from bycatch and the potential threat from noise, Bangladesh could serve as a critical safety net for freshwater and coastal cetaceans whose populations are disappearing elsewhere in Asia and as a "control" for comparison to other areas where many of the same species occur in much noisier waters.

The Workshop Participants therefore make the following **recommendations**:

- In some areas (e.g. Asia), empirical data about species and their ecology have been systematically collected but not compiled to allow cetacean habitats to be identified for noise management. These areas are often located either where noise sources are pervasive but unaddressed as a threat to cetaceans (e.g. in the South China Sea), or where waters are currently relatively quiet but where potential future threats from noise could tip the balance of population or species extinction in the midst of concurrent non-noise related threats, such as incidental and deliberate killing and declining prey from over fishing (e.g. in the Bay of Bengal). For these areas, the compilation of existing data on cetacean abundance, distribution, ecology, and population structure should be given high priority so that biologically important habitats are not excluded from decision-making for the spatio-temporal management of noise. This exercise will also lead to a better understanding of knowledge gaps that should be prioritised for field survey efforts.

- In areas identified as high priority for noise management, a wider variety of local scientists and resource managers should be engaged for gathering and analysing data needed for science-based management decisions and for monitoring the efficacy of these decisions. This recommendation applies particularly to Asia where knowledge of noise issues is virtually non-existent among most conservation scientists (despite the Asian continent supporting the largest number of cetacean species at risk) and where national governments will be reluctant to assertively address them without the strong support and engagement of local authorities.

ii. East Asian waters

East Asia has some of the largest commercial ports and the most extensive coastal development in the world, including oil and mineral exploration and extraction activities that are rapidly increasing, and blast fishing (using explosives) which continues in many areas. Furthermore, growing political tensions in East Asia have resulted in increasing military activities (by the US, Taiwan, China, Japan, the Koreas and the Philippines) in local waters. Powerful naval sonar (e.g. mid-frequency active sonars, low-frequency active sonars) that has been linked to cetacean deaths in other regions of the world is also being used widely in East Asian waters. However, the level of knowledge about cetacean distribution and abundance as well as the levels, distribution and spatio-temporal usage of noise sources is lacking. Examination of a limited number of carcasses of unusual stranding events in Taiwan in 2004 and 2005 resulted in the finding of severe internal injuries to anatomical features related to diving or acoustics (Wang and Yang, 2006).

Known cetacean habitat and MPAs in East Asia are shown (Figure 7). There is presently little, if any, effective protection for cetaceans from noise (and many other threats) and little attention or awareness of noise as a threat to cetaceans in this region. Noise from military sonar usage and other sources is unlikely to decrease in the near future. Still, areas of concentrations and relatively high diversity of sensitive species need to be identified so that noise threats can be managed to minimise exposure for local species and populations in important habitats.

The following is an initial attempt at identifying some research needs to fill important information gaps for a high-risk region. Areas of particular concern include the northern South China Sea and shelf edge and adjacent waters from Japan through Taiwan to the Philippines (recognising that the identification of this region is not an indication that cetaceans in other regions are not affected by noise, but that discussions were limited to these areas). Further to the application of the overarching Workshop Recommendations to this region, the Workshop Participants **recommend**:

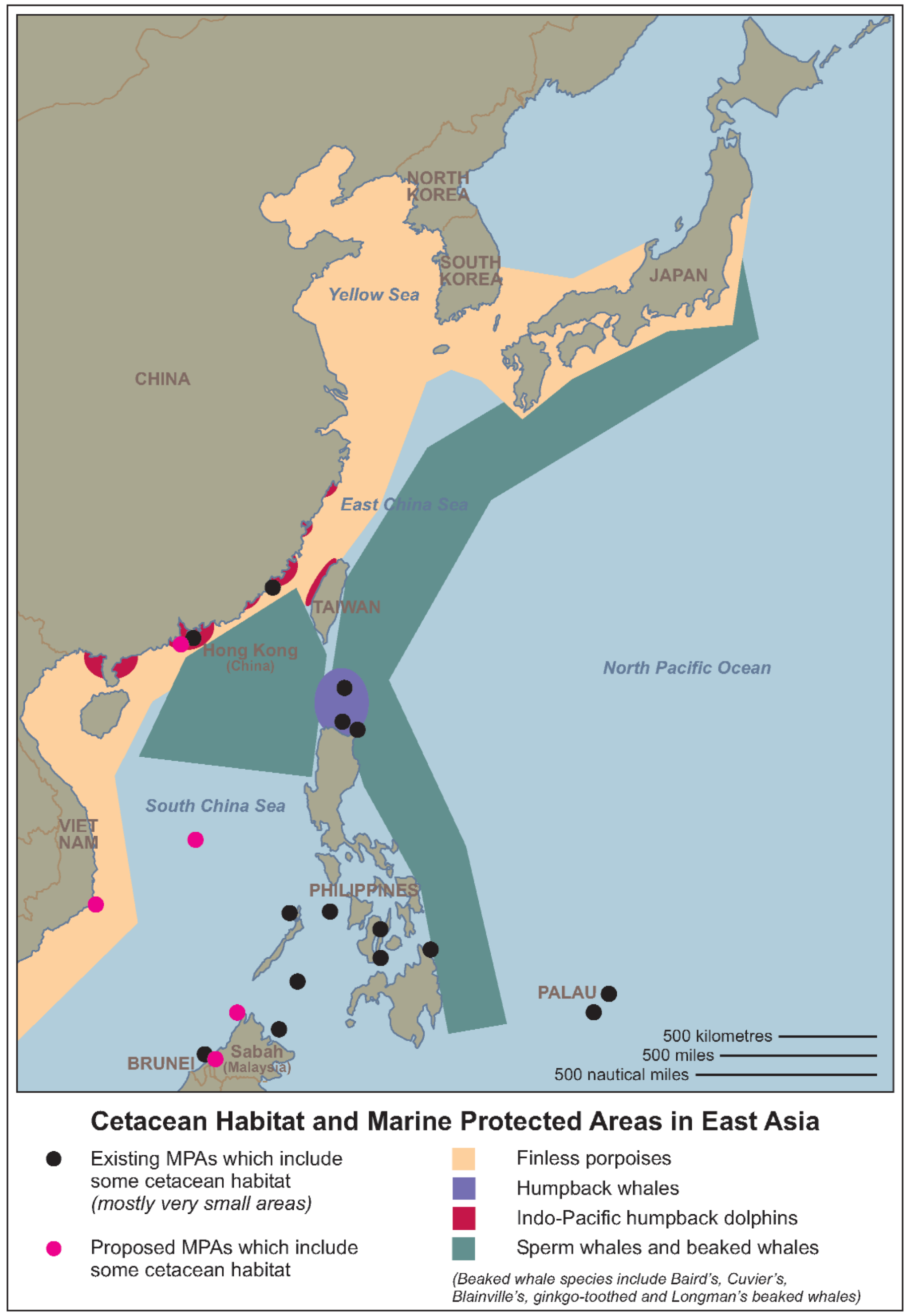
- That research be undertaken to understand the distributions of and impacts of noise on Indo-Pacific humpback dolphins, finless porpoises, other species of concern including deep-diving species such as beaked whales, sperm whales and *Kogia* spp., humpback whales (both on their wintering/calving grounds and on migration routes), the Bryde's whale complex, Indo-Pacific bottlenose dolphins and short-finned pilot whales (*Globicephala macrorhynchus*), throughout the entire region. Both wide-scale visual and acoustic monitoring are recommended.

- That consideration be given, in the planning of military activities, to seasonal issues for military activities (including weather and sightability issues affecting potential mitigation and monitoring, such as winter monsoon winds during typhoon season) that might affect the presently known humpback whale calving ground in the northern Philippines and other possible baleen whale wintering grounds.

- Efforts should be made to preserve entire carcasses of stranded cetaceans (especially deep-diving or oceanic species) for examination by experienced researchers and to collaborate with international experts on cetacean pathology.

- All unusual stranding events should be examined with considerations of recent military or other activities emitting intense amounts of energy (e.g. live fire target practice, seismic research) in local and neighbouring waters.

Figure 7.
Cetacean habitat and MPAs in East Asia



ABSTRACTS FROM WORKSHOP PRESENTATIONS

Session 1. The role of MPAs as a mechanism to protect marine life from noise pollution

I. Global MPAs - Tundi Agardy
II. MPAs and Cetaceans: The role of MPAs as a mechanism to protect marine life from ensonification - Erich Hoyt
III. Abrolhos Bank: The role of MPAs in the protection of the most important humpback whale breeding ground in the Western South Atlantic - Marcia Engel
IV. The Gerry E. Studds Stellwagen Bank National Marine Sanctuary as a model for characterizing and managing the marine acoustic environment - Leila Hatch
V. Canary Islands naval moratoria - Natacha Aguilar de Soto and Vidal Mártin

I. Global Marine Protected Areas

Tundi Agardy

There are currently several thousand marine protected areas (MPAs) around the world, ranging in size and scope from small fisheries reserves to large multiple use areas. The largest MPA to date is the newly designated NW Hawaiian Islands Sanctuary, which will likely be zoned for different permissible uses at some point in the future. A review of these existing protected areas, coupled with theoretical explorations of MPA design, suggest that only a few MPA types could serve as models for innovative noise-free sanctuaries for cetaceans. Given the large home ranges of most cetacean species and the fact that certain classes of sound propagate for exceedingly long distances underwater, small reserves will probably not prove useful.

Most fisheries reserves that have no-take and even no-go restrictions provide useful lessons because of the simplicity of their restrictions, however most of these reserves are quite small and would therefore not demonstrate the design principles marine mammologists would look to for noise abated cetacean sanctuaries. At the same time, large multiple use MPAs like those of NW Hawaiian Islands, Great Barrier Reef, and the Florida Keys National Marine Sanctuary are likely too complex to demonstrate generic principles for noise-free cetacean sanctuary design. Probably the best model is IMO's Particularly Sensitive Sea Area (PSSA) designation, through which large areas of the ocean are deemed important and sensitive enough to warrant restrictions on international ship traffic above a certain tonnage. Because of the apparent sensitivity of certain cetacean species to both LOFAR and SONAR, such cetacean sanctuaries will have to look for ways to restrict not only merchant shipping and passenger vessels, but also most importantly, military ships using or testing sound-based surveillance and weapons use.

Noise-buffered protected areas should be established not only in places that are known to be critical habitat for sensitive or vulnerable cetacean species, but where opportunities to control the many possible sources of noise dangerous to cetaceans exist. While considerations of feasibility should not drive the design and siting of noise-abating MPAs, they will be important in choosing some pilot MPAs to demonstrate the utility of the MPA tool in reducing risk to cetaceans.

II. MPAs and Cetaceans: The role of MPAs as a mechanism to protect marine life from ensonification

Erich Hoyt

Marine protected areas (MPAs) can be valuable tools for cetacean conservation if they help address and manage threats to cetaceans. This value could increase if MPAs could also help reduce the ensonification of cetacean species from various loud impulse sounds, as well as from the increasing ambient noise due to human activities in the ocean. At present, more than 350 MPAs worldwide feature or include cetacean habitat (Hoyt 2005). Another 175 areas have been proposed. Yet few MPAs are thought to provide effective protection from ensonification such as ship traffic, sonar or from seismic exploration, although controls in some areas on oil and gas exploration and other activities may reduce such ensonification. The most common noise stipulation in many cetacean areas may be found in whale watch regulations (Carlson 2005).

However, even if there were regulations reducing ensonification, are existing MPAs large enough to protect cetaceans from noise? The size of the MPA needed depends on the species sensitivity, the location (bathymetry and bottom topography) and noise source (dB, directionality, frequency, duration/repetition). Still, it can be said in general terms that some protection may be conferred if loud mid-frequency sounds of over 200 dB are excluded from areas several tens of kilometers away from critical habitats (implying an area on the order of at least 1000 km^2), while protection from loud low-frequency sounds of over 200 dB might require hundreds or even thousands of kilometers distance from sound sources (implying areas on the order of a million km^2 or more).

Of the 350 MPAs with cetacean habitat, 225 have precisely known sizes for the area of marine protection. At present only 64 of these are 1000 km^2 or larger: 44 MPAs are 1000-9,999 km^2; 14 are 10,000-99,999 km^2; and only 6 MPAs are 100,000-350,000 km^2. (Another 71 MPAs are in the category of 100 to 999 km^2 and could confer some mid-frequency protection if outer low-noise zones were added.) Currently, no area can confer protection from loud low-frequency noise unless national or international sanctuaries could be converted to reduced ensonification or low-noise zones. The 20 national EEZ sanctuaries range in size from 120,000-16 million km^2, with most on the order of 1 million km^2. National sanctuaries offer minimal cetacean protection (except from cetacean hunting) and have no specific management plans, but countries are responsible for managing resources within their EEZ. Two international sanctuaries (the Southern Ocean Sanctuary at 50 million km^2 and Indian Ocean Sanctuary at 103.6 million km^2, both designated through the IWC) would seem to offer some potential but it may be more productive to work within regions such as Latin America with the Eastern Tropical Pacific Seascape (2.1 million km^2) and ACCOBAMS (Agreement on the Conservation of Cetaceans of the Black Sea, Mediterranean Sea and contiguous Atlantic Area) with the PELAGOS Sanctuary for Mediterranean Marine Mammals (87,492 km^2).

To initiate provisions that would reduce ensonification of cetaceans in critical habitat areas, management plans need to be examined for all of the 350 cetacean-habitat MPAs (as well as the 175 currently proposed) to determine the current status regarding provisions related to noise and when the management plan will be prepared or next come up for review. Is it possible to designate or create new low-noise zones surrounding existing MPAs? Further work on designing MPAs from the start with noise mitigation and reduction of ensonification in mind could be very productive.

III. Abrolhos Bank: The role of MPAs in the protection of the most important humpback whale breeding ground in the Western South Atlantic

Marcia H. Engel

The Abrolhos Bank (56,000 km^2) is an enlargement of the Brazilian continental shelf which represents the largest and most biodiverse coral reef system in the South Atlantic, with about 9% of its area within Marine Protected Areas (MPAs). The first MPA created in Brazil, the Abrolhos Marine National Park, is located within this area and protects a rich endemic coral reef system. Humpback whales (*Megaptera novaeangliae*) aggregate at Abrolhos Bank during the spring-winter season for breeding and calving. Since 2001, the Instituto Baleia Jubarte and Humpback Whale Institute - Brazil have undertaken aerial surveys and research cruises to evaluate the population size and distribution of this species along the coasts of Bahia and Espirito Santo states. These studies have demonstrated the importance of the Abrolhos Bank as the main breeding and calving ground of the Southwestern Atlantic humpback whale population, concentrating 84% of the individuals.

In 2003, due to uncertainties regarding the negative impacts of seismic activities for oil exploration on cetaceans, in particularly the importance of the area for the reproductive cycle of the Brazilian humpback whale population, and based on the "*precautionary principle*", the prohibition of seismic surveys during the humpback whale breeding season, from July to November, was proposed to the Brazilian Environmental Agency (IBAMA). IBAMA agreed to incorporate this guideline in the "Guide for licensing of oil activities in the Brazilian coast" and this restriction is currently enforced. The discussion was extended to other areas of concentration of endangered species of marine mammals (*Pontoporia blainvillei*, *Eubalaena australis*, *Balaenoptera edeni* and *Trichechus manatus*) and five species of marine turtles along the Brazilian coast. As a result of the discussion a new edict is being published with clear benefits for conservation.

Also in 2003, a major portion of Abrolhos and Royal Charlotte banks were to be offered in an international auction for concession of blocks for oil exploration and exploitation by the National Oil Agency (ANP). Following discussions with Conservation International - Brazil and partners, an Impact Assessment was carried out regarding the development of standards for oil activity in the Abrolhos Bank, one of the most sensitive and biodiverse areas in the Brazilian coast. Supported by scientific data, CI-Brazil, Instituto Baleia Jubarte - Humpback Whale Institute/Brazil, Fundação SOS Mata Atlântica (Atlantic Forest Foundation), Corallus Foundation, Núcleo de Estudos e Monitoramento Ambiental - Environmental Monitoring Study Group/NEMA and Birdlife Foundation, with the support of the Abrolhos Marine National Park coordination, proposed to the Brazilian government the exclusion of these banks from the auction. A public campaign was initiated and the discussion was spread to the scientific community and wider society. The result was the exclusion of almost the entire proposed area from the auction. For the 2004 and 2005 auctions the ANP refrained from offering the area again following discussions with IBAMA, based on the technical support from the NGOs. The discussions also supported the creation of the Abrolhos Marine National Park buffer zone in 2006, which was paramount in the permanent restriction of oil exploration and exploitation in the region, as well as protecting such a sensitive area against other anthropogenic impacts.

IV. The Gerry E. Studds Stellwagen Bank National Marine Sanctuary as a model for characterizing and managing the marine acoustic environment

Leila Hatch

The Gerry E. Studds Stellwagen Bank National Marine Sanctuary (SBNMS) is home to many marine species that are protected and/or managed under multiple US statutes, including the National Marine Sanctuaries Act, the Marine Mammal Protection Act, the Endangered Species Act and the Magnuson-Stevens Fisheries Conservation and Management Act. Placed right in the middle of Massachusetts Bay, this urban Sanctuary is a busy place for human commerce as well and is subjected to high levels of sound-producing activities. Thus, meeting US marine resource protection and management goals in the SBNMS necessitates understanding the relative inputs of sound sources within the sanctuary and the possible effects of these sources on marine animal behavior.

This talk will present current results from an ongoing, large-scale, collaborative project within the SBNMS that includes scientists, managers and policy experts from the US National Oceanic and Atmospheric Administration's SBNMS, Northeast Fisheries Science Center and Northeast Regional Office, the US Coast Guard's Research and Development Center, Cornell University's Bioacoustics Research Program, the University of New Hampshire's Center for Coastal and Ocean Mapping and Marine Acoustics, Inc. The project uses an array of 10+ acoustic recording units to continuously monitor the low frequency (10-1000Hz) acoustic environment of the SBNMS. In addition, four Automatic Identification System (AIS) receivers are used to track all large commercial traffic transiting greater Massachusetts Bay. Acoustic and ship tracking data are then integrated and analyzed to address multiple questions regarding the locations and behaviors of vocalizing whales, the potential for hearing loss and masking for various species, and sound contributions from individual commercial vessels as well as specific vessel classes. Examples that highlight the utility of these data, especially when used in concert with data from other sanctuary research efforts, for developing effective techniques to minimize and/or mitigate threats to sanctuary resources will be presented; including efforts to accurately estimate reductions in whale ship strikes due to re-routing of shipping lanes, efforts to characterize received sound levels and behavior relative to ships for whales tagged in the sanctuary, and efforts to mitigate impacts to sanctuary resources due to offshore energy development adjacent to the SBNMS. The talk will conclude with brief comments on the "sister sanctuary" arrangement recently formalized between SBNMS and the Marine Mammal Sanctuary of the Dominican Republic, with particular reference to the possibility of enhanced coordination in acoustic management efforts between the two sanctuaries.

V. Canary Islands naval moratoria

Natacha Aguilar de Soto and Vidal Martín

Beaked whales can be considered the "sonar stranders" because certain species have mass stranded many times in association with navy sonar exercises. Prior to 2003, very little was known about the behaviour and use of sound by these species or even their life history. Recent research with acoustic tags has improved this situation and now we have learnt some about their diving behaviour, use of the habitat and vocalizations. New veterinary findings have unravelled the pathologies that the whales suffer in the strandings. However, still too little is known to guess why these animals should be so sensitive or what population-level effect the strandings have. Canary Islands is where most mass strandings have been recorded in coincidence with naval manoeuvres (1985, 1986, 1987, 1988, 1989, 1991, 2002 & 2004). Many of the exercises related to mass mortalities of beaked whales in several parts of the world (Canaries, Greece, Bahamas or Madeira) involved the use of high intensity sonar to detect submarines. However, there is at least one example for which there is no data on the use of this sonar, but the manoeuvres used real fire to sink a boat. This coincided with the stranding of two beaked whales in La Palma (Canary Islands) in 1991, suggesting that other sources of intense underwater sound might also affect beaked whales.

Following the last mass stranding in Canary Islands, the Spanish Ministry of Defence imposed a moratorium on the use of naval active sonars within 50 nautical miles of the Archipelago. This is an important step forward and a pioneering mitigation measure to try reducing the impact of military activity in an area known for its beaked whale populations. However, it might not be enough to fulfil this purpose because of the following reasons:

- The maximum distance between individual stranded whales in one single event in Canary Islands was > 80 nm;
- 2004 Majestic Eagle naval exercise was located at >100 nm NE Lanzarote and related to four strandings in this Island and southern neighbour, Fuerteventura;
- The passage of vessels to areas of exercises near the Canary Islands may imply use of sonar, mainly if they are non-Spanish vessels, not obliged by the Moratorium;
- The Moratorium does not apply to other potentially impacting acoustic sources, such as underwater blasts.

The Canary Islands Moratorium is still unique in the world, in spite of the fact that environmental guidelines of NATO on the use of sonar include avoiding areas with known populations of beaked whales, and areas where previous strandings had been recorded coincident with military exercises. It is relevant also that in October 2004 the European Parliament passed a resolution calling for a moratorium on the operation of "high-intensity naval active sonar". The resolution expresses concern over strandings and mortalities associated with the use of mid-frequency sonar and urges member states to develop international agreements for regulating noise levels in the oceans; to monitor, investigate, and report mortality events associated with sonar use; to restrict the use of high-intensity active naval sonar and to assess the environmental impacts of current deployments in European waters.

The need to prevent new mortalities is supported by the Navies due to their will to comply with environmental safety and for operational reasons, e.g. the NATO Military Oceanography Group, 2005, declared "Unless it can be clearly demonstrated that reasonable measures are being taken to avoid harm to marine mammals, pressure groups will use political and/or legal pressure to stop the use of active sonar."

In this context, scientific expertise can, and should, contribute to develop a realistic mitigation protocol to reduce mortalities. This protocol should include at least the following:

- Avoidance of high risk areas (e.g. there is evidence that Canary Islands is a risk area up to > 100 nautical miles offshore);
- Presence of independent observer teams on the naval vessels; restricting risk activities to daylight and environmental conditions adequate to visual monitoring;
- Performance of aerial surveys in the exercise area before, during and after the manoeuvres, based on the naval vessels to reduce travel time of the aircraft and equipped also with independent observers;
- Implementation of acoustic detection equipment in a proven effective manner.

Beaked whales spend only 8% of their time visible at the surface, with a mean duration of the surfacing intervals of 2 minutes, making visual detection difficult. This is mostly true in wind strength above Beaufort state 3. The recent description of the vocalizations of two species of beaked whales and the characteristic FM clicks they produced, different from any other cetacean clicks described until now, favour the combination of visual and acoustic detection methods. However, these two species coincided in having a silent behaviour during most of their dive cycle, vocalizing at depth around 30 minutes every two hours, and acoustic detection schemes should adapt to this. It must be considered that a lack of strandings coincident with exercises located far from land or in an area where currents or wind circulate seaward, does not directly translate to evidence of unharmed marina fauna unless a strict mitigation protocol is implemented.

Session 2. Application of spatial modeling to predict areas of primary importance within the pilot areas

I. OBIS-SEAMAP: Marine mammal data and modeling - Erin LaBrecque
II. Modeling global densities and biodiversity hotspots of marine mammal species using a relative environmental suitability model - Kristin Kaschner
III. Towards an ACCOBAMS collaborative effort to map high density areas for beaked whales in the Mediterranean - Ana Cañadas
IV. Model-based risk assessment in conservation biology - Brendan Wintle

I. OBIS-SEAMAP: Marine mammal data and modeling

Erin LaBrecque and Pat Halpin

Our ability to understand, conserve, and manage the planet's marine biodiversity is fundamentally limited by the availability of relevant taxonomic, distribution, and abundance data. The Spatial Ecological Analysis of Marine Megavertebrate Animal Populations (SEAMAP) initiative is a taxon-specific geo-informatics facility of the Ocean Biogeographic Information System (OBIS) network. OBIS-SEAMAP has developed an expanding geo-database of marine mammal, seabird, and sea turtle distribution and abundance data globally. The OBIS-SEAMAP information system is intended to support research into the ecology and management of these important marine animals and augment public understanding of the ecology of marine megavertebrates by: (1) facilitating studies of impacts on threatened species, (2) testing hypotheses about biogeographic and biodiversity models, and (3) supporting modeling efforts to predict distributional changes in response to environmental change. To enhance the research and educational applications of this database, OBIS-SEAMAP provides a broad array of web-based products and services, including rich species profiles, compliant metadata, and interactive mapping services. This system takes advantage of recent technological advances in Geographic Information Systems (GIS), Internet data standards, and content management systems to stimulate a novel community-based approach to the development of a data commons for biogeographic and conservation research. To date, the global OBIS-SEAMAP database includes >1 million observation records from 192 datasets, spanning 73 yr (1935 to 2007) provided by a growing international network of data providers. These data make possible a Strategic Environmental Research and Development Program (SERDP) supported project on marine mammal habitat modeling. Hosted by the Marine Geospatial Ecology Lab at Duke University, SERDP provides an analytical framework to facilitate modeling approaches for scales required to support marine mammal forecasting needs of the U.S. Navy. The goals of this project are to: (1) develop and test the robustness of existing and novel spatio-temporal models of marine mammal distribution, as predicted by physical conditions of the marine environment; (2) design a novel, hierarchical framework for analyzing marine mammal distributions across annual, seasonal and synoptic timeframes; and (3) assemble a spatial decision support system that allows Navy users to analyze model outputs and ancillary oceanographic data across multiple forecasting timescales.

II. Modeling global densities and biodiversity hotspots of marine mammal species using a relative environmental suitability model

K. Kaschner, C. M. Stephenson, C. Donovan, R. Wiff, N. J. Quick, F. E. Sharpe, J. Harwood, D. Tittensor & B. Worm

The lack of comprehensive sighting data sets precludes the application of standard habitat suitability modeling approaches to predict distributions of the majority of marine mammal species on very large scales. As an alternative, we used an ecological niche model to map global distributions of 115 cetacean and pinniped species living in the marine environment using more readily available expert knowledge about habitat usage. The model generates predictions about the species-specific relative environmental suitability (RES) of each cell in a global grid of 0.5° latitude/longitude cells. Outputs from this model were then applied to mitigate possible impacts of anthropogenic activities on marine mammal populations.

In the context of mitigation of military sonar exercises, we developed an approach to estimate global densities of marine mammal species. This approach explicitly accounts for the large proportion of unsurveyed areas and time periods by scaling up from available regional density estimates to entire distributions based on predictions about the total suitable habitat available for a given species. Regional density estimates were calculated based on > 1800 published abundance estimates and associated digitized areas of > 350 dedicated line-transect survey conducted around the world between 1978 and 2006. We used seasonal predictions of large-scale marine mammal species occurrence generated by the RES model as an approximation of available habitat. Using general linear models, for each species, we then investigated the relationship between reported densities and area-weighted mean habitat suitability for each survey area during the summer seasons. Coefficients from these models were subsequently used as scaling factors to extrapolate densities in surveyed and unsurveyed areas and to estimate associated uncertainties. To date, we successfully estimated global densities of > 40 pinniped and cetacean species, including all the beaked whales using this approach. Predicted maximum densities estimated for areas representing most suitable habitat ranged between 0.001 animals per km^2 for most beaked whales in the southern hemisphere to almost 1 individual per km^2 for the harbour porpoise (*Phocoena phocoena*) in the northeastern Atlantic.

To facilitate the efficient design of marine protected areas (MPAs), we also conducted a cross-species analysis that produced predictions of global marine mammal species richness. Current predicted species richness patterns were successfully validated using large-scale dedicated survey data sets, corrected for effort using rarefaction analysis. These patterns appear to be quite stable over time, based on a forward projection of RES predictions using data from climate models. This suggests that the preservation of hotspots of marine mammal biodiversity could be achieved through the implementation of sufficiently large permanent MPAs in key areas.

Both analyses represent useful tools to produce predictions of the relative importance of different areas for different species in currently understudied regions that can help to prioritize management and research efforts.

III. Towards an ACCOBAMS collaborative effort to map high density areas for beaked whales in the Mediterranean

Ana Cañadas

The relationship between atypical mass strandings of Cuvier's beaked whales and military manoeuvres has been already proved in several parts of the world, including the Mediterranean (the last reported case of atypical mass stranding in Almería, Spain, in January 2006). Information on their distribution and habitat use in the Mediterranean is of fundamental importance for preventing further events of injury and death. Therefore, the Scientific Committee of ACCOBAMS agreed that a habitat use modeling exercise should be attempted and that appropriate information on distribution and habitat use derived from it should be made available to interested parties (national Navies, NATO, seismic exploration companies, etc.) to prevent the use of high intensity noise in potentially high density or highly suitable areas for this species in the Mediterranean. This work is being carried out through a collaborative effort of many research groups in the area, putting together more than 250,000 km of effort and more than 120 sightings of this species. All effort is being divided into segments of 5nmi long on average. A grid of cells with a resolution of 0.2º has been built, and a number of geographical and environmental covariates have been associated to each grid cell, namely, latitude, longitude, mean depth, standard deviation of depth, slope, aspect and distance from the 1000m and the 2000m depth contour, although others will be added shortly, such as SST or sea altitude. GAMs are used to explore the relationship between relative density of beaked whales and the environmental covariates and a prediction is produced for the whole area. The preliminary surface density maps show 4 areas with high relative density: Alboran Sea, Ligurian Sea, Ionian-Aegean Sea and Southern Adriatic Sea. Further surveys in the South-eastern portion of the basin from 2007, as well as several other datasets, will be added to update the models.

IV. Model-based risk assessment in conservation biology

Brendan Wintle

Quantitative risk assessment techniques are often used in conservation planning to understand the processes that make a population vulnerable to decline or extinction and to explore the likelihood that a population of a species will persist for some chosen time into the future given a certain management regime. Risk assessment techniques, such as population viability analysis, can aid in threatened species management by highlighting important uncertainties, guiding research and data collection, assessing vulnerability and ranking management options. I'll present some case studies that demonstrate the utility of model based risk assessments in conservation and highlight the role of models in an adaptive management framework. Finally, I'll discuss the value of formal decision protocols and the role of system response models for prioritizing conservation actions.

Session 3. The current knowledge of cetacean distribution and abundance in two key pilot areas

I. Part 1: The current knowledge of cetacean distribution and abundance, and noise pollution in the Mediterranean Sea - Giuseppe Notarbartolo di Sciara, Alexandros Frantzis
   Part 2: The noise issue, a challenge for the survival and welfare of marine mammals - Gianni Pavan
II. Part 1: Identifying hotspots of Asian cetaceans for noise management - Brian Smith
   Part 2 - Cetaceans and noise in Southeast Asia - John Wang

Part 1: The current knowledge of cetacean distribution and abundance, and noise pollution in the Mediterranean Sea

Alexandros Frantzis and Giuseppe Notarbartolo di Sciara

Although 22 cetacean species have been recorded in the Mediterranean, only ten are regularly found in the region (fin whale, sperm whale, killer whale, Cuvier's beaked whale, long-finned pilot whale, Risso's dolphin, common bottlenose dolphin, striped dolphin, short-beaked common dolphin and harbour porpoise). Two species have only local populations (killer whale and harbour porpoise, each in opposite geographical extremities of the Mediterranean) and one is present only in the western basin (long-finned pilot whale). The remaining seven species are regularly present in both basins. Knowledge regarding species presence and distribution remains poor in the southern Mediterranean (off the North-African coasts) and especially in the eastern basin. There are no basin-wide abundance estimates for any of the Mediterranean cetacean species (except for the minuscule killer whale population in the Strait of Gibraltar). An IUCN-ACCOBAMS meeting has proposed the regional listing of one species as Critically Endangered (killer whale), three species as Endangered (sperm whale, short-beaked common dolphin and harbour porpoise), two as Vulnerable (common bottlenose dolphin and striped dolphin), while the remaining four were considered Data deficient. An atypical mass stranding of Cuvier's beaked whales caused by NATO tests of active sonar in Greece in 1996 triggered an increase of interest in the issue of anthropogenic noise in the Mediterranean Sea and globally. Nevertheless, very few scientific papers regarding noise and little basic information regarding the main noise sources are available for the Mediterranean Sea. The most important sources of anthropogenic noise in the Mediterranean are: maritime traffic, seismic surveys, military sonar, drilling operations, coastal construction works and underwater explosions originating from military exercises and illegal dynamite fishing. Considering its small area (0.8% of the world's oceans) the Mediterranean Sea suffers the heaviest maritime traffic than any other sea in the world. About 220,000 vessels greater than 100 tonnes cross the Mediterranean each year. The region's maritime traffic volume was estimated ten years ago as the 30% of the world's total merchant shipping and 20% of oil shipping. Although most of the traffic is along an east-west axis, its complexity is very high. The total number of large cargos that are cruising the Mediterranean Sea at any moment is > 2000, indicating that no silent areas exist anymore in the region. The high numbers of vessels crossing the Mediterranean result in high background noise levels that are likely to make it harder for whales to detect approaching vessels. Thus, collisions are likely to increase due to a number of factors: (a) prospected increase of maritime traffic, (b) increased masking ambient noise, and (c) possible hearing impairment due to long-term exposure to unnaturally high noise levels. The past, present and future distribution of naval exercise areas using sound weapons is difficult to know; however, at least eight strandings of Cuvier's beaked whales, most of which "atypical", have occurred during naval exercises in the Mediterranean Sea. Drilling activity is taking place exclusively in the eastern basin to date, and concerns mainly its southern portion, where knowledge of the presence of cetaceans is scant or absent. Finally, two major types of underwater explosions often occur in the region: routine military exercises and illegal dynamite fishing. The noise impact from dynamite fishing is likely to be important (marine mammal deaths caused by dynamite have been reported, even including one critically endangered Mediterranean monk seal), but is difficult to assess, and is largely ignored by policy makers and enforcement authorities. There is only one MPA which was established for cetaceans in the Mediterranean Sea (the PELAGOS Sanctuary), and 14 more have been proposed by the ACCOBAMS Scientific Committee, without considering noise issues so far. At least three of them are crossed by major Mediterranean shipping lanes, and dynamite fishing activity is very common in the core area of a proposed MPA for sperm whales. Mapping noise and noise characteristics in the different areas of the Mediterranean is urgently needed, especially in the areas that have been proposed as cetacean MPAs. The recent success achieved by Spain in changing the shipping lanes in the Alborán Sea and in applying specific traffic regulations in the Straits of Gibraltar demonstrate that noise reduction in critical areas is not impossible. Finally, a selection of legal instruments that are or could be relevant to protect cetaceans against noise pollution in the Mediterranean are briefly presented. These include the EU Habitats Directive, a Motion passed by the European Parliament in 2004, and a Resolution on noise adopted by the Parties to ACCOBAMS at their second meeting (November 2004).

Part II: The noise issue, a challenge for the survival and welfare of marine mammals

Gianni Pavan

Although we know that anthropogenic sound in the ocean is a serious threat, we do not have sufficient information at this time to understand the full extent of the problem. One of the biggest challenges faced in regulating the effects of noise is our ignorance of the characteristics and levels of sound exposures that may pose risks to marine mammals. Given the current state of our knowledge we must therefore take a precautionary approach in the regulation of noise.

We must also expand our efforts to protect and preserve marine mammals by instituting and using effective mitigation measures, such as geographic exclusion zones, to keep marine mammals at a distance from noise sources that have the potential to harm or kill them.

While most interest in anthropogenic noise has focused on marine mammals (mainly cetaceans and pinnipeds) and a few other vertebrates (sea turtles), there is increasing concern regarding the impact of such noise on fishes and marine invertebrates. This issue will need exploration in the future also taking into consideration the effects on the trophic web.

Acoustic impacts on marine environment need to be addressed through a comprehensive and transparent management and regulatory system. This should address chronic and acute anthropogenic noise, long-term and short-term effects, cumulative and synergistic effects, and impacts on individuals and populations.

A regulatory system should be implemented to develop a strategy based on prevention and on the precautionary principle. The implementation of a regulatory system requires a series of steps and synergistic actions to promote education, awareness and research. Much effort should be devoted to developing a legal framework where underwater noise is recognized and regulated as a real threat.

In this context, the creation of Special Areas of Conservation (SAC) and Marine Protected Areas (MPA) that take noise pollution into account should ensure protection of areas of critical and productive habitats, and particularly of vulnerable and endangered species.

The designation of SACs and MPAs can be used to protect marine mammals and their habitats from environmental stressors including the cumulative and synergistic effects of noise. In these areas, noise levels should not be allowed to exceed ambient levels of more than a given value, including the contributions from sources that are located outside of the MPA but whose noise propagates into MPA boundaries. This would require additional research to establish baseline noise data and evaluate thresholds for noise levels that can be considered acceptable; i.e. can be tolerated without any significant negative effect.

In other words, other than defining which impacts should be avoided or mitigated, we also need to define the level of "acoustic comfort" we should guarantee to animals, at least in wide enough protected areas.

II. Asia

Part 1: Identifying hotspots of Asian cetaceans for noise management

Brian D. Smith

Asia supports the greatest number of cetaceans at risk however adequate information is generally lacking to make informed decisions about priority areas for noise management. Among the most vulnerable of marine cetaceans occurring in Asian waters are the nearshore dwelling species, such as Irrawaddy dolphins *Orcaella brevirostris*, Indo-Pacific humpback dolphins *Sousa chinensis*, Indo-Pacific bottlenose dolphins *Tursiops aduncus* and finless porpoises *Neophocaena phocoenoides*. These animals are subjected to intensive anthropogenic impacts including noise disturbance from oil and gas development and commercial shipping. Identification of "hotspots," where these cetaceans occur in relatively high density, is essential for providing protection from the effects of noise. However, in the foreseeable future, broad-scale surveys will be difficult to design and implement because so much of these species' ranges occur along complex shorelines and in archipelagos, and very limited funds and local expertise are available to conduct these activities. One approach for identifying cetacean hotspots in Asia would be to compile existing information in a geographic information system on cetacean occurrence, oceanography, bathymetry, river discharges, and biological features, and then use habitat selection models to identify critical components. These profiles would then be used to select, based on favorable habitat characteristics, unsurveyed areas that are likely to be cetacean hotspots, and then later be tested through field surveys.

An area that has been identified as a regional hotspot for cetacean diversity and abundance are the coastal waters of Bangladesh affected by freshwater inputs from the world's third largest river system and inclusive of the Swatch-of-No-Ground, a 900 + m deep submarine canyon situated less than 40 km from the edge of the Sundarbans mangrove forest. The ongoing Bangladesh Cetacean Diversity Project (BCDP) sponsored by the Wildlife Conservation Society might be a potential model for implementation of cetacean research in other potential hotspots identified by the habitat modeling and prediction exercise described above. The BCDP stresses local capacity building for developing an efficient and accountable infrastructure to carry out rigorous research and effective conservation. All training courses have a strong field component and are connected to specific research and conservation objectives so that newly learned skills can be directly applied to the project. This participatory approach also allows for a large variety of research objectives to be addressed during field activities (e.g., rigorous searching to obtain precise abundance estimates, collection of a suite of environmental data that can be used for developing habitat preference models, and assessments of anthropogenic threats) and builds a cadre of experienced cetacean researchers who can be employed for long-term monitoring of the effectiveness of management measures taken to reduce the impacts of noise.

Part 2: Cetaceans and noise in Southeast Asia

John Y. Wang

Southeast Asia is incredibly diverse in the human (e.g., wealth, religion, culture, history, political systems, etc.) and natural (i.e., habitat types, biodiversity) sense. Many areas have large and dense human population centres and human activities have resulted in severe degradation of the natural environment and wildlife. Very little is known about local cetaceans but several unique and isolated populations have been reduced to critically low numbers (e.g., *Orcaella, Sousa*) and most species are facing multiple threats. Ocean noise as an additional stressor to cetaceans is a growing concern in this region with numerous and increasing numbers or volume of military, oil/gas exploration and development and commercial shipping activities. Other noise producers include: coastal and "offshore" development projects, blast fishing and oceanographic research. Only blast fishing is likely to decrease in the near future. Although many countries have laws protecting marine mammals, a lack of awareness of the noise issue, expertise, resources, information exchange (mainly due to language and resources) and enforcement of laws has provided cetaceans with little effective protection from most threats. No Southeast Asia country has laws that specifically deal with noise and marine mammals. However, Australia and Hong Kong can be viewed as the most advance in this respect as noise issues are considered and enforced under more general protection laws. An example of the potential impact of noise on cetaceans is highlighted in several series of unusual strandings that occurred along the shores of Taiwan in 2004, 2005 and 2006. An examination of a limited number of carcasses revealed severe internal injuries that suggested the cause of death was exposure to high energy. However, the source(s) of the energy could not be confirmed but in most cases, the possibility of natural phenomena such as typhoons and earthquakes causing the strandings was rejected. Southeast Asian waters are highly diverse and the area vast. Unless more resources and attention are given to this region, our rate of understanding of marine mammals in Southeast Asia will continue to progress at the present slow pace.

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