# Acoustic Ecology Institute
# 2008 International Whaling Commission Special Report

IWC consideration of noise generally takes place in two documents produced by members of the Scientific Committee.

The first is the State of the Cetacean Environment Report (SOCER), which summarizes recent research on a wide array of topics, including noise. Each year's SOCER focuses on a particular region (in 2008, the North Atlantic), and also has a section on key research from other parts of the globe. The sections of the 2008 SOCER addressing noise impacts are reproduced below.

The second is within Annex K of the Scientific Committee Report. Annex K is the report of the Standing Working Group on Environmental Concerns. Here, there is a brief summary of the SOCER, as well as summaries of other papers submitted to the IWC Scientific Committee by members of the committee. Several pages of Annex K that include the sections on SOCER and noise impacts are reproduced beginning on the 5th page of this document.

http://www.iwcoffice.org/sci_com/scmain.htm
Scientific Committee on the web

## State of the Cetacean Environment Report (SOCER), SC60E1

Excerpts focusing on noise impacts

**NORTH ATLANTIC FOCUS**

**Noise impacts**

***General***

Evidence of noise impacts on whale vocalisations

Right whales may shift call frequency to compensate for increased background noise. Right whales produce calls with a higher average fundamental frequency and call at a lower rate when they are in high background noise conditions, possibly in response to masking by low-frequency noise (*e.g.*, from shipping). Long-term changes have occurred within the known lifespan of individual whales, indicating that a behavioural change, rather than selective pressure, has resulted in the observed differences. The researchers concluded that "*given the observed behavioral response, the impacts on right whale communication need to be considered to determine what, if any, role increased noise may have on limiting reproduction and recovery of the species*".

(SOURCE: Parks, S. E., Clark, C. W. and Tyack, P. L. 2007. Short- and long-term changes in right whale calling behavior: The potential effects of noise on acoustic communication. *J. Acoust. Soc. Amer.* 122: 3725-3731)

***Seismic surveys***

Marine mammal reactions to seismic surveys in the northwest Atlantic

A monitoring programme during a seismic survey in the northwest Atlantic during 2003 observed marine mammals both visually and acoustically. No marine mammal incidents or adverse reactions were recorded. There was no correlation between visual and acoustical detections; neither method was redundant and using both methods increased the likelihood of obtaining a true indication of cetacean presence. Marine mammals appear to have avoided getting very close (<100 m) to the seismic array during operation, but the overall number of marine mammals within 1-2km did not change significantly when the seismic source was 'on' compared to 'off'. Larger and apparently less vocal groups were observed when the seismic source was active, although the results may be affected by potential sources of bias (such as the combination of data from toothed and baleen whales). The researchers noted that "*seismic surveying can apparently have a behavioral impact at a high level of statistical significance without visual observers reporting seeing fewer marine mammals*". In addition, some high-frequency energy content was detected in the otherwise lower-frequency seismic signal.

(SOURCE: Potter, J. R., Thillet, M., Douglas, C., Chitre, M.A., Doborzynski, Z. and Seekings, P.J. 2007. Visual and passive acoustic marine mammal observations and high-frequency seismic source characteristics recorded during a seismic survey. *IEEE J. Oceanic Engineer.* 32: 469-483)

Atlantic spotted dolphins show a greater reaction to seismic airguns than baleen whales in Angola

Marine mammals were observed from a seismic survey vessel off Angola between August 2004 and May 2005. The encounter rate for humpback and sperm whales did not differ significantly according to airgun operational status. However, encounters of Atlantic spotted dolphins (*Stenella frontalis*) occurred at a significantly greater distance from the airgun array when the guns were 'on'. Spotted dolphins approached the vessel only when the guns were off. There was no evidence for prolonged or large-scale displacement of animals from the region during the 10-month survey duration. Dolphins are generally perceived to be less sensitive to low frequency sound than baleen whales, but nevertheless showed a response greater than the two baleen whale species examined.

(SOURCE: Weir, C.R. 2008. Overt responses of humpback whales (*Megaptera novaeangliae*), sperm whales (*Physeter macrocephalus*), and Atlantic spotted dolphins (*Stenella frontalis*) to seismic exploration off Angola**.** *Aquat. Mamms.* 34: 71-83)

**GLOBAL SECTION**

## Noise impacts

### *General*

High levels of noise could impact harbour porpoises' ability to find prey

Studies conducted on distances at which harbour porpoises and bottlenose dolphins can detect prey via echolocation showed that the former, due to lower source levels, have shorter prey detection ranges than the latter. There was also a substantive decrease in the ability to detect prey in environments with high levels of background noise; the harbour porpoise, with its lower prey detection range, would be especially affected. The authors note that "*the limited echolocation detection range would make it difficult, if not impossible, for harbor porpoise to inhabit a noisy environment*". Therefore, increasing levels of anthropogenic noise could have a particularly strong impact on harbour porpoises, reducing their foraging efficiency.

(SOURCE: Au, W.W.L., Benoit-Bird, K.J. and Kastelein, R.A. 2007. Modeling the detection range of fish by echolocating bottlenose dolphins and harbor porpoises. *J. Acoust. Soc. Am.* 121: 3954–3962)

Two reviews on the impacts of anthropogenic sound sources on cetaceans

An updated review (the first since 1995) of cetacean acoustics research focused on behavioural (*e.g.*, changes in diving and surfacing), acoustic (*e.g.*, type and timing of vocalisations), and physiological (*e.g.*, hearing loss and stress) reactions. The literature review for the first two types of responses was exhaustive, while a thorough review of physiological consequences was beyond the scope of this paper. There has been significant progress in documenting cetacean response to noise sources, but received levels of sound are

rarely measured empirically; the authors urge improvement in this regard. In addition, the effects of certain widespread sources of noise are poorly investigated, such as commercial sonars and depth finders. A second review of noise impacts on cetaceans summarised the current state of scientific knowledge; presented a list of cetacean strandings associated with anthropogenic noise sources; and discussed possible population-level, synergistic and cumulative impacts. The review also considered indirect effects of noise; management implications; and offered a discussion of mitigation shortcomings, possible solutions, and research recommendations.

(SOURCES: Nowacek, D.P., Thorne, L.H., Johnston, D.W. and Tyack, P.L. 2007. Responses of cetaceans to anthropogenic noise. *Mamm. Rev.* 37: 81–115; Weilgart, L.S. 2007. The impacts of anthropogenic ocean noise on cetaceans and implications for management. *Can. J. Zool.* 85: 1091-1116)

Development of noise exposure criteria for cetaceans

A review of available research data on marine mammal hearing capabilities and reactions to sound was used to develop a series of noise exposure criteria for management purposes. The authors estimated the noise levels that could cause physical, acoustic injury to cetaceans (*i.e.*, hearing loss). For most cetaceans, a sound pressure level of 230 dB re: 1µPa for single or multiple pulses was derived, primarily based on studies using captive cetaceans. The review also examined behavioural reactions, which for low-frequency-sensitive cetaceans showed "*an increasing probability of avoidance and other behavioural effects in the 120 to 160 dB re: 1µPa range*". For mid-frequency-sensitive cetaceans, "*[i]n some settings, individuals in the field showed behavioural responses with high severity scores to exposures from 90 to 120 dB re: 1µPa, while others failed to exhibit such responses for exposure [received levels] from 120 to 150 dB re: 1µPa*". The extrapolation of behavioural responses of captive animals to determine the reactions of free-ranging cetaceans was deemed problematic. For high-frequency specialists, reviewed data primarily concerned harbour porpoises, which "*are quite sensitive to a wide range of human sounds at low exposure [received levels] (~90 to 120 dB re: 1µPa)*"; "*[a]ll recorded exposures exceeding 140 dB re: 1µPa induced profound and sustained avoidance behaviour in wild harbour porpoises*". Importantly, some species may be particularly sensitive to acoustic disturbance (*e.g.*, beluga, bowhead whale, harbour porpoise), and the criteria do not account for effects such as masking, stress induction and non-auditory injuries (*e.g.*, gas bubble formation).

(SOURCE: Southall, B.L., Bowles, A.E., Ellison, W.T., Finneran, J.J., Gentry, R.L., Greene, C.R., Kastack, D., Ketten, D.R., Miller, J.H., Nachtigall, P.E., Richardson, W.J., Thomas, J.A. and Tyack. P.L. 2008. Marine mammal noise exposure criteria: initial scientific recommendations. *Aquat. Mamm.* 33: 411-521)

## *Sonar*

Gas emboli found in beaked whale strandings in Taiwan coincident with naval exercises

An unusually high number of cetacean strandings occurred along the coast of Taiwan between 19 July and 13 August 2005. These strandings involved 13 dwarf sperm whales (*Kogia sima*), two pygmy sperm whales, two Longman's (*Indopacetus pacificus*) and two Blainville's beaked whales (*Mesoplodon densirostris*), two striped and one pantropical spotted dolphin (*Stenella attenuata*), and a short-finned pilot whale. Fifteen animals were examined post-mortem; three were fresh enough to allow pathological examination. The beaked whales "*had severe, diffuse vascular congestion and marked disseminated microvascular haemorrhages associated with widespread, round to oval cavitary lesions within vital organs, consistent with gas emboli*". Such gas emboli have been found in tissues of cetaceans that have stranded coincident with naval exercises. During this period, two sonar-utilizing naval exercises were undertaken by China (mid-July to late July in the East China Sea) and the USA (near Okinawa and Guam), although the latter was a considerable distance from Taiwan (>410 miles). No definitive causal relationship with naval sonar was established due to a lack of precise information on where and when sonar activity was conducted in Taiwanese and adjacent waters. The strandings occurred over a longer period of time and were more widespread than other atypical mass stranding events. It was hypothesized that "*if this mortality event was caused by exposure to high-intensity acoustic energy, it is possible that multiple acoustic sources (naval or otherwise) combined to produce the pattern of strandings observed*".

(SOURCES: Yang, W.C., Chou, L.S., Jepson, P.D., Brownell, R.L., Cowan, D., Chang, P.H., Chiou, H.I., Yao, C.J., Yamada, T.K., Chiu, J.T., Wang, P.J. and Fernández, A. 2008. Unusual cetacean mortality event in Taiwan, possibly linked to naval activities. *Vet. Record* 162: 184-186)

## *Seismic Surveys*

Great variation in seismic survey guidelines

A review of international mitigation measures to reduce impacts to cetaceans from seismic surveys found much variety and inconsistency. For example, whilst several countries or regions include all marine mammal species within the mitigation measures, in others only large whale species are considered and there are no appropriate measures for dolphins, porpoises, or pinnipeds. Most regions required trained crew members to search for marine mammals within a zone of possible impact, but there was much variability as to what 'trained' entailed. Some regions required 'dedicated', 'qualified' or 'experienced' observers in 'sensitive' areas, although again definitions of these terms were often not provided. With respect to observers, "*a further concern is the lack of independence of MMOs* [marine mammal observers]. *This is most apparent where MMOs are crew members or otherwise employed directly by the seismic contractor, presenting a clear conflict of interest*". An exclusion zone around an operating seismic survey array is a standard mitigation measure, but these zones again vary widely, from 0.5 to 3km. Differing guidelines consider received levels from 160 to 190 dB re 1 □Pa to be the critical threshold above which seismic surveys could cause impacts. The authors state that "*a further inefficiency of the existing mitigation methods is that the* [observer] *must visually observe the marine mammal entering the* [exclusion zone] *before mitigation can be requested. This does not adequately mitigate for deep-diving species such as sperm and beaked whales*". Another common mitigation measure is the 'soft start' or 'ramp-up', i.e., a gradual increase in airgun output. But guidelines lack consistent information on the nature of 'soft starts'. Poor consideration is given to the number or type of airgun arrays or the effect of water depth and oceanographic conditions. The authors state that "*a single standard* [exclusion zone] *value* [*i.e*., radius of impact] *for all seismic surveys regardless of airgun volume or water depth is inappropriate*". The impacts of weather on the ability to sight cetaceans are generally neglected and guidelines for surveys conducted at night are extremely variable. One critical observation is that "*relatively few aspects of current mitigation have a firm scientific basis and proven efficacy in the field*".

(SOURCE: Weir, C.R and Dolman, S.J. 2007. Comparative review of the regional marine mammal mitigation guidelines implemented during industrial seismic surveys, and guidance towards a worldwide standard. *J. Internat. Wildl. Law Policy*10: 1–27; see also Castellote, M. 2007. General review of protocols and guidelines for minimizing acoustic disturbance to marine mammals from seismic surveys. *J. Internat. Wildl. Law Policy*10: 273-288)

## *Aircraft*

Aircraft cause 'distress' or 'defence' formation in sperm whales

During aerial surveys for cetaceans in the waters around Hawaii, circling aircraft reported a group of sperm whales changing their behaviour. The whales "*ceased forward movement, moved closer together in a parallel flank-to-flank formation…and formed a fan-shaped semi-circle with heads facing out and flukes toward the middle of the semi-circle. The bull was on the left outer edge of the semi-circle and the calf remained near the middle of the group*". One of the sperm whales was observed on its side with its mouth open. This was "*interpreted…as an agitation, distress, and/or defense reaction to our circling aircraft*". The authors state that "*although isolated occurrences of this type are probably not biologically significant, repeated or prolonged exposures to aircraft overflights have the potential to result in significant disturbance of biological functions, especially in important nursery, breeding or feeding areas*". They note that activities that might cause similar harassment of cetaceans include aircraft-based ecotourism flights, research surveys, oil and gas exploration development and military activities.

(SOURCE: Smultea, M.A., Mobley, J.R., Fertl, D. and Fulling, G.L. 2008. An unusual reaction and other observations of sperm whales near fixed-wing aircraft. *Gulf Carib. Res.* 20: 75-80)

Over the next year the CERD could begin to identify key diseases or agents that have met the criteria above and develop case definitions or characteristics that will be peer reviewed by experts. Those case definitions could then be placed on an easily accessible website for dissemination and will be periodically updated as new information becomes available. How this would be maintained nor who would do it is not yet clear.

***Diagnostic Laboratories.*** Some countries have identified national or specialised laboratories which perform the diagnostic evaluations for marine mammals. However most do not have that targeted capacity and may not develop it in the near future (at least for not every disease). Many countries use diagnostic tools and laboratories whose service mission is for other species, and therefore timely analyses are not always possible and validation in marine species may not be available. Given the lack of funding for specific diagnostic laboratories or technology development in most countries, it is not currently feasible to establish national or international reference laboratories specific for marine mammal diseases such as have been developed for terrestrial or economically important farm species to support specific disease surveillance programs. Therefore the SWG **recommends** identifying laboratories and experts currently involved in marine mammal disease surveillance, along with their diagnostic capacities, in order to determine where diagnostic strengths are, where capabilities are low or absent and where collaboration can enhance surveillance.

Given the paucity of available or targeted diagnostic laboratories and diagnostic tests specific for marine mammals the SWG **recommended** that the Scientific Committee compile and maintain a list of laboratories and experts for specific or general diagnostic capabilities by country, continent and/or region. The SRG **recognised** that there are significant differences in capacity and interest by the different member countries and **suggested** that the Scientific Committee identify appropriate researchers in each country or region to compile such a list through known contacts.

***Data sharing, communication and information dissemination.*** It was recognised that there are many significant hurdles to data sharing and information dissemination and that using peer reviewed publications alone does not provide timely access nor communication on specific outbreaks or discoveries. Some of these hurdles include the willingness to share information, the proprietary nature of findings, the confidentiality of results, and in some cases the restrictions posed by in-country policies on the release of disease information. In order to enhance communication and collaboration, the WG suggests the establishment of a secure site such as a private list-serve or discussion board. This would allow rapid notification of outbreaks or new diseases in marine mammals, would allow for consultations, would increase our knowledge, and would enhance diagnostic or assessment capabilities. In addition, the WG suggests that interested member countries report such outbreaks or die-offs in some format. In addition, there should be a CERD website upon which information could be disseminated and would be beneficial in educating governments and the public as well.

In order to accomplish the work of CERD, the steering committee has invited additional experts from various countries to join an email group.

One of the SOCER editors commented on the usefulness of the CERD report and asked if there is any specific information useful to the CERD that could be included in the SOCER. Rowles noted that the CERD report and SOCER overlap (e.g., they both centre on regional issues) and it would be beneficial to link the two.

The SWG thanked Rowles, Van Bressem and the rest of the CERD working group for all their hard work and expressed their appreciation for their excellent report.

In relation to CERD activities, a briefing on the First South American Marine Mammal Stranding and Necropsy Workshop was presented. The Workshop held on 1 June 2008, was organised by the Centro de Conservación Cetacea (CCC/Chile), the National Oceanic and Atmospheric Administration (NOAA) of the United States, the Chilean National Fishery Service (SERNAPESCA) and the Universidad Mayor, in partnership with the International Whaling Commission (IWC). The Workshop, which aimed to increase stranding and necropsy response capacities and to facilitate the coordination among South American organisations, was attended by 39 specialists and students from Argentina, Brazil, Chile, Colombia, Ecuador, Spain, USA and Venezuela. Hands-on necropsies on one pinniped and three dolphin carcasses were conducted. The Workshop concluded with a group discussion on marine mammal stranding experiences and network capabilities in each country, with a major agreement on the need to improve stranding capacities at a national level in each South American country and the need to coordinate stranding networks at a regional level as well as standardise methodologies. Several priorities were identified nationally, including: increase stranding response and necropsy/sample collection capacities; set up of a cooperative framework to report and collect basic data on strandings (stranding network); and secure funding for the establishment and long-term continuity of national stranding networks in each country. At a regional level, the following priorities were identified: standardise data collection protocols; establish a minimum level of important data and samples to be collected to increase our knowledge on the biology and health of South American cetaceans; use the website "Mar de Cetáceos" (www.mardecetaceos.net) and create a discussion forum on stranding events, coordination of activities and information sharing; hold periodic stranding workshops at national and regional levels; search for funding to establish a mechanism for emergency response (i.e., unusual mortality events, mass strandings) to assist national stranding networks ; and establish and enhance cooperation with international organisations to increase resources (i.e., scientific advice, funding resources, capacity building, data sharing, etc.).

The SWG thanked the organisers and supporters of the Workshop and emphasised the importance of this Workshop for providing information on good techniques and increasing the knowledge about diseases in cetaceans to the regional scientific community. The SWG **recognises** the value of capacity building in other countries and regions that need this type of training. The SWG **recommends** developing proposals to plan and fund similar workshops in Latin America and elsewhere.

## 9. STATE OF THE CETACEAN ENVIRONMENT REPORT (SOCER)

The 2008 version of the State of the Cetacean Environment Report (SOCER; SC/60/E1; Appendix 6) highlights the Atlantic Ocean and, as in past years, also contains a global section. It provides information for Commission and Scientific Committee members on issues in the marine environment related or relevant to cetaceans from 2006 up to the time of the SC/60 meeting. The SOCER is based on input through standardised submission forms and literature searches conducted by the three editors. An introductory paragraph outlining the history of SOCER was followed by five sections: (1) a literature analysis, (2) succinct entries on the Atlantic and (3) global events (under headings corresponding to key issues identified by the SWG), (4) a glossary of terms used in the report (e.g. species names, ecological terms, pollutant types), and (5) a set of tables providing an overview of specific pollutant levels in cetaceans.

Over the past year, several studies have added evidence that trace elements and organochlorine pollutants are toxic to white blood cells, and could impair the immune system of cetaceans. These studies have also found that simply summing the levels of contaminants is not sufficient to assess the

toxicity of a mixture of pollutants – some contaminants may have synergistic effects that can increase toxicity. Moreover, many papers have been published recently highlighting environmental impacts on Atlantic bottlenose dolphin (*Tursiops truncatus*) populations, in particular high levels of contaminants have been found in several localised populations, and there are concerns that first calf mortality rates are high because of high pollutant burdens. A surprising finding has been the high prevalence of antibiotic-resistant bacteria in bottlenose dolphins; in fact these animals may be acting as a vector for possible resistant pathogens.

Marine noise continues to be an area of scientific attention, with new studies showing impacts of seismic surveys on the distribution and behaviour of cetaceans. Harbour porpoises (*Phocoena phocoena*) may be especially susceptible to underwater noise pollution and concerns have been expressed about the impacts of anthropogenic sound on porpoise behaviour and their ability to forage. Climate change and its impacts on marine ecosystems has attracted much attention, with a special issue of the journal *Ecological Applications* being devoted to the impacts of climate change on marine mammals. Studies are also showing impacts on the health of certain fish stocks in the Atlantic and climate change-linked changes in bird and cetacean abundance in the Bay of Biscay have been highlighted. Finally a review of the state of ocean ecosystems found widespread habitat degradation, with nearly half the world's marine ecosystems facing multiple anthropogenic stressors. Locations that were highlighted as being particularly impacted by anthropogenic activities include the Bering Sea, the Mediterranean and many regions of the Atlantic including the east coast of the USA, the North Sea and the Caribbean.

The literature analysis (1389 papers evaluated, 785 cetacean related) confirms the results of the previous SOCER analyses: nearly half of all the scientific literature published on cetaceans in 2007 dealt primarily with conservation-related issues (as opposed to 'basic biology and ecology'), indicating the need to actively incorporate environmental concerns into any deliberations on cetaceans. The editors noted that there are now four years of literature analyses and they will work on submitting a paper for publication.

A new feature of the SOCER was inclusion of data tables containing published maximum contaminant concentrations in cetaceans. It was suggested that the editors include ranges or mean values of contaminant concentrations in order to provide more comprehensive information on contaminant exposure levels. It was also suggested that SOCER incorporate recent management actions and measures (e.g., U.S. action on right whale ship strikes). The editors requested that SWG members respond to the annual solicitation for submissions with information on such managerial actions or other material that may not appear in literature searches.

## 10. OTHER HABITAT RELATED ISSUES

Details on an upcoming workshop entitled "Monitoring climate change impacts establishing a Southern Ocean Sentinel program" were provided to the SWG and a flier for this workshop in Hobart, Tasmania from 20-24 April 2009 was distributed. The workshop will focus on sentinel species, as well as the entire ecosystem. Members interested in the workshop were directed to their email address (sos@aad.gov.au).

### 11.1 New information on anthropogenic noise and cetaceans

SC/60/E5 described the strandings over a period of about 3 months starting in mid-January 2008 of 14 Cuvier's beaked whales (*Ziphius cavirostris*), five Sowerby's beaked whales (*Mesoplodon bidens*), four unidentified beaked whales and 22 long-finned pilot whales (*Globicephala melas*) in Scotland, Ireland and Wales. In addition, a mother and dependant calf Sowerby's beaked whale stranded live at Calais, France. Strandings may still be ongoing. The beaked whales relatively rarely strand and the pilot whale numbers also appeared largely unprecedented. It appears that most perhaps all were dead when they stranded. Concerns that an unusual mortality event had taken place prompted further investigations although given the advanced state of decomposition of the majority of carcasses, little information is likely to available to ascertain the cause(s) of death. It remains a possibility that a currently unidentified anthropogenic factor may have been contributory to these mortalities. Although the pattern of strandings reported here does not fit the 'atypical' event previously described—i.e., often involving more than two animals, of one or more species, stranding approximately simultaneously and alive but not in the same location (Frantzis, 1998; Brownell *et al.,* 2004)-the number of carcasses involved and combination of species involved is unprecedented in the UK and Ireland. Possible contributory causes include loud noise, fisheries and prey depletion. The Royal Navy says that it was not deploying sonar at the relevant time but cannot speak for other nations. There seems to have been no change in fishing activity in the region. Modelling is underway to try to determine more accurately the area from which the bodies have come. The authors of SC/60/E5 welcomed the recent agreement by Department of Environment, Fisheries and Rural Affairs (DEFRA), UK government, to fund a web-accessed database of UK strandings data (such as that available on www.iwdg.ie), noting that this will enable more efficient dissemination of information between strandings networks to improve the early identification of any unusual mortality events that may occur in the future. Similarly the creation of a European strandings database [a long-standing aim of the Agreement for the Conservation of Small Cetaceans in the Baltic and North Sea (ASCOBANS)] would be helpful. The SC/60/E5 authors also noted the problems associated with pathology studies if these are only conducted where an unusual event is identified.

Subsequent to the submission of paper SC/60/E5, additional strandings of Cuvier's beaked whales and pilot whales have come to light in Scotland (Bob Reid pers comm.): 25/3/2008 pilot whale, Boreray, North Uist; 27/3/2008 Cuvier's beaked whale, Barra (not reported until 14/5); 22/4/2008 pilot whale, Uig, Lewis; 5/5/2008 Cuvier's beaked whale Monach Islands; 11/5/2008 Cuvier's beaked whale, Ardnamurchan; 16/5/2008 pilot whale, Mull. All of these strandings were of single decomposed animals. It was likely that many other bodies may have been lost out to sea. Ridoux added that, during this same time period, France had stranding events 3 to 5 times the normal rate for similar marine mammal species.

SC/60/E9 reported that little is known about the possibility for seismic surveys to cause temporary or permanent hearing threshold shifts (TTS/PTS) in marine mammals. There is currently just a single empirical measurement of sound levels from an airgun-like sound causing TTS in a beluga whale. Considering this extreme paucity of data, a series of simulations were developed to account for inter-individual variation and uncertainty in assessing the distances at which baleen whales may be susceptible to TTS/PTS from seismic surveys. For each of 100 simulation runs: 10,000 'baleen whales' are assigned a TTS onset level based on a) normal variation expected within a population; b) uncertainty over where the one experimentally measured level falls in that population's distribution; and c) a distribution of potential weighting values to transfer TTS onset levels from beluga to baleen whales. Each whale is then randomly distributed and exposed to 1 pass of a seismic vessel with cumulative exposure level calculated. Initial results illustrate that when uncertainty and individual variation are accounted for, there is a substantially increased risk of hearing loss at much greater ranges than the 1 measured beluga whale TTS onset level would suggest.

The authors of SC/60/E9 took this approach as part of a review of the seismic guidelines by the Australian government. The paper intended to provide quantification, with uncertainty, of the percentage of whales that would suffer TTS at different ranges. From this, a policy decision could be made on the

basis of acceptable risk. One member noted that one TTS incident is probably not significant but chronic TTS exposure could affect cetaceans. Another member noted that more research is needed on TTS and asked if more controlled exposure experiments were planned. The simulations rely on a single empirical data point, so one of the most immediate needs is for additional experimental work.

One member commented that SC/60/E9 provides a method by which to examine the uncertainty of acoustic effects in animals. The U.S. safety guidelines fell on the upper edges of TTS thresholds in the graphs presented and were, therefore, conservative values. He further noted that TTS should not be a major problem to marine mammals, as avoidance reactions below TTS levels and well below PTS levels are generally observed in cetaceans. This prevents most animals from being exposed to levels that would cause harm.

The author responded that from the model simulations, cumulative sound exposure level is primarily determined by the closest point of approach between the source and the whale, irrespective of the whale's movement or avoidance Behavior. It was reported that the Joint Industry Program (JIP) plans to support studies on multi-pulse exposures on a larger sample size of belugas and some other species as well (http://www.soundandmarinelife.org/). It was noted that the beluga used in the noise test cited in SC/60/E9 may have compromised hearing capability as it has been used in previous noise experiments and resides in waters near San Diego, a busy naval and commercial port in California such that the results may not be representative of wild cetaceans. Another member suggested that in mitigation, the distance for TTS in the simulations should be within the distances for sightings from ships.

SC/60/E14 describes preliminary analyses of aerial, vessel-based and acoustic surveys to document bowhead whale distribution before and during an offshore seismic survey in the Central Beaufort Sea during late summer and fall of 2007. Studies conducted in the same area in 1996-8 documented avoidance of seismic operations at distances of 20-30km where received levels of seismic sounds were ~120-130 dB re 1 µPa (rms). During 2007, whales were seen much closer to operating seismic vessels and at distances where received levels were ~150-70 dB. Whales seen feeding west of the seismic area did not appear to change their distribution when seismic started. During 1996-98 whales that were sighted were primarily migrating based on several behavioural parameters including speeds of movement, headings and lack of other behaviours indicative of feeding. In 2007, whales appeared to be feeding based on observations of feeding behaviour, slower speeds and random headings. It appears that bowhead whales will tolerate much more intense levels of seismic sounds when feeding than when migrating. Similar tolerance has also been seen in the summer feeding areas in Canadian waters.

One member noted a paper by Beale *et al*. (2004) suggested that nutritionally stressed animals did not avoid disturbance as much as non-stressed animals. This is also noted in paper SC/57/E8 which states "less response to anthropogenic activities does not necessarily mean less impact on animals."

A comment was made about the change in vocal behaviour (shown in Figure 7 in SC/60/E14) at a time of the year (early fall) when one would expect several calls from the whales. The authors pointed out that even though they used data from one Directional Autonomous Seafloor Recorder (DASAR), it does show that calling rates dropped dramatically after the seismic event. When the noise stopped, the call rates of the whales increased again. Because it would take a whale more than two hours to move back (to the array area), this indicates two things: that some displacement probably took place but that many stopped calling, which makes these data difficult to assess.

A clarification of the authors' conclusions was requested. One of the authors replied that when subjected to seismic noise, if there is not a good reason for whales to be in the area (e.g. feeding) they will either deflect their migratory path or move away from the ensonified area. Furthermore, regardless of whether they are feeding or not, they will avoid areas with high levels of seismic noise. One member suggested a different conclusion; if food resources are in the seismic survey area, the animals may tolerate much higher noise levels than they would under other circumstances, perhaps to the point of permanent hearing loss. It is a difficult 'decision' for an animal, as losing a feeding opportunity during migration may have significant nutritional implications. Research on mysticetes has suggested that a single feeding event can be nutritionally significant. The author replied that the sound levels the whales were exposed to were well below those that cause TTS and not too different from the levels that they are exposed to naturally (e.g., grinding sea ice during spring). Further, their own calls are much louder than the received levels for many whales in the area.

It was noted that very little is known about long-term effects of noise on mysticetes. Lack of avoidance does not mean there is no impact. The author responded that in the eastern Beaufort Sea, whales seem to tolerate noise from seismic operations in order to feed. Another member noted that this is a preliminary study. Additional data are needed, as is a more sophisticated analysis before these findings can be confirmed. It was noted that the whales in the study that were estimated to have been exposed to 180 dB (rms) could have received a TTS after exposure to approximately 20 seismic shots, based solely on the values proposed in the recent Noise Exposure Criteria Group paper.

One SWG member emphasised that following individual whales, rather than groups of whales, is a good way to study changes in their behaviour and inquired if the authors had tracked individual animals. He also asked if follow-up bowhead studies will include both seismic and non-seismic study areas.

The researchers plan to continue the studies over the seasons, but so far they could not track individual animals. They do have data from the past studies and extensive work is planned in the future. Unfortunately doing visual identification is not part of the study, as the main task is to clear areas and do mitigation flights over a large area. Both seismic and non-seismic periods will be included in the flights. Acoustic tracking of the whales is being considered if good methods can be found. There is a long-term study on the noise effects of a manmade island created as a base for oil extraction, but so far the investigators have not been able to acoustically re-identify individual whales in that study. It was noted that there is a need for satellite tagging to answer these questions and it was asked whether any tagging is proposed for this year. It was reported that satellite tagging is ongoing and will occur east (Shingle Point, Canada) and west (Pt. Barrow, Alaska) of the study area.

The Chair noted that four papers, relevant to SC/60/E14, have previously been published in IWC journals. These papers demonstrate that the Central Beaufort Sea is important for bowhead whale feeding in some years. Also, the earlier research indicates that call rates remained high through mid- and late September, in contrast to the low call rates reported in SC/60/E14 during that period when seismic surveys occurred.

New information on shipping noise and marine mammals (FI 15 and FI 16) was briefly reviewed. The Marine Environment Protection Committee of the International Maritime Organization (IMO) agreed at its 57th session (December 2007) to request Member Governments to inform all interested parties (particularly those from the shipping industry, shipyards and ship builders) of the issue of noise generated by international shipping and its potential

adverse impact on marine life. Further, in a 'Statement of Participants' from a subsequent International Workshop on Shipping Noise and Marine Mammals convened in Hamburg Germany (April 2008), a specific goal for noise reduction was established. The goal is for "initial global action that will reduce the contributions of shipping to ambient noise energy in the 10-300 Hz band by 3dB in 10 years and by 10 dB in 30 years relative to current levels". The SWG agreed to **endorse** this noise reduction goal.

An atypical mass stranding event of four beaked whales on 26 January 2006 in the region of Almeria was reported at SC/58 to the SWG (IWC9:254-255), but at that time it was unknown if any naval exercises using mid-frequency sonar was underway. New information available in an Environmental Impact Statement (see text below) reported that active sonar training against a Spanish submarine had been conducted within 50 nm of the stranding site (U.S. Department of the Navy, 2008).

> "The Spanish Cetacean Society reported an atypical mass stranding of four beaked whales that occurred January 26, 2006, on the southeast coast of Spain, near Mojacar (Gulf of Vera) in the Western Mediterranean Sea. According to the report, two of the whales were discovered the evening of January 26 and were found to be still alive. Two other whales were discovered during the day on January 27, but had already died. A following report stated that the first three animals were located near the town of Mojacar and were examined by a team from the University of Las Palmas de Gran Canarias, with the help of the stranding network of Ecologistas en Acción Almería-PROMAR and others from the Spanish Cetacean Society. The fourth animal was found dead on the afternoon of May 27, a few kilometres north of the first three animals.
>
> From January 25-26, 2006, Standing North Atlantic Treaty Organization (NATO) a Force Maritime Group Two (five of seven ships including one U.S. ship under NATO Operational Control) had conducted active sonar training against a Spanish submarine within 50 nm of the stranding site.
>
> Multiple ships (in this instance, five) were operating (in this case, mid-frequency active sonar) in the same area over extended periods of time (in this case, 20 hours) in close proximity."

The SWG found that this was interesting information, because these naval activities were consistent with an "atypical mass stranding" event due to the short time period and the number of whales affected. A member remarked that this shows the importance of a through investigation of these types of events, even when causal or contributory factors may not become clear for several years.

One member reported that detonation of WWII ammunition by the military has occurred in underwater areas of the western Baltic. After public concern, the military agreed to stop and will try to adopt alternative approaches to safely dispose of the ammunition.

**11.2 New information on marine renewable energy and cetaceans**

SC/60/E6 noted that in 2003 the IWC Scientific Committee commented that it "regarded the rapid development of marine windfarms to be of potential concern" and it recommended "that full independent and publicly-accessible environmental impact assessments are conducted wherever they are planned" (International Whaling Commission, 2004). Dolman *et al.* (2007) provided an overview of the potential issues for cetaceans relating to Marine Renewable Energy Developments (MREDs) and suggested that the concerns for cetaceans included the intense noise generated during construction (especially with respect to pile-driving); Noise source levels from impact pile-driving can be in the order of 218-227 dB re 1µPa @1m, comprising short (100-200 ms) but intense impulses with maximum overall energy <1 kHz, but some components from ramming impulses up to 100 kHz (Evans, 2008). Each pile may take two hours to complete. Noise levels will vary, with factors such as the size of the turbines (the bigger the turbines, the greater the noise) and the local substrate being important. E6 reviewed the number of existing and planned wind farm developments in the British Isles and on the continent of northern Europe. There are at least 22 operating MREDS in this region, at least eight more are under construction and we are aware of six more that are being planned. In addition, a further 14 windfarms have already been approved for development. (SC/60/E6 provided two maps showing the distributions of the windfarms). The deployment of marine renewable energy sources is now expanding to include other devices that extract energy from waves or currents and ranging from floating mechanisms to underwater turbines, with largely unknown implications for marine wildlife. However, some idea of the potential consequence of a commercial underwater turbine development can be gained from a modelling exercise that showed for the coast of western Scotland, 10.7% of the local harbour porpoise population (some 1300 individuals) would encounter a rotating blade in the space of one year (Wilson et al., 2007). The authors conclude that "the introduction of these new energy generation technologies may pose a significant new threat to European cetacean populations", and emphasise the urgent need to better understand this matter.

In discussion, it was reported that development of windfarms in Spain has been delayed for several years because the Ministry of the Environment had to produce a chart identifying permitted locations for windfarm construction. This chart was eventually published last December and it is expect that this will now be followed by the construction of new windfarms.

A recent European symposium (reported in For Information 10) was dedicated to considering impacts from windfarms on marine mammals (Evans, 2008). The authors commented that 'offshore renewable energy represents perhaps the fastest moving industrial development facing the coastal zone of Europe' and noted the extensive developments 'in shallow waters across Northern Europe, particularly in a wide band from the Irish Sea eastwards across the southern North Sea to the Baltic.' Evans highlighted the fact that the region of windfarm development is now extending further north to eastern Scotland and south to the Iberian Peninsula. He also made recommendations about the research that should be conducted before, during and after MRED developments to better understand their impacts.

The SWG discussed the positive and negative consequences of developing alternative energy sources, recognising the need to look at immediate consequences (e.g., the dolphins running into sub sea turbines noted earlier) versus the long-term environmental and economical benefits such as lowered carbon emissions. It was noted that alternative energy sources may be another putative environmental stressor that affects the health of marine mammals. However, it is difficult to determine health effects from specific environmental stressors. Of note, the Oregon state government is planning to have a wave energy workshop that will include a marine mammal section regarding the potential impacts on these animals. This project could be challenging due to the number of wave-energy stations required and research is needed to determine potential impacts to marine animals. The biggest opposition to wave energy, thus far, has been the fishing industry (e.g., crabbers, fishers). A working paper on this issue is planned for SC/61.

**11. WORK PLAN**

**12.1 Second Climate Change Workshop**

The SWG approved the revised proposal for CC2 and appointed a steering group, Simmonds as convener and Gales as Workshop Chair. Details and estimated costs are given in Appendix 3.