Scientific Research Caucus
STATEMENT

for The Report of the Advisory Committee on Acoustic Impacts on Marine Mammals to the Marine Mammal Commission

3 January 2006

SCIENTIFIC RESEARCH CAUCUS

Congress, through the Omnibus Appropriations Act of 2003, Public Law 108-7, directed the Marine Mammal Commission to "fund an international conference or series of conferences to share findings, survey acoustic 'threats' to marine mammals, and develop means of reducing those threats while maintaining the oceans as a global highway of international commerce." To meet this directive, the Marine Mammal Commission established the 28-member Federal Advisory Committee on Acoustic Impacts on Marine Mammals, composed of representatives from various stakeholder groups, including the scientific research community. This document describes the views of the Scientific Research Caucus on the issues discussed by the Advisory Committee.

The Scientific Research Caucus unanimously and strongly supports the *Report of the Federal Representatives of the Marine Mammal Commission Advisory Committee on Acoustic Impacts on Marine Mammals.*

Therefore, rather than provide a duplicate statement of areas of consensus, we submit the following supplemental statement covering areas in which the Research Caucus has particular expertise or concern.

Above Image: Pacific White-sided Dolphin. Photo ©Tom Kieckhefer. Cover Image: Killer whales travel in groups (called pods) of up to 30 individuals. They produce discrete calls that are specific to their pod. Photo © Tom Kieckhefer.

The following statement reflects only the views of the individuals listed as submitting authors. The inclusion of this statement does not indicate support or endorsement by other members of the Advisory Committee on Acoustic Impacts on Marine Mammals or by the Marine Mammal Commission.

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Scientific Research Caucus

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Background Image: Humpback Whales. Photo © J. Mobley, NOAA Permit No. 642-1536.

BACKGROUND

Any discussion of sound in the sea must start from one basic fact: the ocean is largely transparent to sound, but opaque to light and radio waves. Light travels only a few hundred meters in the ocean before it is absorbed, but sound can travel much greater distances underwater. Marine mammals therefore rely on sound to sense their surroundings, to communicate, and to navigate. Similarly, oceanographers, fishermen, and submariners—in short, all who work in the ocean—rely on sound to sense their surroundings, to communicate, and to navigate.

Sound is an unavoidable and often intentional addition to the marine environment for virtually all human endeavors in the oceans. Short of abandoning all use of the seas, it is simply impractical, and indeed in many cases inadvisable, to say that no human-generated sound may be produced in the oceans. If we are to continue to explore and use our marine resources, we must determine the critical parameters for safe, sustainable use of the oceans. Active sonar systems are a fundamental tool used by all the navies of the world to accomplish their mission. Towed arrays of acoustic sources and receivers are used in geophysical exploration to create images of geological structures below the seafloor in order to locate oil and gas reserves. Over 90% of the world's commerce depends on transport on the high seas, which produces sound as a by-product. For the scientific community, sound production is fundamental to determining the basic properties of the ocean environment and studying the animals that live in it, including, for example, the development of a more complete understanding of marine mammal foraging, social behavior, and habitats. In addition, acoustics-based subsea imaging techniques provide the most effective means to document and analyze significant natural geological processes such as earthquakes, volcanic activity, and seafloor slides, that can have profound effects not only for marine life, but also for coastal and island communities, as recent world events have made painfully obvious. Sound in the sea is not just noise. It is used for a wide variety of valuable and important purposes.

Four reports published by the National Research Council (1994b, 2000, 2003, 2005) summarize the state of scientific knowledge on the issue of marine mammals and anthropogenic sound, the progress that has been made in understanding the issue over the last ten years, and recommendations for future research. These reports are thoroughly researched documents produced by balanced panels of scientific experts in the relevant fields. Independent experts anonymously reviewed the reports for scientific accuracy. Thus, these reports represent nearly a decade of balanced and comprehensive studies of our knowledge of anthropogenic sound and its potential impacts on marine mammals. The U.S. Commission on Ocean Policy (2004) also considered the issues related to protecting marine mammals, including those related to anthropogenic sound. Their recommendations are fully consistent with those made in the National Research Council (NRC) reports. The findings and recommendations in these reports provide excellent guidance for the way forward. We believe that the Federal Advisory Committee process was less well suited to provide a review of the science than the NRC process, and we will therefore not attempt a detailed synthesis of the relevant research here.

"The basic goal of marine mammal conservation is to prevent human activities from

Dr. Darlene Ketten uses computerized tomography and magnetic resonance imaging, along with traditional physical dissections, to get detailed information about the hearing structures of animals. Inthis image, Dr. Ketten is preparing a harbor porpoise for a CT scan. Photo courtesy of Tom Kleindinst, Woods Hole Oceanographic Institution.

harming marine mammal populations."

NRC, 2005

STATEMENT OF THE ISSUE

Marine mammals face many threats from human activities, including fisheries bycatch, habitat degradation, whaling, ship strikes, and anthropogenic sound. Preventing harm to marine mammal populations requires an accurate understanding of the threats facing them.

The U.S. Marine Mammal Protection Act (MMPA) was designed to protect marine mammals from intentional whaling and from unintentional bycatch in fisheries. While the MMPA has reduced marine mammal bycatch in U.S. fisheries, globally hundreds of thousands of marine mammal deaths still occur annually from fisheries bycatch (Read *et al.,* 2003). Marine mammals are also killed by ship strikes, underwater explosions, and entrapment in power plants and other structures.

Sound is included in the list of threats because we know that it can affect marine mammals in a number of ways. It can alter behavior or compete with important signals (masking). Sound can cause temporary hearing loss or, if the exposure is prolonged or intense, permanent hearing loss. It can even cause damage to tissues other than the ear if sufficiently intense. At present, our knowledge of the extent and nature of these threats for marine mammals is severely limited.

Anthropogenic sound has also emerged as the most likely cause of some marine mammal strandings based on an association between the location and timing of naval activities using active sonar and mass strandings of beaked whales in their vicinity (Cox *et al.,* 2005). (Mass strandings are defined as the stranding of two or more animals simultaneously or in close proximity.) There are multiple causes of strandings, some natural and some related to human activities. Natural causes include toxic algal blooms, disease, and storm surges. Human activities that cause strandings include ship strikes, entanglement in fishing gear, and pollution. On average approximately 3,600 stranded marine mammals were reported per year in the United States alone during the period 1990–2000 (NMFS, 2000). Beaked whale strandings are uncommon and mass strandings of beaked whales are extremely rare. Seventeen beaked whales strandings were reported in the U.S. in 1999 and five in 2000, for example (NMFS, 2000).

The best-documented mass strandings of beaked whales involving activities using high-level, mid-frequency active naval sonar occurred in Greece (1996), the Bahamas (2000), Madeira (2000), and the Canary Islands (2002). In these cases, there is sufficient information about the sonar operations and the times and locations of the strandings to associate the strandings with the naval activities. Each stranding involved between 4 and 18 whales that were found stranded within two days of the sonar use. Approximately half of the stranded animals were found dead or subsequently died, for a total of nearly 40 known animal deaths in the four events. No deaths in any other

family of marine mammals have been clearly associated with sound (NRC, 2005; Cox *et al.*, 2005). Although these strandings are closely related in time and space to active naval sonar operations, the mechanism by which the sonars could have caused the strandings or the traumas observed in some of the stranded beaked whales is unknown.

The small number of known animals involved in the few well-documented strandings associated with active naval sonar activities does not provide adequate evidence to conclude that sound poses a global and critical threat to marine mammals. Until we have a full understanding of these events, however, it is appropriate to be concerned and to continue the investigations needed to fully understand the exact role, direct or indirect, of sound use in them. Until a mechanism is determined, we cannot say definitively whether these stranding events represent unique circumstances that adversely affect relatively few individuals from a single family of whales or if this is a harbinger of a potentially broader problem of anthropogenic sounds adversely impacting other marine animals on wider geographic and temporal scales.

Further, it is important that we look not only at these relatively limited and possibly special cases, but also proceed with investigations that can inform us of other possible impacts in advance and prevent more subtle, but in the long term perhaps more significant, effects. We suspect that the most significant effects of sound on marine mammal populations are more likely to result from cumulative effects of chronic exposures to sounds that cause hearing loss or disrupt behavior and habitats, rather than from a small number of extreme events. Effective protection requires differentiating activities that cause minor changes in marine mammal behavior from activities that cause significant disruption of behaviors critical to survival and reproduction or that cause direct physical harm. The MMPA was originally written to reduce "takes"—mortality, injury, or harassment of marine mammals. The current regulatory framework under the MMPA is not well suited to reducing adverse impacts of cumulative effects of chronic exposure to potential stressors such as sound or chemicals.

A great deal of controversy surrounds the issue of marine mammals and anthropogenic sound. At present, how-

ever, it is not scientifically verifiable whether or not anthropogenic sound is a first order problem in the conservation of marine mammal populations. The most recent National Research Council report (2005) concludes:

> *"With the exception of beaked whale strandings, connections between anthropogenic sound in the oceans and marine mammal deaths have not been documented. In the presence of clear evidence of lethal interactions between humans and marine mammals in association with fishing and vessel collisions…, the absence of such documentation has raised the question of the relative importance of sound in the spectrum of anthropogenic effects on marine mammal populations… On the one hand, sound may represent only a second-order effect on the conservation of marine mammal populations; on the other hand, what we have observed so far may be only the first early warning or "tip of the iceberg" with respect to sound and marine mammals."*

The four reports published by the National Research Council (1994b, 2000, 2003, 2005) make recommendations for the research required to resolve this fundamental uncertainty.

Photo Below: Humpback whales are commonly sighted in nearshore waters near Kauai, Hawaii during the winter months. Photo courtesy of Ann Zoidis.

RISK ASSESSMENT

The issue of protecting marine mammals from adverse effects of sound shares similarities with the problem of protecting humans and wildlife from toxic chemicals. The classic way to manage this kind of problem is called risk assessment. We therefore argue that the intellectual framework required for thinking in a rigorous way about the threats to marine mammals and how best to ameliorate them is also that of risk assessment (Harwood, 2000; Tyack *et al.,* 2003/04). Risk assessment has been reviewed in several reports by the National Research Council (1983, 1993, 1994a) and by the Environmental Protection Agency (1992). It involves several stages:

- Hazard identification
- Exposure assessment
- Exposure-response assessment
- Risk characterization
- Risk management

Hazard identification. The first stage in risk assessment is called hazard identification. As early as 1971, scientists warned that the global increase in low frequency sound from shipping could reduce the range of communication in marine mammals (Payne and Webb, 1971). However, there is still no evidence to indicate whether or not this increased sound poses a hazard. Abundant studies describe how marine mammals avoid anthropogenic sounds, and other changes in behavior have also been described (e.g., Richardson *et al.,* 1995). However, a recent report of the National Research Council (2005) points out that we do not have the scientific techniques required to evaluate whether these changes pose a hazard to marine mammal populations. The one known lethal hazard related to sound involves the mass strandings of beaked whales associated with mid-frequency naval sonars.

Exposure assessment. The next step in risk assessment is exposure assessment. To predict the sound exposure at a marine mammal, one must know the characteristics of the sound source, how sound propagates through the ocean, and the hearing sensitivity of the species. The acoustic characteristics of human sources of sound and the propagation of sound in the marine environment are relatively well understood. It is unrealistic to expect that research conducted to understand effects of noise on marine mammals could make significant improvements in our knowledge of sound propagation. However, as the federal government develops ocean observatories, action agencies should be directed to include acoustic monitoring that can be used to measure trends in ambient noise at a variety of scales.

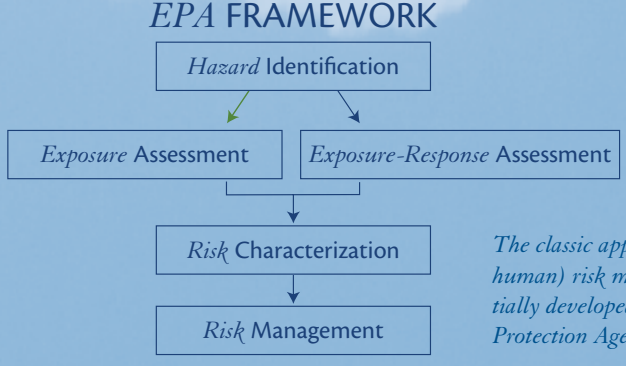
Assessing the exposue of marine mammals to a sound in a specific area requires knowledge of the distribution and abundance of all marine mammal species that can hear the sound in that area. The National Marine Fisheries Service (NMFS) conducts an extensive series of sighting cruises each year within the U.S. EEZ. However, these data are collected to assess the stocks or populations of marine mammals, and the analysis provided by NMFS is not suitable for predicting the probability of encountering animals at different ranges from a source. NMFS should make the raw data public, so that other analyses could be performed. Although this would help resolve uncertainties in U.S. waters, additional survey efforts will likely be needed. Many U.S. activities are conducted all over the globe, however, and additional coordination is required with other nations to predict which species might be exposed when sources operate outside of U.S. waters.

Coordination of data sharing with other nations will reduce uncertainty, but new survey efforts may be required.

Assessing exposure of animals requires knowledge of their hearing. Hearing ability has been measured in a few individual animals from species that can be trained in the laboratory, such as dolphins and seals. Recently researchers have developed a technique that can be used to study hearing in untrained animals in the wild (Nachtigall *et al.*, 2005). This technique is called auditory brainstem response, or ABR, and it depends upon detecting the electrical activity of the brain when an animal hears a sound. A research program should be developed to apply this technique to study hearing in whales and other species for which hearing has not been studied.

Exposure-response assessment. The next step in risk assessment involves determining how animals respond to a particular sound exposure. In recent years, this kind of dose-response study has been used to define what kinds of acoustic exposure begin to pose a risk to hearing in seals and dolphins. ABR studies can help extend these results to other species. However the greatest ambiguity of all for assessing the risk of sound on marine mammals involves our uncertainty in what kind of behavioral response is evoked by a specific dosage of sound. In many cases, we do not even know the correct way to represent the sound dosage. The behavioral responses an animal makes to a sound are more variable than physiological responses, and can depend on the species, population, age-sex class, behavioral context, hearing sensitivity, and history of exposure of the individual. It is impossible to study responses of all species to all sounds, so studies must be prioritized based upon expectation of the potential for harm.

Risk characterization and risk management. Once one can characterize the exposure of animals to a sound source, and one knows the relationship between exposure and the effects of concern, it is possible to calculate the total effect of the summed exposure to characterize the hazard to the population. If the hazard is significant enough to require management, then a final stage involves comparing the benefits of different strategies to manage the risk. Many management strategies in use today involve shutting down a source when animals are detected within a zone of adverse impact. There are considerable uncertainties about the effectiveness of different methods for detecting animals, however. Another management strategy is to slowly increase the level of a source when it is turned on, to give animals an opportunity to move out of harm's way, but there are few data to confirm whether this strategy is successful or not.



The classic approach to environmental (and human) risk mitigation uses aframework initially developed by the US Environmental Protection Agency

Background Image: Humpback whales are known for their songs. These songs, most often heard on their breeding grounds, are associated with courtship displays. Photo ©Tsuneo Nakamura.