

than are those of mysticetes. Odontocete low-frequency hearing is less sensitive than that of mysticetes, and dolphins are often seen from seismic vessels. In fact, there are documented instances of dolphins approaching active seismic vessels. However, dolphins as well as some other types of odontocetes sometimes show avoidance responses and/or other changes in behavior when near operating seismic vessels.

Taking account of the mitigation measures that are planned, effects on cetaceans are generally expected to be limited to avoidance of the area around the seismic operation and short-term changes in behavior, falling within the MMPA definition of "Level B harassment." In the cases of mysticetes, these reactions are expected to involve small numbers of individual cetaceans because few mysticetes occur in the area where seismic surveys are proposed. LDEO's best estimate is that 42 fin whales, or 0.5 percent of the estimated fin whale population in and adjacent to the study area, will be exposed to sound levels ≥ 160 dB re 1 μ Pa (rms) and potentially affected. Similarly, 22 humpback whales, or 0.8 percent, and 18 sperm whales, or 0.2 percent of their populations that occur in and adjacent to the proposed survey area, would receive seismic sounds ≥ 160 dB. Therefore, these potential takings by Level B harassment will have a negligible impact on their populations. Numbers and impact would be even smaller if the 2-GI gun array is used for a substantial fraction of the survey project.

Larger numbers of odontocetes may be affected by the proposed activities, but the populations sizes of the main species are large and the numbers potentially affected are small relative to the population sizes. The best estimate of the total number of odontocetes that might be exposed to ≥ 160 dB re 1 μ Pa (rms) in the proposed survey area in the Norwegian Sea is 878. Of these, 770 are Delphinidae, and of these about 200 might be exposed to ≥ 170 dB. These figures are <0.1 percent of the populations of these combined species that occur in the Northeast Atlantic, and the 200 value is believed to be a more accurate estimate of the number potentially affected.

Mitigation measures such as controlled speed, look-outs, non-pursuit, ramp-ups, avoidance of start-ups during periods of darkness when possible, and shut-down when within defined ranges (See Mitigation) should further reduce short-term reactions to disturbance, and minimize any effects on hearing sensitivity.

Conclusions-effects on Pinnipeds

Very few if any pinnipeds are expected to be encountered during the proposed seismic survey in the Norwegian Sea. A maximum of 70 pinnipeds in the Storegga slide area may be affected by the proposed seismic surveys. If pinnipeds are encountered, the proposed seismic activities would have, at most, a short-term effect on their behavior and no long-term impacts on individual seals or their populations. Responses of pinnipeds to acoustic disturbance are variable, but usually quite limited. Effects are expected to be limited to short-term and localized behavioral changes falling within the MMPA definition of Level B harassment.

Mitigation

For the proposed seismic operations in the Storegga slide area in 2003, LDEO will use 2 GI guns with a total volume of 210 in³ and/or a 6-gun array with a total volume of 1350 in³. The airguns comprising these arrays will be spread out horizontally, so that the energy from the arrays will be directed mostly downward.

Modeled results for the 2- and 6-gun arrays indicate received levels to the 180-dB re 1 μ Pa (rms) isopleth (the level for the potential for Level A harassment applicable to cetaceans) were estimated as 50 and 220 m (164 and 722 ft), respectively. The radii around the 2- and 6-gun arrays where the received level would be 190 dB re 1 μ Pa (rms), (the level for the potential for Level A harassment applicable to pinnipeds), were estimated as 15 and 50 m (49 and 164 ft), respectively. Results from a calibration study that occurred in late the spring of 2003 in the Gulf of Mexico will determine the actual radii corresponding to each sound level. If the modeled radii have not been verified by the time of the Storegga slide surveys, LDEO proposes to use 1.5 times the 180- (cetaceans) and 190- (pinnipeds) dB radii predicted by the model as the safety radii until the radii have been verified. Thus, during the Storegga slide cruise the proposed safety radii for cetaceans are 75 and 330 m (246 and 1,083 ft), respectively, for the 2-GI gun and 6-gun arrays, and the proposed safety radii for pinnipeds are 23 and 75 m (75 and 246 ft), respectively.

Vessel-based observers will monitor marine mammals in the vicinity of the arrays. LDEO proposes to shut down the seismic source if marine mammals are observed within the proposed safety radii. Also, LDEO proposes to use a ramp-up procedure when commencing

operations using the 6-gun array. Ramp-up will begin with the smallest gun in the array (80 in³), and guns will be added in a sequence such that the source level of the array will increase at a rate no greater than 6 dB per 5-minute period over a total duration of about 14 minutes. Ramp-up will not occur for the 2-GI gun array because the total air discharge volume is small (210 in³). Please refer to LDEO's application for more detailed information about the mitigation measures that are an integral part of the planned activity.

Operational Mitigation

The directional nature of the 6-airgun array to be used in this project is an important mitigating factor, resulting in lower sound levels at any given horizontal distance than would be expected at that distance if the source were omnidirectional with the stated nominal source level. Because the actual seismic source is a distributed sound source (2 or 6 guns) rather than a single point source, the highest sound levels measurable at any location in the water will be less than the nominal source level.

Marine Mammal Monitoring

Up to three vessel-based observers will be stationed on the *R/V Maurice Ewing* during seismic operations in the Storegga slide area. Vessel-based observers will monitor for marine mammals near the seismic source vessel for at least 30 minutes prior to and during all daylight ramp-up and airgun operations, and during any nighttime startups of the airguns. Airgun operations will be suspended when marine mammals are observed within, or about to enter, designated safety zones, where there is a possibility of Level A harassment. Observers will not be on duty during ongoing seismic operations at night; bridge personnel will watch for marine mammals during this period and will call for the airguns to be shut down if marine mammals are observed in or about to enter the safety radii. A marine mammal observer will be on "standby" at night, in case bridge personnel see a marine mammal. An image-intensifier night-vision device (NVD) will be available for use at night, although past experience has shown that NVDs are of limited value for this purpose. If the airguns are started up at night, two marine mammal observers will monitor for marine mammals near the source vessel for 30 minutes prior to start up using night-vision devices. The 30-minute observation period is only required prior to commencing seismic operations following an extended shut down period.