Proceedings of the Seismic and Marine Mammals Workshop London 23-25 June 1998

Edited by
Mark L Tasker and Caroline Weir

Contents

7 PROTECTION FROM, AND MITIGATION OF, THE POTENTIAL EFFECTS OF SEISMIC EXPLORATION ON MARINE MAMMALS

Mark O. Pierson[1], Jay P. Wagner[2], Vance Langford[2], Patricia Birnie[3], and Mark L. Tasker[4].

[1]US Department of the Interior, Minerals Management Service, Pacific OCS Region, 770 Paseo Camarillo, Camarillo, California 93010, USA.
[2]Petroconsultants, Economics and Policy Analysis Group, Europa House, 266 Upper Richmond Road, London SW15 6TQ, UK.
[3]78 Windmill Street, Brill, Aylesbury, Bucks HP18 9TG
[4]Joint Nature Conservation Committee, Dunnet House, 7 Thistle Place, Aberdeen AB10 1UZ, UK.

7.1 Introduction

In recent decades, concern has arisen that sounds introduced into the ocean by humans could have adverse effects on marine mammals. Sound is transmitted very efficiently through water, and underwater sound can often be detected many kilometres from the source. This efficiency of underwater sound propagation has also allowed marine mammals to use underwater sounds as a primary method of communicating and exploring their environment.

In the United States (US), these concerns have contributed to the enactment and expanded application of the Marine Mammal Protection Act (MMPA) of 1972, and other laws and regulations and have generated research on the effects of man-made noise on marine mammals (Richardson *et al.* 1995). Much of the research on this problem to date has focused on the behavioural responsiveness of marine mammals to underwater sound. The US Minerals Management Service (MMS) has funded many of the studies related to the effects of seismic survey noise, especially on bowhead whales (*Balaena mysticetus*) in Alaska and grey whales (*Eschrichtius robustus*) off the central California coast.

Although the effects of low-frequency sound on marine mammals have increasingly become the focus of research, much uncertainty remains. In 1992, the US National Research Council (NRC) formed a Committee on Low-Frequency Sound and Marine Mammals to review current knowledge on the subject and identify research needs (NRC 1994). In its 1994 report, the Committee concluded that the existing data were extremely limited and could not constitute the basis for informed prediction or evaluation of the effects of intense low-frequency sounds on any marine species.

In recent years, the MMPA also has had major significance for seismic survey work in particular. In the 1970s and 1980s, man-made sound was not yet recognised as a potentially serious threat to marine mammals and little attempt was made to avoid disturbance or other effects in the course of noise-producing offshore activities. In the Alaskan Beaufort Sea, monitoring programs in support of offshore seismic, construction, and drilling activities began in the mid-1980s (Richardson 1997a). These programs focused on migrating bowhead whales and were developed in response to concerns by the local Inuit whalers over possible impacts to their annual subsistence hunt.

For geophysical exploration in federal offshore Californian waters, only one of the geophysical permit stipulations that were imposed on operators by the MMS applied to marine mammals. This stipulation applied specifically to a single marine mammal population, the California grey whale, which migrates annually through California waters and, until 1994, was listed as endangered under the US Endangered Species Act (ESA) of 1973. It stated simply:

"All operations under this permit shall be conducted with due consideration for the migrating whale population. No geophysical acoustic pulse generating equipment shall be started in federal waters when whales are observed within two kilometres of permittee's geophysical vessel. Should any operational conflict with migrating whales be observed and responsibly reported to the Regional Supervisor, Office of Resource Evaluation, an order of cessation from that time until the matter is resolved may be issued".

No MMS oversight was provided to ensure that the stipulation was followed.

This situation began to change in the western US in the 1990s, especially as other activities involving the introduction of low-frequency noise into the marine environment, such as the Acoustic Thermometry of Ocean Climate (ATOC) study (Richardson *et al.* 1995) and the US Navy's Low Frequency Active Sonar (LFA) research

(Marine Acoustics, Inc. 1997), began attracting public attention. Because the MMPA includes harassment in its definition of taking, because noise-related disturbance is considered to be a form of harassment, and because seismic surveys produce some of the highest source levels of man-made noise, increasing attention has focused on the effects of seismic survey sounds on marine mammals. Attempts to mitigate the potential effects of seismic noise on marine mammals under the MMPA have led to the imposition of a number of operational restrictions and monitoring requirements on seismic survey activities in areas under US jurisdiction. Most of these restrictions and requirements have been developed for specific areas and potential marine mammal disturbance problems, rather than for general application in US waters. For example, in the Gulf of Mexico, where baleen whales are rare and pinnipeds absent, mitigation has not been required to date. A number of these US provisions have been adopted for regulations in other countries (Richardson *et al*. 1995).

This review focuses on current efforts to mitigate the potential effects of low-frequency seismic sounds on marine mammals in US waters, particularly in the western US from Alaska to California. Available information on mitigation measures currently in use in other regions of the world is also presented. Section 7.2 presents an introduction to, and general description of, the standard mitigation and monitoring measures now in use. Sections 7.3 and 7.4 describe examples of specific mitigation employed in recent and ongoing seismic surveys worldwide.

7.2 Standard mitigation and monitoring measures

7.2.1 Seasonal and geographic restrictions

In some areas, permits for marine seismic survey operations prohibit or discourage activities where and when marine mammals of concern are present. Discouragement may include increased operational restrictions when marine mammals of concern are expected to be present (Richardson *et al.* 1995).

One of the simplest means of reducing potential noise-related effects on marine mammals is to avoid areas where they are abundant or that are important for some aspect of biology of a species. Seismic survey operations may be re-routed or restricted from sensitive areas. Of course, such measures are often employed in conjunction with seasonal limitations. Examples of such areas include coastal pinniped haul-out sites and offshore areas used by marine mammals for feeding, breeding, or socialising (Richardson *et al*. 1995).

There are practical problems that complicate attempts to implement such restrictions. Since different species of marine mammals occupy particular areas during different seasons, choosing a specific period for a seismic survey may still result in some species being affected. It may be necessary to compromise by giving priority to species with vulnerable conservation status and/or greatest sensitivity to the dominant sound frequencies produced by seismic surveys. Thus, the timing of a survey along the Atlantic Frontier north-west of Shetland might be determined based upon the seasonal presence of species such as fin (*Balaenoptera physalus*) and humpback (*Megaptera novaeangliae*) whales, rather than pilot whales (*Globicephala melas*) or killer whales (*Orcinus orca*) (Evans 1998). This would entail seismic surveys being mainly between November and March rather than during the summer months, even though pilot and killer whales are present during that period (Evans 1992; Stone 1997, 1998). Some specific examples of seasonal and geographical restrictions or requirements imposed for marine seismic survey operations are presented in sections 7.3 and 7.4.

7.2.2 Ramp-up

The ramp-up procedure generally involves the gradual increase in intensity of a sound source from some basal level to full operating intensity over a period of several minutes. Ramp-up has become a standard mitigation measure for seismic operations in many areas (NMFS 1995a,b, 1997a, 1998; Richardson 1997b; JNCC 1998), as well as for other activities involving high-energy sound sources such as the ATOC study (Richardson *et al.* 1995) and the US Navy's LFA sonar research (Marine Acoustics, Inc. 1997). This has occurred in recognition of the potential risk that immediate hearing damage could occur to a nearby marine mammal if a high-energy sound source, such as an airgun array, were turned on suddenly.

It is assumed that if marine mammals will find the sound increasingly aversive, they will move away before hearing damage or physiological effects occur (Richardson *et al.* 1995; Richardson 1997b). If this is true, ramp-up can be effective mitigation, even for undetected animals

present beneath the surface near the sound source. However, this has primarily been a common-sense measure, since there have been no comprehensive studies of the effectiveness of ramp-up procedures (Richardson *et al*. 1995; Richardson 1997b).

It is also possible that ramping up a high-energy sound source actually could be harmful. Conceivably, marine mammals could gradually accommodate to increasing sound intensity until harmful levels are reached. This probably would be more likely to occur if the survey area were important to them for feeding or some other vital activity (Evans 1998). Humans repeatedly exposed to loud noises can have their hearing physically damaged over the long term; this may also happen to marine mammals (Ketten *et al*. 1993; Todd *et al*. 1996). Alternatively, they might be attracted to the source by initially weak sounds and thus exposed to potentially harmful levels as the sound intensity increases. It is probable that ramp-up effectiveness would vary with species and circumstances.

The NRC (1994) discussed ramp-up procedures in their review of topics for future research on low-frequency sound and marine mammals. Richardson *et al*. (1995), which provides the most comprehensive recent review of marine mammals and noise, recommended that the effectiveness of ramp-up be studied, as did an expert panel of acousticians and marine mammalogists at an MMS-sponsored workshop in 1997. Such a study is currently being considered for funding by the MMS.

In US waters, the ramp-up protocol most commonly followed is that developed as a mitigation condition for issuance of Incidental Harassment Authorizations (IHAs) by the National Marine Fisheries Service (NMFS) (see section 7.3.1). This protocol requires that the airgun array be ramped up to full operating levels at a rate not to exceed 6 dB per min between 160 dB and the operating level at the commencement of operations or anytime that the array is powered down below 160 dB (re 1 µPa) maximum output.

In the United Kingdom (UK), where the procedure is termed a slow build-up or soft start, guidelines (JNCC 1998) specify that power should be built up slowly from a low energy start-up (e.g., starting with the smallest airgun in the array and gradually adding in others) over at least 20 min to give adequate time for marine mammals to leave the vicinity. The guidelines also state that there should be a soft start every time the airguns are used, even if no marine mammals have been seen (particularly, e.g. by night).

7.2.3 Safety zones

7.2.3.1 Definition of safety zones

As discussed above, although it is unknown whether marine mammals that are very close to an airgun array would be at risk of temporary or permanent hearing impairment, it is recognised that there is a potential for such impacts within a few hundred metres of a seismic source (Richardson *et al*. 1995). In order to avoid exposing marine mammals close to a seismic source to sound levels that could cause hearing damage, safety zones have been designed. For a number of seismic surveys conducted in US waters, the NMFS (1995a,b, 1997b, 1998) has established safety zones to prevent permanent hearing damage to marine mammals from exposure to impulsive devices with peak amplitudes at frequencies below 250 Hz.

Safety zones are defined by the radii of received sound levels believed to have the potential for at least temporary hearing impairment for marine mammals. As discussed in Richardson *et al*. (1995), the limited evidence available indicates that there are differences in responsiveness to seismic sounds among marine mammal groups, with baleen whales, and perhaps sperm (*Physeter macrocephalus*) whales, being the most sensitive and eared seals the least. Using the best current data on marine mammal hearing, NMFS, in a recent IHA (NMFS 1998), identified what they believed to be conservative safety distances, defined by received sound pressure levels of 180 dB re 1 µPa (rms) for baleen and sperm whales, and 210 dB re 1 µPa (rms) for odontocetes and pinnipeds. In earlier seismic surveys in US waters, the somewhat more conservative received level of 190 dB re 1 µPa (rms) had been adopted for odontocetes and pinnipeds (NMFS 1995a,b, 1997a).

At a workshop on marine mammals and low-frequency sound convened by the MMS-sponsored High-Energy Seismic Survey (HESS) Team in 1997, an expert panel concluded that they were apprehensive about levels above 180 dB re 1 µPa (rms) with respect to overt behavioural, physiological, and hearing effects on marine mammals in general (HESS 1997). As a consequence, it is likely that the 180 dB radius will be recommended as the safety zone distance to be used for all marine mammals during future seismic surveys offshore southern California, although NMFS may use other levels elsewhere.

Table 7.1 depicts the safety zones defined for several recent seismic surveys in US waters and for surveys covered by the UK guidelines. These safety zone definitions are described further in sections 7.3 and 7.4.2.

Initial calculation of the sound level isopleths that bound the safety zone areas, usually presented as dB re 1 µPa (rms) (Richardson *et al*. 1995), is generally performed using transmission loss models. Such models can be used to estimate the rate at which the source sound levels produced by particular airgun arrays attenuate as a function of increasing distance from the source. Sophisticated models incorporate site-specific information on water depth, slope, bottom topography and type, and other factors.

However, in some regions, particularly in US waters, concern regarding the adequacy of models to accurately calculate transmission loss in specific seismic survey areas

has led to requirements for site-specific verification of the transmission loss models (e.g., NMFS 1995b). This frequently has been performed prior to the start-up of seismic survey operations and occasionally has involved relatively large-scale, expensive field efforts. Another approach, currently being recommended for use in southern California waters by the HESS Team, would allow a survey to begin using safety zones defined by a model, followed by field verification early in the operational period. This verification would be designed to be done quickly and relatively inexpensively, either by a subcontractor or by the geophysical contractor using the seismic vessel's own hydrophone array.

Table 7.1 Safety zone radii employed during recent seismic surveys

Survey safety zone radius	*Mysticetes*[1]	*Odontocetes*	*Pinnipeds*
Alaska (Beaufort Sea), Northstar, 1997	1,020 m (3,346 ft)[2]	1,020 m (3,346 ft)[2]	260 m (853 ft)[3]
Southern California (Santa Barbara Channel), Santa Ynez Unit, 1995	450 m (1,476 ft)[2]	152 m (500 ft)[3]	152 m (500 ft)[3]
Washington/British Columbia (Puget Sound region), SHIPS, 1998	500 m (1,640 ft)[4]	200 m (656 ft)[5]	100 m (328 ft)[6]
United Kingdom, 1995 to present	500 m (1,640 ft)[7]	500 m (1,640 ft)[7]	500 m (1,640 ft)[7]

Notes:
[1] This category includes sperm whales for some surveys
[2] The distance at which the received level was estimated to be 180 dB re. 1 µ Pa (rms) for the largest array used
[3] The distance at which the received level was estimated to be 190 dB re. 1 µ Pa (rms) for the largest array used
[4] An additional 100 m was added to the distance at which the received level was estimated to be 180 dB re. 1 µ Pa (rms)
[5] This was twice the distance at which the received level was estimated to be 210 dB re. 1 µ Pa (rms)
[6] The distance at which the received level was estimated to be 210 dB re. 1 µ Pa (rms)
[7] A distance at which cetaceans may be relatively reliably observed

7.2.3.2 Approach criteria

The most basic approach to safety zone monitoring involves careful visual monitoring of the defined safety zone area around the airgun array by one or more observers on the seismic source vessel for some period preceding and during ramp-up. Observations generally begin approximately 1 hr to 30 min prior to start-up (NMFS 1995a; JNCC 1998). If marine mammals are sighted within the safety zone during this period, the ramp-up procedure is delayed to give the animals sufficient time to clear the area. This approach assumes that marine mammals that find the seismic sounds disturbing will remain clear of the safety zone once full operational levels have been attained.

A more rigorous level of safety zone monitoring involves the requirement that the safety zones be monitored continuously whenever the airgun array is operating, and that the array be shutdown if any marine mammal is sighted within the zone. This reflects the concern that marine mammals that are foraging or intent on other activities might inadvertently swim close enough to the airguns to expose themselves to potential hearing damage. This is the approach currently being followed for most seismic surveys in US waters (NMFS 1995a,b, 1997a).

However, pinnipeds, especially sea lions, may represent a special problem, since they are thought to be relatively insensitive to low-frequency sound (Richardson *et al*. 1995) and have been reported, at least anecdotally, to approach operating airgun arrays (NMFS 1997b). A recent example of such problems occurred during a 57-day seismic program in the Beaufort Sea, where airgun operations were interrupted 135 times when seals were seen within the safety zone (Richardson 1997a). Note however, that in this case, shutdown was comparatively simple as seabed hydrophones were used, and only the seismic source was being towed.

In its required mitigation for a US Geological Survey seismic survey of the Puget Sound region in March 1998 (see section 7.3.2.3), NMFS (1997b, 1998) attempted to deal with this problem by requiring that the airgun array be shut down if the seismic source vessel approached a pinniped, but not if the pinniped itself approached the array. This appears to be a workable compromise for seismic survey operations in regions where pinnipeds are common.

In a recent review of current issues involving marine mammals and man-made noise, Richardson (1997b) discussed the problems surrounding the safety criteria currently being used. He pointed out that, although safety-zone radii are defined based on the best available data on reaction or injury thresholds, these data are often weak and extrapolated from terrestrial or human situations. This means that regulators attempting to establish adequate safety zones often make subjective judgements, which can result in difficult operational conditions (such as that described above for the Beaufort Sea). He argued that better data are needed both to ensure appropriate protection for marine mammals and to avoid unnecessary disruption of important human activities.

7.2.4 Real-time monitoring

7.2.4.1 Visual monitoring

All visual monitoring techniques have inherent limitations. Marine mammals more than a few metres beneath the surface are invisible, even from the air. In addition, not all animals present at the surface are detected, even by experienced, well-rested observers under ideal viewing conditions. As viewing conditions deteriorate, the percentage of animals missed by visual monitoring increases.

Other factors affecting detectability include the observational procedures, the species, and the distance from the observer (Richardson 1997b). Richardson (1997b) pointed out that the specific probabilities of detecting different marine mammal species under various conditions are seldom estimated, and he observed that better data are needed on the effectiveness of real-time monitoring under realistic field conditions.

7.2.4.1.1 Shipboard monitoring

In general, ship-based observers employed during seismic survey operations serve one or both of two functions: 1) monitoring the designated safety zones around the seismic airgun array during r amp-up and full operation, and providing the basis for real-time mitigation (airgun shutdown); and 2) collecting data on the species, numbers, and behaviour of marine mammals observed, the estimated number of animals that may have been 'taken' by harassment (in US waters), and any behavioural responses to the seismic survey activities. In practice, shipboard observers have generally filled both these functions, even in situations where observations are limited to the areas within the safety zones.

At the most basic level of coverage, the monitoring of safety zones during ramp-up, a single observer may be appropriate, since duties involve intermittent watches generally lasting 2 hrs or less. If safety zones are monitored continuously during airgun operations and/or marine mammal sighting data are collected, additional observers are required. Two experienced observers are capable of handling these expanded duties for relatively short surveys, and two have been used, with mixed success, for seismic operations lasting as long as a month (Impact Sciences 1996; see section 7.3.2.2).

However, for surveys lasting more than a few days, a minimum of three observers would be preferable, in order to limit individual watches to a reasonable length (no longer than 4 hrs) to avoid observer fatigue and reduced efficiency. Given the limited berth space aboard many seismic vessels, this may lead to operational conflicts, and compromises may have to be made.

Observers are generally stationed at the highest vantage point on the seismic source vessel from which they have an unobstructed view of the safety zones and surrounding waters. During daylight, observers scan the waters near the vessel with naked eye and binoculars. Reticular 7x50 power binoculars are most commonly used. Reticules are gradations on the binocular eyepieces that are used to estimate distance by measuring the vertical angle of the line of sight to an animal relative to the horizon. Since the vertical uncertainty increases with distance, accuracy diminishes with distance and is dependent on the observer's elevation above the water (LGL Ltd. & Greeneridge Sciences Inc. 1997). Occasionally, higher-power, 'Big-eye' binoculars or spotting scopes may be used to supplement hand-held binoculars for sightings made at substantial distances from the vessel.

When night-time observations are conducted, some form of night-vision equipment is generally employed. Two types, light-amplifying and infrared (IR), have been used for seismic surveys to date. The light-amplifying night-vision equipment works by amplifying ambient light from the moon, stars, and artificial light sources to brighten the visual field. IR night-vision equipment works by detecting differences in temperature. Both systems have advantages and limitations; NMFS is currently supporting field comparisons of available light-amplifying and IR equipment (K. Hollingshead, NMFS, pers. comm.).

Although various formats exist for recording marine mammal sighting data (Impact Sciences Inc. 1996; LGL Ltd. & Greeneridge Sciences Inc. 1997; JNCC 1998), certain data are routinely recorded: species; number; age, sex, and size, if they can be determined; behaviour; heading; distance from the seismic vessel at sighting; and reaction, if any, to the seismic vessel. Information on the vessel's location, heading, speed, and operational status, and the ongoing environmental conditions (sea state, visibility, cloud cover, wind, ice state) are also collected.

Some specific examples of the use of shipboard observers for monitoring during seismic survey operations are presented in sections 7.3 and 7.4.

7.2.4.1.2 Aerial surveys

Aerial surveys have been flown as required mitigation or monitoring measures in conjunction with several recent seismic surveys in US waters (NMFS 1995a,b, 1997a). In general, the objectives of aerial surveys conducted in conjunction with seismic operations have been: 1) to obtain pre-survey information on the numbers and distribution of marine mammals in the seismic survey area; 2) to document changes in the behaviour and distribution of marine mammals in the area during seismic operations; and, in some cases, 3) to obtain post-survey information on

marine mammals in the survey area to document whether detectable changes in numbers and distribution have occurred in response to the seismic operations.

Aerial surveys are severely limited in their usefulness as mitigation measures for seismic survey operations. Given the patchiness of marine mammal distribution at sea, it would be necessary to establish a relatively long-term, fine-grained baseline of sighting data to detect changes in distribution due to a single seismic survey. This is further complicated by the fact that most marine seismic surveys employ a moving, shipborne sound source. The costs of conducting such aerial surveys, in addition to surveys during the period of the actual seismic activity, are substantial.

Aerial surveys are likely to be most effective when the marine mammal species of interest are migrating along a relatively well-defined corridor or are concentrated temporarily in an area for important biological purposes, such as feeding or reproduction. A good example of such a situation is the fall, westward migration of bowhead whales along the Canadian and Alaskan coasts in the Beaufort Sea. Aerial surveys have been a required element of the monitoring programs conducted in conjunction with seismic survey operations in this area for more than a decade (Richardson 1997a; LGL Ltd. & Greeneridge Sciences Inc. 1997; see section 7.3.2.1).

Aerial survey transect locations and sequences will depend on the specific circumstances of individual seismic surveys. Equally spaced, parallel transect lines may be appropriate for estimating numbers of migrating animals, such as bowhead whales in the Beaufort Sea, whereas it may be necessary for statistical purposes to partially randomise transect locations within a survey area to estimate numbers of non-migrating animals (Richardson 1997a).

Aerial surveys for marine mammals during recent seismic surveys in US waters have been flown at an altitude of approximately 305 m (1,000 ft), which is the altitude required by permit to avoid potential disturbance to animals by the survey aircraft itself (see section 7.3). Procedures generally involve visual search by one or more observers of an unbounded corridor out from the aircraft trackline. Right-angle sighting distance is calculated from the declination of a sighting from the horizon measured with a hand-held inclinometer; sighting distances can then be transformed to calculate the effective search area, and thence, to estimated observed animal densities (Bonnell *et al*. 1983; LGL Ltd. & Greeneridge Sciences Inc. 1997).

Certain aircraft types and equipment have become standard for conducting aerial surveys of marine mammals. A high-wing, two-engine aircraft, particularly one modified for low-speed performance and increased range, is desirable for offshore survey work. Survey crews generally include at least two primary observers, a data logger, and pilot(s). Survey aircraft should also have a global positioning system (GPS), large (or bubble) windows, and high-quality intercom and headsets. Appropriate safety gear, including life raft and life vests or (for arctic waters) survival suits, should also be carried.

Some specific examples of the use of aerial surveys for monitoring during seismic survey operations are presented in sections 7.3 and 7.4.

7.2.4.2 Acoustic monitoring

In addition to its usefulness for characterising the seismic source signal and measuring signal propagation properties and ambient noise, acoustic receivers can also be used to record marine mammal vocalisations. Acoustic monitoring may provide useful supplementary information, especially if capable of determining the locations of vocalising marine mammals (Richardson *et al*. 1995).

Richardson *et al*. (1995) review procedures for underwater acoustic measurement. A variety of types of passive acoustic systems have been used for monitoring during seismic survey operations conducted in US waters, with mixed success (Greene 1996; Bain & Calambokidis, 1997; LGL Ltd. & Greeneridge Sciences Inc. 1997). These systems have included both boat-based and moored hydrophone arrays, bottom recorder units, and ocean-bottom cable receivers.

To date, acoustic monitoring during US seismic operations has proven most effective in the shallow, cold Beaufort Sea, where it has provided valuable supplemental information on migrating bowhead whales (Richardson 1997a). Cost-effective acoustic systems capable of locating vocalising marine mammals precisely enough to be used to monitor safety zones are not yet commercially available (C. Greene, pers. comm.).

Obviously, silent animals cannot be detected by passive acoustic means. In addition, some species primarily vocalise at particular times of the year in association with specific behaviour patterns. For example, minke whales (*Balaenoptera acutorostrata*) frequently are sighted visually during summer surveys in the Hebrides, but regular acoustic monitoring has registered vocalising minke whales only rarely (Evans 1998).

However, there is some evidence that passive acoustic monitoring may serve a useful supplemental function in areas frequented by deep-diving marine mammals that might be undersampled by visual survey techniques. A recent study (Barlow & Taylor 1998) indicates that sperm whales may be detected much more effectively by a towed passive acoustic array than by shipboard observers. This is an area in need of further research.

Some specific examples of the use of acoustic monitoring during seismic survey operations are presented in sections 7.3 and 7.4.

7.2.5 Summary

Table 7.2 presents a summary of the mitigation and monitoring measures employed during three recent seismic surveys in western US waters and those recommended for surveys covered by the UK guidelines. As previously discussed, a suite of standard mitigation and monitoring measures has evolved, including seasonal and geographical restrictions, ramp-up, ship-based visual monitoring of safety zones (plus associated shutdown procedures), and, in certain situations, aerial surveys and passive acoustic monitoring.

In California, the HESS Team is currently developing a protocol for identifying mitigation measures to be applied to high-energy seismic surveys conducted in federal and state waters off southern California (Mayerson *et al.* 1998). These guidelines are intended to be advisory - it is understood that responsible agencies will make decisions on appropriate mitigation based on the best current information available during project-specific reviews. The protocol would be reviewed annually by the HESS Executive Committee and updated as new information becomes available from studies, monitoring results, and other sources. It also may be modified by the results of future environmental documents on high-energy seismic surveys produced by MMS, NMFS, and the California State Lands Commission.

Table 7.2 Mitigation and monitoring measures employed during recent seismic surveys

Survey mitigation or monitoring measure	*Seasonal restrictions*	*Area restrictions*	*Ramp-Up/ Soft start*	*Safety Zones*	*Shipboard Observers*	*Acoustic Monitoring*	*Aerial Surveys*
Alaska (Beaufort Sea), Northstar, 1997	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Southern California (Santa Barbara Channel), Santa Ynez Unit, 1995	Yes	No	Yes	Yes	Yes	Yes	Yes
Washington/British Columbia (Puget Sound region), SHIPS, 1998	Yes	No	Yes	Yes	Yes	Optional	Optional
United Kingdom, 1995 to present	Yes	Yes	Yes	Yes	Yes	Optional	No

7.3 Mitigation in US waters

7.3.1 Regulatory background

The US currently has the most extensive regulatory framework in the world dealing with the potential effects of man-made noise on marine mammals. The three most significant pieces of legislation that provide policy and procedural guidelines for activities affecting marine mammals, the Marine Mammal Protection Act (MMPA) of 1972, the Endangered Species Act (ESA) of 1973, and the National Environmental Policy Act (NEPA) of 1969, are discussed below.

7.3.1.1 Marine Mammal Protection Act of 1972

In order to promote the conservation of marine mammal populations and their habitats, the MMPA established a moratorium on the taking of marine mammals, which by definition includes harassment, as well as hunting, killing, and capturing. Exceptions to this prohibition were made for scientific research (with the issuance of a scientific research permit) and for the unintentional, incidental take of marine mammals in the course of other activities. This did not apply to incidental take by commercial fishing activities, for which there are specific provisions in the Act.

The latter exceptions are covered by the Small Take Regulations, Section 101(a)(5)(A) of the Act, which allow the incidental take (which includes killing, injury, and harassment) of small numbers of marine mammals by US citizens engaged in a specified activity in a specified geographical region. The NMFS may grant an Incidental Take Authorization if it finds that the taking will have a negligible impact on the species or stock(s); will not have an unmitigable adverse impact on the availability of the species or stock(s) for subsistence uses; and the permissible methods of taking and requirements pertaining to the monitoring and reporting of such a taking are set forth.

Submitted requests for a permit for incidental take must include: 1) a description of the activity; 2) information on the species and number of animals in the area, their status, and distribution of stock(s); 3) a description of the type of incidental taking requested; 4) an estimate of the number of animals to be 'taken'; 5) an analysis of the anticipated impact of the take on the species/stock(s) and/or habitat; 6) a description of the methods effecting the least impacts; and 7) suggested monitoring and reporting methods.

Once NMFS has received an adequate, complete request and made a preliminary finding of negligible impact, it publishes the proposed regulations in the US Federal Register (a daily publication of regulations and legal notices issued by federal agencies) and opens them for public review and comment. If, after considering all the information and comments received, NMFS determines that no new, substantive information exists, it publishes the final regulation and issues the appropriate Letter of Authorisation. The entire process usually takes about one year.

The regulations prescribe the authorised methods of taking, the means of effecting the Least Practicable Adverse Impact, and the monitoring and reporting requirements. Monitoring plans are site-specific. They are submitted to NMFS for review and approval to ensure that there is a negligible impact. The plans must describe the survey techniques to be used and how the number of animals 'taken' will be estimated (and the precision of that estimate). Reporting requirements include the dates and types of activities, the dates and location of monitoring, and the results of monitoring, including any behavioural changes noted and an estimate of the number of animals 'taken'.

In 1994, the MMPA was amended (Section 101(a)(5)(D); NMFS 1995c) to allow NMFS to issue Incidental Harassment Authorizations (IHAs) which permit the incidental take of small numbers of marine mammals by harassment, if the take results in a negligible impact to the species or stock(s). The MMPA defines harassment as:

"...any act of pursuit, torment, or annoyance which (a) has the potential to injure a marine mammal or marine mammal stock in the wild; or (b) has the potential to disturb a marine mammal or marine mammal stock in the wild by causing disruption of behavioural patterns, including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering".

The IHA application procedure was designed to be an expedited process in comparison to the Small Take Regulations. After receiving a complete application and making a preliminary finding of negligible impact, NMFS has 45 days to publish the proposed IHA in the Federal Register. This is followed by a 30-day public comment period, after which NMFS has an additional 45 days to issue the IHA, if appropriate, or deny the request.

Although obtaining an IHA and implementing its provisions requires substantial effort and expense, many organisations proposing noise-producing activities, such as seismic surveys, have chosen to obtain an IHA rather than operate without permits and risk legal action for harassing marine mammals (Richardson 1997b). Certain mitigation and monitoring measures are becoming standard IHA requirements for seismic survey operations in many areas, particularly on the West Coast and in Alaska. Examples of these measures are discussed in the sections below.

7.3.1.2 Endangered Species Act of 1973

The ESA protects and promotes the conservation of plants and animals listed as endangered or threatened. The goal of the Act is to bring populations of such listed species to healthy levels, so that they no longer need special protection. The ESA and MMPA overlap in the protection they provide to various marine mammal species, and two federal agencies share listing authority for marine mammals: NMFS and the Fish and Wildlife Service (FWS). Some of the provisions in the ESA are more restrictive than those in the MMPA. Of particular importance is Section 7, which requires that actions or activities conducted, funded, or authorised by federal agencies do not jeopardise the continued existence of listed species, or destroy or adversely modify their critical habitats and requires consultation with NMFS or FWS over federally sponsored projects. The NMFS must insure that the programs it authorises or funds do not jeopardise the continued existence of any listed species under its jurisdiction, or result in the destruction or adverse modification of "critical habitat" as defined by the ESA. This is an internal, rather than a public, process.

7.3.1.3 National Environmental Policy Act of 1969

NEPA also has important implications for noise-producing activities such as seismic surveys. The NEPA regulations require the environmental review of major US federal actions, both within and outside the US Many studies of the effects of man-made noise on marine mammals have been performed to provide data for NEPA environmental documents, such as Environmental Impact Statements (EISs), for MMS and other US federal agencies (Richardson *et al*. 1995). In fact, MMS, in co-operation with the State of California and NMFS, is currently considering preparation of a programmatic EIS that will examine the potential impacts of seismic surveys on marine mammals and other resources off southern California.

7.3.2 Examples of recent mitigation in US waters

7.3.2.1 Alaska (Beaufort Sea)

The mitigation and monitoring measures required for the 1997 British Petroleum Exploration (Alaska) Inc. Northstar Unit seismic surveys in the Beaufort Sea comprised the same mitigation program as that employed in that area during the previous year (LGL Ltd. & Greeneridge Sciences Inc. 1997; NMFS 1997a). Identified mitigation measures included:

1) Safety zones. The required safety zones were dependent on array size and depth and on marine mammal group. Safety zones for pinnipeds ranged from a minimum of 60 m (197 ft) at any depth where the array was 120 in^3 or smaller or a single airgun was used, to a maximum of 260 m (853 ft) where survey area depths were 2.5 m or less and the array was 720-1,320 in^3 in size. For bowhead, grey, and beluga (*Delphinapterus leucas*) whales, the safety zones ranged from a minimum of 640 m (2,100 ft), to a maximum of 1,020 m (3,346 ft). These zones corresponded to received levels of 190 and 180 dB re 1 µPa (rms), respectively, for the two groups (Table 7.1).

2) Ramp-up. Ramp-up was to be accomplished at a rate no greater than 6 dB per minute.

The monitoring plan for this project was peer-reviewed and involved three basic elements: vessel-based visual monitoring, aerial surveys, and acoustic measurements.

1) Vessel-based visual monitoring. Vessel-based observers were required as mitigation by NMFS IHA for BP's 1997 open-water seismic program. Seismic operations were scheduled to begin as early as July 1 and continue until as late as October 20. Observers were required to be aboard the seismic source vessel whenever it was operating, from the start of operations in July until the end of the survey in September or October.

The stated objectives were: 1) to monitor the designated safety zones and provide the basis for real-time mitigation (airgun shutdown); 2) to gather information needed to estimate the 'take' of marine mammals by harassment, for report to NMFS; and 3) to collect data on the occurrence, distribution, and behaviour of marine mammals in the area of seismic operations.

Two contract observers and an Inupiat observer from the local community would be aboard the primary source vessel. The Inupiat observer would serve as a third observer and, after September 1, a communicator with the bowhead whaling crews and a community co-ordination centre. If two source vessels were used, there were to be observers on each vessel.

A minimum of one observer was to be on duty whenever seismic operations were in progress and for at least 30 minutes prior to the planned start of shooting. For comparison, observations were also to be conducted during "some fraction of the time with no shooting". Individual watches were to last no more than 4 hours.

From the highest practical vantage point of the vessel, the observer was to scan the area immediately around the vessel with reticulated binoculars during the day and with night-vision equipment (identified as Bushnell/ITT Night Ranger 250 or 150) during the night (noting that there are no hours of total darkness prior to mid-August).

2) Aerial surveys. Weather permitting, daily aerial surveys of the seismic exploration area and nearby areas were to be conducted. Surveys were scheduled to begin on September 1 (when the first few bowheads might be present in the Prudhoe Bay region) and continue until 3 days after the end of seismic operations (to allow for the collection of post-seismic control data).

The stated aerial survey objectives were to obtain daily data on the occurrence, distribution, and movements of marine mammals (especially bowhead whales) within an area extending 50 km (27 nm) east and 20 km (11 nm) west of the seismic exploration area, and from nearshore waters (barrier islands) north to about the 100-m contour (a distance of greater than 50 km). This coverage was intended 1) to provide data from both within and beyond the immediate zone of influence of the seismic source (as required by NMFS monitoring guidelines); and 2) to document the main 1997 bowhead migration corridor, in relation to the seismic exploration area.

There were two series of north-south transect lines: 1) a primary, or extensive survey grid; and 2) a secondary, or intensive survey grid. Transects were flown from north to south, rather than partially randomised, because the migrating bowheads were the main survey targets.

Because of the low probability of bowhead sightings in shallow waters, the intensive survey grid was needed 1) to increase the power of the aerial surveys to document the proximity of the bowhead migration corridor to the seismic exploration area, 2) to estimate the number of marine mammals (especially bowheads) 'taken' by the seismic survey, and 3) to help identify times when marine mammals were within or heading toward the safety zone (the seismic vessel was notified if marine mammals were seen within the safety zone). The intensive survey grid consisted of 4 transect lines spaced 8 km (4 nm) apart and located between the extensive grid lines, from the barrier islands to 35 to 40 km (19-22 nm) north. Thus, these lines totalled 140 to 160 km (76-86 nm).

The extensive survey grid consisted of 12 transect lines spaced 8 km apart, extending from 20 km west of the western side of the then-current seismic exploration area to 50 km east of the eastern edge, and extending offshore from the barrier islands north to about the 100-m contour. The lines totalled about 890 km (480 nm), or 4 hrs of survey time (plus about 1.2 hrs ferry time).

Surveys were flown at an altitude of about 305 m (1,000 ft) and a ground speed of 220 kph (120 kts). There were two primary observers and one data logger/observer. The survey aircraft was a two-engine Commander 680FL, with bubble windows for the primary observers. Two pilots were employed.

3) Acoustic measurements. The acoustic measurements made in 1997 were designed to be a sequel to the 1996 Northstar program. They included three components: 1) the retrieval of bottom recorders that had been deployed in 1996, and analysis of usable data; 2) vessel-based acoustic measurements; and 3) measurements using ocean-bottom cable (OBC)-based acoustic receivers. The objectives were 1) to delineate the characteristics of the airgun array source; 2) to measure radiated sound from the vessels; 3) to measure the transmission-loss properties of the survey environment; 4) to measure ambient noise; and 5) to record whale calls.

7.3.2.2 California (Santa Barbara Channel)

In November and December 1995, Exxon Company, USA. (Exxon), conducted a three-dimensional (3-D) seismic survey in its Santa Ynez Unit in the western Santa Barbara Channel, offshore southern California. A number of mitigation, monitoring, and reporting requirements were imposed on the survey by conditions of the IHA and Supplemental IHA issued by NMFS (NMFS 1995a,b; Impact Sciences Inc. 1996). They included the following:
1) Seasonal limitations. To ensure that the seismic survey's acoustical sounds did not impede the south-bound grey whale migration, Exxon was required to notify NMFS if the survey continued after December 15 1995, in order for a NMFS biologist to board an Exxon vessel to observe grey whale behaviour and to determine if a more than negligible impact on migration was occurring. If at any time the NMFS biologist could no longer make a negligible-impact determination for grey whales, Exxon would have been required either to terminate the survey or to move to an area where a negligible impact determination could again be made. Additionally, no incidental harassment takings were authorised after December 31 1995. These conditions were not eventually used as the survey was completed on December 12 1995.
2) Ramp-up. It was required that the airgun array be ramped up to operating levels at a rate not to exceed 6 dB per min at the start of operations or testing, when beginning a new trackline, or any time the array was powered down below 160 dB.
3) Safety zones. Two safety zones were established for this seismic survey, based on the original transmission loss model employed by Exxon (Exxon 1995). A safety distance of 152.4 m (500 ft) was established for pinnipeds and odontocetes. For mysticetes and sperm whales, the safety zone radius was 450 m (1,476 ft). These radii corresponded to the estimated 190 dB and 180 dB isopleths, respectively.

In response to a number of questions regarding the adequacy of the original model, the supplemental IHA required that an independent contractor with expertise in this area conduct a field-verification test of the loss model. The test had to be completed, and any required adjustments to the IHA issued by NMFS, prior to initiation of the seismic survey.

A verification test was conducted by BBN, Inc., under contract to Exxon (BBN, Inc. 1995). Although the results indicated the distances to the 190 dB and 180 dB isopleths were substantially less than calculated by the original loss model, 77 m (253 ft) and 316 m (1,037 ft), respectively, Exxon elected to retain its original, more conservative safety zones.
4) Shipboard observers. Ship-based observers were required to be aboard the seismic source vessel for the duration of the survey according to the conditions of the IHA and the Supplemental IHA.

The stated objectives were to monitor areas immediately around the airgun array and adjacent waters in order to 1) ensure that no marine mammals entered their respective safety zones while the array was operating; and 2) to collect data on the species, numbers, and behaviour of marine mammals observed, the estimated number of animals that may have been 'taken' by harassment, and any behavioural responses to the seismic vessel.

Two observers were aboard the seismic source vessel. One observer was on duty at all times. Each observer served one 8 hr and one 4 hr watch during a 24 hr period. During approximately two-thirds of the daylight watches, a second, MMS observer was also present.

From several vantage points on the vessel (generally the fantail or the mainmast catwalk), the observers scanned the waters surrounding the vessel with reticulated binoculars during the day and a night-vision scope (McLennan Marine Limited, Vistar Im 101) during the night.
5) Aerial surveys. Aerial surveys were required by conditions of the Supplemental IHA. Four aerial surveys were required: 1) within 1 week prior to the seismic survey, 2) after the first week of the survey, 3) during the last week of the survey, and 4) within 1 week after completion of the survey. One of these surveys could not be completed due to fog; the others were flown successfully.

The stated aerial survey objectives were 1) to identify and provide additional information on the relative abundance and distribution of marine mammal species present in the vicinity of the seismic survey activities, and 2) to provide supplemental information on any observed behavioural modifications of these species due to the seismic survey.

The aerial survey area encompassed an approximately 10 x 39 km (5 x 21 nm) rectangle centred on the seismic survey area. The survey grid consisted of three 39 km (21 nm) east-west lines spaced 5 km (3 nm) apart. Each survey took approximately 45 mins to complete. A total of about 698 km (377 nm) were flown in 2.4 hrs, including ferry time and the aborted survey.

Surveys were flown at an altitude of about 305 m (1,000 ft) and a ground speed of 185 kph (100 kts). The crew consisted of one pilot, three to four primary

observers, and one data logger/observer. The survey aircraft was a Bell 412/312 helicopter.

6) Acoustic monitoring. The Supplemental IHA also required that a contractor perform passive acoustic monitoring of the seismic survey area. Monitoring was to be conducted during all night-time seismic shooting periods and during daylight shooting periods with heavy fog, with the intent of providing real-time locations (bearing and estimated range) for marine mammals within the survey area. Acoustic monitoring was conducted, using a sonabuoy array moored near shore just outside the seismic survey area, but with minimal results: only one set of marine mammal calls was recorded from a position inside the survey area during the month-long survey (Greene 1996).

7.3.2.3 Washington/British Columbia (Puget Sound region)

During March 1998, an international consortium of geoscientists conducted an intensive seismic survey to collect data on the potential earthquake hazards of the Puget Sound region, under the acronym SHIPS (Seismic Hazards Investigations in Puget Sound). The consortium included scientists from the US Geological Survey (USGS), the Canadian Geological Survey, the University of Washington, Oregon State University, the University of British Columbia, the University of Victoria, and the University of Texas at El Paso. A number of mitigation and monitoring measures were required for the US portion of the SHIPS seismic survey by the conditions of the IHA issued by NMFS (NMFS 1997b, 1998). Mitigation required for the portion of the survey conducted in Canadian waters is discussed in section 4.1. Required mitigation included the following:

1) Seasonal restrictions. To minimise potential disturbance to marine mammals, the survey was planned to occur in February and March, when marine mammal abundance in Puget Sound is generally low.

2) Ramp-up. Airguns were required to be ramped up to full operational strength at a rate no greater than 6 dB per min.

3) Safety zones. Three separate safety zones were established and monitored continuously. For grey, minke, and humpback whales, considered to be the large whale species most likely to be present in the survey area and the most sensitive to low-frequency sound, the radius of the safety zone was 500 m (1,640 ft). For odontocetes, the safety distance was twice the radius calculated for preventing temporary hearing impairment (temporary threshold shift, or TTS), or 200 m (656 ft). Lastly, for pinnipeds, the safety distance was set at 100 m (328 ft) for circumstances under which the seismic vessel approached an animal. If a pinniped were to approach the seismic vessel, the airguns were not required to be shut down. It was agreed that information on behaviour and the apparent effects of the airguns would be collected.

4) Vessel speed limitations. During operations, the seismic vessel's speed was limited to 7 to 9 kph (4-5 kts).

5) Shipboard observers. NMFS-accredited marine biologists were required to be onboard both the seismic and scout vessels for the duration of the seismic survey, which occurred over a two-week period in March 1998. Objectives varied somewhat for observers aboard the two vessels.

Observers aboard the seismic vessel 1) monitored the designated safety zones to ensure that no marine mammals entered the zones; and 2) recorded data on the species, number, and reaction of marine mammals to the seismic vessel. Observers had authority to shut down operations if an animal entered a safety zone.

Observers aboard the scout vessel 1) recorded observations of marine mammals exposed to variable received levels of seismic sound; 2) collected data on the sighting rates of marine mammals for comparison with sightings from the seismic vessel; and 3) made detailed behavioural observations, employing additional observations from a deployed small boat and land.

Six observers were aboard the seismic vessel, with a minimum of three on duty whenever the array was operating during daylight (12 hrs at this latitude and season), and two at night. During the day, observers scanned using 7 x 50 binoculars fitted with internal compasses and reticules; at night, observers used an IR night-vision scope.

There were four observers aboard the scout vessel, with a minimum of two on duty during the day. The scout vessel, which towed its own hydrophone array, employed two survey patterns. During what were termed 'expanding spread' runs, the seismic source vessel and scout vessel began at opposite ends of a transect line and proceeded toward and past each other to the ends of the line. On the remaining transect lines, the scout boat functioned as a guard boat, maintaining station 4 km (2 nm) behind the seismic source vessel.

5) Emergency shutdown. If a marine mammal had been observed beaching itself in the vicinity of survey operations, it was required that the airguns be shut down until it was been determined that the beaching was unrelated. This did not occur during the SHIPS survey.

6) Mortality investigations. If a marine mammal had been found dead in Puget Sound, the San Juan Archipelago, or the Strait of Juan de Fuca when the seismic source was in operation in those bodies of water, NMFS would investigate and could shut down the seismic survey operations, if necessary. This did not occur during the SHIPS survey.

The objectives of monitoring were 1) to mitigate the potential harassment of marine mammals, 2) to document the numbers of marine mammals in the vicinity of the seismic source, and 3) to evaluate the reactions of marine mammals to the sounds produced.

7) Aerial surveys. Although aerial surveys were not required by the conditions of the IHA, they were funded as

a research project by the USGS (Bain & Calambokidis 1997). Six aerial surveys were conducted: 1) two scouting surveys prior to the start of seismic operations, and 2) four grid surveys conducted during the seismic operations. The exact timing of these surveys in relation to the seismic operations was not described.

The scouting surveys were intended to search the areas proposed for seismic operations and identify sensitive areas where additional monitoring (including the grid aerial surveys) would be focused. The grid surveys were intended to examine changes in the behaviour and distribution of marine mammals in the sensitive areas identified by the scouting surveys as the seismic vessel passed through.

Scouting surveys were flown along the planned route of the seismic vessel. Each grid survey area encompassed an 18 x 18 km (10 x 10 nm) box (or equivalent, depending on the shoreline), with parallel lines spaced at 1.8 km (1 nm) intervals. It was planned that the grid would be flown at least three times in rapid succession: 1) while the seismic vessel was at least 9 km (5 nm) from the grid, 2) as the seismic vessel entered the grid, and 3) as the seismic vessel was completing its passage through the grid. Thus, each grid survey would be expected to cover approximately 560 km (300 nm). Both scouting and grid aerial surveys were expected to take about 7 hrs to complete, for a total of approximately 42 hrs in the air.

In addition, focused surveys, which were intended to be at least partially aerial, were planned for specific areas and species of concern. These included surveys of: 1) grey whales migrating past the western entrance to the Strait of Juan de Fuca, or summering in Puget Sound (near Whidbey Island) or the Strait of Juan de Fuca; 2) humpback whales near Swiftsure Bank and west of the Strait of Juan de Fuca; 3) harbour porpoises (*Phocoena phocoena*) in Puget Sound (near Whidbey Island); and 4) minke whales foraging over shallow banks in the Strait of Juan de Fuca.

Survey altitude and ground speed were designed to be about 215 m (700 ft) ASL at 185 kph (100 kts). The aerial survey crew included one pilot, two observers, and one data logger. The survey aircraft was a Cessna 182.

8) Hydrophones. A collateral marine mammal research project, funded by the MMS, focused on the effect of airgun noise on marine mammals as a function of received sound levels and distance. This work, led by Dr David E. Bain of the University of Washington, was conducted from a launch and involved two sampling regimes. In the first, ambient noise and received sound levels were measured by a hydrophone deployed at selected distances and orientations from the airgun array, and at locations within the Puget Sound region of particular interest in the study of sound propagation. In the second, ambient noise and sound levels were measured at locations near marine mammals to produce a best possible estimate of actual noise exposure and, if possible, to correlate marine mammal behaviour with actual, received sound levels.

7.4 Other mitigation worldwide

7.4.1 International Legal Framework

There are, at present, no global or regional treaties directly relating to all marine mammals. Only one treaty, the 1946 International Convention for Regulation of Whaling (ICRW), which established the International Whaling Commission (IWC), is addressed to whales globally and, to date is almost exclusively concerned with the large whales that formed the basis of the whaling industry at the beginning of the 21st Century. It replaced a series of ad hoc conventions concluded from 1931 onwards aimed at reducing the number and type of whales killed for commercial purposes. It has not been extended to cover small cetaceans (although IWC Scientific Committee discusses them); this remains a controversial issue.

The IWC Working Group on Environmental Concerns is currently addressing the issue of 'noise'. The Scientific Committee's 1998 Report notes that "this topic is often difficult to address because of its highly technical and specialist nature, and a lack of published material coupled with a preponderance of grey literature", and concludes that it is difficult to assess its impact. While recognising that the issue was relevant and important, the Working Group found that "attempting a major initiative on the impact of noise on cetaceans was not within (its) current purview". No progress can be expected until more information is available, although the IWC has recommended to its members some general guidelines on whale watching, which the members may or may not adopt.

The United Nations Convention on the Law of the Sea 1982 (UNCLOS), which entered into force on November 16 1994, includes only two short articles (among 320) concerning marine mammals, and these are expressed in general terms. Article 65, in its Part V on the Economic Exclusion Zone (repeated as Article 120 in Part VII on the high seas), affirms that "nothing in this Part restricts the right of a coastal state or an international organization, as appropriate to prohibit, limit, or regulate the exploitation of marine mammals more strictly than provided for in this Part. States shall cooperate with a view to conservation of marine mammals and in the case of 'cetaceans' shall in particular work through the appropriate international organisations for their conservation, management, and study". It is silent both concerning which are the

appropriate organisations and on the meaning of "work through." Views of IWC members diverge on interpretation of this Article.

At the regional level, three exclusively conservatory conventions have been concluded recently. Only one, the 1992 North Atlantic Marine Mammal Agreement (NAMMCO) covers all marine mammals (including cetaceans and pinnipeds) in its area, the North-east Atlantic. The remaining two have been concluded as regional agreements under the 1979 Bonn Agreement on Conservation of Migratory Species of Wild Animals. They are the 1994 Agreement on Small Cetaceans in the Baltic and North Sea (ASCOBANS) and the 1996 Agreement on Conservation of Cetaceans of the Black Sea, Mediterranean Sea, and Contiguous Atlantic Area (ACCOBAMS). None of the three has power to issue instantly binding regulations, but ASCOBANS and ACCOBAMS provide for the recommendation of conservatory measures, which their parties must enact, that could apply to seismic activities. To date, however, no measures on acoustic degradation or seismic activities have been recommended or adopted.

There are other international and regional conventions that can be used to conserve or protect marine mammals, but only for the purposes that fall within their scope. These include the 1973 Convention on Trade in Endangered Species (CITES), the 1971 Ramsar Convention on Wetlands of International Importance, and the 1992 Convention on Conservation of Biodiversity (CBD). It is an increasing understanding that protection and conservation of the habitat of marine mammals are as vital to their survival as is restraint from over-exploitation. All the conventions referred to, except CITES, could be used to make recommendations on various aspects of habitat protection, but there are no means, at present, to ensure that this is done on a global or even regional basis through the current plethora of ad hoc treaties. Collectively, they do not compose a coherent strategy for this purpose.

This is not surprising, given that the relevant treaties have been concluded only in this century, mostly after World War II. Many, however, have been concluded or revised in the run-up to or in response to such seminal events as the Declaration of Principles and Action Plan on the Human Environment adopted at the 1972 Stockholm Conference (UNCHE), the 1982 UNCLOS; and, most recently, the Declaration of Principles and Agenda 21 adopted at the 1992 United Nations Rio Conference on Environment and Development (UNCED). These have generated principles and strategies that can be invoked to protect marine mammals from new as well as old threats.

The international community has changed greatly since the conclusion of the ICRW in 1946, when there were only 50 states in the United Nations - there are now over 180, most of them developing states. The UNCHE gave high profile to environmental issues, including the establishment of principles and strategies for the conservation of marine mammals. The UNCED built on this, but took specific developmental needs into greater consideration. As a result, there has been a movement away from the adoption of additional treaties and toward the issuance of what have popularly been designated as 'soft law' documents. These are non-binding codes, guidelines, declarations, generalised principles, conclusions, etc. They emanate mostly from the UN and other international bodies, but also from regional bodies at all levels and ad hoc regional conferences, such as the North Sea Ministerial Conferences that have considered conservation of small cetaceans. The thrust of the UNCHE and UNCED instruments is largely implemented through these means, as states adopt national legislation and administrative practices and their own 'soft' and 'hard' laws to further the consensus arrived at the conferences.

Since these international 'soft law' instruments, as well as many treaties, do not deal with the minutiae of the rules required (as is the case in relation to the potential threats to marine mammals by seismic activities), individual states, prodded by NGOs, are left to deal with these problems through the enactment of statutes, delegated legislation, or the issuance of guidelines. In doing so, they can accomplish more than is possible at the international level and enact stricter regulations on a wider range of topics.

7.4.2 Examples of recent mitigation

This is a brief survey of information that has been obtained on mitigation measures being taken elsewhere in the world. No previous review of this nature appears to have been carried out. Mitigation measures may be compulsory and enforced by national legislation or guidelines, or be voluntary by the geophysical survey companies (or a mixture of the two). Much of the information is unpublished, and was obtained by Joe Karwatowski (Mobil), Genevieve Leaper or Mark Tasker (JNCC). All those who supplied information are gratefully thanked, and any further information to make this or future reviews more complete would be gratefully received.

7.4.2.1 Canada

In Canada, offshore seismic exploration is regulated by both federal and provincial legislation. At the federal level, the Minister of the Environment is advised and assisted by the Canadian Environmental Assessment Agency.

At the federal level, there are four main acts affecting the regulation of offshore seismic exploration and the conservation of marine resources: the Canadian Environmental Protection Act, 1985; the Canadian Environmental Assessment Act, 1992; the Canada Oil and Gas Operations Act, 1985; and the Canada Wildlife Act, 1985 (CWA). There are also several applicable provincial legislative acts, particularly in Newfoundland and Nova Scotia that regulate geophysical operations and provide for

environmental assessments, monitoring, and mitigation of projects.

Canadian federal regulation provides for environmental assessment, public input, and review panels. The CWA provides authority for the establishment of protected marine areas. The Canadian Fisheries Act (CFA) provides that "no person shall carry on any work or undertaking that results in the harmful alteration, disruption, or destruction of fish habitat". Marine mammals are included in the definition of "fish".

In the early 1970s, both federal and provincial governments imposed moratoria on offshore oil and gas exploration on the Canadian west coast because of environmental concerns and jurisdictional disputes. Although the moratoria were lifted in 1987, renewal of exploration awaits the conclusion of a federal-provincial agreement on offshore resource management and revenue sharing.

There are no legislated seasonal restrictions on seismic explorations in Canada, but licensing applications are evaluated on a case-by-case basis, and practical restrictions may be imposed. Canadian permits for marine seismic surveys generally prohibit operations within 500 m of any marine mammal. In recent years, seismic surveys have been discouraged in one bowhead whale summering area when there are whales present, and survey activities have been required to stop if bowheads are observed within 4 km (2 nm) of the seismic vessel (Richardson *et al.* 1995).

In practice, the Department of Fisheries and Oceans (DFO) has imposed conditions on seismic exploration. During the SHIPS seismic survey in the Puget Sound region in 1998, about half of the seismic operations were conducted in Canadian waters, mostly between Vancouver Island and the British Columbia mainland. For operations in Canadian waters, the DFO imposed several requirements. First, airgun operations were prohibited within 5 km (3 nm) of five identified pinniped haul-out areas in the Vancouver Island area. This requirement forced the abandonment of one of the planned seismic survey transect lines.

The DFO also originally required that airgun operations be shutdown whenever marine mammals were sighted within 2 km (1 nm) of the seismic survey vessel. Since this very stringent requirement would have made survey operations in the narrow, inland waterways virtually impossible, a compromise was reached. A DFO-approved observer was placed aboard the seismic source vessel for the Canadian portion of the survey with the task of ensuring that disturbance to marine mammals in Canadian waters was minimised. This arrangement apparently worked to everyone's satisfaction.

At present, offshore oil and gas exploration (including seismic) and development in Canada occur only on the East Coast, where they are regulated by quasi-independent federal-provincial boards (R. Davis, pers. comm.). The Scotian Shelf and the Grand Banks were active exploration areas in 1999 and 2000. In waters off Nova Scotia, including the Scotian Shelf, the Canada-Nova Scotia Offshore Petroleum Board (CNSOPB) is the regulatory agency that issues all permits. Off Newfoundland and Labrador, the Canada-Newfoundland Offshore Petroleum Board (CNOPB) is the relevant agency. Neither board has formal environmental requirements for seismic exploration.

A 1998 environmental assessment prepared for seismic exploration on the Scotian Shelf (Davis *et al.* 1998) recommended that systematic monitoring by conducted by observers based on the seismic vessel or guard boat (including documentation of close approaches to the seismic vessel by marine mammals). This has not occurred, although some fishery observers have been used. Ramp-up is employed in both areas as part of standard industry practice. Although there is no large-scale moratorium on drilling or seismic exploration on the Scotian Shelf, there is a limited moratorium in the Gully area. The Gully is a large submarine canyon along the shelf edge east of Sable Island. The Gully has been proposed as a marine protected area, primarily to support populations of northern bottlenose whales (*Hyperoodon ampullatus*) and sperm whales. The present moratorium in the Gully includes both exploration drilling and seismic exploration in the Gully and in a 10 km buffer area. There is a possibility that this moratorium will become permanent (R. Davis, pers. comm.).

7.4.2.2 United Kingdom

Section 128 of the Environmental Protection Act of 1990 (EPA) splits responsibility for habitats and species between the Nature Conservancy Council for England and the Countryside Council for Wales and Scottish Natural Heritage. The Department of Trade and Industry (DTI) is responsible for formulating any special licence terms necessary to protect species in the marine environment from exploration and production operations. In this function, the DTI is advised by the Joint Nature Conservation Committee (JNCC). The DTI also consults with a number of other departments and agencies, including the Department of the Environment, Transport and the Regions (DETR), the Ministry of Agriculture, Fisheries and Food (MAFF), the NCCs and local authorities for coastal areas.

In waters under jurisdiction of the UK, protection is given to cetaceans under Section 9 of the Wildlife and Countryside Act of 1981, which prohibits the deliberate killing, injuring, or disturbance of any cetacean (equivalent legislation in Northern Ireland is Article 10 of the Wildlife (Northern Ireland) Order 1985) (JNCC 1998). These provisions reflect the requirements of the Convention on the Conservation of European Wildlife and Habitats (the Bern Convention) and Article 12 of the E.C. Habitats and Species Directive (92/43/EEC), implemented by The Conservation (Natural Habitats, etc.) Regulations 1994 and The Conservation (Natural Habitats, etc.) Regulations Northern Ireland 1995. The UK is also a signatory to the

Agreement on the Conservation of Small Cetaceans of the Baltic and North Seas and has applied its provisions in all UK waters. These include the requirement that the signatories "work towards....the prevention of...disturbance, especially of an acoustic nature".

Other important legislation includes the Wildlife and Countryside Act of 1981, and the Sea Fisheries (Wildlife Conservation) Act of 1992. The Petroleum Production (Seaward Areas) Regulations of 1988 provide that licensed operations must not interfere unjustifiably with fishing or with the conservation of living resources of the sea.

In the 16th Licensing Round, licences for blocks in nearshore areas carried the condition that the DTI and specified local authorities be notified at least 90 days before the commencement of seismic operations within 3 miles of the coast. This was imposed to allow the DTI to determine whether the licensee should prepare an environmental impact assessment (EIA) for the proposed seismic survey.

Some of the special licence terms and conditions imposed by the DTI relate to the presence of marine mammals. In previous licensing rounds, these have included consultation with bodies such as the JNCC before commencing seismic surveys, seasonal restrictions on seismic surveys, and the conduct of seismic exploration in accordance with the JNCC's Guidelines for the Minimisation of Acoustic Disturbance to Small Cetaceans (JNCC 1998).

Area or seasonal restrictions are generally provided through special conditions attached to operators' licenses. Generally, licensees must not carry out prospecting activities in such a manner as to interfere unjustifiably with navigation, fishing, or with the conservation of the living resources of the sea. In environmentally sensitive areas, special licence conditions may be imposed to restrict seismic surveys due to the presence in certain times of the year of marine habitats and cetaceans. In the 17th Licensing Round, certain blocks were offered subject to an indicative condition prohibiting seismic surveys in specified parts of the block, or prohibiting seismic surveys during certain parts of the year.

Evans (1998) has identified certain areas in the North-east Atlantic as particularly sensitive due to their importance for a diverse group of marine mammals and, thus, worthy of consideration for seasonal restrictions. They include the following (from north to south): 1) the European continental shelf slope (200-2,000 m depth), which appears to be used by the majority of baleen whales and some of the more oceanic toothed whale and dolphin species; 2) oceanic basins and troughs such as the Norwegian Basin, Rockall Trough, Porcupine Abyssal Plain, Biscay Abyssal Plain and Trough, and Iberian Abyssal Plain, which are likely to be favoured by deep-diving species such as sperm whales and beaked whales; 3) frontal systems of high biological productivity, which tend to concentrate a variety of plankton, fish, cetaceans, and seabirds; and 4) sheltered bays and island sounds, where populations of some species like bottlenose dolphins and harbour porpoises may be resident.

Application of the JNCC Guidelines is required under licence conditions in blocks licensed under the 16th and 17th rounds of offshore licensing. In addition, member companies of the UK Offshore Operators Association (UKOOA) and the International Association of Geophysical Contractors have indicated their intention to comply with these guidelines in all areas of the UK Continental Shelf and, in some cases, elsewhere. The guidelines were originally prepared in 1995 and subsequently have been reviewed twice by the JNCC. They cover three periods: pre-seismic survey planning, the actual seismic survey, and post-survey reporting.

During the survey planning stage, the guidelines recommend that operators contact the JNCC. If consultation with the JNCC indicates that it is likely that marine mammals will be present in the survey area, operators are urged to place qualified and experienced marine mammal observers aboard the seismic survey vessel. It is suggested that, at a minimum, these observers should have attended an appropriate training course.

In areas where marine mammals are abundant, additional precautions to reduce disturbance and possible scientific studies may also be recommended by the JNCC. Specifically, it is recommended that operators schedule surveys to reduce the likelihood of encountering marine mammals, and that they attempt to reduce or baffle unnecessary high-frequency noise produced by the airguns or other equipment.

During a seismic survey, the recommended guidelines apply mainly to the airgun array ramp-up period. Observations should begin 30 mins prior to start-up of the seismic source. It is suggested that passive acoustic techniques be used to provide additional information on the presence of inconspicuous species or submerged animals, especially in poor weather. If marine mammals are detected within 500 m (1,640 ft) of the seismic array, adequate time (at least 20 mins following the last sighting) must be allowed for the animals to move well away. If pinnipeds are congregated near an oil platform, it is recommended that the seismic source be started up at least 500 m (1,640 ft) from the platform.

The guidelines refer to the ramp-up procedure as slow build-up, or soft start. It is recommended that the seismic source be powered up slowly, beginning with the smallest airgun in the array and gradually adding others, over a period of at least 20 mins. The array should be ramped up every time it is used, even if no marine mammals have been sighted, and the lowest practicable power levels should be used throughout the survey.

Following a seismic survey, the JNCC requires that a report be submitted detailing marine mammal sightings, monitoring methods, problems encountered, and any other comments that would increase information and help to improve the guidelines.

7.4.2.3 Australia and New Zealand

In Australian waters, all marine mammals are totally or partially protected under various legislative acts (Tucker & Puddicombe 1988, cited in Richardson *et al.* 1995). The primary regulatory framework for marine mammal protection is provided by the Endangered Species Protection Act of 1992, which requires that an environmental evaluation be prepared where a proposed work programme proposes a threat to listed species. In practice, however, EIAs are mainly applied prior to exploration drilling, and development and production activities.

Seismic surveys are subject to marine wildlife conditions imposed by the Department of Minerals & Energy (DME). These include keeping watch for marine mammals and turtles and interrupting the survey if any are sighted within a specified distance of the seismic vessel. Operators also are required to release low-pressure warning bursts at the start of each series of seismic survey transect lines. Seasonal restrictions on seismic surveys are also imposed by DME to avoid breeding and nursery grounds of marine mammals and turtles. Although an environmental permit is not required for seismic activities, such specific environmental conditions may be attached to an exploration permit or production licence area (Peter Farrell, Mobil, pers. comm.). Recent permits for seismic surveys within the southern right whale (*Eubalaena australis*) wintering range have included provisions similar to those required by US and Canadian permits for seismic work in bowhead or northern right whale (*Eubalaena glacialis*) areas (Richardson *et al.* 1995).

There are no specific regulations applicable to the protection of marine mammals from offshore exploration and production activities in Australia. However, Mobil (Australia) has established a set of guidelines entitled Procedures for Management of Whale Encounters during Seismic Surveys. These include procedures for observation prior to and during seismic survey operations, postponement of survey operations if a whale is sighted within 2 km of the seismic source vessel, extra precautions to be taken if whales are in the vicinity of the seismic survey, ramp-up, and recording of all whale sightings.

In addition, the Australian Petroleum Exploration Association (APEA) has elaborated a Code of Environmental Practice - Onshore and Offshore. Among the precautionary measures required by the Code is the use of alternative types and/or configurations of energy sources during seismic surveys; special emphasis is also placed on monitoring.

In 1997, The Queensland Parliamentary Counsel produced the Nature Conservation (Whales and Dolphins) Conservation Plan of 1997. The Plan provides penalties for failing to observe specific restrictions in proximity to whales and dolphins, vessel speeds, and various forms of human interaction with cetaceans, including the accidental taking or stranding of whales or dolphins.

New Zealand's Marine Mammal Protection Regulations of 1990 limit vessel and aircraft operations near whales (Gordon *et al.* 1992; Richardson *et al.* 1995).

7.4.2.4 Italy

There is no specific legislative framework regarding the protection of marine mammals from offshore exploration and production activities in Italy. Italian legislation of wildlife protection is focused primarily on hunting and fishing issues. Controls are implemented on a case-by-case basis following the licensing application process. For example, it is not permitted to shoot seismic lines within one mile of the coastline at night and three miles during the summer months. Exploration and production activities are prohibited in specific marine areas, such as the Gulf of Naples and Gulf of Salerno, and in areas defined by law as marine biology protection zones or repopulation areas. The principal means of control is the EIA, which is required for seismic operations.

The Ministry of the Environment has recently initiated research on marine mammals. It is understood that the Italian authorities are preparing a law on wildlife protection.

7.4.2.5 Norway

Three agencies have joint responsibility for offshore exploration and production planning, permitting, and enforcement: the Ministry of Petroleum and Energy (MPE), the Norwegian Petroleum Directorate (NPD), and the State Pollution Control Authority (SFT). Since 1997, the MPE has had overall responsibility for administrative and financial control.

The primary legislative source is the Petroleum Activities Act of 1996 (PAA), which provides for exploration licenses and liability for pollution damage in Norwegian internal waters, territorial sea, and the continental shelf. In offshore areas, the Act imposes a general obligation on licensees to take all reasonable precautions to prevent damage to marine fauna and flora. Although conditions attached to the grant of a production licence may be based on the protection of wildlife in offshore areas (Petroleum Regulations 1997, section 11), there is no specific provision for the protection of marine mammals during the exploration stage. However, the information and reporting requirements pursuant to an exploration licence enable the NPD to regulate the harmful effects of exploration activities on marine mammals.

Since terms and conditions for seismic surveys are imposed by the NPD on a case-by-case basis, they could impose restrictions on the location of seismic exploration where it is likely to have adverse impacts on marine mammals. However, seismic exploration activities have not been formally prohibited in any offshore area to date.

Although provisions allowing the NPD to put inspectors aboard exploration vessels were repealed in 1997, the

Fisheries Experts Regulations of 1991 may require that fisheries experts be placed onboard.

Although the Petroleum Activities Act of 1996 imposes a general obligation on licensees to take "reasonable precautions" to prevent damage to animal life and vegetation in the sea, there are no provisions in Norway for additional methods (e.g. ramp-up) that take marine mammals into account. The NPD is responsible for monitoring licensees to ensure that adverse impacts on marine mammals are minimised.

The NPD is currently reorganizing and streamlining Norwegian petroleum and environmental legislation, in cooperation with other concerned and competent authorities. It is still unclear to what extent the Norwegian authorities plan to introduce guidelines or legislation on the protection of marine mammals exploration and production activities.

Fugro-Geoteam AS have environmental guidelines that include methods to reduce interactions with marine mammals that are applied both in Norwegian waters and elsewhere the company is working (Geoteam 1996; Fugro-Geoteam 1997). This company has also installed an automatic soft-start facility on one of its ships (Einar Edstrøm, pers. comm.).

7.4.2.6 Egypt

There is no specific legislation in Egypt addressing the issue of marine mammals in the context of offshore oil and gas activities, although the competent authorities can apply general environmental legislation on a case-by-case basis. The competent authorities are the Ministry of Interior and the Egyptian Environmental Affairs Agency (EEAA). Egyptian law does prohibit the catching, transfer, killing, or disturbing of land or sea creatures.

One geophysical operator in the Mediterranean, British Gas, routinely employs a 20 min ramp-up (soft start) (Howard Crook, British Gas, pers. comm.). British Gas has a policy that, in addition to meeting any requirements of the licence and local governments, it conducts environmental impact assessments in all areas of operation and imposes criteria on itself that would satisfy at least the minimum standards in the UK

7.4.2.7 Madagascar

Although no legislation exists, Triton Energy, which conducted a seismic survey in Madagascar waters, produced a full EIA and placed environmental observers onboard the seismic vessel to watch for cetaceans and turtles (Phil Smith, Deborah Booth, Triton Energy, pers. comm.). Ramp-up (soft start) was used, and the policy was not to start if marine mammals were observed within about 500 m (1,640 ft) of the seismic vessel (very few marine mammals were seen).

7.4.2.8 Equatorial Guinea

Although no legislation exists, Triton Energy also followed the UK guidelines here (Deborah Booth, pers. comm., see previous discussion).

7.4.2.9 Arabian Gulf and nearby seas (Bahrain, Iran, Iraq, Kuwait, Oman, Quatar, Saudi Arabia, United Arab Emirates)

The Regional Organisation for the Protection of the Marine Environment (ROPME) Protocol concerning Marine Pollution resulting from Exploration and Exploitation of the Continental Shelf includes guidelines on the conduct of seismic operations (ROPME 1993a.b). The guidelines are fairly general, e.g. before approving any Seismic Operations Plan, the Competent State Authority should check on the possibility of interference with the breeding cycles of any marine animals...and...the presence of any migratory species which might be affected.… The Protocol does not state which countries, other than Kuwait, are Member States of ROPME. Triton Energy has followed the UK guidelines here as well (Deborah Booth, pers. comm.).

7.4.2.10 Caspian Sea (Kazakhstan)

A large-scale seismic survey was carried out in the northern Caspian Sea in 1994 to 1997 (John Addy, B.P., pers. comm.). Much of the survey area is very shallow and environmentally sensitive, including the breeding grounds of the entire Caspian seal (*Phoca caspica*) population. An EIA, which identified the most sensitive locations and times of year for seals and recommended places and/or dates to avoid, was prepared. The operators of the seismic survey followed these recommendations, although it was suggested (J. Addy, BP, pers. comm.) that the potential impact was minimal and the measures were only precautionary.

7.4.2.11 Vietnam

There is no specific legislation in Vietnam regarding the protection of marine mammals in relation to offshore oil and gas exploration and production activities. The Ministry of Environment, Science, and Technology (MOSTE) imposes, jointly with PetroVietnam, the state oil company, conditions relating to exploration on a case-by-case basis as part of the exploration license.

7.4.2.12 Argentina

The Horizon geophysical company used ramp-up (soft start), and observed JNCC reporting requests when conducting seismic operations off Argentina (Sean Waddingham, pers. comm.).

7.4.2.13 Brazil

In Brazil, environmental issues in relation to offshore exploration and production activities are the responsibility of the Ministry of Environment, Water Resources and the Legal Amazon (MMA), assisted by the Brazilian Institute for Environmental Protection and Renewable Natural Resources (IBAMA). In this capacity, IBAMA is the exclusive permitting and enforcement authority for offshore oil and gas projects. Within IBAMA, the Directorate of Renewable Resources is in charge of faunal protection, fisheries, and aquaculture.

There are no specific provisions in Brazilian legislation relating to seismic surveys or associated noise emissions; stipulations are imposed on a case-by-case basis. There is no standard requirement to conduct an EIA for seismic operations. However, oil and gas activities are prohibited in an area that has not been leased. Prior consent from the government must be obtained in order to carry on exploration and production activities in an ecological preserve.

The regulatory situation in Brazil is in a state of flux, pending the opening of acreage to private sector investment. While fundamental responsibilities regarding environmental change are unlikely to change, it is understood that the current system, particularly with respect to offshore regulation, is likely to evolve and become more sophisticated. It is unclear whether these changes will specifically address the issue of marine mammals.

7.4.2.14 Falkland Islands

Horizon, a geophysical company, has observed the UK guidelines while conducting seismic survey operations for Shell off the Falklands (Sean Waddingham, Horizon, pers. comm.).

7.4.2.15 Trinidad

The Geco-Prakla geophysical company and British Gas used ramp-up (soft start) during seismic operations off Trinidad (Ian Cheshire, Howard Crook, pers. comm.). Sea turtles are more abundant than marine mammals in this region and thus of greater concern, and Geco-Prakla was requested to shut down the array if any were sighted close to the vessel (it is unclear whether this was legislation or company policy).

7.4.2.16 Venezuela

There is no specific legislative framework regarding the protection of marine mammals from offshore exploration and production activities in Venezuela. Instead, general provisions of three environmental laws are applied on a case-by-case basis. Although the Ministry of Environment and Natural Renewable Resources (MARNR) is involved in the licensing and EIA process and can require that special provisions regarding the protection of marine mammals be applied, it is unclear to what extent this has happened due to the limited extent of offshore activities in Venezuela.

Geco-Prakla, a geophysical company, used ramp-up (soft start) during seismic operations off Venezuela, but to a lesser extent than it had when conducting a 3-D seismic survey for Exxon off southern California (see section 7.3.2.2) (Ian Cheshire, Geco-Prakla, pers. comm.).

7.5 References

Bain, D.E., & Calambokidis, J. 1997. *Effect of airgun noise on marine mammals: response as a function of received sound level and distance.* A proposal to the Minerals Management Service.

Barlow, J., & Taylor, B.L. 1998. Preliminary abundance of sperm whales in the northeastern Pacific estimated from a combined visual and acoustic survey. *International Whaling Commission Working Paper SC/50/CAWS20.*

BBN, Inc. 1995. *Exxon SYU sound propagation study, November 1995*. (Contractor: BBN, Inc., Acoustic Technologies Division, Cambridge, Massachusetts.). Unpublished report to Exxon Exploration Company, Houston, Texas. BBN Report No: 8120.

Bonnell, M.L., Pierson, M.O., & Farrens, G.D. 1983. *Pinnipeds and sea otters of central and northern California, 1980-1983: status, abundance, and distribution.* (Contractor: University of California, Santa Cruz.) Final Report to the Minerals Management Service, Contract 14-12-0001-29090. OCS Study MMS 84-0044.

Davis, R.A., Thomson, D.H., & Malme, C.I. 1998. Environmental assessment of seismic exploration on the Scotian Shelf. Prepared for Mobil Oil Canada Properties Ltd., Shell Canada Ltd., and Imperial Oil Ltd., Calgary, Alberta, Canada for submission to Canada/Nova Scotia Offshore Petroleum Board, Halifax, Nova Scotia, Canada. LGL Ltd. Environmental ResearchAssociates, King City, Ontario, Canada and Charles I. Malme, Eng. and Sci. Services, Hingham, MA.

Evans, P.G.H. 1992. *Status review of cetaceans in British and Irish waters.* Report to UK Department of the Environment. Sea Watch Foundation, Oxford.

Evans, P.G.H. 1998. *Biology of cetaceans of the northeast Atlantic (in relation to seismic energy).* Proceedings of the Seismic and Marine Mammal Workshop, June 23-25, 1998, London, UK Chapter 5, this volume.

Exxon Company, USA. (Exxon). 1995. *Request for incidental harassment authorization, Santa Ynez Unit 3-D seismic survey.* Submitted to National Marine Fisheries Service, Washington, D.C.

Fugro-Geoteam. 1997. *Environmental protection procedure marine operations, Document number SP711, second issue.* Fugro-Geoteam AS, Oslo.

Geoteam. 1996. *Work instruction for marine mammal watch, Document number WI.MAR.211.* Geoteam AS, Oslo

Greene, C.R., Jr. 1996. *Acoustic monitoring for marine mammal calls during the Exxon 3-D seismic survey of the Santa Ynez Unit, 15 Nov-12 Dec 1995, Santa Barbara Channel.* Report to Exxon Company, USA., Thousand Oaks, California, Consulting Agreement No. C-25504. Greeneridge Sciences, Inc., Santa Barbara, California

Gordon, J., Leaper, R., Hartley, F.G., and Chappell, O. 1992. Effects of whale-watching vessels on the surface and underwater acoustic behaviour of sperm whales off Kaikoura, New Zealand. *Science and Research Services, 52*. New Zealand Department of Conservation, Wellington.

High-Energy Seismic Survey Team (HESS). 1997. *Draft recommendations of the expert panel at the Workshop on High-Energy Seismic Sound and Marine Mammals convened at Pepperdine University, Malibu, California, June 11-12, 1997.*

Impact Sciences Inc. 1996. *Visual monitoring of marine mammal activity during the Exxon 3-D seismic survey, Santa Ynez Unit, offshore California, 9 November to 12 December 1995.* Report to Exxon Company, USA., Thousand Oaks, CA.

Joint Nature Conservation Committee (JNCC). 1998. *Guidelines for minimising acoustic disturbance to marine mammals from seismic surveys.* April 1998 version. Aberdeen, UK.

Ketten, D.R., Lien, J., & Todd, S. 1993. Blast injury in humpback whale ears: evidence and implications. *Abstact In: Journal of the Acoustic Society of America*, 94(3):1849-1850.

LGL Ltd. and Greeneridge Sciences Inc. 1997. *Proposed technical plan for marine mammal monitoring during BPXA's 1997 open-water seismic program.* (Contractors: LGL Ltd., King City, Ont., and Greeneridge Sciences Inc., Santa Barbara, CA.) Prepared for BP Exploration (Alaska) Inc., Anchorage, AK. LGL Project TA2150.

Marine Acoustics Inc. 1997. *Draft Environmental Assessment for low frequency sound scientific research program in the Southern California Bight, September/October 1997.* Prepared for National Marine Fisheries Service, Office of Protected Resources, 1315 East-West Highway, Silver Spring, MD. Marine Acoustics, Inc., Arlington, VA.

Mayerson, D.A., Pierson, M.O., & Greve, G.M. 1998. *Review and mitigation of seismic survey impacts on marine mammals off southern California. Abstract In: Seismic and Marine Mammal Workshop,* June 23-25, 1998, London, UK

National Marine Fisheries Service (NMFS). 1995a. *Small Takes of Marine Mammals Incidental to Specified Activities; Offshore Seismic Activities in Southern California; Notice of issuance of an incidental harassment authorization.* Federal Register 60(200, October 17): 53753-53760.

National Marine Fisheries Service (NMFS). 1995b. *Supplement to Incidental Harassment Authorization issued to Exxon Company, USA., Thousand Oaks, California, on October 11, 1995, to incidentally harass a small number of marine mammals incidental to the operations of 3-D seismic surveys in the Santa Ynez Unit located in the western portion of the Santa Barbara Channel, offshore California.*

National Marine Fisheries Service (NMFS). 1995c. *Small takes of marine mammals; harassment takings incidental to specified activities/Proposed rule; request for comments.* Federal Register 60(104, May 31):28379-28386.

National Marine Fisheries Service (NMFS). 1997a. *Taking and importing of marine mammals; offshore seismic activities in the Beaufort Sea/Notice of issuance of an Incidental Harassment Authorization.* Federal Register 62(237, July 17):38263-38267.

National Marine Fisheries Service (NMFS). 1997b. *Environmental Assessment on the issuance of an Incidental Harassment Authorization for a seismic survey in Puget Sound, Washington.* Office of Protected Resources, National Oceanic and Atmospheric Administration, US Department of Commerce.

National Marine Fisheries Service (NMFS). 1998. *Small takes of marine mammals incidental to specified activities; seismic hazards investigations in Puget Sound/Notice of issuance of an Incidental Harassment Authorization.* Federal Register 63(9, January 14): 2213-2216.

National Research Council (NRC). 1994. *Low-frequency sound and marine mammals: Current knowledge and research needs*. National Academy Press: Washington, D.C.

Richardson, W.J., *ed.* 1997a. *Northstar marine mammal monitoring program, 1996: marine mammal and acoustical monitoring of a seismic program in the Alaskan Beaufort Sea.* Report to BP Explor. (Alaska) Inc., Anchorage, AK, and NMFS, Anchorage, AK, and Silver Spring, MD. Contractors: LGL, Ltd., King City, Ont., and Greeneridge Sciences, Inc., Santa Barbara, CA.

Richardson, W.J. 1997b. *Marine mammals and man-made noise: current issues. Preprint from Proceedings, Underwater Bio-Sonar and Bioacoustics Symposium, Loughborough University, 16-17 Dec. 1997.* Institute of Acoustics, St. Albans, Herts., UK.

Richardson, W.J., Greene, C.R., Jr., Malme, C.I., & Thomson, D.H. 1995. *Marine mammals and noise.* Academic Press, Inc., San Diego.

Regional Organisation for the Protection of the Marine Environment (ROPME). 1993a. *Protocol concerning Marine Pollution resulting from Exploration and Exploitation of the Continental Shelf.* ROPME, Kuwait

Regional Organisation for the Protection of the Marine Environment (ROPME). 1993b. *Guidelines to the Protocol concerning Marine Pollution resulting from Exploration and Exploitation of the Continental Shelf.* ROPME, Kuwait

Stone, C.J. 1997. Cetacean observations during seismic surveys in 1996. *JNCC Report* No. 228.

Stone, C.J. 1998. Cetacean observations during seismic surveys in 1997. *JNCC Report* No. 278.

Todd, S., Stevick, P., Lien, J., Marques, F. & Ketten, D.R. 1996. Behavioural effects of exposure to underwater explosions in humpback whales (*Megaptera novaeangliae*). *Canadian Journal of Zoology*, [reference incomplete].