WESTERN GRAY WHALE PROTECTION PLAN: A FRAMEWORK FOR MONITORING AND MITIGATION MEASURES RELATED TO SAKHALIN ENERGY OIL AND GAS OPERATIONS ON THE NORTHEAST COAST OF SAKHALIN ISLAND, RUSSIA

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INTRODUCTION

Sakhalin Energy Investment Company Limited (hereafter, Sakhalin Energy) is a consortium comprised of Shell, Mitsubishi Corporation, and Mitsui Corporation. Sakhalin Energy is currently developing oil and gas reserves on its Piltun-Astokhskoye (P-A) petroleum license area in the Okhotsk Sea off the northeast coast of Sakhalin Island, Russia.

Currently, Sakhalin Energy operates a single offshore production platform (Molikpaq) and associated marine terminal (Vityaz Complex) 17 km offshore and approximately 24 km southeast from the entrance of Piltun Bay. The shallow (generally less than 20 m deep) nearshore area adjacent to Piltun Bay is occupied during the summer-autumn open water feeding period (May-November) by critically endangered Okhotsk-Korean or "western" gray whales (*Eschrichtius robustus*). Although few gray whales are recorded in the Molikpaq area during the summer feeding period, some activities associated with normal Sakhalin Energy operations, such as geophysical seismic operations, extraction and production activities, appraisal well drilling north of the Molikpaq, and regular helicopter and vessel movements to and from Sakhalin Island south of Piltun Bay, could have impacts on gray whales migrating through or otherwise occurring in the P-A license area or those at or near the summer feeding grounds.

Because of these potential impacts, Sakhalin Energy has implemented mitigation measures and monitoring programmes and has developed this gray whale protection plan to ensure that all reasonable efforts are made to reduce impacts on this critically endangered population of whales.

Sakhalin Energy has (1) prepared an Environmental Impact Assessment (EIA), (2) prepared various environmental management plans, programmes and procedures, (3) obtained appropriate permits and licenses to conduct its operations (4) conducted offshore environmental monitoring studies in association with the Molikpaq production platform and marine terminal, (5) implemented mitigation and protection measures to reduce or eliminate impacts on the local environment, including gray whales, and (6) conducted gray whale monitoring studies to provide information required to create mitigation and protection measures.

This document describes Sakhalin Energy's gray whale protection plan, which in the past has been referred to as a habitat conservation plan (HCP) (see following paragraph for clarification). As such, this document does not specifically represent the interests of other stakeholders, i.e., other petroleum developers, the Russian Federation, the Sakhalin Oblast, and/or various commercial fishing and/or shipping interests. Nevertheless, the measures outlined here do incorporate current information about potential direct, indirect, and cumulative impacts from other stakeholders and recent information that may influence future mitigation measures adopted by Sakhalin Energy.

The focus of this document is primarily on the critically endangered Okhotsk-Korean or Western North Pacific (western) population of gray whales (Hilton-Taylor 2000). The development of a HCP, as defined by the U.S. Fish and Wildlife Service (USFWS) and the U.S. National Marine Fisheries Service (NMFS) (USFWS and NMFS 1996), is a requirement of the U.S. Endangered Species Act when a proposed activity may have impacts on an endangered species in the United States or in International Waters by a United States entity. To date, no HCP has been prepared for any cetacean or pinniped species inside or outside the United States. Furthermore, outside the United States, and for a non-United States entity such as Sakhalin Energy operating outside United States jurisdiction, there is no regulatory requirement for the development of an HCP. Nevertheless, Sakhalin Energy has agreed to develop this protection plan under the terms of its finance agreement and to implement mitigation strategies, protection measures and continued monitoring programmes to reduce the possibility that its activities may cause harm to this population.

Sakhalin Energy's operations and the development of a protection plan for gray whales do not occur in isolation of other activities by industry or by the Russian Federation. There are other current and planned petroleum developments in the region, and the Russian Federation has national, regional, and local interests in maintaining other commercial and domestic activities (e.g., fishing, shipping, industrial development). Some of these other interests also have the potential to affect the gray whale population while on the summer feeding grounds. Because of the irregular and uncertain nature of these other activities, and because these activities are not within the control of Sakhalin Energy, they are not the focus of this protection plan. Nevertheless, Sakhalin Energy will continue to cooperate with other stakeholders in the region, e.g., other petroleum developers, Russian Federation, Sakhalin Oblast, and local and regional conservation groups.

This document is presented to demonstrate that (1) Sakhalin Energy has conducted a detailed gray whale monitoring programme during Phase I operations between 1997-2001 off northeastern Sakhalin Island, (2) gray whale monitoring and related studies sponsored by Sakhalin Energy provides sufficient information to design mitigation and protection measures for western gray whales off northeastern Sakhalin Island, (3) Sakhalin Energy has implemented mitigation and protection measures, (4) Sakhalin Energy has planned future gray whale studies to meet information needs, and (5) Sakhalin Energy will annually evaluate the effectiveness of its mitigation and monitoring programmes and modify plans and studies as necessary in order to respond to new information as it becomes available, i.e., adopt an adaptive approach to assessing and managing impacts on the gray whales and their habitat.

To that end, this document presents the general approach used by Sakhalin Energy to help protect critically endangered western gray whales while on their summer feeding grounds and to ensure that impacts to their northeast Sakhalin Island habitat are minimised. A summary of background information on western gray whales, and reviews Sakhalin Energy activities that may have impacts on western gray whales are included in the following sections. This document also presents a review of mitigation/protection measures employed by Sakhalin Energy to reduce impacts on gray whales, reviews the results of monitoring studies designed to evaluate the effectiveness of the various mitigation/protection measures, and then reviews additional information required to meet the goals and objectives of the gray whale protection plan. Final sections of this document describe studies that Sakhalin Energy plans to support for 2002-2003 to meet future monitoring needs. A final summary and conclusions section reviews the Sakhalin Energy gray whale protection plan and discusses impacts, or the absence of impacts, of Sakhalin Energy activities on western gray whales.

GENERAL APPROACH

Sakhalin Energy has adopted the following ‘principles’ in implementing their western gray whale protection plan. Throughout this plan, unless otherwise indicated, the term “gray whale” refers to the western gray whale while in Russian waters.

- Western gray whale and western gray whale habitat conservation measures are under the authority of the Russian Government during the period of time these whales are in Russian waters.
- The primary elements of this gray whale protection plan is the development and implementation of protection/mitigation measures and outlining a multi-year monitoring programme based on the findings of past monitoring and research, additional data needs, and anticipated future operations and activities.

- Sakhalin Energy will make every effort to coordinate its gray whale monitoring activities with other stakeholders (such as Exxon Neftegas, BP International, and the Russian Federation).
- Sakhalin Energy will strive to maximise Russian content in gray whale studies in accordance with its commitments to the Russian Federation.
- Sakhalin Energy will continue to provide monitoring and study findings to Russian authorities.
- Sakhalin Energy intends to make monitoring and study findings available to the public and interested non-governmental organizations wherever possible.
- Sakhalin Energy will retain a scientific consultant to assist in evaluating whale-related issues.
- Sakhalin Energy will work to promote cooperation and sharing of information among whale researchers/contractors to ensure a coordinated overall understanding of the gray whale issue.

BACKGROUND INFORMATION ON GRAY WHALES

This section of the gray whale protection plan discusses relevant background information about the western population of gray whales. It includes a discussion of their present and past status in relation to the non-endangered eastern or California-Chukchi population of gray whales, describes the habitat characteristics and feeding ecology of the gray whales, and discusses recent concerns about the apparent emaciated state of some adult whales during summer 1999, 2000, and 2001.

Past and Present Status, Distribution and Abundance

There are two extant populations of gray whales, both dwelling in the Pacific Ocean, (1) the Eastern North Pacific or California-Chukchi population, and (2) the Western North Pacific or Okhotsk-Korean population (Jones *et al*. 1984, LeDuc *et al*. 2000). An Atlantic population was extirpated prior to the 19th century (Jones *et al*. 1984).

The eastern or California-Chukchi population was once considered endangered. From an estimated low of about 1500 individuals in the mid-1940s, the population grew to near-historical levels (~26,000 individuals) by the mid-1990s and was removed from the U.S. endangered species list in 1994 (59 FR 31094, 16 June 1994).

Currently, there are approximately 26,000 California-Chukchi gray whales (hereafter referred to as the eastern gray whale) (Rugh *et al*. 1999) that over-winter in the lagoons of Baja California and summer in the Bering and Chukchi seas. Some individuals are summer residents at locations along the migration route, e.g., coastal Oregon, Washington, and British Columbia (Jones *et al*. 1984, Darling *et al*. 1998).

The other population of gray whales is the Western North Pacific or Okhotsk-Korean population (hereafter referred to as the western gray whale). The only presently known summering and feeding area of this population of gray whales is located off the northeast coast of Sakhalin Island (Brownell and Chun 1977; Sobolevsky 1998, 2000; Würsig *et al*. 1999, 2000a; Weller *et al*. 1999, 2000, 2001). Gray whales begin arriving off northeast Sakhalin Island in late May, after sea ice has left the area, and some remain until late November, when sea ice returns (Weller *et al*. 1999, Sobolevsky 2000). Migration routes used by these gray whales are presently unknown, but it is likely that individuals migrate through La Perouse Strait (south of Sakhalin Island) and migrate along the eastern coast of Sakhalin Island (Weller *et al*. 2001).

The historical distribution of gray whales in the Okhotsk Sea apparently included Sakhalin Bay (west of the NW end of Sakhalin Island), Akademiia, and Tugurskii bays south of the Shantarskiy Islands (in the far western Okhotsk Sea, west of the NW end of Sakhalin Island), the coastal waters of northeast Sakhalin Island, in Shelikhova, Penzhinskaya and Gizhiginskaya bays in the far northeast portion of the Okhotsk Sea, and in the waters west of the Kamchatka Peninsula (Krupnik 1984; Yablokov and Bogoslovskaya 1984; Perlov *et al*. 1996). The long-held belief that the wintering grounds of western gray whales were along the south coast of the Korean Peninsula has not been substantiated (Rice 1998; Weller *et al*. 2001). Wintering grounds are now believed to be located in the South China Sea, possibly along the coast of Guangdong province and around Hainan Island (Wang 1978, 1984; Rice 1998). However, specific calving and breeding sites have not been determined.

The western gray whale is listed as a Category I species (endangered) in the Red Book of the Russian Federation (Red Book of the Russian Federation 2000) and is currently considered "endangered" by the United States government (USFWS 1997). This population was recently reclassified as critically endangered (extremely high risk of extinction) by the IUCN-World Conservation Union (IUCN) (Hilton-Taylor 2000, Weller and Brownell 2000). The IUCN Red List criteria (Criteria D) used to support this reclassification were as follows:

(1) the population is geographically distinct, and (2) the population plausibly contains less than 50 reproductive individuals (Hilton-Taylor 2000, Weller and Brownell 2000).

It is estimated that there were initially 1,500-2,000, and possibly as many as 10,000 gray whales in the western population (Rice and Wolman 1971; Yablokov and Bogoslovskaya 1984), but over-exploitation by commercial whaling decimated the population. This population was reported to be "probably extinct" in the early 1970s (Bowen 1974). Subsequent sporadic sightings, however, indicated that the western gray whale was not extinct (Brownell and Chun 1977). Aerial surveys by Russian researchers indicated that small groups of gray whales were present at several locations in the Okhotsk Sea, but the only regular sightings of feeding whales are from shallow waters (i.e., generally within the 20 m isobath) off Piltun Bay (Berzin *et al*. 1988, 1990, 1991; Vladimirov 1994). There have been repeated observations of gray whales off the Piltun area over the past two decades (Berzin *et al*. 1988, 1990, 1991; Blokhin *et al*. 1985; Votrogov and Bogoslovskaya 1986; Brownell *et al*. 1997; Sobolevsky 1998, 2000, 2001; Würsig *et al*. 1999, 2000a; Weller *et al*. 2000, 2001), while sightings elsewhere in the Okhotsk Sea have been infrequent during this same period (Weller *et al*. 2001).

In the mid-1990's, estimates of the numbers of western gray whales ranged from 100 individuals (Blokhin 1996) to approximately 250 (Vladimirov 1994). More recent estimates based on monitoring studies sponsored by Sakhalin Energy and others (Sobolevsky 2000, 2001; Weller *et al*. 2000, 2001; Würsig *et al*. 1999, 2000a) indicate that the number summering off Piltun Bay, which likely represents a significant proportion of the entire population, is less than 100 individuals. However, the entire historical range of the western gray whale has not been systematically surveyed, and therefore the size of the entire population is currently unknown.

Habitat Characteristics and Feeding Ecology

The gray whale is unique among baleen whales because it feeds mainly on benthic (bottom-dwelling) organisms (Zenkovich 1934, 1937; Tomilin 1937; Mizue 1951; Pike 1962; Rice and Wolman 1971; Zimushko and Lenskaya 1970; Thomson 1983; Thomson and Martin 1983; Nerini in Jones and Swartz 1984). When feeding in the benthic environment, they feed by rolling to one side, making close contact to bottom sediments with the side of the head, sucking benthic and epibenthic organisms (along with bottom sediments) into their mouth, and then expelling water and most of the inorganic sediments (which is often visible as a mud plume), while retaining food organisms along the baleen plates (Thomson 1983, Thomson and Martin 1983, Nerini 1984). However, gray whales are not obligatory benthic feeders. In some instances, gray whales are known to feed on fish and other nectonic organisms in the water column and on the surface (Norris *et al*. 1984, Nerini 1984, Darling *et al*. 1998).

As large organisms with an active metabolism, gray whales depend upon a high biomass of prey organisms per unit area for feeding and may consume from 400-1200 kilograms of food/day during the summer feeding period (Zimushko and Lenskaya 1970, Brodie 1975, Thomson 1983, Thomson and Martin 1983). The reason why gray whales aggregate in the area around the mouth of Piltun Bay is not clear. Weller *et al*. (1999) speculated that the nutrient-rich waters from Piltun Bay provided a significant source of nutrients for benthic communities in the area, creating "prime" feeding habitats for gray whales. Presently, however, there is only a limited understanding of the benthic resources available to gray whales in the shallow waters off northeast Sakhalin Island, and recent systematic aerial surveys (Sobolevsky 2000, 2001) indicate that western gray whales are distributed over a wider section of the northeast Sakhalin Shelf than originally suspected (Fig. 1). Presently there are no quantitative data to support or discount the idea that food resources are "unique" in the Piltun area.

The recent review by Kussakin *et al*. (2001) of the benthic environment and food organisms in the main gray whale feeding areas on the northeast Sakhalin shelf and off Chukotka in East Siberia (Bering Sea) provides the most comprehensive synthesis of available information, especially in the Russian literature, on this subject. Kussakin *et al*. (2001) indicated that the standing stocks of gray whale food organisms off northeast Sakhalin Island are considerably lower and have a different composition (mainly isopods and amphipods) than in the gray whale feeding areas off Chukotka (mainly amphipods, Thomson 1983, Thomson and Martin 1983, Nerini 1984, Highsmith and Coyle 1992), and that food resources may ultimately be a limiting factor for western gray whales feeding off Sakhalin.

Samples taken near feeding whales in the Piltun area by SCUBA divers in 1995 (Sobolevsky *et al*. 2000) indicated that amphipods, mainly *Pontoporeia affinis*, *Anisogammarus pugettensis* and *Eonaustozius eous eous* comprised the largest group. The two isopods *Synidotea cineria* and *Saduria entomon* and various species of bivalve molluscs were also abundant in the area. Maximum wet weight biomass recorded during quantitative sampling by divers in the area off Piltun Bay was 427 g/m^2 at 7 m depth. In waters 12 m deep, the biomass of benthos was considerably less—ranging from 85 to 137 g/m^2 (Sobolevsky *et al*. 2000).

The results of Sobolevsky *et al*. (2000), in contrast to those of Kussakin *et al*. (2001), are similar to results from studies in the northern Bering Sea, where the distribution of eastern gray whales coincides with that of an extensive benthic and epibenthic community which is dominated by amphipod crustaceans, most notably *Ampelisca macrocephala*. The estimates of the biomass (wet weight) within the 20 m isobath east of Sakhalin Island range from 200-1000 g/m^2 (Kuznetsov 1964), compared to 482 ± 286 g/m^2 off Chukotka (Thomson 1983, Thomson and Martin 1983, Stoker 1978-), of which *Ampelisca macrocephala* alone comprised about 30% of the total benthic biomass (Thomson 1983, Thomson and Martin 1983, Nerini 1984).

To date, the only direct information on gray whale food habits in the Piltun region has come from fecal samples collected from feeding whales in 1998 and 1999. These samples indicated that whales were feeding almost exclusively on ampeliscid amphipods (Würsig *et al*. 1999). Additional information will be obtained from a benthos and sediment chemistry study conducted during 2001 by IBM.

Koblikov (1986) conducted an 8-year benthic research programme that involved the collection and analysis of 845 sediment samples along the entire east coast of Sakhalin Island, including a small number of samples collected near Piltun Bay. Koblikov recognized 34 distinct benthic communities and assessed their species composition, geographical range, and biomass. In the general nearshore area, the benthic community was dominated (93% total biomass) by *Echinarachnius parma*, the common sand dollar, which is unlikely to be an important food source for western gray whales. The mean wet weight biomass of this community was estimated at 684 g/m^2, similar to the benthos biomass estimates in the Bering Sea. This community is widespread and dominates sediments in shallow coastal waters of Sakhalin Island from the northern tip of the island south to the area around the mouth of Chayvo Bay (52°20'N). Further south at Nabyl' Bay (51°40'N), another benthic community is prevalent along the coast, dominated by ampeliscid amphipods, mainly *Ampelisca eschrichti.* The mean biomass of ampeliscid amphipods near Nabyl' Bay was estimated at 393 g/m^2, of which 56% was *Ampelisca eschrichti* (Koblikov 1986).

Benthic sampling associated with the offshore environmental monitoring programme near the Molikpaq platform in 1998 and 1999 (Sakhalin Energy 2000) indicated that amphipods, bivalves, the echinoid *Dendraster excentricus* (eccentric sand dollar), and several species of polychaete worms were the most abundant organisms in that area. However, although the Molikpaq is located in 30 m of water, it also lies near a finger-like projection of the 20 m isobath. Few gray whales have been reported within 10 km of the Molikpaq. As shown in Figure 1, the majority (305, 97%) of the total 315 gray whale sightings (151 during 1999 and 154 in 2000) recorded during systematic surveys of a coast-wide extensive sampling grid and a nearshore intensive grid centered near Piltun Bay, were reported within the 20 m isobath, and most were within 5 km of shore (Sobolevsky 2000, 2001). However, in 2001 gray whales were also observed feeding offshore significantly south of Piltun Bay and in water depths of approximately 35-45 m (ENL personal communication 2001).

"Skinny" Gray Whales

In 1999 and 2000 some members of both the eastern and western populations of gray whales were reported to be unusually "skinny". In the case of the eastern population, many apparently undernourished ("skinny") whales died during winter in the lagoons of Baja California and during their northward migration in 1999 (LeBoeuf *et al*. 2000). In 2000, nearly twice as many eastern gray whales as in 1999 died in the wintering lagoons of Baja California (LeBoeuf *et al*. 2000). High mortality in eastern gray whales was not documented during winter 2000-2001 nor during the 2001 northward spring migration (Brownell *et al*. 2001). In the case of western gray whales, a notable proportion of adults also appeared to be malnourished and skinny during 1999 and 2000, but no dead gray whales were recorded from the northeast Sakhalin coast. During photo-identification surveys in 1999 (Weller *et al*. 2000), 14% of all whales identified (10 of 70) were judged to be skinny, and during similar surveys in 2000 (Weller *et al*. 2001) nearly half (27 of 58, 47%) of the gray whales identified were skinny. Preliminary results from the 2001 field season (Weller *et al*. in prep) indicate that 72 individual whales were identified and that some (approximately 19) adult gray whales in the western population were skinny. These numbers may change however after detailed photo analysis is completed. It is notable, however, that some gray whales identified as skinny in 2000 were observed to be recovering in 2001, and some whales not previously reported to be skinny were found to be skinny in 2001 (Weller *et al*. in prep).

The causes of emaciation in both North Pacific populations of gray whales are not clear, but several lines of evidence suggest over-exploitation of the available food supply and/or a possible large scale climatic/oceanographic regime shift affecting productivity in the North Pacific region (LeBoeuf *et al*. 2000) were at least partially responsible. It was hypothesized that a large scale climatic/oceanic regime shift has resulted in increased sea-surface temperatures, which in turn has resulted in reduced secondary productivity in the North Pacific region (Agler *et al*. 1999), including the summer feeding grounds of gray whales (LeBoeuf *et al*. 2000). It is conceivable that these large-scale climatic/oceanographic events may have affected the entire North Pacific region and thus may have had simultaneous and similar impacts on both the western and the eastern gray whale populations (see Brownell and Weller 2001). It is also conceivable that some other factor(s), such as disease or anthropogenic impacts during winter, migration, and/or the summer feeding period, may have simultaneously and similarly affected one or both gray whale populations.

Recent population modeling suggests that the natural annual mortality of a gray whale population of 26,000+ individuals would be approximately 800-1,200 individuals (Wade in press). Thus, the existence of animals in poor condition and the death and stranding of over 270 eastern gray whales along the coast of North America in 1999-2000 may be a reflection of natural mortality in a population that has reached or exceeded its natural carrying capacity, rather than the result of some more complicated oceanic process resulting in reductions in productivity. Nevertheless, the large number of strandings recorded during the 1999-2000 season was not observed in 2000-2001, suggesting that some more complex explanation may exist for the observed high level of strandings and emaciated eastern gray whales reported in 1999-2000 (IWC 2001). This view is further supported by the sighting of skinny western gray whales, since it is highly unlikely that a population of <100 whales has over-exploited its food supply.

POTENTIAL IMPACTS OF SAKHALIN ENERGY ACTIVITIES ON GRAY WHALES

Sakhalin Energy is developing oil and gas reserves off the northeast coast of Sakhalin Island, Okhotsk Sea, Russia, where gray whales are present during the summer and fall months (May to November). Operations include the drilling, production and transfer of hydrocarbons along with associated support and exploration activities. During Phase 1 of the Sakhalin 2 development, produced oil is delivered from a fixed platform (Molikpaq) to a floating storage and offloading (FSO) facility through a 2-km sub-sea pipeline. The FSO, a large tanker that is moored to a Single Anchor Leg Mooring (SALM) buoy, periodically offloads oil to shuttle tankers that carry the oil to market (Fig. 2).

Drilling activities occur year-round from the Molikpaq (14 production wells have been drilled and an additional 13 pressure maintenance wells are planned), but oil production occurs only during a portion of the year, generally a 6 or 7 month period when ice cover is not prohibitive to navigation and SALM operation. During the ice-covered period, from approximately December through May, oil production ceases, the FSO is disconnected from the SALM and leaves the Okhotsk Sea, and all oil transfer operations are suspended.

The potential impacts of Sakhalin Energy operations on the gray whales that spend the summer off northeast Sakhalin Island may fall into the following four general categories: (1) physical presence of facilities, (2) underwater and airborne noise, (3) permitted discharges, and (4) accidental discharges (spills). These potential impacts, associated with a number of sources and operations, are discussed below. Following the discussion of potential and observed impacts, there is a discussion of mitigation/protection measures, both implemented and being considered, by Sakhalin Energy to reduce possible impacts on gray whales. This is followed by a section that discusses the results of monitoring studies conducted by Sakhalin Energy, to provide information on the biology of gray whales and to evaluate the effectiveness of its mitigation/protection measures.

Physical Presence of Facilities

Various Sakhalin Energy structures, facilities, and modes of transportation to and from these structures currently exist in the P-A license area, and could potentially affect the distribution, abundance, and behaviour of gray whales. These include the following: (1) Fixed structures and associated facilities, including the Molikpaq, Single Anchor Leg Mooring (SALM) system, Floating Storage and Off-loading (FSO) facility, and sub-sea pipeline connecting the Molikpaq with the FSO via the SALM (collectively known as the Vityaz Marine Terminal Complex, (Fig. 2), and (2) vessels, including (a) 1 or 2 supply and service vessels and an ice breaker; (b) a spill response standby vessel; (c) a crew boat; (d) vessels to conduct environmental, geophysical, or other inspection surveys; (e) specialized vessels present during construction ; (f) shuttle tankers; and, (3) air support, including (a) helicopters for crew transfers; and (b) helicopters and fixed-wing aircraft used in environmental surveys.

The Molikpaq production facility is located approximately 17 km off the northeastern coast of Sakhalin Island at N52° 43’, E143° 34’, in approximately 30 m of water. The SALM system is located 2 km SSW of Molikpaq and is connected to the Molikpaq by the sub-sea pipeline. During the 6 to 7 month ice-free production period (May--December), the FSO facility, which consists of a storage tanker, is moored to the SALM system, and oil tankers with approximately 700,000 bbl capacities offload oil from the FSO system (load-outs) and transport it to market about once every 7-9 days. In 2000 there were 24 such offloads and shipments of oil to market. These tankers arrive at the offshore terminal (Vityaz Terminal) from offshore, and when departing they travel due east away from the terminal and away from shore into international waters before turning south to Asian export markets.

Crew changes occur on a rotating basis (i.e., not all at once) by way of helicopter flights from Molikpaq to the Nogliki airport 2-4 times each week, weather permitting. There may be as many as 100 such helicopter flights each 185 – 200-day production season. Crew changes are made by small ship from the Molikpaq to the coastal port of Kaigan (several kms south of Nogliki) when weather precludes helicopter flights; the number of such trips ranges from 10-25 per month and totals about 100-120 trips per production season. Supply boats bring equipment and other materials and supplies from Kholmsk on the southwest side of Sakhalin Island (Fig. 3). Trips by these supply boats occur approximately every 10 days and total about 20 trips each production season.

During the period of ice cover (December through May), the deactivated pipeline is flushed with water and left in its normal position on the sea floor, the SALM buoy is lowered to the sea floor, and the FSO departs the Okhotsk Sea. During this winter period, drilling activities continue on the Molikpaq and are expected to continue for approximately two more years.

Potential Impacts

Potential behavioural modifications exhibited by whales that are close to physical structures in or near their habitat may include movement away from the area, avoidance of the area and/or obstruction of normal movement patterns, interrupted feeding, and collisions (see review in Moore and Clarke in press). Interrupted feeding, movement away from an area, and avoidance of a feeding area may have multiple impacts, i.e., impacts could potentially affect migration and feeding patterns which in turn could affect both the condition of whales and the overall well-being of the population.

Moore and Clarke (in press) indicate that vessel traffic (including commercial fishing) may have negative impacts on gray whales through collisions and/or by entanglement in lines and nets. Information about gray whale mortality or injury caused by vessel (or fishing operations) are usually inferred from stranding records (Heyning and Dalheim 1999). Laist *et al*. (2001) recently summarized all available information on collisions between whales and vessels, including many collisions with eastern gray whales. Migrating gray whales appear to be most susceptible to collisions (Laist *et al*. 2001). Although Sakhalin Energy supply vessels and crew change vessels generally travel to and from the Molikpaq well south of the main gray whale feeding area near Piltun Bay, some migrant whales moving along the coast in May and November may be vulnerable to collisions with these vessels. Additional potential impact could occur with survey and environmental monitoring vessels performing work within the P-A area. This said, however, no such collisions have been reported to date.

Observed Impacts

To date, there have been few documented reports of western gray whales in the vicinity of any of the offshore fixed structures and associated facilities (see Fig. 1). Since the placement of the structure in 1998, few gray whales have been sighted within 10 km of the Molikpaq production facility. During systematic aerial surveys in 1998 (Weller *et al.* in press), 1999 and 2000 (Sobolevsky 2000, 2001) no gray whales were sighted within 10 km of the Vityaz Complex (Fig. 1). As noted earlier, most gray whale sightings during the 1999 and 2000 aerial surveys were shoreward of Sakhalin Energy operations, primarily in waters less than 20 m deep (305 of 315; 97%). However, occasionally some gray whales have been recorded more offshore in waters deeper than 20 m (Sobolevsky 2000).

Based on reviews of logs of all vessels operating in the P-A license area, there have been no reports of vessel collisions, near collisions, or entanglements of western gray whales on the northeast Sakhalin shelf. A few dead whales, however, have been observed on beaches in the area but none of these were reported to be gray whales (D. Weller, Pers. comm. 2001).

Noise

Marine mammals rely heavily on the use of underwater sound to communicate and to gain information about their surroundings. Experiments also show that they hear and react to many man-made sounds (see review in Richardson *et al.* 1995). The following discussion focuses on potential impacts of various man-made noises to which gray whales may be exposed in the P-A license area. A more detailed discussion of noise affects in the marine environment is given in Appendix I.

Potential Impacts

As discussed in Appendix I, noise in the marine environment has the potential to interfere with a whale's ability to communicate, which in turn has the potential to affect their distribution, abundance, behaviour, and general well-being (Richardson *et al*. 1995). Very loud noises at close range may also cause hearing and other physical damage in whales (Richardson *et al*. 1995). Potential behavioural modifications that may be displayed by whales that are, or have been, exposed to noise include (1) changes in general behaviour patterns, (2) changes in orientation and breathing and movement (swimming) patterns and speeds, (3) interrupted feeding, and (4) avoidance of an area previously occupied (Richardson *et al*. 1995, Moore and Clarke in press).

Avoidance of areas where noisy activities are occurring also has the potential to modify whale migration routes, displace them from feeding areas, and ultimately to affect the condition of the whales and the well-being of the population. Because the northeast Sakhalin Shelf is used primarily for feeding by endangered western gray whales and not for mating and calving (which occur on the southern wintering grounds in or near the South China Sea), the potential impact(s) of noise on mating and calving are not considered in this document. A comprehensive discussion of impacts of noise on gray whales is provided in Appendix I.

The sources of noise to which gray whales may be exposed in the P-A license area include the categories described below. Noises from these sources may be either water- or air-borne and may be transmitted either directly through water or indirectly through air and then through water. Ranges in sound frequency and intensity for some examples of the various sources given below are summarized in Table 1.

Platform Noise. These noises may be associated with (1) platform equipment such as the drill rig itself, the rotation of the drill stem, and the movement of pipe associated with drilling, and (2) operation of generators, pumps, hydraulic equipment and other large machinery on the platform associated with production.

Vessel Noise. These noises may be associated with (1) propellers, engines and other on-board equipment including winches, generators, pumps, and hydraulics on supply/service boats, the FSO, shuttle tankers, and the spill response stand-by vessel, and (2) and operation of generators, pumps, hydraulic equipment and other large machinery on the vessels. Some vessels move back and forth between the Molikpaq and Sakhalin Island along movement corridors established to the south of the main gray whale concentration near Piltun Bay.

Helicopter/Aircraft Noise. These noises are usually generated by helicopters or fixed-wing aircraft engines and usually are transmitted through air and then through water.

Helicopters regularly move back and forth between the Molikpaq and Sakhalin Island along flight corridors established to the south of the main gray whale concentration near Piltun Bay.

Exploration Activity Noise. These noises may be associated with (1) transportation, installation, and operation (generators, pumps, etc.) of a mobile rig used to drill appraisal wells, and (2) high-pressure air releases from air-guns used in seismic surveys, engines and winches, propellers, generators, pumps, and hydraulics associated with seismic exploration and sub-bottom profiling.

Construction Activity Noise. These noises may be associated with (1) equipment operating on an offshore platform, (2) vessels in the area, (3) pile-driving, (4) trenching operations associated with the construction of a marine pipeline, and (5) pumping associated with dredging operations.

TABLE 1. Summary and comparison of source sound levels for a variety of sources of man-made underwater noises similar to those that might occur in or near Sakhalin Energy's Piltun-Astokhskoye license area (Adapted from Lawson *et al*. 2001). 1/3rd octave band center frequencies (0.05-2 kHz) shown below are most representative of sounds actually heard by gray whales.

Sound Source	Source levels, dB re 1 µPa at 1 m								Highest Level 1/3rd octave band	
		1/3rd octave Band Center Frequencies (kHz)								
	Broad-band (45-7070 Hz)	0.05	0.1	0.2	0.5	1	2	Freq.	Level	Strong infra-sonics[e] ?
Transient Sources										
Super Puma helicopter takeoff[a]	-	112	96	94	90	90	86	16	122	Yes
Super Puma flyover at 305 m[a]	-	98	96	85	88	88	85	20	109	Yes
Sik-61 helicopter fly-over at 305 m[b]	108	97	94	97	97	91	88	25	98	Yes
Bell 212 helicopter flyover	162	154	155	151	145	142	142	22	159	Yes
Seismic airgun array (multiple guns)	216	210	209	199	184	191	178	50	210	Yes
Pile driving on Scotian Shelf[c]	165	134	145	158	154	141	136	250	159	Yes
Supplier III vessel thruster (900 HP)	190	176	182	173	169	168	164	50	184	Yes

TABLE 1 (Cont'd)

Sound Source	Source levels, dB re 1 µPa at 1 m								Highest Level 1/3rd octave band	
		1/3rd octave Band Center Frequencies (kHz)								
	Broad-band (45-7070 Hz)	0.05	0.1	0.2	0.5	1	2	Freq.	Level	Strong infra-sonics[e] ?
Continuous Sources										
Tug and barge, 18 km/h	171	143	157	157	161	156	157	630	162	Yes
5-m Zodiac	156	128	124	148	132	132	138	6300	152	No
Supply ship (*Kigoriak*)	181	162	174	170	166	164	159	100	174	Yes
Large tanker underway	186	174	177	176	172	169	166	100+ 125	177	Yes
Kulluk Drillship (45-1780 Hz)	185	174	172	176	176	168	-	400	177	No?
Canmar Explorer II Drillship	174	162	162	161	162	156	148	63	167	No?
Sedco J jackup rig during drilling[d]	59	55.9	54	55.6	46.9	-	-	16	62.5	-
Sedco J during highlevel tripping[d]	68	61.2	65.2	68	56.4	-	-	200	68	-

.

[a] Brueggeman *et al.* 1990 (note that these data are *received levels*).

[b] These data are *received levels*.

[c] Scotian Shelf pile driving recording by Greene and Davis (1999) and RAM model verification by Malme *et al.* (1998). Note that this was a smaller hammer than that required at some sites, and the hammer impacts occurred in air rather than in an underwater caisson. Values are for received levels at 1.5 km.

[d] Buerkle (1975). The *Sedco J* jackup rig operated in 63 m of water; it may have had a rotary drill table; "tripping" occurs when the drill string is pulled from the hole, the bit changed, and the string is lowered back in the hole; the drill bit was operating at 2440 m.

[e] Some sources also emit strong sounds at frequencies below 45 Hz (not considered here).

Observed Impacts

During 1999 and 2000, extensive underwater acoustics programmes were conducted in the P-A license area and near Piltun Bay to monitor industry-generated and ambient noise levels (Sobolevsky 2000, 2001). These studies generated a large volume of results indicating that noise levels in the areas where gray whales were present were highly variable, generally less than 100 dB re 1 µPa rms. This is well below levels thought to cause serious physiological impacts to gray whales and other baleen whales (e.g., well below 180 dB re 1 µPa rms), but nevertheless within the hearing range of gray whales, and potentially within the range to elicit subtle behavioural responses (Würsig *et al*. 1999, 2000a).

Shore-observations and boat surveys (Blokhin *et al*. 2001; Weller *et al*. 2000, 2001) suggest that the general distribution of gray whales has changed among recent years of study, i.e., that within the area adjacent to Piltun Bay, the distribution of gray whales was more southerly in 1997 and 1998 and shifted to a more northerly distribution in 1999 and 2000. Although the factors responsible for this proposed distribution shift are currently unknown, it has been speculated that whales may have moved away from the noise associated with the Vityaz/Molikpaq complex in the south or that the distribution of the available food base shifted to the north and that whales followed it (Blokhin *et al*. 2001).

Evidence that noise associated with seismic exploration may have caused changes in gray whale behaviour during 1997 has been reported (Würsig *et al*. 1999). Gray whale behavioural studies conducted in 1997 from the Piltun Lighthouse (located about 12 km W of the western boundary of the P-A license area and 25 km WNW from the Molikpaq) indicated changes in behaviour that may have been associated with seismic surveys conducted in the P-A license area during summer 1997 (Würsig *et al*. 1999). These behavioural changes included alterations in swimming speed and direction (Mean Leg Delta and Mean Leg Speed), distance traveled (Linearity), and surface-respiration-dive characteristics (blow interval) during periods when seismic surveys were being conducted, as compared to periods when seismic shooting was not occurring and the 1-hr period after the seismic survey. Some changes in behaviour (blow interval) appeared to be inconsistent (shorter rather than longer) with results from other studies on the effects of seismic pulses on other baleen whale species (Richardson *et al*. 1995). However, there was no evidence to suggest that western gray whales were displaced from their feeding grounds as a result of the 1997 geophysical exploration activities.

Impulsive sounds from seismic surveys are among some of the loudest noises that can occur in the marine environment, and Sakhalin Energy has developed specific mitigation plans to ensure that vessels involved in seismic surveys, geohazards surveys, sub-bottom profiling (all involving airguns or similar devices that emit relatively low frequency sounds) operate within guidelines designed to reduce or eliminate impacts on whales (see more detailed discussion in *Mitigation* section, below).

Discharges and Disturbances to the Seabed

Potential Impacts

Approximately 3.7 km^2 of seabed was altered as a result of installation of the Molikpaq production platform in 1998. In addition, water based drilling mud and cuttings discharges from the platform associated with Phase I development commenced during December 1998 and ended when drilling was completed during December 2000. Other discharges from the platform (and the FSO when on station for approximately 6 months of the year) include treated sewage, waste water and cooling water. To date there has been no water production and consequently no produced water discharges.

Potential effects of the installation of the Molikpaq and discharges of various materials associated with production have the potential to impact the local marine environment, including benthic organisms that may appear in the diet of gray whales. It is also possible that gray whales can detect discharges as either visual or olfactory stimuli, although there are no records in the literature of impacts on gray whales from water discharges from oil or gas production platforms. Nevertheless, potential impacts from the alterations or discharges could include avoidance of the area, interrupted feeding, and adverse impacts on food sources for whales (as described in Moore and Clarke in press). Consequently, Sakhalin Energy implemented an offshore marine environmental monitoring programme in 1998 to study the potential effects of operations-related impacts on the marine environment in the area (DVNIGMI, i.e. Far-East Regional Hydrometeorological Research Institute 2001). The following is a summary of results from the past 3 years of offshore monitoring, taken from the annual monitoring reports.

Observed Impacts

Over the 3-year period 1998 through 2000, a research ship conducted environmental monitoring surveys (June and October 1998, October 1999, and October 2000) near the Molikpaq and a baseline survey in adjacent waters. Results of the studies in 1998, the year the Molikpaq was installed in the P-A license area, showed local changes in some parameters, including changes in sediment grain distribution and a change in benthos biomass, within 250 m of the Molikpaq.

The 1999 studies were designed to assess the condition of the marine environment and pelagic and benthic communities one year after platform installation, and to see whether there had been any impacts on the Molikpaq area, including the area near the SALM.

Further field and laboratory studies in 2000, as well as further analysis and integration of data from the 1998 and 1999 studies in 2000, led the investigators to the following major conclusions (DVNIGMI 2001):

Physico-Chemical Characteristics of Sea Water

Results of hydro-chemical studies (e.g. temperature, salinity, oxygen, turbidity, pH, etc.) in the Okhotsk Sea surrounding the Molikpaq in October 2000 were similar to results from the earlier 2-years of studies (1998-1999); and in all years, parameters were within baseline values reported in studies prior to installation of the Molikpaq and associated structures. Suspended matter levels were also within baseline values.

Petroleum Hydrocarbons in Sea Water

Over the 3-year study period, the average concentration of petroleum hydrocarbons in sea water did not exceed 41 μg/l, which is well below the maximum permissible concentration value for fish-bearing waters (0.05 mg/l) and within baseline levels (Hydrometerology & Hydrochemisry, 1993, SEIC, 1997). There was no indication of changes in sea water petroleum hydrocarbons either (1) near the Molikpaq site, or (2) in years after the placement of the Molikpaq.

Plankton in Sea Water

<u>Chlorophyll a</u>

The distribution profiles of *chlorophyll a* in 2000 and 1998 were very similar -- both were low compared to 1999. These low values likely were reflections of sampling during the autumn when algae growth and production processes decrease. This result is supported by other data collected in October 2000 that demonstrated physiological inertness of 50% to 90% of the *chlorophyll a* cells during the fall sampling period. In contrast, autumn 1999 was found to be 2 to 5 times more productive than autumn 2000. This higher productivity in 1999 is likely explained by the fact that it was a warmer summer, there were more sunny days, and more sampling was conducted at mid-day, all of which increase *chlorophyll a* production.

There were no significant declines in photosynthetic activity in the Molikpaq area during the 2 years after installation of the Molikpaq in the P-A license area.

Phytoplankton

In October 2000, total biomass and density of phytoplankton averaged 675.5 (1495.4 in October 1998) mg/m^3 and 571.7 (149.1 in October 1998) thous. cells/l, respectively. Existing literature indicated that the neritic zone of the Sakhalin coast is considered rich when the phytoplankton biomass value is higher than 500 mg/m^3. In comparison, in the summer of 1990, when DVNIGMI was conducting similar environmental work off northeast Sakhalin Island, phytoplankton biomass and density highs were 7,907 mg/m^3 and 454 thous. cells/l, respectively; and lows were 262 mg/m^3 and 7.7 thous. cells/l., respectively.

Overall, the analysis of quantitative characteristics, composition and distribution of phytoplankton showed no negative changes in the phytoplankton community in the Molikpaq area over the 3 years of study.

Zooplankton

In October 2000, total zooplankton density and biomass averaged 23,112 specimens per m^3 (8220 specimens per m^3 in October 1998) and 825.4 mg/m^3 (216 mg/m^3 in October 1998) respectively. For northern seas, medium zooplankton biomass values are deemed to be in the range from 200 to 500 mg/m^3 and high biomass values are deemed to exceed 500 mg/m^3 (DVNIGMI 2001). In the summer of 1990 the DVNIGMI environmental surveys in the north-eastern Sakhalin coastal waters registered biomass values ranging from 475 mg/m^3 to 1,660 mg/m^3.

Together with mature specimens, younger copepod phases, and eggs and fry of chaetognaths, euphausids, polychaetes, mollusks and shellbacks (Cirripedia) that are known to be highly sensitive to pollution, were also found. Throughout the entire period of the studies, *Oithona similes* was recorded as the dominant copepoda species. *Oithona similes* is believed to be an indicator of clean water (DVNIGMI 2001).

Ichthyoplankton

Results of analyses of ichthyoplankton samples provide no basis for any definite conclusions about abundance, species diversity, and distribution of fish eggs and larvae in the study area. During autumn, ichthyoplankton abundance on the northeastern Sakhalin Shelf is normally low (DVNIGMI 2001).

Grain-Size Distribution in Sediments

The 1998 monitoring programme indicated an insignificant reduction in coarse-grain fractions and an increase in fine sands, as compared to the results of the study conducted in 1998 prior to the installation of Molikpaq. These changes were likely related to the dredging of mainly gravel at the platform site and the filling of the platform core with fine sand. Sampling data from 1999 and 2000 (DVNIGMI 2001) showed that benthic sediments had recovered to their initial parameters measured in June 1998, prior to placement of the Molikpaq. Averaged grain-size distribution curves for October 1998, October 1999 and October 2000 were virtually identical. Since the above mentioned changes were insignificant, the average values remained virtually the same. It was concluded that natural movements of benthic materials have offset anthropogenic disturbance of benthic sediments recorded in October 1998.

Metals in Sediments

Studies during 1998-2000 of gross metal levels in benthic sediments showed that levels of all elements under study (Al, As, Ba, Cd, Cr, Cu, Fe, Hg, Pb, Zn) at the main and reference stations in the Molikpaq area were not significantly different from levels measured at reference sites away from the Molikpaq

Comparisons of the 2000 and 1998 data disclosed higher levels of cadmium and lead in samples from several stations in the Molikpaq area in 2000 compared to 1998 (DVNIGMI 2001). Russia has no maximum permissible concentrations (MPC's) for heavy metals in marine sediments. However, the maximum levels of cadmium (0.126 μg/l) and lead (9.81 μg/l) measured in 2000 are significantly lower than the internationally accepted minimum concentrations that may have adverse impact on marine biota, 1.2 μg/l and 46.7 μg/l respectively (Long *et al*, 1995).

Petroleum Hydrocarbons in Sediments

Measurements show that the petroleum hydrocarbon distributions in samples collected near the Molikpaq and at reference stations up to 20 km distant were below 11.2μg/g (DVNIGMI 2001). Such levels are typical of clean bottom areas of northern seas not exposed to anthropogenic impact (DVNIGMI 2001).

Comparison of results from 1999 to 2000 showed that average petroleum hydrocarbon levels in sediments were at or below the 1998 level. Petroleum hydrocarbon tests on samples taken at the SALM site during 1999-2000 indicated a slight increase in levels compared to 1998. However, in all cases the petroleum hydrocarbons are at very low levels and the samples are described as uncontaminated.

Benthos

The results of traditional single-factor methods and multivariate statistical analysis indicate no qualitative changes in the sampling areas in benthos composition between 1999 and 2000. Comparison of quantitative parameters of benthos obtained in 2000 against earlier years has shown an increase in the benthos biomass (up to 9.5 times) in the Molikpaq area, especially at stations located at 125m and 250 m off the platform. These data indicate that recovery processes are occurring in benthic communities since Molikpaq placement in 1998.

In comparison to the Molikpaq area, there was an overall lower biomass of benthic organisms in the SALM area. Notwithstanding this lower biomass, the ecological parameters (species composition and diversity) of the SALM area communities were found to be similar to levels measured at the Molikpaq. Species composition and diversity reflect the ecological welfare of benthic communities.

Marine Mammals

During the environmental monitoring surveys lone marine mammals were encountered and recorded in various sectors of the area during the brief one or two week periods that these surveys were conducted around Molikpaq. A small rorqual (probably a minke whale, *Balaenoptera acutorostrata*) was recorded moving slowly (no obvious disturbance) on the surface within 500 m of the Molikpaq. However, overall, the numbers of marine mammals, especially whales, in this area were significantly lower than reported from other studies in coastal sectors (see Sobolevsky 2000, 2001 and Weller *et al*. 2001 summarized in later sections of this document). Most western gray whales on the northeastern Sakhalin coast have been recorded feeding in shallow coastal waters, primarily adjacent to Piltun Bay. In 2001, however, gray whales were reported feeding in deeper waters (35-40m) 35 km offshore and southeast of the Molikpaq (ENL personal communication). Furthermore, it is known that gray whales do feed in deeper offshore areas when and where prey is abundant (Norris *et al*. 1983, Nerini 1984, Darling *et al*. 1998). However, as previously stated, during systematic aerial surveys in 1998 (Weller *et al*. in press), 1999 and 2000 (Sobolevsky 2000, 2001) no gray whales have ever been sighted feeding within 10 km of the Vityaz Complex (Fig. 1).

Tissue sampling from gray whales occupying the northeast Sakhalin shelf has occurred during 1998-2001 as part of studies conducted under the Marine Mammal Project under Area V: Protection of Nature and the Organization of Reserves) within the U.S.-Russia Agreement on Cooperation in the Field of Environmental Protection (Brownell *et al*. 1997). Although these tissue samples have not been analyzed for toxicants, such analysis could help to determine toxicant contamination levels for western gray whales. Contamination is most likely to occur when whales feed on contaminated food organisms. However, determining potential sources of contamination in western gray whales may be difficult, considering that multiple potential sources of contamination may exist onshore and offshore, and the fact that for half the year (December through May) they migrate a long distance and overwinter at a distant location during which time limited feeding may occur.

Summary

Results of a 3-year (1998-2000) offshore environmental monitoring programme that was implemented to monitor potential impacts of placement of the Molikpaq on the seabed, and the effects of subsequent drilling and production operations, have shown virtually no impact on the marine benthic community beyond approximately 250 m. Within 250 m, short-term impacts were noted in the first year of study, but results in the following years of study, with the exception of increased PHC levels and depressions in the density of benthic prey very near the SALM, indicated no impacts. Based on sampling at sites systematically monitored in the offshore marine environment, the prey of western gray whales or their primary feeding habitat near Piltun does not appear to have been affected by disturbances to the seabed around Molikpaq or by discharges originating from the P-A license area. Direct benthic and sediment chemistry sampling in near shore areas where whales are known to feed was conducted during 2001 and should confirm this finding. Results of extensive aerial and boat-based surveys between 1997-2000 (Würsig *et al*. 1999, 2000a; Weller *et al*. 1999, 2000, 2001, Sobolevsky 2000, 2001) indicate that western gray whales continue to aggregate and feed in the nearshore waters off the northeastern coast of Sakhalin Island.

Oil Spills

Potential Impacts

Oil spills have the potential to affect gray whales and their habitats. The probability for an oil spill from the Molikpaq is considered to be low because of (1) the relatively short (6-7 month) production season, (2) the relatively small number of wells (14 wells) that have been drilled and produced and the small number envisaged for the future (13 additional wells), and (3) the numerous safety valves, backup systems, and audit protocols that are in place. Spills may also occur, and are more likely, during oil transfer operations between the FSO and shuttle tankers, and from other vessels operating in the Vityaz Marine Terminal area. Potential impacts of a spill in the P-A area could include (1) direct adverse impacts on the gray whales through contact with the oil and inhalation of toxic vapors, (2) indirect adverse impacts on gray whales via effects on their food resources, (3) interrupted feeding by the whales, (4) contamination of coastal bays or lagoons that are potentially important to the nutrient and carbon flow of the nearshore ecosystem, including benthic communities that gray whales feed on (5) avoidance of the spill area by the whales due to noise and activities associated with clean-up and (6) physical impact between response vessels and whales.

Moore and Clarke (in press) summarize information on the effects of oil spills on gray whales. Preliminary laboratory tests show that gray whale baleen, and possibly skin, may be somewhat resistant to damage from short-term exposure to oil (Geraci and St. Aubin 1985, Geraci 1990). However, Hansen (1985) points out that oil or clean up dispersants could have indirect negative effects on gray whales by killing or contaminating their benthic food supply.

Observed Impacts

There have been no major oil spills in the P-A License area since installation of the platform in 1998. One relatively minor oil spill (< 2 bbls) occurred in late September 1999. This spill was caused by the parting of the break-away coupling when a hawser connecting the FSO to the SALM failed. To date, this is the only notable spill of oil or fuel that has occurred in the P-A license area. An oil spill response vessel (OSRV) was on stand-by when the spill occurred, as recommended by the oil spill response/contingency plan. Trained oil spill response personnel on board the OSRV deployed a boom and skimmer system to recover a total of 560 liters of emulsified oil south of the Vityaz Marine Terminal (prevailing ocean currents carried the oil south). It was estimated that 112-224 liters, or 0.7 to 1.4 bbls (50-90%), of the spilled oil was recovered. Recovery estimates vary due to the differing amounts of oil in different emulsions. There are no data indicating that western gray whales have been affected by oil spilled in the P-A license area.

POTENTIAL CUMULATIVE IMPACTS

A discussion of cumulative impacts in this document is appropriate because cumulative impacts, rather than the isolated impacts associated with specific Sakhalin Energy operations, are ultimately more likely to have effects on western gray whales and their environment. This discussion of cumulative impacts is by necessity more expansive and considers impacts on the broader environment occupied by the western gray whale.

Cumulative impacts are defined in United States regulations (40 CFR 1508.7) as effects on the environment which are expected to result, "… from the incremental impacts of an action when added to other past, present, and reasonably foreseeable future actions… Cumulative impacts can result from individually minor, but collectively significant, actions taking place over a period of time."

The U.S. Council on Environmental Quality (CEQ) provides additional guidance to United States entities considering cumulative effects. The CEQ suggests that regulatory authorities and proponents do the following:

(1) determine the magnitude and significance of the environmental consequences of the proposed action in the context of the cumulative effects of other past, present, and future actions;

(2) identify significant cumulative effects and focus on truly meaningful effects;

(3) address additive, countervailing and synergistic effects;

(4) exclude future actions from the cumulative effects analysis if the actions are outside the geographic boundaries established for the cumulative effects analysis; and

(5) address uncertainty through monitoring."

This cumulative impacts analysis takes guidance from the CEQ and follows the format laid out in such documents as the Northstar Final Environmental Impact Statement (USACE 1999). Accordingly, this analysis involves four distinct activities:

(1) Determination of the geographic scope of the past, present, and reasonably foreseeable future actions considered.

(2) Describe the individual actions that may contribute to cumulative effects.

(3) Assess available information concerning environmental resources, project impacts, and identified past, present, and foreseeable future actions for the purposes of identifying potential issues that require further evaluation.

(4) Investigate identified potential issues and present the results of that investigation.

Geographic Area

The geographic area considered in this cumulative impacts assessment was determined by considering the geographic extent of other past, present, and reasonably foreseeable future actions that could result in cumulative impacts on western gray whales.

The migratory nature of the western gray whales and the adverse impacts that these whales may experience in waters distant from the P-A field area complicates the selection of a geographic area for detailed analysis. The activities of Sakhalin Energy are limited in extent to northern Sakhalin Island and its associated offshore regions, with transportation corridors operating toward the south from the southern Sakhalin Island ports of Kholmsk and Korsakov, and tanker traffic departing from the P-A field south to Asian export markets. In contrast, the migratory western gray whales spend a significant portion of the year (November-May) in (or traveling to and from) waters presumed to be in the South China Sea (Rice 1998). Since the western gray whale population is considered critically endangered (Hilton-Taylor 2000, Weller and Brownell 2000), any adverse impacts to the whales while they are migrating and on their summering or wintering grounds would likely be significant (Weller *et al*. 2001). The discussion that follows therefore distinguishes two separate geographic areas: (1) the entire eastern side of Sakhalin Island out to a distance of 50 kilometers offshore and including all transportation routes from the P-A field to the ports in southern Sakhalin Island, and (2) the unknown migratory corridor and wintering grounds of the western gray whale population.

The analysis of potential cumulative impacts arising from the P-A field is conducted using the first geographic area (see (1) above). A separate section will briefly detail possible cumulative impacts to the south of Sakhalin Island.

Past, Present, and Reasonably Foreseeable Future Actions

A number of diverse activities occur within both geographic areas under consideration. The principal actions considered are:

(1) Oil and gas activity

(2) Community growth

(3) Fishing activity

(4) Ocean-going transportation

(5) Past and present whaling activity

Oil and Gas Activity

The first onshore oil was discovered and produced on Sakhalin in the early 1900's, and though offshore oil was indicated, the Soviet Union lacked money and technology to explore these reserves. A Japanese-Russian joint venture discovered the first offshore fields in the Sakhalin region in the 1970s, though declining oil prices and increasing international tensions stopped the project by the early 1980s. In the early 1990s the Russian government began tendering Sakhalin offshore leases to foreign consortia.

There are currently seven oil and gas projects offshore Sakhalin in various stages of development. The total expected volume of investment could exceed US$100 billion over the next forty years. Within a decade, production levels could reach 30 million metric tonnes of oil per year.

Development of the Sakhalin II project began in 1994 and consists of two oil fields, the P-A field and the Lunskoye field (the latter being gas). Sakhalin Energy is currently involved in Phase 1 development, which consists of exploration and operation of the Molikpaq offshore production platform and the adjacent marine terminal complex in the P-A field. The Molikpaq drilling and production platform was set in 1998, and began producing oil in 1999 making it the first producing offshore development in the region. Exploration activities included a 3D seismic survey in 1997 and two appraisal wells, one each in 1998 and 2000. The Sakhalin II fields are believed to contain in place reserves of 600 million metric tonnes of oil and 700 billion cubic meters of natural gas. Production is currently 80,000 barrels per day, and field life is anticipated to be 40 years. The Sakhalin I consortium was formed in 1995 and exploration of the Arkutun-Dagi, Chayvo, and Odoptu fields on the Sakhalin shelf began in 1996. Appraisal wells determined that a sizeable oil rim was present around the Chayvo gas deposit. Development plans for these fields call for initial directional drilling from shore to access the Chayvo field concurrent with installation of a modified arctic drilling rig offshore and construction of a pipeline to transport the oil to shore. A 3D seismic programme was conducted during 2001 at the Odoptu Field.

Potential developments are also being considered at Sakhalin 3, 4, 5, and 6. In 1998, a 3-D seismic survey was shot at Sakhalin 4 (northwest of Sakhalin Island), followed by appraisal drilling in summer 2000. Also in summer 2000, a 2-D seismic survey was conducted in the Sakhalin 5 license area (northeast of Sakhalin Island). Plans to develop Sakhalin 6 by directional drilling from onshore and the use of offshore platforms remain speculative.

Community Growth

Sakhalin Island covers approximately 76,400 square kilometers. The largest city is Yuzhno-Sakhalinsk with a population of more than 165,000 people. The remaining communities are relatively small, with the two port cities of Korsakov and Kholmsk populated by about 50,000 people each (Figure 3). The two communities nearest the P-A license area are Nogliki and Okha, with populations of about 10,000 and 50,000, respectively. The primary industries on the island are fishing, timber extraction, coal mining and petroleum. If significant foreign investment continues in Sakhalin the population can be expected to grow as people are attracted to the region.

Fishing Activity

Sakhalin Island is the third-largest producer of fish products in the Russian Far East. The total annual fish quota is 1.4 million tons, with an additional 345,000 tons of squid, shrimps, oysters and other marine invertebrates harvested. Although the number of fishing boats working in Sakhalin's waters is not available, an expansion in the island's population could be expected to increase fishing pressures.

Ocean-going Transportation

Virtually all cargo arriving in Sakhalin Island arrives by sea. As economic growth associated with oil and gas development occurs on Sakhalin Island, ocean-going transportation will be expected to increase, possibly significantly. In the short term, such transportation will supply modules and equipment for use in the oil field development; while over the long term, ocean-going transportation will serve the demands of the increased island population.

Past and Present Whaling Activity

Although the original size of the western gray whale population is speculative, there is little doubt that whaling severely decimated the whale population in the western Pacific. An estimated pre-whaling population of 1,500-10,000 gray whales in the western Pacific (Rice and Wolman 1971; Yablokov and Bogoslovskaya 1984;) has been reduced to approximately 100 animals (although it is currently not known if the gray whales seen at Sakhalin Island represent the entire western Pacific population). The IUCN-World Conservation Union reclassified the western gray whale population as critically endangered in 2000, and the population is completely protected from hunting by national and international law. Although legal commercial whaling is prohibited, at least one instance (in 1996) of an illegal take of a western gray whale in Japan is known (Brownell and Kasuya 1998). Illegal harvesting at any level can be expected to have significant impacts on the remnant western gray whale population.

Sakhalin II Development Effects in Combination with Past, Present or Reasonably Foreseeable Future Actions

Cumulative Impacts on the Physical Environment

Geology and Hydrology

With the exception of a large oil spill, no significant impacts to geologic conditions, ocean-floor sediments, or hydrologic processes should be associated with the P-A development. Minor impacts associated with the physical presence of facilities, sediment disturbance during dredging and trenching, and disposition and permitted discharges can be expected. All of these impacts can be expected to be very localized (within a few hundred meters of the Molikpaq) and therefore no additive effects from other developments are anticipated.

Air Quality

No significant impacts are anticipated to result from permitted air emissions associated with the P-A field. Those emissions that do occur can be expected to contribute to cumulative air quality issues related to industrial emissions from Sakhalin Island and any future offshore developments. The meteorological conditions in the region, including high winds, help with dispersal of regulated air emissions. Air emissions are monitored and results are made available to regulators as separate reports.

Climate Change

Industrial activities contribute to global greenhouse gas emissions and the P-A field development will add to those emissions. The P-A is currently producing 80,000 barrels per day, compared to global daily production figures of 75 million barrels per day (the P-A field therefore produces approximately 0.1% of the world's total oil production). Sakhalin Energy has built safeguards into its operations to minimise the amount of carbon emissions from it production facilities. In normal operations, all excess gas is reinjected into the formation, with the exception of an emergency flare. In future phases, gas will be brought to shore for distribution and export. Temperature of water is included in normal monitoring criteria to determine any changes in average temperature and effects on biota.

Marine Water Quality and Sea Ice

No significant impacts to water quality have been observed following a 3-yr (1998-2000) monitoring programme near Sakhalin Energy operations (DVNIGMI 2001). As noted in previous sections, a relatively small area on the seabed (approximately 3.7 km^2) was altered as a result of installation of the Molikpaq production structure in 1998 (Sakhalin Energy 1998). Discharges from the platform include treated sewage, water based drilling mud and cuttings, wastewater, and cooling water (Sakhalin Energy 1998). Impacts associated with the installation of the Molikpaq and discharges of various materials associated with production have the potential to impact the local marine environment, including benthic organisms that may be found in the diet of gray whales. It is also possible that gray whales can detect discharges as either visual or olfactory stimuli, although there are no records in the literature of impacts on gray whales of water discharges from oil or gas production platforms.

Operational discharges from the production facilities are not expected to result in cumulative impacts due to their localized occurrence. In addition, for future drilling from Molikpaq, Sakhalin Energy plans to inject the majority of its mud and cuttings into approved injection wells.

Sakhalin Energy operations occur offshore in an area where moving sea ice (as opposed to land-fast ice) occurs for about half the year. Gray whales are absent from this area during most of the period when heavy sea ice is present (December through May). Sea ice does not represent important habitat for western gray whales. Notwithstanding this fact, no significant impacts to sea ice are anticipated in connection with this project. Given the spatial separation of other foreseeable developments, no cumulative effects are anticipated.

Cumulative Impacts on the Biological Environment

Plankton and Marine Invertebrates

Project related impacts to plankton and marine invertebrates are expected to be negligible to minor based on the results of the 3 year monitoring programme. Those impacts that do occur are associated with alteration of sediment, turbidity and discharges. These effects are anticipated to be localized and temporary and no cumulative impacts are expected from other developments in the region.

Marine Mammals

Western gray whales are only one of a number of marine mammal species present in the Okhotsk Sea. Other species have been noted in the Phase 1 environmental impact assessment, including all Red Book species, and mitigation measures and environmental protection plans have been developed for all marine mammals. This protection plan is focussed on the western gray whale because it is a critically endangered population known to feed during the open water season on the northeast Sakhalin Shelf.

Noise (including seismic noise) related impacts on gray whales are discussed in detail in Appendix 1. Seals are encountered at and may become habituated to the facilities and associated activities, increasing the risk of injury. The development of additional offshore fields in the region could result in cumulative impacts to pinnipeds. However, the proposed offshore locations for most developments are distant from haul-out areas and other sensitive areas, which should help to minimise cumulative impacts at a population level. Whales, including gray whales, generally avoid the area immediately around the Molikpaq. Additionally, there has been only localized and minor impact from offshore discharges. Therefore, it is unlikely that the physical presence of, or discharges from these future installations will impact whales, assuming that planned developments will not occur directly in principal gray whale feeding areas.

Cumulative Impacts of Oil Spills

An oil spill would be expected to impact numerous resources in the area, including sediments, surface water, birds, marine mammals and marine fish and invertebrates. Coastal impacts are also possible, including damage to coastal vegetation, bays and lagoons, sand bars, beaches and mud flats. Other developments on the Sakhalin Shelf may be expected to add to the cumulative risk of an oil spill associated with the P-A development. Since Sakhalin Energy operations began in 1998, there has been only one notable spill, and that was less than 2 bbls in 1999 associated with production operations.

Determination of the future likelihood of an oil spill is clearly dependent on evaluating the effectiveness of safety protocols and procedures designed to prevent spills from occurring, and preventing them from reaching the environment in the event that they do occur. The actual spill volumes and ratios are given in the table below:

Oil Spills/Sheens from Vityaz Complex
Since Commencement of Production in 1999

	1999	2000	2001	Total
Oil Spills/Sheens Volume, bbl	2.0158	0.1675	0.00022	2.18352
Total Oil Produced Volume, bbl	1,058,665	12,361,993	15,015,000	24,435,658
Ratio Per Million bbls. Produced	1.9	0.013	$0.15x10^{-4}$	0.077

The frequency and amount of oil spilled can be mitigated by regular maintenance and inspections, frequent training, and regular spill drills. The vast majority of spills that occur in industrial complexes are small: 84.1 percent of crude spills and 92.2 percent of product spills on the North Slope of Alaska from 1977-1997 were less than 2 barrels (84 gallons). Small releases can be expected to have localised water quality impacts and limited long term cumulative effects due to the chemical properties of Vityaz crude oil (relatively high evaporation rate and high natural dispersibility). However, these impacts will continue to be monitored in the future as part of the ongoing offshore environmental monitoring survey programme.

Spills from other industrial developments (including onshore developments) and vessels (both oil-related and non-oil related) can be expected to add to the cumulative impact of oil spills in the region.

Cumulative Impacts of Noise

Continued coordination of support traffic and implementation of travel routes that avoid the main gray whale feeding area will serve to lessen impacts. For example, helicopter flights paths will continue to be chosen to avoid the principal whale feeding areas offshore Piltun, and minimum altitude restrictions will remain in place to minimise disturbance to whales and wildlife in general. Additionally, proposed future development work includes building a pipeline to shore from the offshore installations, which will eliminate the need for (and noise from) a FSO and shuttle tankers. However, other components of industrial development will occur across a broad geographic area, such as the placement of additional platforms offshore, and will include onshore development as well. The additive effects of these future installations will have to be taken into consideration during the design and planning stages and in development of future monitoring and mitigation measures. Consecutive or simultaneous projects involving seismic surveys could result in both short-term and cumulative impacts on feeding gray whales. Measures can be implemented, however, to reduce the likelihood of such cumulative impacts occurring (see later sections entitled *"Mitigation of Impacts Associated with Man-Made Noise "* and *"Mitigation of Cumulative Effects"*.

Cumulative Impacts along the Migratory Route and on the Wintering Grounds of Western Gray Whales

Sakhalin Energy operations are not likely to have impacts on western gray whales once they leave their summer feeding grounds. However, impact may occur from other activities throughout the migration route and over-wintering grounds . It is not within the scope of this document to detail impacts that could occur many thousands of kilometers from Sakhalin Island, but a brief review is appropriate. By necessity this review is speculative, since the actual migration route(s) and location of the wintering/calving grounds are presently unknown.

It had previously been thought that the wintering grounds for the western gray whales were along the south coast of the Korean peninsula; that does not now appear to be the case (Rice 1998; Weller *et al*. 2001). It is now believed that the wintering grounds are in the South China Sea, possibly along the coast of Guangdong province and around Hainan Island (Rice 1998). The migration route of the gray whales between Sakhalin Island and the South China Sea is also unknown, but given the coastal nature of gray whales probably involves a route along the east coast of Korea or west coast of Japan (Weller *et al*. 2001), and keeping close to shore through the East China Sea and into the South China Sea.

This region is among the most heavily developed in the world, with extensive industrial development along the coast in Japan, Korea, Taiwan, and China (Weller *et al*. 2001). Major cities, including Hong Kong, Macao and Kaohsiung, are the hubs for significant vessel traffic, including tankers and fishing fleets. Many of these areas also have global reputations for air-borne and water-borne pollution. As noted above, illegal whaling may still be occurring and could impact some whales from the western gray whale population.

MITIGATION AND PROTECTION MEASURES

The marine environment of the Okhotsk Sea is highly diverse and supports a wide variety of wildlife species, including birds, waterfowl, fish, and marine mammals, including an estimated 100 critically endangered western gray whales that spend the summer feeding off the northeast coast of Sakhalin Island. Accordingly, measures have been and will be employed by Sakhalin Energy to mitigate potential impacts of their operations on the western gray whale. The discussion below outlines the various mitigation and protection measures designed to address impacts outlined in the preceding section. Mitigation alone, however, without a concurrent monitoring programme does not provide the type of information necessary to implement an effective gray whale protection plan. Mitigation measures are often based on past knowledge of the potential impacts on an organism, or extrapolated from studies on other similar species. Monitoring programmes provide up-to-date information on the present situation and when viewed in the context of current operations and new information about western gray whales, can help determine the effectiveness of mitigation measures and help to determine if additional mitigation measures are warranted.

The organization of this mitigation section generally follows the same format as above, i.e., mitigation of impacts associated with (1) physical presence of structures, (2) noise, (3), discharges and seabed disturbances, and (4) spills. For future activities, consideration will be given during the design and planning stages to offset these potential impacts.

Mitigation of Impacts Associated with Physical Presence of Facilities

Various Sakhalin Energy structures and facilities currently exist in the P-A license area that could affect the distribution, abundance, and behaviour of endangered western gray whales. These facilities include fixed structures and associated facilities that include the Molikpaq, Single Anchor Leg Mooring (SALM) system, Floating Storage and Off-loading (FSO) facility, and the sub-sea (seabed) pipeline connecting the Molikpaq with the FSO via the SALM (collectively known as the Vityaz Marine Terminal). Sakhalin Energy facilities also include vessels such as (1) 1 or 2 supply and service vessels and an ice breaker; (2) a spill response standby vessel; (3) a crew boat; (4) helicopter and fixed-wing aircraft used to, respectively, transfer crew and conduct surveys; (5) vessels to conduct environmental, geophysical, or other inspection surveys; (6) specialized vessels present during construction. and (7) shuttle tankers that carry oil to market.

General Environmental Guidelines/Mitigation Measures for All Facilities and Operations

General Health, Safety and Environment (HSE) guidelines apply to all Sakhalin Energy facilities and operations (Sakhalin Energy 2000). The general environmental guidelines/mitigation requirements associated with these HSE guidelines are outlined below.

1. Environmental awareness and wildlife training will be required for all employees and staff.
2. Feeding, injuring, pursuing, harassing or hunting wildlife is prohibited.
3. Firearms are expressly prohibited for all project and contractor personnel and in all facilities.
4. No pets are allowed on any project facilities.
5. Foodstuffs that may attract wildlife are not allowed in open areas.

Mitigation Measures for Marine Operations

General environmental guidelines/mitigation requirements have also been developed by Sakhalin Energy for marine operations (Sakhalin Energy 2000). These guidelines/mitigation requirements are directed toward reducing impacts (collisions, entanglements, discharges, noise disturbance) on western gray whales and other marine mammals. These more specific mitigation measures for marine operations are outlined below. Other measures, related to specific operations, such as very noisy operations that may disturb gray whales, are discussed in more detail in subsequent sections (i.e., see section entitled *"Mitigation of Impacts Associated With Man-Made Noise"*).

1. As outlined in the document entitled "Programme of Operational and Ecological Monitoring during Operation of Oil Production Complex Vityaz for 2001-2003" (Sakhalin Energy 2001), visual surveillance for marine mammals is carried out during all daytime operations.

2. Vessels attempt to maintain a minimum of 1,600 m (1 nm) separation from any large whale that is not identifiable to species, otherwise a separation distance of 500 m is maintained for all other marine mammals including pinnipeds. If any whale is heading for the vessel, the vessel will take precautionary measures, and if necessary stop, until it has been determined that the potential danger to the marine mammal has passed.

3. All project vessels are to observe the following guidelines:

   a) Support vessels will not cross directly in front or in the immediate vicinity of migrating/moving/stationary whales.

   b) When moving parallel to whales, support vessels will operate at a constant speed no faster than the whales.

   c) Care will be taken to not separate female gray whales from their calves.

   d) If a whale engages in behaviour considered to be evasive, support vessels will withdraw from the area until the whale departs the area.

4. In periods of reduced visibility (e.g., fog, darkness), determining whether there are any marine mammals in the specified safety zone is difficult. Where practical, however, every effort is made to detect marine mammals within the safety zones (indicated above) during periods of reduced visibility.

5. Maximum separation (notwithstanding the above safety radii) will be maintained between vessels and marine wildlife.

6. When a whale is sighted in the project area, vessel operator(s) will immediately notify the bridge of FSO ***Okha*** providing information on date, time, location of sighting, direction of travel, species identification and number of whale(s) or the marine mammals if known, as outlined in Sakhalin Energy's Mitigation Measures for Marine Supply Vessels (MSV's) (Sakhalin Energy 2001). The bridge of the FSO ***Okha*** then notifies other vessel traffic in the vicinity, including the Molikpaq platform. Operations are altered as necessary to minimise disturbance and avoid physical impact to marine mammals and other wildlife.

7. Voyage orders for incoming tankers are faxed to the vessel 72 hours before arrival in the Vityaz Complex. These orders include information about the sensitivity of the marine environment, presence of endangered gray whales and other marine wildlife, and recommendations to proceed with due watch at appropriate speeds.

Notification/Documentation

Sightings of whales and any other significant marine wildlife activity reported to the bridge of FSO Okha (see discussion in (6) above), are logged by the bridge crew of the FSO and also reported to the Offshore Operations Manager (OOM). Information recorded in the ship's log include date, time, sighting location, numbers and species identification of whales or marine wildlife (if known), and mitigation action taken. The FSO sends monthly logs to the Yuzhno Environmental Supervisor. The Environmental Supervisor will use this information to determine the adequacy of mitigation measures in place at the Vityaz Complex to avoid disturbance or physical impact.

Mitigation of Impacts Associated with Man-Made Noise

Operations in the marine environment that are potentially distressing for marine mammals are those that generate high noise levels or increase the potential for physical impacts such as hearing or other physical damage from loud noises, and collisions or entanglements. The following mitigation measures have been employed during marine operations to mitigate specifically against noise impacts:

1. Vessel operators, Molikpaq, and the FSO will conduct a specific visual search of the area prior to initiating operations that may disturb wildlife. In particular, small-scale seismic operations (sub-bottom profiling, geohazards surveys) will not be initiated if an unidentified baleen whale or gray whale is sighted within 1000 m of the sound source. This 1000 m buffer is the zone beyond which no disturbance response is likely from gray whales (or other baleen whales) exposed to small-scale sound sources, i.e., 163.9 – 327.7 cm^3 (10-20 cubic inch) airguns, pingers, boomers (Greene 1997, Greeneridge and LGL 1998, Burgess and Lawson 2001). The safety zone for baleen whales, i.e., the zone beyond which physical damage is unlikely, is 250 m (Greene 1997, Greeneridge and LGL 1998, Burgess and Lawson 2001). For other marine mammals (e.g., toothed whales and pinnipeds), the buffer zone for small-scale sound sources is 250 m and the safety zone is 100 m.

2. Ongoing surveillance will be maintained during all periods of potentially disturbing operations.

3. Potentially disturbing operations should be conducted in good visibility conditions whenever feasible. If such operations under poor visibility conditions are unavoidable, additional precautions will be taken, such as increased bridge watch, use of spotlights, and reduced speed when feasible.

4. When operating in waters shoreward of the 20 m depth zone in areas where gray whales aggregate to feed during the summer open-water period (see Figure 1), or

when gray whales have been reported near offshore operations areas, extreme care will be taken to avoid activities that may have negative impacts on gray whales (i.e., those that are noisy or may cause entanglement or collision). When operating in these areas, specific mitigation plans and measures have been and will continue to be designed and implemented to mitigate activities (i.e., seismic surveys [including sub-bottom profiling], geotechnical and geohazards surveys, etc.) that may have negative impacts on gray whales. These mitigation measures will incorporate all those relevant precautions identified in this document and will be tailored to the specific activity in question. Buffer zones and safety radii beyond which it is safe to conduct noisy operations will be identified and implemented. (see discussion in (1) above, and below is section on "*Blasting and Seismic Operations*").

Aircraft Overflights

Flight paths south of Piltun Bay have been selected to avoid flying directly over gray whale habitat. During aircraft overflights, pilots have been instructed to maintain a minimum 300 m vertical separation and 1000 m horizontal separation, as weather permits, to avoid disturbing wildlife. When gray whales are known to be in the area this increases to 500 m vertical separation and 1000 m horizontal separation, weather and safety considerations permitting. This will reduce the amount of airborne noise that propagates into the sea. Athough overflights of aircraft are likely to result in only brief startle reactions by marine mammals, repeated exposure to such may lead to cumulative impacts. Aircraft operators are prohibited from circling or hovering over gray whales or other marine mammals unless essential for safety or operational purposes.

Blasting and Seismic Operations

For blasting and full-scale seismic operations, both of which produce loud noises in the marine environment, compliance to all of the relevant measures outlined above are required, and additional specific mitigation measures will be developed for the specific blasting or seismic operations proposed. Research on eastern gray whales in the Bering Sea has indicated that a 4-5 km buffer zone may be necessary when conducting full-scale seismic surveys around feeding gray whales (Malme *et al*. 1986, 1988). Beyond this distance (4-5 km), 90% of feeding gray whales continued to feed and were not overtly disturbed by the actively shooting seismic ship; up to 50% of whales were disturbed, i.e., stopped feeding and moved away from the seismic ship, when the actively shooting ship approached to within 2-3 km of feeding gray whales (Malme *et al*. 1986, 1988). Noisy operations of this type should not commence until at least 10 minutes after any large whales have departed the appropriate safety zones. To the extent possible, operators will initiate any noisy operations at less than full power (referred to as "soft starts"), such that the source sound level is initially low for a period of at least 10 minutes. These soft starts or "ramping-up" are intended to allow marine mammals in the vicinity of operations to depart the area prior to being exposed to sound levels that are potentially harmful.

The most current guidelines for minimizing acoustic impact to marine mammals will be used to develop mitigation plans (see Appendix 3 of this document). An experienced marine mammal specialist will be contracted to review and approve the mitigation plan prior to commencement of operations. All relevant operations personnel are required to review the plan and receive environmental awareness and wildlife training prior to commencement of operations.

Mitigation of Impacts Associated with Discharges, Wastes, and Disturbances to the Seabed

Impacts on the marine environment will be minimised through control of discharges from the Molikpaq, FSO and other vessels, and by ensuring prudent management and maintenance of on-board environmental protection and cleanup equipment.

Fuel Transfer Operations

As described in the MSV mitigation measures document, all hazardous operations at sea, such as fueling, oil off-loading operations, and hazardous waste transportation, are conducted in compliance with the guidelines outlined by the Convention for the Prevention of Pollution from Ships (MARPOL 73/78), and with Russian Federal law. Furthermore, at-sea bunkering locations are chosen to minimise risk and to minimise impact to marine wildlife in the event of a spill.

Liquid Waste

Produced water is treated prior to discharge to ensure the average monthly oil and grease level is at or below 15 mg/l to meet current water use license standards. To date, the volumes of produced water have been low. The wet crude has been directed to the FSO-***Okha*** where it has been left to settle to allow separation of the water. The separated water is then directed to the oil-water separator for treatment prior to discharge to ensure that the oil and grease level meets the current water use license standards.

All discharges of **kitchen wastes and sewage** from the Molikpaq, the FSO-***Okha*** and the marine support vessels (MSVs) are required to be in compliance with the relevant international MARPOL 73/78 standards.

Bilge water is required to be treated with a MARPOL-approved device prior to discharge.

Deck washing and other discharges are required to be minimised. On the Molikpaq strict controls are in place with respect to use of detergents, dispersants or other chemicals during deck washing. Typically, the use of such chemicals is restricted to bunded areas from which effluents are directed to the oil-reclamation process equipment. In the event that such chemicals are used for open deck washing the waste water can be directed to the oil-reclamation process equipment. The Treated effluent from the oil-reclamation process equipment is transferred to the FSO-***Okha*** which in turn transports the treated effluent for disposal at suitable port facilities.

Oil contaminated water from maintenance operations, such as wash water from fuel oil tanks, is normally directed to the FSO-***Okha*** with the wet crude oil. This water is separated out and then directed to the oil-water separator for treatment prior to discharge to ensure compliance with the current water use licence conditions.

Use of solvents and hazardous or toxic chemicals is also strictly controlled in order to prevent potential accidental discharge to the marine environment. Chemical and oil spillages are normally cleaned up with mops and / or absorbant pads which are incinerated after use.

Ballast water is released from shuttle tankers and FSO-***Okha*** during loading of oil. All tankers and the FSO-***Okha*** have segregated ballast tanks and therefore no oil contaminates the ballast water. Biocides are not used in the ballast tanks for the tanker or the FSO-***Okha***.

Seawater is used to cool equipment such as diesel generator units. This once-through cooling water is essentially uncontaminated. Automatic detection systems together with routine sampling and visual checks are in place for monitoring of potential oil and gas contamination of the cooling water.

Solid Waste

Vessels must comply with MARPOL 73/78 with respect to all waste generated on the vessel. Combustible wastes are incinerated. Solid wastes and hazardous materials are not discharged during operations. Instead they are transferred to shore for disposal in accordance with the requirements of the waste management procedures.

Molikpaq Drilling Mud and Cuttings Discharges

In order to further mitigate potential impacts on the marine environment, Sakhalin Energy will implement a mud and cuttings injection programme during the 2001 to 2003 phase of drilling from the Molikpaq platform. Approximately 70% of the drilling mud and cuttings will be reinjected, substantially reducing the amount of drilling discharges to the marine environment. Furthermore, as in the past, only low toxicity water-based mud and cuttings will be discharged. All discharges from Molikpaq and the FSO are controlled in accordance with the facility's water use license and are monitored regularly.

Mitigation of Impacts Associated with Oil Spills

Oil Spill Preparedness

Sakhalin Energy's operating procedures are designed to minimise the potential for an oil spill during drilling, production and marine operations at the Vityaz Complex. As outlined in more detail below, a specific oil spill response/contingency plan (OSCP) has been developed by Sakhalin Energy (Sakhalin Energy 1999). This plan outlines all procedures for reporting and responding to a spill and is designed to minimise impacts of a spill to both the offshore and the nearshore-coastal environments. A dedicated oil spill response vessel with emergency equipment and trained crew is maintained on stand-by in the project area throughout the production season to facilitate rapid oil spill response, and containment and cleanup if a spill occurs.

The OSCP (Sakhalin Energy 1999) is subject to periodic updates as a result of (but not limited to) the following:

1. If a deficiency in the plan is identified;
2. If there are changes to legislation;
3. If new technological developments are available;
4. If response equipment changes;

5. If there are recommended changes based on drills/exercises.

Suggested changes to the oil spill response/contingency plan are forwarded to the Health, Safety and Environment (HSE) manager in Yuzhno-Sakhalinsk. All suggested changes are evaluated for inclusion in the plan.

Every spill has unique characteristics, challenges, and priorities that will vary widely as a result of oil characteristics, weather conditions, safety considerations, equipment availability, and environmental sensitivities. Although the Sakhalin Energy OSRP shall serve as a guide for response managers, the overall response priorities are as follows:

1. Protection of health and safety of all workers and the public is the most important priority during any oil spill response effort;
2. Stop the release of oil;
3. Prevent fires and explosions through the elimination of ignition sources;
4. Control and extinguish fires;
5. Maintain Molikpaq, drilling rig, and FSO integrity to prevent further release;
6. Contain released oil to prevent further oil spreading and to maximise the efficiency of recovery operations;
7. Protect environmentally sensitive areas through diversion, entrapment, and other nearshore strategies;
8. Prevent wildlife injuries through hazing and other deterrence mechanisms. Where appropriate, consider establishment of oiled wildlife treatment facilities;
9. Treat areas that have become impacted to the extent that an overall net benefit to the environment is achieved and;
10. Ensure response operations are co-ordinated with Russian governmental authorities and agencies, and that information is promptly communicated to the appropriate agencies.

Vessel Oil Spill Preparedness

All vessels coming to and going from the P-A license area have oil and fuel spill response/contingency plans and spill kits on board in accordance with MARPOL regulations. Oil, chemicals and hazardous materials are required to be properly stored to prevent spills from occurring. In the event of an oil or chemical spill from one of these vessels, a response effort would be initiated immediately to contain and clean up the spill and prevents its spread. All spills to the marine environment in the P-A license area and Vityaz Marine Terminal must be reported immediately according to procedures specified in the spill response/contingency plan (Sakhalin Energy 1999).

Mitigation of Dredging, Pipeline Construction, and Offshore Installations

For future pipeline construction activities, dredging, and offshore installations, environmental protection plans will be developed containing mitigation measures to reduce impacts not only to western gray whales, but to the marine environment in general. Additionally, mitigation will be addressed during the design and planning stages to offset potential impacts associated with these activities.

Sakhalin Energy will solicit input from marine mammal specialists to help develop, review and approve the environmental protection plans associated with such operations. All operations personnel will be required to review plans for each specific operation, and will be required to receive environmental awareness and wildlife training prior to commencement of operations.

Mitigation of Cumulative Impacts

By definition, the effective mitigation of cumulative impacts will involve all parties involved in activities on the Sakhalin Shelf and in those areas through which western gray whales migrate and over-winter. Since the latter are currently unknown, there are presently no mechanisms available to mitigate as yet unknown cumulative impacts occurring outside of the project area. However, Sakhalin Energy is planning a satellite telemetry study that could answer questions about where gray whales go when they leave the waters off northeastern Sakhalin Island. This information will be directly relevant to developing plans to mitigate cumulative impacts elsewhere in the range of the western gray whale.

The mitigation of cumulative impacts on the Sakhalin Shelf will require the cooperation and participation of myriad interested parties. As noted previously, at least seven oil and gas projects offshore Sakhalin are in various stages of development. The companies involved are diverse and include national and international corporations. Sakhalin Energy will share this gray whale protection plan with other operators and with Russian authorities in an ongoing effort to facilitate coordination of mitigation practices and monitoring programmes.

WESTERN GRAY WHALE MONITORING PROGRAMME

Although gray whales are rarely observed in the Molikpaq area during the summer feeding period, activities associated with normal Sakhalin Energy operations could potentially impact gray whales that migrate through or otherwise occur in the P-A license area, as well as those in known feeding grounds during late May to November. Because of these potential impacts, Sakhalin Energy has implemented mitigation measures (outlined above) and gray whale studies and monitoring programmes (described below) to ensure that all reasonable efforts are made to reduce impacts on this critically endangered whale population.

Gray whale studies and monitoring programmes have been supported by Sakhalin Energy, in cooperation with Exxon Neftegas Limited in some years, since 1996. The overall objective of these studies has been to obtain information about western gray whales that will enable Sakhalin Energy and other stakeholders with interests in the area to conduct activities off northeast Sakhalin Island in a way that reduces potential impacts on these whales to a minimum. Aside from studies specifically focussed on gray whales, studies have also been conducted to monitor impacts of specific exploration and production activities on the local and regional physical and biological environment. The monitoring activities summarized below are described in more detail in the various annual reports of these studies (Würsig *et al.* 1999, 2000a; Weller *et al*. 2000, 2001; Sobolevsky 2000, 2001; Kussakin 2001).

Offshore Monitoring Programme

Sakhalin Energy is conducting an ongoing offshore environmental monitoring programme in support of their production operations at the Vityaz Marine Terminal complex situated in the P-A license area. The results of this monitoring programme are outlined in detail in the report by DVNIGMI (2001). This programme has a broader regional context than specific studies related to gray whales or other marine mammal issues. Nevertheless, some of the information gathered in the offshore monitoring programme is also relevant to the western gray whale protection plan. Preliminary studies, including sediment sampling, were conducted in 1995 and 1996 during the planning for the placement of the Molikpaq, but the major elements of the offshore environmental monitoring programme were initiated in 1998 and repeated in 1999 and 2000 DVNIGMI (2001). Offshore monitoring studies included:

1. Water column sampling

2. Sediment sampling
3. Underwater video transects
4. Observations of marine mammals and birds
5. Measurements of discharge rates and volumes during drilling
6. Hydro-meteorological observations during drilling

The sediment sampling and the observations of marine mammals components of this offshore monitoring programme provided information that was particularly relevant to the gray whale protection plan.

As mentioned earlier, one of the most significant findings of the offshore environmental monitoring studies was the very local nature of effect of Sakhalin Energy's activities. In most cases (see earlier review of results), there was no evidence of non-noise man-made impacts beyond 250 m of the Molikpaq, indicating that there has been no impact from Sakhalin Energy's offshore operations on western gray whale feeding habitat and prey organisms. Direct benthos and sediment studies in the whale feeding area to confirm this were conducted during 2001, and the results from that work will be addressed in a future update of this plan. Sakhalin Energy plans to continue offshore environmental monitoring studies into the foreseeable future to assess environmental impact from its operations.

Western Gray Whale Monitoring Programme

Sakhalin Energy initiated studies of western gray whales on the northeast Sakhalin Shelf in 1996 when it contracted Russian and Western scientists to conduct information and literature reviews of all marine mammals likely to be present in the Sakhalin II lease area. In 1997 Sakhalin Energy, in cooperation with Exxon Neftegas Limited, provided further support for western gray whale monitoring studies by providing a contract to Texas A&M University (TAMU) and the Kamchatka Institute of Ecology and Nature Management (KIENM) to conduct gray whale monitoring as part of the Marine Mammal Project under Area V: Protection of Nature and the Organization of Reserves) within the U.S.-Russia Agreement on Cooperation in the Field of Environmental Protection. The Area V joint US–Russian environmental cooperation agreement, which was administered through the Gore–Chernomyrdin and later Gore-Kasyanov Committee. The Area V studies continue today, although they are not administered through Gore-Kasyanov. Sakhalin Energy, in cooperation with Exxon Neftegas Limited in some years, has continued to contribute to this monitoring programme through 2001. Over the years the total suite of studies that have been conducted as part of this programme include (1) aerial surveys, (2) photo-identification surveys, (3) acoustic measurements, (4) behaviour observations, (5) food studies, and (6) literature/information reviews. The joint US-Russian team comprised of scientists from TAMU, KIENM, and the Pacific Research Institute of Fisheries and Oceanography (TINRO) performed most of the research during 1997 and 1998, and TAMU and KIENM continued to conduct monitoring studies in 1999, 2000, and 2001 (Würsig *et al*. 1999, 2000a; Weller *et al*. 2000, 2001, in prep). A Russian team of scientists from the Institute of Marine Biology, Far Eastern Branch of the Russian Academy of Sciences, Vladivostok (IBM), and the Pacific Oceanological Institute, Vladivostok, was contracted to conduct additional monitoring (systematic offshore and nearshore aerial surveys and a comprehensive acoustics monitoring programme, respectively) in 1999 and 2000 (Sobolevsky *et al*. 2000, 2001), and gray whale food studies in 2000 (Phase 1, information review: Kussakin 2001) and 2001 (field sampling programme).

International experts on marine mammals and gray whales have periodically met and made independent recommendations about the types of studies that should be conducted to better understand and protect western gray whales. In 1997, marine mammal scientists with the Marine Mammal Research Programme, TAMU, and the U.S. National Marine Fisheries Service independently recommended a suite of potential monitoring studies for western gray whales on the northeast Sakhalin Shelf. In 1999, a panel of gray whale experts was convened by the U.S. National Marine Fisheries Service (La Jolla, CA) to independently review (1) the status of western gray whales, (2) human-related threats to the population, and (3) research and monitoring needs. Further monitoring recommendations for western gray whales were developed at that meeting. In 2001, Sakhalin Energy solicited and received recommendations for future gray whale monitoring from marine mammal specialists at TAMU, KIENM and IBM. These and other recommendations from Russian marine mammal specialists have led to the development of the current programme of monitoring studies.

Since 1997, Sakhalin Energy has contracted an outside consulting company (LGL Limited) with significant marine mammal expertise and considerable experience developing and conducting marine mammal monitoring programmes for the petroleum industry (in North America and elsewhere) to review and advise on marine mammal issues relative to the Sakhalin II project. LGL biologists have helped develop scopes of work, reviewed and commented on various contract reports, and provided advice and assistance on other technical matters related to marine mammals and petroleum development on the northeast Sakhalin Shelf.

The sections below briefly summarize studies conducted since 1996.

Literature/Information Reviews

In 1996, a series of background reports on the current status of marine mammals, sea birds, and the impacts of potential oil industry activities on the biota of the northeastern Sakhalin shelf were completed on behalf of Sakhalin Energy (Perlov *et al*. 1996). All subsequent studies have also involved reviews of published and unpublished literature and information related to the specific topic(s) of study. The recently completed literature and information review on the benthic feeding environments of eastern and western populations of gray whales (Kussakin *et al.* 2001) is the most comprehensive document to date on this subject, especially for the Russian literature.

All of the information reported in the various literature reviews has direct relevance to some or all of the various mitigation measures implemented by Sakhalin Energy to reduce impacts on western gray whales.

Aerial Surveys

Opportunistic and other systematic aerial surveys in nearshore waters seaward of the Piltun Bay area were conducted in summer 1997 and 1998 during the course of other marine mammal research activities (Würsig *et al*. 1999, 2000a; Weller *et al*. in press). Only 5 gray whales were recorded during 1997 because of the very restricted area surveyed during the one opportunistic flight conducted in July. Three systematic aerial surveys were conducted in the Piltun area during August and September 1998. A maximum of 15 gray whales was recorded during the survey on 29 September.

Systematic aerial surveys of extensive and intensive sampling grids were conducted in nearshore and offshore waters of northeast Sakhalin Island during 1999 and 2000. These systematic surveys documented the regional and local distributions of feeding gray whales and corroborated earlier findings (Würsig *et al*. 1999, 2000a; Weller *et al*. in press) that the majority of gray whales aggregated in waters generally less than 20 m deep offshore the Piltun Bay area, although some gray whales have been observed feeding in deeper offshore waters (30-50 m) (Fig. 1). The maximum number of gray whales recorded on any single survey in 1999 or 2000 was 45 individuals, and the estimated size of the gray whale population in this area (based on aerial surveys) was estimated to be approximately 100 individuals (Sobolevsky *et al.* 2000, 2001).

Aerial surveys are conducted to determine the number of whales present in the area, and to determine the temporal and spatial distributions of whales in relation to Sakhalin Energy activities. This information is important to Sakhalin Energy in planning future exploration and production programmes, and in evaluating existing mitigation and protection measures for western gray whales. Specifically, aerial surveys help define the extent of feeding areas so that appropriate mitigation measures are developed for various operations that could potentially affect the feeding habits and habitat of gray whales (i.e., dredging, construction, vessel traffic, aircraft flights, etc.) if such operations are to be carried out in known feeding areas.

Photo-Identification Surveys

Systematic photo-identification surveys of gray whales present off Piltun Bay were sponsored fully or in part by Sakhalin Energy during 1997, 1998, 1999, 2000, and 2001 (Würsig *et al*. 1999, 2000a; Weller *et al*. 2000, 2001). These surveys were in addition to brief photo-identification surveys conducted during 1994 and 1995 during independent research in the area (see Brownell *et al*. 1997;Weller *et al*. 1999). Based on these photo-ID studies, nearly 100 different gray whales have been identified (Weller *et al*. 2001). The 1999 and 2000 photo-identification surveys also determined that some whales were emaciated in both years. Furthermore, in 2000, fewer than expected calves (based on the number of females with calves observed in 1998) were present in the population, possibly due to the poor condition of many females (Weller *et al*. 2001).

Seventy-two individual whales, including six calves were identified in 2001. Six mother-calf pairs were identified, and ranked among some of the most frequently sighted whales. Of the six mothers identified, four had been observed with calves off Piltun in previous years. All of the mothers identified in 2001 were sighted in 2000 when they were pregnant. Field observations suggest that 19 whales were unusually thin (i.e. "skinny whales"). The number of skinny whales in 2001 is higher than reported in 1999 (n = 10) but lower than the number observed in 2000 (n = 27). All six 2001 mothers, to varying degrees, were identified as being "skinny". Some "skinny whales" from 1999 and 2000 appeared to be recovering in 2001 (i.e. gaining weight) but other apparently healthy whales in 1999 and 2000 appeared "skinny" in 2001. The numbers of "skinny whales" reported here are tentative at this time because the labor-intensive review required for proper analysis of all photographic material pertaining to this issue has yet to be completed.

The multi-year photo-identification and re-identification surveys have provided information on the annual return and site fidelity of individual whales to summer feeding ground from one year to the next, helped define the local distribution and movement patterns of whales, and has established the population size, survivorship, productivity, and reproductive intervals of the western population. In addition, the overall physical condition and health status of whales summering off Piltun has been continuously monitored since 1997.

This information helps define the extent of the gray whale feeding areas, and provides distribution and abundance information important in interpreting the potential effect of Sakhalin Energy's operations on the whales and the effectiveness of existing mitigation and protection programmes, such as avoiding noisy activities (e.g. aircraft overflights, seismic surveys) in areas where gray whales are known to be present.

Food Studies

Opportunistic research was conducted in 1998 and 1999 on food organisms found in fecal samples collected from actively feeding gray whales near Piltun Bay (Würsig *et al*. 1999). Other benthic samples were collected in 1998,1999 and 2000 near the Molikpaq drilling production platform (Continental Shelf Associates Inc. [cited in Würsig *et al.* 1999]; Sakhalin Energy 2000), and in nearshore areas where whales were known to be feeding and areas whales were not feeding during 2000 (Weller, pers. Comm., October 2001). There was virtually no overlap in the species composition of the samples from the inshore and offshore locations.

Part I of a gray whale food study was initiated in 2000, with a contract to the Institute of Marine Biology, Vladivostok, to conduct a comprehensive review of literature and information on gray whale feeding areas in other parts of the Pacific and on the benthic environment in known gray whale feeding areas off Chukotka and on the northeast Sakhalin Shelf. This review (Kussakin *et al*. 2001) has been completed and provides a valuable overview on this topic for both the eastern and the western populations of gray whales, and is especially useful in outlining the extensive Russian literature on this subject.

Part II of the gray whale food study was a field sampling programme conducted in 2001. The 2001 programme involved benthic sampling of invertebrate communities at fixed stations along 10 transects perpendicular to the shoreline, and extending from shallow near shore waters used by feeding gray whales, to offshore waters not typically used by feeding gray whales, i.e., sampling was conducted near to and distant from known gray whale feeding areas. Benthic sampling will help identify prey types and assess prey density in these areas, and the study should help clarify reasons why the whales aggregate to feed offshore Piltun Bay each year. Addtionally, sediment samples were obtained during the benthic sampling programme and will be analyzed for chemical compostion.

Gray whale feeding areas typically support high standing stocks of benthic and epibenthic invertebrates. Sakhalin Energy, in cooperation with Exxon Neftegas Limited, has contracted benthic studies to help understand the distribution of gray whale food resources in the Piltun area. The importance of this area to summering gray whales (in relation to nearby areas where whales are also occasionally seen feeding) is relevant to ongoing and planned exploration and production activities by Sakhalin Energy and others. Furthermore, the food studies provide important information for mitigation and protection plans by defining gray whale feeding areas and the subsequent need to establish mitigation measures if industry activities are planned in these areas.

Acoustic Studies

Acoustic measurements were recorded in near shore waters near Piltun Bay during the summer of 1997 (Würsig *et al*. 1999) when seismic exploration was occurring in the P-A license area. Results indicated received levels of approximately 153 dB re 1 µPa in areas where gray whales were present when the seismic ship was 30-35 km away.

As previously discussed, extensive underwater acoustics programmes were conducted in the P-A license area and near Piltun Bay during 1999 and 2000 to monitor industry-generated and ambient noise levels (Sobolevsky 2000, 2001). These studies indicated that noise levels in the areas where gray whales were present was generally less than 100 dB re 1 µPa rms, which is below levels thought to cause physiological impacts to gray whales and other baleen whales but within the hearing range of gray whales.

Additional acoustic studies were conducted in 2001 to further document industry-generated noises emanating from the Molikpaq complex, with specific objectives to define noise attenuation, i.e., transmission loss at different distances from varying sources (production, tanker load-out, vessel activity). Acoustic measurements were carried out in different areas, including the gray whale concentration area near Piltun Bay, and several other locations between Piltun and Molikpaq. This acoustic study was conducted in conjunction with acoustic studies conducted in 2001 by Exxon Neftegas Limited as part of the monitoring programme associated with their seismic surveys.

Acoustic studies were conducted to determine both ambient and industry-related noise levels in the marine environment near industry activities (i.e., near the Molikpaq) and at locations where gray whales are known to occur (offshore Piltun Bay). This information is important in helping Sakhalin Energy evaluate and potentially adjust existing mitigation and protection measures for gray whales, such as helping define noisy activities that should be avoided when gray whales are present in adjacent feeding areas, helping define aircraft flight corridors, and determining avoidance distances for Sakhalin Energy operations and vessels operating in the area. The information may also prove useful in helping to evaluate and mitigate potential noise impact during the design stage of future installations.

Tissue Sampling

Tissue sampling from gray whales occupying the northeast Sakhalin shelf was conducted during 1998-2001. This sampling was not a specific task in the Sakhalin Energy monitoring programme and was not sponsored by Sakhalin Energy, but was conducted by Sakhalin Energy contractors as part of other studies conducted under the auspices of the Area V environmental cooperation agreement between the United States and Russia (Weller *et al*. 2001). Nevertheless, some aspects of the tissue sampling programme are relevant to this western gray whale protection programme and therefore are described here.

Tissue samples were collected primarily to supply mtDNA (mitochondrial DNA) used in genetics analyses of western gray whales (LeDuc *et al*. 2000), and helped to differentiate the eastern and western population. As a result of this study, the eastern and western gray whales are considered to be isolated populations (LeDuc *et al*. 2000). In addition to genetic comparisons, tissue samples could also be used to determine the level of toxicants in western gray whales, although to date they have not been used for this purpose. The study of pollutant "signatures" have proved beneficial in defining stock/population boundaries for some large whale species, and in some cases can be used to help determine the geographic area from which the toxins were likely to have been accumulated.

Behavioural Studies

Shore-based behavioural observations of gray whales were conducted during 1997 and 1998 (Würsig *et al*. 1999, 2000a). The 1997 observations were conducted before, during, and after the period when Sakhalin Energy was conducting a seismic survey offshore, and the 1998 observations were conducted during the period before, during, and after the installation of the Molikpaq. These observations were conducted from the Piltun Lighthouse using a theodolite to determine precise locations, movement directions, swimming speeds and a variety of behavioural characteristics exhibited by gray whales in the Piltun area. Both the 1997 and 1998 studies suggested that the behaviour (surface-respiration-dive characteristics, orientation and movement patterns) of gray whales offshore Piltun Bay may have been influenced by industry activities and possibly other unmeasured factors (Würsig *et al*. 1999, 2000a). Notwithstanding the changes in behaviour that were documented, the gray whales remained in the area offshore Piltun Bay during these two years (and most have returned to the area in subsequent years)(Würsig *et al*. 1999, 2000a; Weller *et al*. 2000, 2001).

These behavioural surveys were conducted to better understand patterns of gray whale behaviour under normal and disturbed (e.g., in the presence of ongoing industrial activities) conditions. They are also conducted to obtain data to help develop and monitor the effectiveness of Sakhalin Energy's mitigation/protection plans, which are directly related to the impacts of noise and other industry operations that could negatively affect western gray whales.

Integrated Research and Monitoring

Over the past five years, Sakhalin Energy has supported a broad suite of monitoring studies to learn more about the western gray whales that spend the summer near the P-A license area. These studies have generally been conducted as distinct tasks, and results of each study have been presented separately as annual reports. Some reports (e.g., Würsig *et al*. 1999, 2000a; Weller *et al*. 2000, 2001) incorporate information and results from previous years of study. To date, there has been no overall integration of the results of the various tasks and studies in order to give a broader view of the entire gray whale studies and monitoring programme. Furthermore, it has been difficult when conducting studies of western gray whales to relate or correlate observed results of the various studies (especially the behaviour and distribution studies) with the myriad of industry and other activities occurring on the northeast Sakhalin Shelf. In essence, the various studies have been multidisciplinary in nature, rather than interdisciplinary.

Future studies supported by Sakhalin Energy will be designed in such a way that results of one study may be useful in interpreting results of other related studies. Information about industry activities, e.g., the timing, duration, location and activities associated with drilling programmes, seismic surveys, sub-bottom profiling, tanker load-outs, construction activities, will be made available to scientists conducting studies on the western gray whales. Researchers will then be able to integrate results and discussions of their reports with those from other tasks and activities being conducted in the gray whale monitoring programme. If necessary, a separate integration report will be prepared each year that will draw all relevant results together into a single document.

Information Requirements for Effective Mitigation and Monitoring

To develop a western gray whale protection plan, various types of information and data are required to (1) evaluate Sakhalin Energy activities that have the potential to affect gray whales, (2) identify and better understand the gray whale population, (3) design and implement mitigation/protection measures to minimise and mitigate potential impacts; (4) monitor the gray whale population and evaluate the effectiveness of the mitigation measures and, (5) periodically make adjustments to the mitigation/protection measures and to the monitoring programme.

Although some methods/studies (e.g., satellite and/or radio telemetry) have not yet been implemented by Sakhalin Energy, they have all been considered and are likely to be supported to some extent during the course of the gray whale monitoring programme.

The table below identifies the research goals and methods/studies and cross-references them with information needs.

	INFORMATION NEEDS									
	Population Size, Productivity, Health	Distribution	Location Relative to Sakhalin Energy Operations	Seasonality	Site Fidelity	Foods and Feeding	Reaction to Noise	Reaction to Structures	Reaction to Oil Spill[1]	Reaction to Discharges
GOALS										
Better Understand Impacts	X	X	X	X	X	X	X	X	X	X
Develop Mitigation/Protection Plans	X	X	X	X	X	X	X	X	X	X
Monitor Effectiveness of Mitigation	X	X	X	X	X	X	X	X	X	X
METHODS/STUDIES										
1. Literature/Information Reviews	X	X	X	X	X	X	X	X	X	X
2. Aerial Surveys	X	X	X	X			X	X	X	
3. Photo Identification Studies	X	X	X	X	X	X				
4. Food Studies		X	X	X		X			X	
5. Tissue Analyses	X					X				
6. Acoustic Studies							X			
7. Behavioural Observations	X	X	X	X	X	X	X	X	X	X
8. Telemetry Studies		X	X	X	X	X	X	X	X	

[1] These studies can only be conducted during an oil spill. No oil or other toxic substances may be discharged into the water near whales or other marine mammal for research or any other purposes.

ADAPTIVE ENVIRONMENTAL ASSESSMENT AND MANAGEMENT

Adaptive environmental assessment and management (AEAM) (Holling 1978) is an iterative process of reviewing and updating information so that decision-making may be based on the most up-to-date and relevant knowledge about a particular issue. It provides real-time feedback of information from ongoing studies to help make new decisions and revise previous decisions about mitigation and future research needs. Sakhalin Energy has adopted the AEAM approach for evaluating mitigation procedures and for planning future monitoring studies in response to new information and issues arising from reviews of mitigation measures, results of monitoring studies, and reviews of Sakhalin Energy operations.

By adopting the AEAM approach, Sakhalin Energy will conduct annual reviews of (1) existing mitigation measures, (2) all new information about the local marine environment including new information from the onshore, offshore and western gray whale monitoring programmes, and (3) ongoing and potential new impacts of Sakhalin Energy operations on the local environment and on gray whales. This adaptive approach to review and assessment will ensure integration of various aspects of (1) Sakhalin Energy operations and associated potential impacts with (2) information generated by the monitoring programmes. This approach will help ensure that mitigation measures keep pace with important changes and remain effective as Sakhalin Energy operations continue through various planned stages of development. In the event that the monitoring programmes identify substantive risk to western gray whales, the annual review may be pre-empted by an immediate review to correct actions during the current field season.

INTER-RELATIONSHIP BETWEEN MITIGATION, MONITORING AND ADAPTIVE ENVIRONMENTAL ASSESSMENT AND MANAGEMENT

Measures have been employed by Sakhalin Energy to mitigate potential impacts of their operations on the critically endangered western gray whale. The discussions above outline the various mitigation and protection measures designed to address the potential impacts. As mentioned earlier, however, mitigation alone without a concurrent monitoring programme and a regular evaluation of the mitigation measures and monitoring results will not provide the type of information necessary to implement an effective western gray whale protection plan.

Initial mitigation measures are often based on past knowledge or previous experiences regarding potential impacts on an organism. Well-designed monitoring programmes, based in part on recommendations from recognized specialists (in this case, marine mammal specialists), will provide the necessary real-time information on the current situation for western gray whales and their habitat. This information, in turn, enables the design of realistic and practical mitigation measures. Annual reviews of (1) potential impacts from planned or ongoing operations (2) the mitigation measures employed to protect the gray whales, (3) results of monitoring plans designed to provide up-to-date information on the status of gray whales and their environment, and (4) subsequent appropriate revisions of both the mitigation and monitoring plans, are part of the AEAM process described above (Holling 1978). This adaptive and dynamic process ensures that changes relevant to Sakhalin Energy operations that may be necessary to protect western gray whales and their environment will be made as quickly and as effectively as possible.

QUALITY CONTROL PROGRAMME

Sakhalin Energy will periodically assess implementation of the mitigation measures outlined in this protection plan via internal periodic audits.

FUTURE STUDIES: 2002-2003

SE is committed to continue western gray whale monitoring into the future and for as long as its operations could potentially have an impact on these whales. Specifically, the following studies are planned for 2002-2003 to supplement existing information on the western population. These programmes may be adjusted following a review of the 2001 programmes and identification of any particular data gaps.

Aerial Surveys

As in earlier years, aerial surveys will be conducted in 2002 and 2003. The programme will be designed to provide essential information about the distribution and abundance of gray whales. It is expected that at least three such surveys will be conducted annually. The first survey will be conducted at the beginning of the season, in late June or early July. The second survey will be conducted at the peak of the season in early-mid August, and the third survey will be conducted at the end of the season in late October. These surveys are designed to detect gross changes in the temporal and spatial distribution and abundance of gray whales in the study area.

Photo-identification Surveys

Vessel-based photographic identification work will be continued in 2002 and 2003 to meet the same objectives and provide the same information as in previous years: (1) refine population estimates, (2) further investigate annual return and site fidelity of whales to specific feeding areas, (3) document habitat use, (4) assess general health and body condition, and (5) estimate calf production. In addition, if whales are reported to be occupying more offshore waters during 2002 and 2003 as was observed in 2001, the programme may be modified to include photo-ID work in those areas. The results of photo-ID surveys provide information useful in evaluating all mitigation measures currently implemented by Sakhalin Energy.

Satellite Telemetry Study

Recent industry-sponsored monitoring of western gray whales on the northeast Sakhalin shelf has included (1) aerial surveys, (2) photo-identification, (3) behaviour, (4) acoustics, (5) and benthos-whale food studies (Sobolevsky 2000, 2001; Weller *et al*. 2000, 2001; Würsig *et al*. 1999, 2000a). All of these studies have provided important information about the whales during the May-November open-water period when the whales are present on their summer feeding grounds and when they are in proximity to industry operations in the area. However, recent concerns about the health, condition and productivity of gray whales (Weller *et al*. 2000, 2001), suggests that some factor(s) is (are) affecting the condition of the whales, either when they are on their summering grounds, during migration, or on their presently unknown wintering grounds (see Brownell and Weller 2001). Also, since the western gray whale population may only be about 100 individuals, with plausibly only 50 reproductive adults (based on the assumption that the population is limited to those individuals observed during the course of the monitoring programme undertaken from 1994 – 2000 (Hilton Taylor 2000, Weller and Brownell 2000)), it has become considerably more important to define migration routes, wintering areas, and regional movement patterns. For these reasons, Sakhalin Energy is committed to supporting a satellite telemetry study of western gray whales as part of their future studies when tagging procedures have been sufficiently developed to enable safe tagging of the western gray whales.. Such studies were originally scheduled to be conducted in 2001, but a recommendation by the International

Whaling Commission indicated that the study would be best deferred for at least one year in order for the tagging procedures to be first tested by TAMU and NMFS researchers on eastern gray whales.

Independent Consultation and Management

Sakhalin Energy will continue to contract independent and objective consultants to provide advice, consultation, and review of marine mammal issues, plans, and studies.

SUMMARY AND CONCLUSIONS

Sakhalin Energy recognizes that there may be several potential impacts on gray whales that arise from their operations in the Piltun-Astokhskoye Field. As outlined earlier, these potential impacts fall into the following four categories: (1) physical presence of facilities (platforms, vessels, helicopters) (2) noise from facilities (Molikpaq and appraisal drilling platforms, vessels, helicopters) and specific activities (seismic surveys, dredging), (3) discharges from the platform and vessels and (4) oil spills. To date, the data suggest that Sakhalin Energy activities have not had any long-term negative effects on the gray whale feeding habitat or population of western gray whales (or any other marine mammals) in or near the P-A field. Cumulative impacts will be evaluated through continued monitoring.

Würsig *et al*. (1999, 2000a) suggested that the results of behavioural studies during 1997-2000 indicated subtle behavioural responses and changes in distribution by gray whales possibly in response to activities by Sakhalin Energy (seismic surveys in 1997, placement of the Molikpaq in 1998). However, other factors possibly influencing the behaviour of whales during these years may have contributed to these findings. On the other hand, the observed changes in behaviour and distribution, albeit subtle, indicate the possibility that industry activities may be having some impacts on the behaviour and distribution of gray whales. Therefore, Sakhalin Energy has continued to implement mitigation measures and support gray whale monitoring surveys.

Sakhalin Energy is aware of a number of apparently malnourished gray whales reported in 1999, 2000 and 2001 (Weller *et al*. 2000, 2001, personal communication), and will continue to support the photo-identification studies that provide important information about the condition of the whales, as well as other important information about the size and distribution of the population and the number of females with calves. Benthic studies conducted in 2001, and the planned future use of radio- or satellite telemetry may help determine why some whales are malnourished.

As discussed earlier, it is important to understand that Sakhalin Energy's operations and the development of a western gray whale protection plan are not in isolation of other activities by industry or by the Russian Federation. The activities of others active in the area also have the potential to affect the local gray whale population. To avoid complications and better ensure effective protection plans, Sakhalin Energy will make every reasonable effort to coordinate its gray whale monitoring and mitigation/protection activities with other stakeholders, such as Exxon Neftegas, BP International, SakMorNefteGas, other resource developers in the area, and the Russian Federation.

Sakhalin Energy is committed to operating in an environmentally responsible manner in Russia, and will take measures to minimise impacts on western gray whales.

Sakhalin Energy will implement effective protection/mitigation measures and will regularly review and amend these measures if the findings of the annual monitoring programmes warrant such amendments (e.g., adaptive approach of Holling [1978]).

The western gray whale monitoring programme will focus on assessments of potential impacts that Sakhalin Energy operations may have on the whales. The scope of each year's monitoring will be developed based on accumulated knowledge and advice from technical consultants. Sakhalin Energy will consult with their Lenders and welcomes regular input from marine mammal specialists each year regarding the scope of the monitoring programme. Furthermore, Sakhalin Energy will seek cooperation on the issues of gray whale protection with the Russian authorities and other industry stakeholders in the area.

Sakhalin Energy will also continue to make results of the monitoring programmes available to Russian authorities and, wherever possible, also make such information available to the public. SE will also promote cooperation and sharing of information, including this protection plan, among whale researchers/contractors and other interested parties such as other operators, non-governmental organizations (NGO's), and the public, in order to promote understanding. The document will be updated periodically and the comments received from these sources will be evaluated and incorporated into the document as appropriate.

An adaptive, reviewed and fully implemented western gray whale protection plan will provide the mechanism for the effective conservation of this critically endangered population. Training will ensure that all relevant personnel are aware of marine mammal issues. Sakhalin Energy's management will continue to ensure that these issues are given high priority.

Internal audits and external review will further ensure that all appropriate mitigation measures are implemented as expected with commensurate benefits to the gray whale population.

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APPENDIX I. EFFECTS OF UNDERWATER NOISE ON MARINE MAMMALS

Marine mammals rely heavily on the use of underwater sounds to communicate and gain information about their surroundings. Experiments also show that they hear and react to many man-made sounds (Richardson *et al*. 1995). The following discussion focuses on various man-made noises to which the gray whales may be exposed in the P-A license area (see Appendix 2). Responses to geo-technical exploration (seismic surveys, sub-bottom profiling, geo-hazards surveys) are an especially important consideration since the range of frequencies and pressures generated by these activities (including associated ships and support vessels) are among those types of underwater noises that have the greatest potential to affect gray whales.

The hearing abilities of baleen whales, including gray whales, have not been studied directly. Nevertheless, behavioural evidence indicates that they hear very well at frequencies below 1 kHz (Richardson *et al*. 1995). Baleen whales also react to sonar sounds at 3.1 kHz and other sound sources centered at 4 kHz (see Richardson *et al*. 1995 for a review). In addition, baleen whales produce sounds at frequencies up to 8 kHz, so it is likely that they can also detect sounds within this same range. The anatomy of the baleen whale inner ear seems to be particularly well adapted for detection of low frequency sounds (Ketten 1991, 1992, 1994), and they may hear low frequency sounds (possibly as low as 10 Hz) from sources many hundreds of kilometers away.

There have been several reviews of the effects of underwater noise on marine mammals. These include Richardson *et al.* (1989, 1995), McCauley (1994), Turnpenny and Nedwell (1994), Turnpenny *et al.* (1994), and Gordon and Moscrop (1996). Although there have been several extensive reviews, the same limited experimental and observational data underlie each of these reviews. The reactions of only three species of baleen whale to loud noises (e.g., seismic impulses) have been studied in detail -- bowhead whale, gray whale, and humpback whale.

There are several zones or radii around a strong source of sound within which various effects on marine mammals are expected. These zones include the area within which the underwater noise is audible to the marine mammal, the areas within which behavioural responses or auditory masking may occur, and the (theoretical) zones within which there could be hearing loss and physical damage (Richardson *et al*. 1995). The zones are briefly discussed in the following sections.

Hearing Abilities of Baleen Whales (Mysticetes)

Due to their large size and the consequent difficulties in maintaining them in captivity, the hearing abilities of mysticete whales have not been studied directly using behavioural or audiogram methods.

The available data on low-frequency hearing suggest that in odontocetes and pinnipeds, as in terrestrial mammals, sensitivity deteriorates with decreasing frequency below the "best" frequency. This is probably, in part, an adaptation to the typically high levels of natural underwater noise at low frequencies. However, it is not known how closely mysticetes follow this trend. They are known to emit low-frequency sounds. That, plus the anatomy of their auditory organs (Ketten 1991, 1992, 2000), suggests that mysticete whales have good low-frequency hearing.

Behavioural evidence indicates that mysticetes hear very well at frequencies below 1 kHz (Richardson *et al.* 1995). Mysticete whales have also been observed to react to sonar sounds at 3.1 kHz and other sources centered at 4 kHz. Some mysticetes react to pinger sounds up to 28 kHz, but not to pingers or sonars emitting sounds at 36 kHz or above (Watkins 1986).

Some mysticetes produce sounds at frequencies up to 8 kHz, although their calls are predominantly at low frequencies, mainly below 1 kHz (see Chapter 7 in Richardson *et al.* 1995). Based on this, plus the anatomical evidence mentioned earlier, it is presumed that their hearing abilities are good at low frequencies. The auditory system of mysticete whales is almost certainly more sensitive to low-frequency sounds than is the auditory system of the small- to moderate-sized odontocete whales. Mysticetes are known to detect the low-frequency sound pulses emitted by seismic airguns and change their direction of movement (e.g., Richardson *et al.* 1986; Miller *et al.* 1999; McCauley *et al.* 2000), or change their calling behaviour (Greene *et al.* 1999).

Based on this indirect field and anatomical evidence, we can probably assume that mysticete whale hearing is similar at frequencies ranging from <1 kHz to 8 kHz, and then deteriorates with increasing frequency. Ambient noise energy in the ocean is higher at low frequencies than at mid frequencies. At frequencies in the 1 to 8 kHz range, ambient noise levels occurring under the quietest natural conditions (and in the absence of man-made sound) are rarely less than 60 dB on a 1/3rd octave basis, i.e. in bands roughly approximating the filter bandwidth of the mammalian ear (Richardson *et al.* 1995). It is unlikely that mammals would have evolved a hearing system able to hear sounds much lower than the weakest masking noise that would ever be encountered. We might therefore expect that the hearing threshold for mysticete whales is about 50 dB at their best frequencies. Sensitivity probably deteriorates at higher frequencies. It probably also deteriorates slowly with diminishing frequency below 1 kHz, in parallel with the lowest levels of natural ambient noise (on a 1/3rd octave basis).

Zone of Behavioural and Related Effects

Zone of Audibility

The zone of audibility is the zone within which a marine mammal can hear sounds. The size of this zone depends on the hearing threshold of the species at the frequency of the emitted sound, the received level of the sound at that distance, and the level of ambient noise at corresponding frequencies. For baleen whales such as gray whales that hear well at low frequencies, it can be assumed that ambient noise levels at low frequencies will usually be higher than the hearing threshold, so the ambient noise will define the maximum radius of audibility. Toothed whales hear relatively poorly at low frequencies, so their maximum detection radius for low-frequency sounds will normally be determined by absolute hearing threshold rather than the ambient noise level (Richardson *et al*. 1995:356; Richardson and Würsig 1997). The maximum radius of audibility for pinnipeds is intermediate between that for baleen and toothed whales.

The theoretical zone of audibility for impulsive sounds (such as seismic) can be quite large, reaching distances of over 50 km even for toothed whales (Richardson *et al*. 1995; Richardson and Würsig 1997; Davis *et al.* 1999). Although, the zone of audibility establishes the theoretical maximum possible zone of effect, there is no evidence that merely hearing weak sounds from a distant source has any negative effect on marine mammals in their naturally noisy underwater environment (Richardson *et al*. 1995).

Masking

Man-made noise can interfere with detection of acoustic signals such as communication calls, echolocation calls, and environmental sounds important to marine mammals. If the man-made noise is strong enough relative to the received signal, the signal will be "masked" and undetectable. There is very little information about masking of sounds important to marine mammals. However, it is probably safe to conclude that masking will result primarily from continuous noise rather than the short impulsive noises (Richardson *et al.* 1995).

Behavioural Effects

Studies of marine mammal responses to underwater noise have documented a significant difference in response thresholds for sequences of short impulsive sounds compared to the response thresholds for continuous or slowly varying sound levels (Malme et. al. 1983, 1984; Richardson *et al.* 1995). Behavioural effects can range from a visible acknowledgement by an animal that it has heard the sound, such as a brief startle response, to panic flight. Most commonly, marine mammals react by changing their direction and/or speed of movement or behavioural activity. If a marine mammal does react to an underwater sound by changing its behaviour or moving a small distance, the impacts of this change may not be significant to the individual marine mammal, the stock, and the species as a whole. On the other hand, if a sound source displaces marine mammals from an important feeding or breeding area for a prolonged period of time, impacts on the animals could be significant.

Different species and even different individuals of the same species react to a given acoustic stimulus in different ways. At times, the reactions also vary by season, reproductive state and current activity of the animal. Some marine mammals seem to be very tolerant of underwater noise under some circumstances but more responsive at other times.

Zone of Physical Effects

In humans, prolonged or repeated exposure to high levels of airborne sound accelerates the normal process of gradual hearing deterioration with increasing age (Kryter 1985). This deterioration is a 'permanent threshold shift' (PTS). In addition, temporary increases in threshold occur during and shortly after exposure to high noise levels. This 'temporary threshold shift' (TTS) can last from minutes or hours to days. The magnitude of TTS depends on the level and duration of noise exposure, among other things. TTS is a naturally occurring phenomenon and occasional mild TTS probably has little long-term effect. However, TTS is of interest because sound levels that are high enough to elicit mild TTS provide information regarding sound levels above which more serious auditory effects are likely to occur.

Reactions of Gray Whales to Underwater Noise

Studies of the reactions of gray whales to underwater noise and other anthropogenic activities have been summarized by Richardson *et al*. (1995) and more recently by Moore and Clarke (in press) who describe potential impacts from (1) offshore oil and gas development, (2) commercial fishing and vessel traffic, and (3) whale-watching and scientific research. As noted by Moore and Clarke (in press), underwater noise from these activities is often regarded as the main source of disturbance, with oil contamination of whales and their food organisms, entanglement in cables and fishing gear, and collisions with ships occurring less frequently and therefore having somewhat lesser impacts.

The exploration phase of oil and gas development is often considered the noisiest, since it often involves seismic exploration and drilling activities, which both produce loud underwater noises in the frequency ranges likely to affect baleen whales. Several studies of effects of noise on gray whales have been conducted on their summer feeding grounds in the Bering Sea and during their migration off the coast of California. Malme *et al.* (1986, 1988) studied the responses of feeding gray whales to geophysical noise, i.e., playbacks of industry-generated sounds using an underwater projector, and seismic pulses from a single 1,638.7 cm^3 (100 in^3) airgun operated at 4500 psi, in the Bering Sea. Extrapolation of experimental results from a single 1,638.7 cm^3 (100 in^3) airgun to a much larger array (32,774.2 cm^3 – 49,161.3 cm^3 (2000-3000 in^3)) is a reasonable approach if source sound levels and source energy levels are considered in the extrapolation.

Observers on boats followed the whales and calculated whale movements from triangulated positions and collected other behavioural data. Acousticians computed received sound levels at locations corresponding to behavioural observations. Observers on boats searched for whales. When a group was found, the boat with the noise source (projector and geophysical equipment) approached the area. Eight observations of the movements and behaviour of focal animals in relation to received sound levels were made. Feeding whales responded to the impulses at estimated received sound levels (extrapolated from the small airgun array to that of a large-scale airgun array) of 164 dB re 1 μPa rms and at estimated distances of up to 4-5 km. In one case, little response was observed from a whale that was exposed to an estimated received sound level of 165 dB at a distance of 0.66 km. On five occasions there was cessation of feeding and movement away from the boat that carried the noise source. In three of these cases, whales resumed feeding in the same area during the experiment or immediately after it. Two other whales stopped feeding and one of these moved away. Most of the responses involved an abrupt change in direction or an increase in swim speed with movement away from the source (Malme *et al*. 1986, 1988).

In response to impulsive sounds, gray whales increased the interval between blows and decreased the length of surfacing, duration of dive, and number of blows per surfacing. This is the same pattern that has been documented in bowhead whales exposed to impulsive sounds in the Alaskan Beaufort Sea (Richardson *et al.* 1986; Ljungblad *et al*. 1988). Their dive cycles sped up as the gray whales switched from feeding to travelling in response to the airgun noise. Recovery to pre-disturbance surfacing/dive behaviour took place about one hour after the end of disturbance (Malme *et al*. 1986). Malme *et al*. (1986) estimated, based on small sample sizes, that 50% of feeding gray whales will cease feeding at an average peak pressure level of 173 dB re 1 µPa rms, and that 10 % of feeding whales will interrupt feeding at received levels of 163 dB. Malme *at al*. (1986) estimated that average peak pressure levels of 173 dB and 163 dB will occur at ranges of 2.6 to 2.8 km and 4 to 5 km, respectively, from an array with a source level of 250 dB.

Results generally consistent with the summer results summarized above were obtained when gray whales migrating along the California coast were exposed to seismic impulses (Malme *et al.* 1983, 1984). The experiments with migrating gray whales involved considerably larger sample sizes than the experiments on feeding gray whales, and tend to corroborate the reaction thresholds estimated for feeding gray whales. Aside from the sample sizes, the fundamental difference between the experiments on feeding and migrating whales was the fact that, in the migration experiment, the whales were already moving and were moving toward the source. During the experiment on feeding whales, the source moved toward the whale and some whales changed activity from feeding to travelling. The main objective of the migration study was to measure the distance from the sound source at which deflection of swimming directions occurred, and the associated sound levels. In summarizing these data, Malme and Miles (1985) concluded that swimming pattern changes occurred for 10% of the whales at an average pulse pressure levels of 163 dB re 1 µPa and higher, as measured on an (approximate) rms basis. The 50% probability of avoidance was estimated to occur at a distance of 2.5 km from a 65,548.4 cm^3 (4,000 cubic inch) array. This would occur at an average received sound level of about 170 dB. Some initial behavioural changes were noted at received sound levels of 140 to 160 dB.

There are no data on hearing thresholds versus pulse duration in mysticetes. However, there is some evidence that disturbance response thresholds in gray whales may be related to pulse duration in a manner similar to the relationship between hearing threshold and pulse duration in odontocetes and pinnipeds. Malme (1993) summarized the received levels of seismic (airgun) sounds at which an estimated 50% of bowhead and gray whales avoided the source. He then examined the received levels in relation to effective pulse pressure and in relation to response thresholds of the same two species to continuous sound

(Fig. 3.1 in Malme 1993). With pulsed (airgun) sounds, the sound pressure necessary to elicit avoidance in 50% of the whales was about 50 dB higher than that for continuous sounds.

Cumulative Effects of Noise

Shipping

Distant shipping noise dominates the ambient noise spectrum at frequencies of 20 to 300 Hz in the world's oceans. In coastal regions, the combined noise of many distant fishing vessels can contribute significantly to ambient noise (Richardson *et al*. 1995). There are likely hundreds of transits across various portions of the northeast Sakhalin Shelf annually by tankers, small cargo ships, supply vessels, research vessels (including small boats), and fishing boats. Fishing vessels also spend time fishing in the area and small research boat activity occurs on a daily basis during summer when weather is good. Thus, it is probable that shipping and boat noise may contribute to the low-frequency ambient noise in the portion of the northeast Sakhalin Shelf occupied by gray whales.

The trend in commercial shipping has been to larger and faster vessels. The principal source of sound from a vessel is cavitation noise made by the propellers. This sound generally increases in level with increasing speed of the vessel. In general, large ships are noisier than small ships. However, cavitation is a function of the speed of the propeller blades and can be very high, and hence noisy, for even small vessels that are dealing with high loads, such as a fishing boat pulling a large trawl. A supply ship will produce continuous broadband source levels of about 170 to 180 dB re 1 µPa at 1 m (Richardson *et al*. 1995), and recent modelling (Lawson *et al*. 2001) demonstrates that vessels using thrusters can produce high levels of underwater sound (~190 dB re 1 µPa at 1 m, see Table 1 [Lawson *et al*. 2001]). While the modeled sound levels for a supply ship, a large pipelaying vessel, and a tug and barge are lower than from pile driving or some other types of noisy operations, the durations of their highest sound output are much longer (see Table 1).

Seismic Surveys

Seismic exploration is the first stage in the search for potential undersea hydrocarbon deposits. The amount of future seismic exploration on the northeast Sakhalin Shelf is difficult to predict; however, at least two major seismic surveys have been conducted in the past – one offshore survey by Sakhalin Energy in the P-A license area in summer 1997 and a survey closer to shore in the Odoptu license area by Exxon Neftegas Limited in summer 2001. Prior to these two surveys, extensive seismic surveys of the entire northeast Sakhalin Shelf were also conducted by various Russian petroleum interests.

Seismic arrays emit pulsed sounds with high source levels in the low frequency ranges, nominally in the range of 250-260 dB re 1 μPa, at intervals of about 10 s (Richardson *et al*. 1995). Although seismic arrays are configured such that most of the energy is directed downward, marine mammals at considerable distance can still hear them (see Davis *et al*. 1998 for a review). Thus these impulsive sound sources may be as disturbing to marine mammals as are the more continuous sounds associated with vessel traffic, and drilling and production operations. The Joint Nature Conservation Committee (JNCC) has drafted guidelines for seismic operations in an effort to reduce or mitigate the effects of seismic operations on marine mammals (see Appendix 3 for a review of JNCC guidelines). These guidelines have been accepted as industry standards in many regions of the world, and should be considered as minimum standards for operations on the northeast Sakhalin Shelf.

Given the amount of activity that has occurred in the past and is presently occurring on the northeast Sakhalin Shelf, it is legitimate to conclude that the underwater environment is already somewhat noisy, and is likely to become nosier in the future. The sounds from oil and gas industry activities, including supply boats, individual drilling rigs, and seismic exploration, undoubtedly will add to the underwater ambient noise levels in the area.

Offshore Structures

In future years on the northeast Sakhalin Shelf, the oil and gas industry may be using or supporting several exploration and/or production platforms, which may involve many trips per week by supply vessels, dozens of trips by transfer oil tankers (until completion of the pipeline to shore), and frequent seismic operations. Production drilling may be conducted at two or more sites on the shelf at the same time. Furthermore, it is possible (but unlikely) that the distance between developments may be quite close, thereby adding to the amount of noise in the marine environment where western gray whales are known to occur and thus western gray whales may be exposed to increased underwater noise from oil production operations over a broad area of this shelf.

Marine mammals in this area are already exposed to the sounds from many different kinds of noise over the annual overwintering, spring and fall migration, and summer feeding periods, but at this point it cannot be determined if the incremental noise of activities associated with the Piltun-Astokhskoye development will have significant effects on western gray whales. There may be displacement of marine mammals from the noisier sound sources (e.g. pipeline and platform construction activities) likely to occur in the foreseeable future. The duration of such disturbance/displacement cannot be determined in advance however, but potential impacts will be evaluated and appropriate mitigation measures developed prior to commencement of operations.

In summary, marine mammals are adapted to living in the ocean, which in some regions is a naturally noisy environment that can experience elevated noise levels for extended periods during storms and strong wind events. This is likely to be especially true for western gray whales that are thought to migrate through some of the busiest waters on earth (i.e., coasts of Japan, Korea, and China). The cumulative effects of past, present and future noise from activities associated with the development, production and decommissioning phases of the P-A license area development will continue to be evaluated through annual gray whale monitoring and studies.

Additional Noise Reduction

Although the effects of noise from many sources in the Molikpaq area are not considered to be significant, in combination with other future activities on the northeast Sakhalin Shelf, the cumulative of industry-generated noise in the marine environment could be significant. In future developments, some noise sources could be reduced and potential impacts further mitigated by additions to or changes in equipment, operational procedures, timing of activities, or other measures. For future operations in the P-A license area, measures to further reduce the effects of noise on marine mammals could include the following:

1. Operators of noisy equipment should “ramp-up” sound sources, much as seismic operators do when employing “soft-start” procedures with airgun arrays (see details above). This might take the form of a gradual increase in power settings, or a gradual increase in the rate at which a repetitive activity is conducted. For example, seismic gun or pile-driver operators should begin operating at a reduced rate or power setting and gradually increase the rate or power to normal operational levels. Personnel involved in these noisy operations (e.g., pile-driving, seismic surveys) should monitor waters near the operation prior to and during operations. If marine mammals are observed close to noisy operations, the operation should be delayed until the marine mammal moves away. Würsig *et al.* (2000b) reported on an innovative technique to reduce received noise levels

and potential impacts on marine mammals from very noisy point source industry activities, such as pile driving. The propagation of the percussive hammer blow sounds of the pile driver were reduced dramatically by an underwater bubble curtain in place around the piling barge.

2. Where feasible, the most effective possible isolation mounts should be used for any platform-based fixed sources of strong noise, most notably gas turbines. This would reduce the amount of noise and vibration that propagates through the platform structure into the sea.
3. Where feasible, the most effective possible enclosures and mufflers should be used on air intakes and exhaust outlets for gas turbines
4. Where feasible, propellers and drive shafts on ships should be tuned and propellers should be shrouded to reduce noise.
5. Where feasible, supply vessels should be moored (using a fixed mooring station near offshore facilities) or tied-off (to the platform or other stationary vessels), rather than using thrusters for station-keeping.
6. Where feasible, the number of vessels travelling to, or standing by, the platform should be reduced at any one time.

APPENDIX 2. POTENTIAL NOISE SOURCES, ADVERSE EFFECTS, AND GRAY WHALE MITIGATION MEASURES FROM AN OFFSHORE STRUCTURE.

CONSTRUCTION

Project Activity	Potential Adverse Effect	Possible Mitigation	Evaluation Criteria for Assessing Effects						Signif-icance	Level of Confidence
			Magnitude	Geographic Extent (km)	Frequency	Duration	Reversi-bility	Ecological Context		
Pipelaying Operation	Disturbance	Avoid conc. of whales	0-1	4 to 7	4	2	R	2	NS	H
Pile Driving Operation	Disturbance	Ramp-up; shut down or delay start when whales nearby; install bubble curtain	0-1	4 to >100	1	1	R	2	NS	L
Install Offshore Facility	Disturbance	Avoid conc. of whales; maintain steady course & speed, reduce noise	1	< 0.1	1	3	R	2	NS	H
Ships and Boats (e.g., tug and barge)	Disturbance	Avoid conc. of whales; maintain steady course & speed, reduce noise	1	1 to 11	3	5	R	2	NS	H
Support Vessel Traffic (e.g., supply ship)	Disturbance	Avoid conc. of whales; maintain steady course & speed, reduce noise	1	1 to >100	3	5	R	2	NS	H
Helicopter Traffic	Disturbance	Fly at minimum alt. of 300-500 m; no circling/hovering over whales	0	< 0.1	3	5	R	2	NS	H

APPENDIX 2. (CONTINUED)

PRODUCTION

Project Activity	Potential Adverse Effect	Possible Mitigation	Evaluation Criteria for Assessing Effects: Magnitude	Geographic Extent (km)	Frequency	Duration	Reversi-bility	Ecological Context	Signif-icance	Level of Confidence
Drilling Operations	Disturbance	Insulate Noisy Equipment	0	< 0.1	4	5	R	2	NS	H
Underwater Structure Maintenance	Disturbance	Shut down or delay start when whales nearby	0	< 0.1	3	5	R	2	NS	L
Fluid Pumping	Disturbance	Insulate noisy equipment	0	-	4	5	R	2	NS	H
Ships and Boats (e.g., tug and barge)	Disturbance	Avoid conc. of whales; maintain steady course & speed, reduce noise	1	1 to 11	3	5	R	2	NS	H
Support Vessel Traffic (e.g., supply ship)	Disturbance	Avoid conc. of whales; maintain steady course & speed, reduce noise	1	1 to >100	3	5	R	2	NS	H
Helicopter Traffic	Disturbance	300-500m altitude; no circling/hovering over whales	0	< 0.1	3	5	R	2	NS	H

APPENDIX 2. (CONTINUED)

Magnitude	Frequency	Duration	Reversibility	Ecological Context	Significance Rating	Level of Confidence in Effect Prediction
0 = Negligible	1 = Happens once	1 = < 1 month	R = Reversible	1 = Area not adversely affected by human activity	NS = Not a Significant Adverse Effect	**L** = Low Level of Confidence
1 = Low	2 = Infrequent	2 = 1-6 months	I = Irreversible	2 = Likely other existing adverse effects	S = Significant Adverse Effect	**H** = High Level of Confidence
2 = High	3 = Regular, but intermittent	3 = 7-12 months				
	4 = Continuous	4 = 13-60 months				
		5 = > 60 months				

APPENDIX 3. JOINT NATURE CONSERVATION COMMITTEE (JNCC) GUIDELINES FOR MINIMIZING ACOUSTIC DISTURBANCE TO MARINE MAMMALS FROM SEISMIC SURVEYS

These guidelines are aimed at minimizing acoustic disturbance to marine mammals from seismic surveys and other operations where acoustic energy is released, e.g., large scale seismic surveys, sub-bottom profiling, geohazards surveys, other activities using “pingers”, “boomers”, and large or small volume airguns. Member companies of the UK Offshore Operators Association (UKOOA) and the International Association of Geophysical Contractors (IAGC) have indicated that they will comply with these guidelines in all areas of the UK Continental Shelf (UKCS) and in some cases elsewhere. The guidelines apply to all marine mammals, including seals, whales, dolphins and porpoises. All surveys using higher energy seismic sources (including **site surveys** as well as **large scale seismic surveys**) should comply with these guidelines.

Precautions to reduce the disturbance caused by seismic surveys

Seismic surveys at sea do not necessarily constitute a threat to marine mammals if care is taken to avoid situations that could potentially harm the animals.

A. The Planning Stage

When a seismic survey is being planned, operators should:

- Contact the Joint Nature Conservation Committee (JNCC - see Further Information for address) to determine the likelihood that marine mammals will be encountered. In sensitive areas, the JNCC may request precautions in addition to those outlined below (for example, the special conditions attached to some oil and gas licenses).
- In areas which are important for marine mammals (as indicated in consultation with the JNCC) operators should seek to provide the most appropriately qualified and experienced personnel to act as marine mammal observers on board the seismic survey vessel. If possible, such observers should be experienced cetacean biologists. As a minimum, it is recommended that observers should have attended an appropriate training course.
- If advised to do so by the JNCC, discuss the precautions which can be taken to reduce disturbance, and the design of any scientific studies with the Sea Mammal Research Unit (see Annex for address). In areas where marine mammals are abundant, properly conducted observation and recordings using qualified observers

(see above) carried out before, during and after the seismic survey, can provide valuable information on its effect.

- Operators should plan surveys so that their timing will reduce the likelihood of encounters with marine mammals, although at present there is limited information on their distribution in some areas.
- Operators should seek to reduce and/or baffle unnecessary high frequency noise produced by air-guns or other acoustic energy sources.

B. During the Seismic Survey

When conducting a seismic survey, the following guidelines should be followed:

LOOK AND LISTEN

Beginning at least 30 minutes before commencement of any use of the seismic sources, the operator and observers should carefully make a visual check from a suitable high observation platform to see if there are any marine mammals within 500 meters, using the cues mentioned later in these guidelines to detect the presence of cetaceans. Hydrophones and other listening equipment may provide additional information on the presence of inconspicuous species, such as harbour porpoises, or submerged animals, and should be used whenever possible. This will be particularly appropriate in poor weather, when visual evidence of marine mammal presence cannot be obtained.

DELAY

If marine mammals are present, the start of the seismic sources should be delayed until they have moved away, allowing adequate time after the last sighting (at least 20 minutes) for the animals to move well out of range. Hydrophones may also be useful in determining when cetaceans have moved. In situations where seal(s) are congregating immediately around a platform, it is recommended that commencement of the seismic sources begins at least 500 metres from the platform.

THE SLOW BUILD UP

Where equipment allows, power should be built up slowly from a low energy start-up (e.g. starting with the smallest air-gun in the array and gradually adding in others) over at least 20 minutes to give adequate time for marine mammals to leave the vicinity. There should be a soft start every time the air-guns are used, even if no marine mammals have been seen. The soft start may only be waived for surveys where the seismic sources always remain at low power levels e.g. some site surveys.

KEEP IT LOW

Throughout the survey, the lowest practicable power levels should be used.

C. Report after the survey

A report detailing marine mammals sighted (standard forms are available from JNCC), the methods used to detect them, problems encountered, and any other comments will help increase our knowledge and allow us to improve these guidelines. Reports should be sent to the JNCC (see Further Information for address).

Reports should include the following information:

- Date and location of survey
- Number and volume of airguns used
- Nature of air-gun discharge frequency (in Hz), intensity (in dB re. 1μPa or bar meters) and firing interval (seconds), or details of other acoustic energy used
- Number and types of vessels involved in the survey
- A record of all occasions when the air-guns were used, including the watch beforehand and the duration of the soft-start (using standard forms)
- Details of any problems encountered during marine mammal detection procedures, or during the survey
- Marine mammal sightings (using standard forms)
- Details of watches made for marine mammals and the seismic activity during watches (using standard forms)
- Reports from any observers on board

Background to the guidelines

These guidelines reflect principles which could be used by anyone planning marine operations that could cause acoustic or physical disturbance to marine mammals. The recommendations contained in the guidelines should assist in ensuring that all marine mammals in areas of proposed seismic survey activity are protected against possible injury, and disturbance is minimised.

The guidelines were originally prepared by a Working Group convened at the request of the U.K. Department of the Environment, developed from a draft prepared by the Sea Mammal Research Unit. The guidelines have been reviewed twice by the Joint Nature Conservation Committee following consultation with interested parties and in the light of experience after their use since 1995.

Please note: As these guidelines are concerned with reducing risks to marine mammals, all other notifications should be given as normal.

Existing protection

In the UK, Section 9 of the Wildlife and Countryside Act 1981 prohibits deliberate killing, injuring or disturbance of any cetacean (equivalent in Northern Ireland is Article 10 of the Wildlife (Northern Ireland) Order 1985).

This reflects the requirements of the Convention on the Conservation of European Wildlife and Habitats (the Bern Convention) and Article 12 of the EC 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.

In addition, the UK is 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. Amongst other actions required to conserve and manage populations of small cetaceans, the Agreement requires range states to "work towards...the prevention of ...disturbance, especially of an acoustic nature".

Marine mammal presence in UK waters

Records indicate there may be 22 species of cetacean either resident in, or passing through, UK waters.

There are 9 regular visitors seen in coastal waters, the most common species of which are harbour porpoise, white-beaked dolphin, bottlenose dolphin and common dolphin; the most common seen in deeper offshore seas are the long-finned pilot whale, common dolphin, harbour porpoise and killer whale.

Northern right whales are very rare - they are an endangered species, having been hunted very close to extinction.

There are two species of seal which are resident in UK waters, the common or harbour seal and the grey seal. Both species breed in the UK, with common seals pupping in June/ July, and grey seals pupping from September to December, the exact timing depending on their location. Seals may be particularly vulnerable to disturbance during the pupping season. Other species, such as the hooded seal, may occasionally be seen in waters to the north of the UK.

Cues for detecting the presence of cetaceans

Even when quite close to vessels, cetaceans are often difficult to detect. The following points should help in ensuring that an adequate search has been made.

- Seismic operators should allow adequate time (at least 30 minutes) for sightings to be made prior to commencement of any use of the seismic sources
- The ease of detecting cetaceans declines with increasing sea state, so care should be taken to ensure an adequate search has been made in the prevailing conditions.
- Searches should be made from a high vantage point with a clear all-round view, e.g. the bridge roof or crow's nest. If necessary use two or more vantage points to give an all-round view.
- The sea should first be scanned slowly with the naked eye and then scanned slowly with binoculars.
- Hydrophones are a useful aid to detecting cetaceans. Cetaceans communicate with each other using whistles, creaks, chirps and moans which may be heard over considerable distances. Trains of clicks are used for echolocation and while foraging. They may be heard with a hydrophone at distances of several kilometers. In areas which are known to be frequented by small cetaceans, any hydrophones used should be capable of receiving the high frequency sounds used by these animals.
- Submerged cetaceans are much more at risk than those on the surface. This makes it particularly important to use a hydrophone whenever possible to detect vocally active animals that may be invisible from the surface.
- Dolphins and porpoises generally surface 2-3 times per minute in order to breathe. Dive times and surfacing behaviour are more erratic when they are feeding, but most dives are unlikely to exceed 5 minutes. Large whales surface less often and may remain submerged for some time.

- Splashes may be a cue to the presence of cetaceans, although in seas rougher than sea state 2 cetacean splashes may be difficult to detect and distinguish from wave splashes.
- Blows of large whales may be more obvious, but still may be difficult to detect in strong winds.
- Some species may be attracted to boats from some distance away, probably by engine noise. They may accompany a vessel for a considerable period and even bowride if it is fast-moving. If possible, look over the bow of the ship to check for cetaceans close in to the ship that may be hidden from view from the normal vantage points. The arrays of hydrophones which are towed by survey vessels may also be attractive to dolphins.
- Feeding seabirds can sometimes be evidence of the presence of cetaceans. Species which are likely to associate with cetaceans include gannets, kittiwakes and Manx shearwaters, although any flock of birds should be checked for the possible presence of cetaceans.
- An oily slick at the sea surface may signify the presence of cetaceans. These slicks may also be attractive to birds such as fulmars and storm petrels.

Cetaceans are capable of brief swimming speeds of 30 knots (34 mph), and sustained movement at 8 knots (10 mph), although some may swim at much slower speeds. If disturbed, they may alter their heading rapidly.

Seismic surveys

Modern large-scale surveys are conducted using towed arrays of "air-guns" - cylinders of compressed air. Each cylinder contains a small volume (typically between 163.9 ml (10 cubic inches) and 1,638.7 ml (100 cubic inches)) at a pressure of about 13,789.5 Kpa (2000 psi). The array, typically containing some tens of such cylinders, is discharged simultaneously, to generate a pressure pulse which travels downwards into the sea bed. Some of this acoustic energy is emitted into the wider marine environment; however, the designers of air-gun arrays seek to maximise the transmission of energy into the sea bed, with the result that the energy dissipated into the wider environment is reduced. As a survey proceeds, the air-gun array is recharged with air from a compressor on board the towing vessel. The process is repeated at intervals of approximately ten seconds - the timing dependent on the objectives of the survey.

Potential effects of acoustic disturbance on cetaceans

The most prevalent form of acoustic disturbance in UK waters is probably the noise generated by boats; however, the noise caused by boat traffic is so widespread that many cetacean populations may have become used to it, although this does not necessarily mean that the animals are unaffected. The limited research on the effects of disturbance due to the passage of vessels shows there is some evidence that cetaceans will avoid approaching ships and may alter migration routes in response to marine traffic.

Effects of seismic surveys

The extent to which seismic disturbance from airguns affects cetaceans is not well known for all species, since only a limited amount of research has been done (see Annex for further details). Most published research relates to the effect on large whales (particularly bowhead whales) of older air-gun arrays, which were different from those currently in use.

Seismic air-guns are designed to produce low frequency noise, generally below 200 Hz, used to build up a picture of the seabed and the underlying strata. However, recent research has shown that high frequency noise is also produced (Goold 1996a). Low frequency noise is more likely to disturb baleen whales than toothed dolphins; baleen whales communicate at frequencies mostly below 3 kHz, which are likely to overlap with the dominant frequencies used by seismic air-guns. The sensitivity of toothed dolphins to sound falls sharply below 1 kHz, and sounds below 0.2 kHz are probably inaudible to them. The sounds used by dolphins for communication are often above 4.8 kHz, and echolocation sounds can occur up to 200 kHz.

Goold (1996a) found significant levels of energy across the recorded bandwidth up to 22 kHz. This high frequency noise, incidental to seismic operations, will overlap with the frequencies used by toothed dolphins, and could potentially cause disturbance. There is some evidence of disturbance of dolphins by seismic activity (Goold 1996b, Stone 1997, 1998).

Seismic activity could have a number of different effects on small cetaceans: it may interfere with communication or alter behaviour. In the worst case, there is some risk of physical damage in the immediate vicinity of air-guns. There is no evidence to suggest that injury has occurred to any cetacean in UK waters as a result of seismic activity, although such injuries may be difficult to detect. Seismic surveys may have indirect effects on local cetacean populations because of changes they may cause in the distribution of prey species.

The risk to cetaceans is increased by their natural inquisitiveness, and the fact that they may be attracted to areas of human activity where seismic surveying is about to take place. Further information and comments on these guidelines Standard forms (electronic and hard copy) are available for observers on seismic surveys.