Chapter 5:
Impact Assessment

5.1 Introduction

In the following sections, the potential impacts of the proposed SEIC oil and gas development on the critically-endangered western gray whale are discussed and assessed. Many activities during the construction phase (see Chapter 2 for project details) and operation phase (see Chapter 3 for details) of the proposed project could potentially adversely affect western gray whales. The project will also undertake a seismic programme in the Lunskoye field, which also has the potential to adversely affect western gray whales (Section 5.3.4.8).

SEIC realises the importance of avoiding and/or minimising impacts to western gray whales caused by their activities near Sakhalin Island. Chapter 7, therefore, introduces and describes a set of mitigation measures by which impacts on western gray whales could be avoided, minimised, and/or remedied. Chapter 8 describes the residual impacts on western gray whales after mitigation measures have been implemented.

This section discusses the methodological approach used in identifying and assessing potential impacts to western gray whales associated with or caused by construction, exploration, and operation of the SEIC project.

5.2 Impact Assessment Methodology

This EIA deals with only one species, the critically-endangered western population of the gray whale. This species is arguably the highest-profile element of the marine environment that could potentially be affected by oil and gas production/development on the northeast Sakhalin shelf in view of its conservation status, vulnerability, and international importance. The population was recently reclassified as Critically Endangered by the IUCN because the population is geographically and genetically distinct, and plausibly contains less than 50 reproductively-active individuals. It is vulnerable because its only presently-known summering and feeding area is located off the northeast coast of Sakhalin Island.

The methodology used in this EIA is based on that used in the more general and wide-ranging EIAs drafted for the Sakhalin II Project, and is adapted specifically for the western gray whale.

5.2.1 Nature and Extent of Impacts

Several criteria were taken into account when evaluating the extent of impacts on western gray whales: Magnitude, geographic extent, and duration.

Magnitude describes the nature and extent of the environmental effect for each activity.

Magnitude was defined as

Low	Affects ≤1 % of individuals present off northeast Sakhalin Island. Effects can be outright mortality, sublethal effects, or exclusion attributable to disturbance.

Medium	Affects 1-5 % of individuals present off northeast Sakhalin Island. Effects can be outright mortality, sublethal effects, or exclusion attributable to disturbance.
High	Affects ≥5 % of individuals present off northeast Sakhalin Island. Effects can be outright mortality, sublethal effects, or exclusion attributable to disturbance.

Geographic extent refers to the area affected by the project. Geographic extent was categorised as

Sub-Local	<1 km²
Local	1-10 km²
District	11-100 km²
Regional	101-1000 km²
Global	1001-10,000 km²

Duration describes how long a project activity and/or environmental effect is expected to last/occur. Duration was categorised as:

Short	<1 month
Medium	1 month – 1 year
Long	1 – 3 years
Very long	>3 years

Short and medium durations are considered to be transient, whereas long and very long durations are considered to be permanent.

5.2.2 Significance Criteria

SEIC's International EIA prepared for the project defines the criteria used for evaluating the level of significance of all impacts. Included are four significance levels: Major, moderate, minor, and no (or negligible) impact. Clearly, specific criteria are required for western gray whales, given their high ecological value, vulnerability, and sensitivity, (see further, below). However, it is important to note that in developing criteria for the western gray whale, the *precautionary principle* has been applied. That means that impacts that would have been classified as being of minor significance for other less sensitive species will be evaluated as being of moderate significance for western gray whales. The minor significance category is not used at all for evaluating the significance of impacts to western gray whales. In fact, any impact not deemed negligible (that is, indistinguishable from natural background variation) is considered as important, and therefore at least moderate.

For the specific case of the affected western gray whale population, a ***major impact*** occurs if an activity affects the population in such a way so as to potentially cause a decline in abundance and/or change in distribution beyond which natural recruitment (reproduction, immigration from unaffected areas) would not return the population to its former level in up to several generations. Because of the very low population size, death or serious injury to just a single individual, or deprivation of, and/or reduction in the opportunity for a number of whales to feed adequately during a single season, could significantly affect the entire population.

Major impacts require the development and application of mitigation measures (e.g., alternative technology, location, or schedule of activity) in order to reduce the impact to moderate or negligible.

A major impact would be caused by a combination of the following magnitude, duration, and geographic extent:

A transient impact of high or medium magnitude for a duration greater than one month and over a geographic extent greater than 100 km^2 (e.g., excluding a number of whales from a feeding area for more than a month).

OR

A permanent impact of low, medium, or high magnitude for a duration greater than one year and over any geographic extent (e.g., mortality of one or more whales as a result of collision with a vessel).

A ***moderate impact*** would occur if an activity affects a portion of the population, without threatening the integrity of the entire population. Temporary displacement from a migration route or interrupted feeding for a short period of time, for instance, would be considered moderate impacts.

Moderate impacts would require the development and application of mitigation measures to reduce the impacts to as low as reasonably practicable (ALARP) levels.

A moderate impact would be caused by a combination of the following magnitude, duration, and geographic extent:

A transient impact of low, medium, or high magnitude for a duration greater than one month over a geographic extent between 1-100 km^2 (e.g., displacement of a migration corridor because of industrial noise).

A ***negligible impact*** would occur if an activity affects a portion of the population but the identified effects are not distinguishable from those that could be attributed to natural variation. Negligible impacts require no mitigation measures.

A negligible impact would be caused by a combination of the following magnitude, duration, and geographic extent:

A transient impact of low, medium, or high magnitude for a duration less than one month over a geographic extent less than 1 km^2 (e.g., a few whales swimming through treated oily water discharge).

There is ***no impact*** if no effects can be expected, e.g., because of the biology of western gray whales or their distribution in the project area. A no impact situation includes, for example, noise outside of the whales' hearing range or project activities in locations where whales are not known to occur.

5.3 Construction and Exploration

5.3.1 Solid Wastes, Air Emissions, and Effluents

5.3.1.1 Solid Wastes

The majority of the waste generated during the lifetime of the SEIC project (except decommissioning) will be generated during construction (over 60%). Onshore facilities are expected to generate over 95% of the construction waste. During offshore construction activities, although a wide range of waste may be generated, most will be sorted, accumulated, and transported for onshore disposal.

It is important that solid wastes are not disposed of at sea. There have been numerous reports of marine life ingesting garbage. It is believed that floating debris is mistaken for food or accidentally ingested as the animals feed on their prey. Pinnipeds, toothed whales, and baleen whales are all known to have ingested plastic products (Martin and Clarke 1986; Barros *et al.* 1990; Walker and Coe 1990). Foreign objects can obstruct their gastrointestinal tract and cause gastric inflammation, nausea, and loss of appetite, which may result in starvation and death (Dierauf 1990).

Because western gray whales are predominately bottom feeders, they may be less likely than other baleen whales to ingest floating plastic bags. However, analysis of gray whale stomach contents indicates that they do ingest mud, sand, silt, gravel, and plant material along with their usual food items (Nerini 1984). Whereas the ingestion of inorganic material may be accidental, kelp and algae were consistently found in the stomachs of gray whales during the days of commercial whaling. Eastern gray whales found dead in California have been found with plastic bags and plastic sheeting in their stomachs (California Coastal Commission 2002). Walker and Coe (1990) have commented that bottom-feeding cetaceans are at risk from ingesting non-buoyant debris.

Disposal of solid wastes onshore during the construction phase of the project is, therefore, expected to have *no impact* on western gray whales.

5.3.1.2 Air Emissions

Marine vessels, helicopters, and construction equipment (e.g., dredgers, generators) used offshore will generate air emissions. The air polluting substances generated during construction offshore are essentially the same (with the exception of dust) as those produced onshore.

Emissions are not expected to be detectable beyond the immediate area of discharge, as they will rapidly disperse because of their volatility and temperature and the meteorological conditions of the receiving environment. Emissions will not, therefore, accumulate to potential deleterious levels over the duration of the construction phase. Although atmospheric emissions could, in theory, affect the health of western gray whales, emissions of potentially-harmful materials will be small, there will be rapid dispersion of emissions to undetectable levels, and whales spend relatively little time at the surface.

Potential impacts attributable to atmospheric emissions released during the construction phase will be of *low* to *medium* magnitude, *sub-local* geographic extent, and *short* duration, and are therefore considered *negligible*.

5.3.1.3 Effluents

The various transport, supply, and construction vessels used during the construction phase of the project will produce wastes. Treated oily-water discharge from deck drainage and bilge water could affect western gray whales (see also 5.3.1.4). However, gray whales rely on blubber rather than fur for insulation, and are less likely to be affected by exposure to oily water. Also, releases of treated oily water will dilute and disperse rapidly. Organic matter from sanitary and domestic wastes will be quickly dispersed and degraded by bacteria. It is estimated that water chemistry will be at normal levels 250 m beyond the discharge point. Hydrostatic testing fluids are immediately diluted upon release; and even if discharge occurs rapidly, none of the component chemicals are hazardous to marine mammals (Black *et al.* 1994).

Potential impacts attributable to effluents released during the construction phase will be of *low* to *medium* magnitude, *sub-local* geographic extent, and *short* duration, and are considered *negligible*.

5.3.1.4 Small, Chronic Spills

Accidental, small spills of hydrocarbons potentially could cause interrupted feeding and adverse impacts on food resources used by western gray whales. Impacts to water quality potentially could affect western gray whales directly through skin contact, clogging of the blowhole, respiration, absorption, or ingestion; visually by affecting the clarity of the water; or indirectly by contaminating prey on which western gray whales feed.

Most marine mammals are not very susceptible to the effects of oil and hydrocarbon-based fuels. Whales rely on a layer of blubber for insulation, and oil fouling of the external surface does not appear to have any adverse thermoregulatory effects (Kooyman *et al.* 1977; Geraci 1990). Whales could ingest spilled fuel or oil with food, or the baleen of baleen whales could become contaminated.

Effects from small spills are unlikely to cause serious internal damage to cetaceans. Chronic spills of any kind, including oil, fuel, or chemicals are likely to be small, and will dilute and disperse rapidly.

Impacts of small and/or chronic spills during the construction phase of the project are expected to be of *low* to *medium* magnitude, *sub-local* geographic extent, and *short* duration. Thus, potential impacts attributable to small, chronic spills are considered *negligible.*

5.3.2 Impacts from Underwater Construction

Industrial activities that will occur underwater include the construction of jetties, and the installation of pipelines, cables, a tanker loading unit (TLU), and gravity-based structures (GBSs; see Chapter 2 for more details about construction). Most effects of underwater construction activities on western gray whales are related to effects of noise and the presence of vessels; those impacts are discussed in Sections 5.3.4 and 5.3.3, respectively.

However, dredging that might be required for the installation of the subsea pipelines, cables, GBS, TLU, jetty, and landing pier, will disrupt seafloor habitat and cause an increase in suspended sediment. Those changes in the environment may ultimately affect western gray whales.

Western gray whales may be particularly vulnerable to seafloor construction activities because they feed at or near the bottom during the time when dredging activities and infrastructure installation are scheduled to occur. It is unlikely that increases in turbidity and loss of habitat from underwater construction at LUN-A, the Lunskoye landing site, and Aniva Bay will impact western gray whales, as they are not known to occur in those areas for long periods of time. Also, underwater construction activities required for the installation of the GBS at PA-B that result in increased turbidity and loss of habitat are unlikely to affect western gray whales, as that site is approximately 7-9 km from the eastern edge of their known primary feeding area.

The underwater construction location of greatest concern is the pipeline shore approach extending from the Piltun landfall to the PA-A platform site. Construction of the Piltun nearshore pipeline route will occur in important western gray whale feeding habitat and at a time when they are most abundant in the area (from June to October). Western gray whale sighting records in the Piltun region indicate that the main summer feeding area generally occurs in a 50-km long strip along the coast, at a depth of 5-10 m. That area has a surface extent of ~200 km^2. The area of overlap between the feeding area and the dredged area (i.e., pipeline trench) is limited to the pipeline landfall, and is estimated at 0.5 km^2. Thus, the trench dredged at the Piltun landfall may disrupt about 0.3% of the main feeding area. The disruption of seafloor feeding area will result in the temporary loss of food resources for some whales. It is estimated that it will take two years before seabed conditions return to pre-disturbance state (HAM Offshore Services in Sofresid document #6009000-190-ENV-10.17-00200).

Increased turbidity may have indirect negative effects on whales that feed on invertebrates. However, any increase in turbidity will be short term, and it is estimated that turbidity associated with underwater construction is relatively low when compared to the turbidity caused by a large storm (Sofresid document #6009000-190-ENV-10.17-00200). Also, western gray whales frequently encounter areas with increased turbidity, generated by their own bottom-feeding activity.

Increased turbidity and temporary disruption of seabed habitat resulting from the construction of jetties, the TLU, and the GBSs are predicted to have *no impact* because western gray whales are not known to feed at those locations.

However, the disruption of seabed habitat through the installation of pipelines and cables from PA-A to shore is predicted to be of *low* to *medium* magnitude, *sub-local* geographic extent, and *long* duration. Thus, potential impacts on western gray whales are considered *moderate*.

5.3.3 Impacts of the Physical Presence of Vessels

As mentioned in the previous section, numerous vessels will be involved in construction activities associated with the project. In addition to vessels associated with pipeline/cable installation, numerous large vessels will be used to tow and install the GBSs at the PA-B and LUN-A sites (probably four tugboats). Other vessels will be required to construct the

jetty and install the TLU in Aniva Bay, and the landing pier and approach channel at Lunskoye.

Aside from the noise generated by those vessels, the presence of the vessels could have potential impacts on whales. The presence of structures and movement of vessels during construction activities (exclusive of noise) are likely to have very small zones of influence, on the order of only metres or tens of metres in most cases. Further, it is uncertain how the physical presence of many vessels (>25 at one time in some cases), pipelines/cables, and anchors in a relatively small area will influence western gray whales. It is possible, for instance, that vessels could act as a physical barrier (and an "acoustic barrier") to the whales' movement. 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, obstruction of normal movement patterns, interrupted feeding, and collisions (see review in Moore and Clarke 2002). Interrupted feeding, movement away from an area, and avoidance of a feeding area may have multiple and/or interactive impacts, i.e. impacts could potentially affect migration and feeding patterns, which, in turn, could affect both the condition of the animals and the overall well being of the entire population.

Moore and Clarke (2002) indicate that vessel traffic (including commercial fishing) may have negative impacts on whales through collisions. Although efforts are usually made by vessel operators to avoid marine mammals, some whales, especially migrant western gray whales moving along the east coast of Sakhalin Island in May and November, may be vulnerable to collisions with vessels. Migrating gray whales appear quite susceptible to collisions compared to other whale species (Laist *et al.* 2001). Hence, western gray whales that have not moved out of the portion of the Piltun feeding area where pipeline installation occurs (PA-A to shore) may also be at risk of collision.

Potential impacts from collisions with vessels involved in construction activities are considered permanent, of *low* to *high* magnitude, *medium* to *long* duration, and of *regional* geographic extent. Such impacts are, therefore, considered *major*.

5.3.4 Noise

Noise, often defined as unwanted sound, is one of the most common environmental issues associated with aircraft and vessel operations and industrial activities. One of the concerns about potential noise effects involves whales at or just below the surface of the water. Thus, transmission of airborne sound into the ocean is a consideration. Construction activities associated with the Sakhalin II project will introduce a substantial amount of noise into the marine environment. Marine mammals rely heavily on the use of underwater sounds to communicate and to gain information about their surroundings. Thus, there is concern about potential negative effects caused by the introduction of man-made noise into the marine environment. There have been several reviews of the effects of underwater noise on marine mammals. They include Richardson *et al.* (1989, 1995), McCauley (1994), Turnpenny and Nedwell (1994), Turnpenny *et al.* (1994), Gordon and Moscrop (1996), Evans and Nice (1996), Richardson and Würsig (1997), Gisiner (1999), Würsig and Evans (2001), and Moore and Clarke (2002).

As discussed below, noise in the marine environment has the potential to interfere with whales' 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 damage and other physical damage (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, breathing, and movement patterns and speeds, (3) interrupted feeding, and (4) avoidance of an area previously occupied (Richardson *et al.* 1995; Moore and Clarke 2002). Avoidance by marine mammals of areas where noisy activities are occurring also has the potential to modify migration routes or displace western gray whales from feeding areas, in which case it may affect the condition and the well being of the population.

There are three types of potential effects of man-made sounds on marine mammals. Temporary reduction in hearing sensitivity evident as *Temporary Threshold Shift* (TTS); permanent hearing impairment evident as *Permanent Threshold Shift* (PTS); and changes in behaviour and distribution of the animals that are of sufficient magnitude to be biologically significant.

Temporary Threshold Shift (TTS).—TTS is the mildest form of hearing damage that occurs on exposure to a strong sound (Kryter 1985). While experiencing TTS, hearing sensitivity is decreased. TTS can last from minutes or hours to days. The magnitude of TTS depends on the level and duration of noise exposure, among other considerations (Richardson *et al.* 1995). For sound exposures at or somewhat above the TTS threshold, hearing sensitivity recovers rapidly after exposure to the noise ends.

Permanent Threshold Shift (PTS).—When PTS occurs, there is physical damage to the sound receptors in the ear. In some cases, there can be total or partial deafness, whereas in other cases, the animal is unable to hear sounds at specific frequency ranges. Physical damage to a marine mammal's hearing apparatus can occur if it is exposed to sound impulses that have high peak pressures, especially if they have very short rise times. Such damage can result in permanent decrease in functional sensitivity of the hearing system at some or all frequencies.

Changes in Behaviour and Distribution.—Behavioural reactions of marine mammals to a sound are difficult to predict. Reactions to sound, if any, depend on species, state of maturity, experience, current activity, reproductive state, time of day, weather, and many other factors. If a whale does react to an underwater sound by changing its behaviour or moving a small distance, the impacts of the change may not be significant to the individual, the stock, or the species as a whole. On the other hand, if a sound source displaces whales from an important feeding or breeding area for a prolonged period, impacts on the animals could be significant.

The main noise sources associated with construction/installation activities will be (1) site preparation activities (e.g., pumping operations associated with dredging operations); (2) tug-tow of the platform from the fabrication yard; (3) equipment operating on an offshore platform; (4) deposition of materials to form rock berms; and (5) vessels and aircraft providing support to the platform. Because underwater noise propagates for long distances, the potential zone of influence around a particular vessel can be many tens of kilometres in radius. The zone of influence of underwater noise at the construction areas include zones around the development area, shipping routes between the supply base and the platforms, and the helicopter flight routes between mainland and the platforms and ships.

The sources of noise to which western gray whales may be exposed in the Sakhalin II project area include the categories described below. Noises from those sources may be water-borne, air-borne, or via subsurface vibrations, and may be transmitted directly through water or indirectly through the ground or air and then through water. Noise measurements do not exist for many of the proposed construction activities, and there is very limited information on propagation loss in the waters around Sakhalin Island. Also, it is uncertain how the presence of numerous, simultaneous construction activities in a small area will contribute to overall noise levels. We are uncertain how western gray whales will react to the noise from many of the construction activities. All of these unknowns make impact predictions of noise on western gray whales very difficult and at best, speculative. Lack of certainty in impact predictions, and, more specifically, assessing an impact as less serious than it may be, may negatively influence the critically-endangered western gray whale. Thus, impact predictions are based on available information on underwater noise, and on other whale species and the eastern gray whale.

Noise will be introduced into the marine environment from the following construction activities:

- pipeline/cable installation,
- GBS and topsides installation,
- construction of a landing pier and approach channel,
- construction of a jetty,
- TLU installation,
- numerous supply vessels used to support the above construction, and
- helicopters and fixed-wing aircraft.

Potential impacts from noise on western gray whales in the study area are discussed below. The text is organised by type of construction activity, and the potential impacts on western gray whales.

5.3.4.1 Pipeline/Cable Installations

The Piltun and Lunskoye pipelines will be extended from landfall directly seawards towards the PA-B and LUN-A platforms. The pipeline to the PA-A platform will continue from the PA-B platform. Pipelines will also be installed between the OET and the TLU in Aniva Bay. Collectively, that entails laying pipeline within an approximately 56-kilometre long corridor off the northeast coast of Sakhalin Island and along a 4-km corridor in Aniva Bay. Those activities will take place primarily from June to October. Construction activities will be quite intense (estimated 24 hours per day, seven days a week), and will involve many vessels and installation stages.

Trenches will be excavated along the pipeline routes with a cutter suction dredge (CSD) in shallow waters (<8-10 m) and a trailing suction hopper dredge (TSHD) in waters >10 m. The TSHD has a dredging speed of up to 1-3 knots, and excavated material is normally dumped approximately 500 m from the pipeline route with a floating hose. The CSD also works at a slow speed, and the dredged soil is pumped and stockpiled about 450 m from the pipeline route. Numerous support vessels that will make periodic visits to the dredging site will aid those operations. Dredging alone will produce strong sources of continuous noise, especially at low frequencies. In the Beaufort Sea, broadband received

sound levels from dredges diminished to 115 dB some 4-20 km away. It is uncertain how propagation losses in the Sakhalin area would compare to the Beaufort Sea findings. Another major contributor to the overall noise level associated with dredging is the use of bow thrusters on the TSHD vessels. Some whale species, including gray whales (at least migrating gray whales), show avoidance when low-frequency steady sounds, like those from dredges, exceed 115 dB re 1μPa. Western gray whales may avoid a CSD operating nearshore by at least 2 km.

The next stage is the actual laying of the pipe (and cable in the case of the LUN-A to shore route) in the trench. Eleven vessels may be involved in pipelaying for about 88, 31, and 13 days at Piltun, Lunskoye, and Aniva Bay, respectively. Should the marine pipe lay vessels use thruster systems to maintain position, then very loud noises will be produced that may cause reactions by whales for as much as several kilometres away (Greene 1987; Brueggeman *et al.* 1990). Estimates of the levels of noise produced by dynamic-positioning (DP) thrusters, based on their physical characteristics, have been made for some specific situations (Lawson *et al.* 2001). Also, other types of noise associated with handling large pipes and the ship's turbine generators are not specifically known and are difficult to estimate. When the pipe lay vessel is re-supplied with pipe by another supply vessel (presumably with bow thrusters), near-field cumulative sound levels (i.e., overall received levels at some places within the near-field) could be as high as 177 dB re 1 μPa rms. Continuous broadband sounds will be transmitted through the vessel's hull from the gas turbines used to produce power for pipe welding station(s), movement of pipe sections and the welded pipe string, and other shipboard sounds.

Pipeline post-trenching is scheduled at the Piltun sites during a 15-day period. That will be accomplished with a jetting sledge pulled at the surface by a dedicated vessel. To the best of our knowledge, no acoustic recordings are available for that procedure.

Noise associated with pipe-laying activities on the northeast Sakhalin shelf, especially in shallow waters within 4-5 km of the shore, has the potential to disturb western gray whales. Pipe laying in Aniva Bay is not a concern, as western gray whales have not been seen there. In particular, loud noises in the near shore zone in the Lunskoye area and farther north near Piltun Bay have the potential to block the spring northward migration of western gray whales and prevent them from reaching their feeding grounds in the Piltun Bay area. Such a blockage of the western gray whale migration and disruption of feeding may have population-level impacts. Also, even if western gray whales reach their Piltun feeding area, pipeline installation activities, especially those actually in their feeding area (nearshore area within 4 km of shore) may disturb whales. As many as 21 vessels, including dredges and vessels with bow thrusters, may be operating at one time in or near the Piltun feeding area during August 2004. Those activities will generate significant noise levels that are audible to western gray whales. The whales may move away from the feeding area, at least temporarily; whales may habituate to the noise, but evidence for that is speculative at best.

Potential impacts from noise associated with pipeline/cable installation on western gray whales are predicted to be of *high* magnitude, *medium* to *long* duration, and *regional* geographic extent. Those predictions constitute a potentially *major* impact. Exclusion of some western gray whales from their feeding area may affect the condition and the well being of the entire population.

5.3.4.2 GBS and Topsides Installation

The platforms' Gravity Based Structures (GBSs) will be towed at a slow pace (a few knots) from a location on the Russian Far Eastern mainland coast via the south of Sakhalin Island, and will be positioned and lowered at the designated sites (PA-B and LUN-A) on the northeast Sakhalin shelf. It is anticipated that the installation of each GBS and the topsides will take 60 days. The exact timing of the installations has not yet been finalised, but they will occur during the open-water season.

Activities of concern will be focused at the PA-B platform installation site. If dredging is required at the sites, noise levels near the platform sites could be quite high but would be lower in the nearshore Piltun feeding area, which is 7-9 km inshore of PA-B. Although the whales are generally distributed near the shore in that area, i.e., generally shoreward of the 20-m isobath, the platform will be within hearing distance of peak noise events. It is noteworthy that in 1998 when the PA-A platform was installed, whales continued to frequent the coastal zone, including areas between the platform (PA-A) and the coast.

Potential impacts attributable to noise associated with GBS and topside installations are predicted to be of *high* magnitude, *medium* duration, and *district* (<100 km^2) geographic extent. Thus, potential impacts on western gray whales are considered to be *moderate*.

5.3.4.3 Landing Pier and Approach Channel Construction

The landing beach facility at Lunskoye, located at least 500 m from the pipeline landfall, will be constructed in 2003-2004, with marine-based works in 2004. Dredging will be required to install a temporary beach landing pier and approach channel to the Lunskoye beach landing facility. The construction of the channel will take 2-3 weeks during the ice-free season. Sheet pile walls along the channel and for the pier will have to be driven into place. Pile driving is likely to be the construction activity that produces the loudest noises that may affect whales. Dredging also produces strong sounds, especially at low frequencies.

Noise associated with construction activities at the landing pier and approach channel construction along the coast have the potential to disturb western gray whales. In particular, continuous loud noises associated with vessel traffic and with nearshore pier construction (dredging and pile-driving) in the Lunskoye area have the potential to block the spring northward migration of western gray whales and delay or prevent their migration to their feeding grounds in the Piltun Bay area. Such an interruption of migration and disruption of feeding may have implications at the population level.

If western gray whales do migrate past Lunskoye, which is likely but not confirmed, impacts from noise associated with landing pier and approach channel construction are predicted to be of *high* magnitude, *medium* duration, and *regional* (>100 km^2) geographic scale. Thus, potential impacts on western gray whales are considered *major*.

5.3.4.4 Jetty Construction

Construction of a jetty in Aniva Bay will increase noise levels in the water column because of construction activities and increased vessel traffic. Pile driving is likely to be the construction activity that produces the loudest noises. Noise levels will also be substantially increased by dredges, which are required for caisson placement and to

deepen the approach for vessels. The exact schedule for the jetty construction (most likely during the open-water season) and the number and types of vessels required are presently unknown.

Western gray whales likely will not be impacted by the noise produced during jetty construction, as they have not been reported to occur in Aniva Bay. Noise from jetty construction in Aniva Bay is predicted to have *no impact* on western gray whales.

5.3.4.5 TLU Installation

The TLU will be towed by tugboats to a site 4.5 km offshore in Aniva Bay during July and August 2005. Installation of the TLU will require dredging to remove unsuitable material from the seabed, and perhaps to deepen the seabed. Intensive vessel traffic and dredging machinery will generate a substantial amount of noise during the July-August period. Dredging alone will produce strong sources of continuous noise, especially at low frequencies (see Section 5.3.4.1, Pipeline/Cable Installation).

Western gray whales are unlikely to be impacted by the noise produced during TLU installation, as they have not been reported in Aniva Bay. Noise from TLU installation in Aniva Bay is, therefore, predicted to have *no impact*.

5.3.4.6 Vessels

Numerous vessels (tug boats, barges, supply vessels, etc.) will be used to support the construction activities discussed above. Many of the vessels will occur in a relatively small area at the same time, which will increase overall noise levels.

Noise generated by vessels is a combination of narrowband and broadband sounds. Sound levels and frequencies are generally related to the vessel size, vessel design, and vessel speed (Richardson *et al.* 1995). Noise from very large vessels (275 m) can reach source level sounds of up to 198 dB re 1μPa (Richardson *et al.* 1995). There are very few data available on noise produced by small boats with outboard engines. Large outboard engines can produce source level sounds of about 175 dB re 1μPa (Richardson *et al.* 1995).

Reactions of whales (including gray whales) to boat and other noises include changes in swimming direction and speed, blow rate, and the frequency and kinds of vocalisations (Richardson *et al.* 1995). Baleen whales may approach or avoid boats (Watkins 1986). Avoidance is strongest when boats approach directly or when vessel noise changes abruptly (Watkins 1986; Beach and Weinrich 1989). Humpback whales responded to boats at distances of at least 0.5 to 1 km, and avoidance and other reactions have been noted in several areas at distances of several km (Jurasz and Jurasz 1979; Dean *et al.* 1985; Bauer 1986; Bauer and Herman 1986). During some activities and at some locations, humpbacks exhibit little or no reaction to boats (Watkins 1986). Right whales also show variable response to boats. There may be an initial orientation away from a boat, followed by a lack of observable reaction (Atkins and Swartz 1989). A slowly moving boat can approach a right whale, but an abrupt change in course or engine speed will elicit a reaction (Goodyear 1989; Mayo and Marx 1990; Gaskin 1991). When approached by a boat, right whale mothers will interpose themselves between the vessel and calf, and will maintain a low profile (Richardson *et al.* 1995). The closely related bowhead whale will begin avoiding diesel-powered boats at distances of 4 km; they first

attempt to flee and then swim perpendicular to the boat (Richardson *et al.* 1985a,b; Koski and Johnson 1987). They may be displaced by a few km when fleeing, although some bowheads return to an area within a day. Bowheads show strong reactions to boats and will flee, change dive profiles, or exhibit other changes in behaviour when approached by boats (Richardson *et al.* 1995). Effects are transitory.

While on their southern wintering grounds, eastern gray whales show little response to slow moving or anchored vessels, but do show short-term escape reactions to boats that are moving fast and/or boats following an erratic course (Reeves 1977; Swartz and Cummings 1978; Swartz and Jones 1978, 1981). The whales appear to habituate to the presence of whale-watching boats over the course of the winter. Eastern gray whales may not be seriously disturbed by noises from small boats, but change calling behaviour to compensate for masking effects of the noise (Dahlheim 1987). Heavy ship traffic has been known to cause gray whales to abandon a specific wintering ground (Rice and Wolman 1971; Gard 1974; Reeves 1977). While migrating, eastern gray whales may change course when within 15-300 m of a ship (Schulberg *et al.* 1989). However, many collisions have been reported (Patten *et al.* 1980; Schulberg *et al.* 1989; Laist *et al.* 2001). Off the west coast of North America, there is a possibility that the eastern gray whale migration route has been displaced offshore by nearshore vessel traffic and other human disturbance (Rice 1965; Wolfson 1977). However, the change in route may have occurred for other reasons and there is no clear evidence implicating shipping. Overall, most of the range of the eastern population of gray whales is used by vessels and is subject to noise and disturbance by other human activities, and the population has recovered from over harvesting. That would indicate little overall impacts of disturbance at the population level. Similarly, several years of seismic projects, installation and operation of an offshore drilling platform, regular aircraft and shipping traffic, and close approaches to the feeding whales by researchers in small boats have not displaced feeding western gray whales summering on the northeast Sakhalin Shelf.

Impacts from noise generated by vessel traffic associated with the construction phase of the Sakhalin II project are predicted to be of *medium* to *high* magnitude, *long* duration, and *local* to *district* geographic extent. Thus, impacts on western gray whales are considered *moderate*.

5.3.4.7 Helicopters

Whales show variable reactions to aircraft overflights; some dive, others exhibit no reaction, and others leave the area. Eastern gray whales sometimes react to aircraft overflights at altitudes below 400 m (Ljungblad *et al.* 1983; SRA 1988; Clarke *et al.* 1989). Reactions include abrupt turns, dives, mothers covering the calf with her body, or the calf swimming under the mother. Western gray whales off Piltun Bay "retained their position and practically did not react to the noise …" from the Mi-8 helicopter used for aerial surveys in 1999, flying at 150-180 m (Sobolevsky 2000).

Potential impacts from noise generated by helicopters associated with the Sakhalin II Project are considered to be of *medium* to *high* magnitude, *long* duration, and *district* geographic extent. Thus, impacts on western gray whales are considered *moderate*.

5.3.4.8 Seismic Exploration

A seismic survey is planned for the Lunskoye Licence Area, lasting for one month (operating 24 hours per day) beginning in July or August 2003. This section provides a brief summary of the survey programme, which has been assessed and reported fully in the *Lunskoye Seismic Survey ES*, produced on behalf of SEIC by ERM and LGL Limited (2003). That includes 10 days for weather down time or equipment failure.) The seismic survey vessel will traverse back and forth in an east-west direction across the proposed 327 km^2 survey area, which extends from 8 to 16 km from shore and spans a north-south distance of about 25 km. The planned source level is quoted as 90 bar-m peak to peak (out – 128 Hz filter) when operating at a depth of 6 m. That equates to a source level of 259.1 dB re 1 μPa-m p-p, or about 243 dB re 1 μPa-m rms. That source level applies to the energy directed downward. The effective source level in the horizontal direction for a typical large airgun array is likely to be about 235-240 dB re 1 μPa-m rms. The range of water depths in the planned survey area is 25 to 60 m. Especially in the western (shallower) part of the operating area, water depth is sufficiently shallow that the lowest frequency components are likely to attenuate more rapidly than the higher frequency components. Even so, strong pulses of underwater sound, predominantly at low frequencies but also extending up to medium frequencies, will occur and propagate to long distances.

Malme *et al.* (1986, 1988) studied the responses of feeding gray whales to pulses from a single 100 cubic inch (1.64 L) airgun on a vessel moving toward them off St. Lawrence Island in the northern Bering Sea. Eight observations of the movements and behaviour of whales in relation to received sound levels were made. Feeding whales responded to the sound of the airgun at estimated received sound levels of 149 to 176 dB re 1 μPa rms and at distances of up to 4 km. In one case, little response was observed from a whale that was exposed to a 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 airgun source. In three of those cases, whales resumed feeding in the same area during the experiment or immediately after it. Two other whales stopped feeding and one of them moved away (Malme *et al.* 1986, 1988).

In response to airgun sounds, the whales increased the interval between blows and decreased the length of surfacing, duration of dive, and number of blows per surfacing. That is the same pattern that has been documented in bowhead whales exposed to airgun pulses (Richardson *et al.* 1986; Ljungblad *et al.* 1988). Their surfacing/dive cycles sped up as the eastern 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.* 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 on an approximate rms basis, and that 10% of feeding whales will interrupt feeding at received levels of 163 dB. Malme *et al.* (1986) estimated that an average peak pressure level of 173 dB will occur at a range of 2.6-2.8 km from an array with a source level of 250 dB.

Results generally consistent with the summer results summarised above were obtained when eastern gray whales migrating along the California coast were exposed to a single airgun or a full-scale airgun array (Malme *et al.* 1983, 1984). The experiments with migrating whales involved considerably larger sample sizes than the experiments on

feeding whales, and tend to corroborate the reaction thresholds estimated for feeding 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.

In summarising their data, Malme and Miles (1985) concluded that a few gray whales avoided the area around the airgun(s) where average pulse pressure levels were 160 dB re 1 μPa (approximate rms basis), and about 50% avoided the area where those levels were 170 dB. The latter level was estimated to occur at a distance of 2.5 km from a 4,000 cubic inch (65.5 L) array operating off the central California coast, where underwater sound tends to attenuate quickly with increasing distance. (The corresponding distance would be greater in an area with more efficient propagation of underwater sound.) Some initial behavioural changes were noted at greater distances and lower received sound levels, about 140-160 dB. Upon receiving those levels, eastern gray whales approaching the airguns began to show subtle indications of behavioural changes, including slight deflection of the migration route (by a few degrees) to avoid swimming directly toward the airgun. However, they continued generally toward the source, passing sufficiently far to the side such that a typical whale avoided exposure to levels above approximately170 dB (Malme and Miles 1985).

A study conducted in 1997 to monitor influences of seismic activity on western gray whales near Sakhalin Island (P-A license area) indicated that whales were not displaced from their feeding grounds (Würsig *et al.* 1999). However, there were apparent changes in their behaviour, including alterations in swimming speed and direction, distance travelled, and surface-respiration-dive characteristics (blow interval). The reduction in average blow interval observed upon exposure to airgun pulses was in the opposite direction to the trend in some other studies on the effects of seismic pulses on gray and bowhead whales (Richardson *et al.* 1995). It is uncertain whether changes in behaviour of that nature affect the overall well being of individual whales.

In 2001, Exxon Neftegas Limited (ENL) conducted a seismic survey covering their Odoptu field, which is located immediately north of the PA license area. A calibration study carried out prior to the seismic survey determined that the distance at which seismic pulses attenuated to 163 dB re 1μPa rms was about 7 km from the airgun array operating at full volume (3,090 cu in or 50.6 L) and about 4 km from the array operating at about half volume (1640 cu in or 26.9 L). ENL therefore imposed strict buffer zones (4-5 km buffer between the seismic vessel and gray whales) to avoid exposing feeding western gray whales to seismic pulses louder than 163 dB re 1 μPa (rms) (Johnson 2002). The 163-dB level was an experimentally-determined noise threshold at which only 10% of eastern gray whales stopped feeding and departed their feeding area (Malme *et al*. 1986, 1988). With the 47.5-L array planned for the Lunskoye survey, the distance likely would be 6 to 7 km.

Notwithstanding the employment of the buffer zone and a variety of other noise mitigation measures (including reduction of the size of the airgun array, reduction in number of seismic lines blocksurveyed, visibility restrictions, ramping-up or soft starts, shut-downs for whales and real time monitoring programmes), a small number (3 to 5) of western gray whales responded to the Odoptu seismic surveys by shifting southward away from the seismic area and into the main feeding area off Piltun Bay (Johnson, 2002). Weller *et al*. (2002b) reported a southward shift away from the Odoptu seismic

surveys by a much larger number of individuals but their method of calculation did not consider other factors such as weather and vessel traffic.

Predicted Impacts on feeding western gray whales

As discussed in Section 4.4.1, it is possible that a small (but presently unknown) proportion of the western gray whales that summer in the Okhotsk Sea feed within or near the planned seismic survey area at times during the spring, summer, or autumn. To date, there has been no strong evidence of regular feeding in the Lunskoye area, although aerial survey coverage there has not been particularly comprehensive. If they do feed there during the survey period, they may be exposed to seismic pulses for a substantial proportion of the time when both they and the survey vessel are present. Feeding is likely to be disrupted if and when the seismic vessel approaches within a few km, and subtle effects on behaviour are probable at some times while the airgun array is operating farther away. The extent of any such disruption of feeding, and its effect on individual animals, is unknown. If the operating airguns approach within a few kilometres, the whales are likely to show at least localised displacement. Whether they would move entirely out of the Lunskoye Field area is unknown.

There are alternative feeding areas to which they could move (e.g., the Piltun and Chayvo feeding areas). However, it is not known whether they would move entirely out of the Lunskoye area, what the energetic costs of such a move would be, or whether competitive interactions with whales already using the alternative areas might result in detrimental effects on the displaced whales and/or the whales already using the alternative areas. In the likely event that numbers feeding in the Lunskoye area are small, then competitive effects are unlikely to be severe even if those animals are displaced to another feeding area. However, if some individuals did incur significant reduction in feeding opportunities for one month or more, that could be detrimental to those individuals. Given the small population size of western gray whales, there could be effects at the population level, such as loss of reproductive potential, reduction in growth, and reduction in ability to survive winter.

The potential acoustic impacts on feeding western gray whales are judged to be on a *regional* scale (>100 km^2, i.e. a circle with radius 6 km, the distance to which interruption of feeding in only 10% of western gray whales is predicted) and for a *medium* duration (1 month to 1 year). Disturbance is not expected to extend beyond the period of shooting, although any substantial energetic effects of reduced feeding and/or increased swimming that might occur could persist for more than a year (*long* duration). Probably only a few individuals of the ~100 western gray whales would be affected, resulting in a *medium* magnitude or possibly *high* magnitude. Based on previous survey observations, few whales are expected to be within the field between July and September, however, there is a possibility that new data will show that whales are feeding or are otherwise present during this period. The assessment of potential impacts therefore requires a precautionary approach to be taken, which has resulted in the prediction of *major* potential impacts on any feeding western gray whales that may be present within the field.

Intensive baseline surveys of the Lunskoye area were conducted during the summer of 2002. Several western gray whales were seen there in July and August but there was no evidence of feeding. If those limited observations can be taken as evidence that western gray whales do not feed there, a summer seismic survey is expected to have at most a *moderate* impact on feeding western gray whales.

Predicted Impacts on migrating western gray whales

The seismic survey is planned to begin in July or August 2003, when few if any western gray whales are expected to migrate through the Lunskoye area. However, if the seismic survey were to occur during a migration period, and if the whales migrate through mid-shelf waters where the Lunskoye seismic survey is to occur, they could be displaced from their usual migration route, either in the offshore or the inshore direction. Based on the eastern Pacific data, any displacement of the migration corridor is likely to be by only a few km, and it is unlikely that migration would be blocked by the presence of an operating seismic vessel.

In the unlikely event that migrating western gray whales occur in the Lunskoye area during the period of seismic operations, the predicted acoustic impacts are judged to be of *local* or *district* geographic extent (an assumed maximum displacement of 10 km), and for a *short* or *medium* duration. (For any individual whale, disturbance is not expected to extend beyond the few hours that it would require to pass through the area where it would receive substantial levels of airgun sounds, but for the population, displacement could occur for the duration of the survey.) Diversion by a few km and any concomitant delay in reaching the feeding grounds is not expected to have substantive effects on energy balance. Because most migration likely occurs before or after the survey period, probably only a few individuals of the ~100 western gray whales would be affected, resulting in a *medium* or possibly *high* magnitude. Thus, potential impacts on migrating western gray whales are considered *moderate*.

Predicted Physical Impacts

Assuming that the ramp-up ("soft-start") mitigation method is applied, TTS, PTS, and non-auditory physiological impacts on western gray whales are considered *negligible* because of the known avoidance reactions of the species that have been studied at the close distances that are necessary for damage to occur.

5.3.5 Major Oil Spills

A major oil spills could occur during the construction phase of the project, but that is less likely than during the operations phase. Oil spills are discussed in Section 5.4.4.

5.3.6 Impact Summary

Potential impacts during the construction phase of the Sakhalin II Project are summarised in Table 5-1.

5.4 Operations

Operations activities during the project have the potential to affect western gray whale behaviour, abundance, distribution, and their prey. Notably, the presence of structures, discharges, noise, and disturbance have the potential to impact the western gray whale population feeding near Sakhalin Island. Potential behavioural modifications (mainly attributable to increased noise levels) may include a) movement away from the area, b) avoidance of the area previously occupied, c) changes in orientation, breathing and movement (swimming) patterns and speeds, d) interrupted feeding, and e) collisions.

TABLE 5-1. Predicted impacts of the construction and exploration phases of the Sakhalin II Project on western gray whales.

Source of predicted impact	Effect	Magnitude	Duration	Geographic extent	Predicted impact before mitigation
Air emissions (marine vessels, helicopters, construction equipment)	Health/sublethal effects	Low to Medium	Short	Sub local	Negligible
Effluents-(oily water discharges, domestic and sanitary waste),	Health/sublethal effects	Low to Medium	Short	Sub local	Negligible
Installation of pipelines and cables (disruption of seafloor habitat and increased turbidity)	Temporary loss of food resources	Low to Medium	Long	Sub local	Moderate
Physical presence of vessels	Movement away from the area, avoidance of the area and/or obstruction of normal movement patterns, interrupted feeding, and collisions	Low to High	Medium to Long	Regional	Major
Noise from pipeline/cable installations	Blockage of spring northward migration, disruption of feeding	High	Medium to Long	Regional	Major
Noise from GBS and Topsides installation	Short-range avoidance movements, possible disruption of feeding	High	Medium	District	Moderate
Noise from landing pier and approach channel construction	Blockage of spring northward migration, disruption of feeding	High	Medium	Regional	Major
Noise from support vessels	Change in behaviour, short-range avoidance movements	Medium to High	Long	Local to District	Moderate
Noise from helicopters	Change in behaviour, short-range avoidance movements	Medium to High	Long	District	Moderate
Seismic exploration, *if* western gray whales are feeding near the survey area[3]	Avoidance movements, disruption of feeding	Medium to High	Medium to Long	Regional	Major
Seismic exploration, if western gray whales are migrating past the survey area	Short-range avoidance movements, displacement of migration corridor	Medium to High	Short to Medium	Local to District	Moderate

[3] On the basis of current data, there are no western gray whales feeding in the Lunskoye area, which would make impacts at most *moderate*. However, if new data would show that whales are feeding, the potential impact would be *major* before mitigation

5.4.1 Presence of Structures and Vessels

Although potential effects on western gray whales are mainly related to the effects of noise produced by offshore structures and activities (discussed in Section 5.3.4 and below), there is a possibility that western gray whales will interact with offshore structures, such as the base of the platforms. Potential behavioural modifications exhibited by whales may include movement away from the area, avoidance of the area, and/or obstruction of normal movement patterns. However, whales, as well as other marine mammals, tend to habituate to stationary sources of disturbance.

Potential impacts of the presence of the structures *per se* are predicted to be of *low* to *medium* magnitude, *sub-local* geographic extent, and *short* duration. Thus, impacts are considered *negligible.*

The presence of the platform bases also permanently disrupts bottom habitat. Disruption of bottom habitat may, in turn, affect the feeding grounds of western gray whales, which are benthic feeders. However, western gray whales are not known to feed in the immediate vicinity of the platforms. Thus, there will be *no impacts* on western gray whales related to disruption of bottom habitat by the platforms.

Results of a three-year (1998-2000) offshore environmental monitoring programme that was implemented to monitor potential impacts of placement of the Molikpaq platform on the seabed, and the effects of subsequent drilling and production operations, have shown no impact on the marine benthic community, outside the limits of natural variation, beyond 250 m from the platform (DVNIGMI 2001). In addition, results of extensive aerial and boat-based surveys between 1997-2000 (Würsig *et al.* 1999, 2000; Weller *et al.* 1999, 2000, 2001b, 2002b; Sobolevsky 2000, 2001) indicate that western gray whales continue to aggregate and feed in the nearshore waters off the northeast coast of Sakhalin Island.

Some supply vessels and crew change vessels may be traveling directly through the known main western gray whale feeding area near Piltun Bay to get to and from the PA-A and PA-B platforms. Vessels will also be traveling to the LUN-A site. Some whales feeding during the summer and migrating along the coast in May-June and October-November may, therefore, be vulnerable to collisions with those vessels. Additional potential collisions could occur with survey and environmental monitoring vessels performing work within the P-A area.

Moore and Clarke (2002) indicate that vessel traffic (including commercial fishing) may have negative impacts on whales through collisions. Many collisions have been reported (Patten *et al.* 1980; Schulberg *et al.* 1989; Laist *et al.* 2001). Migrating eastern gray whales appear more susceptible to collisions compared to other whale species (Laist *et al.* 2001), and the same is presumed to be the case for western gray whales.

Potential impacts from collisions with vessels are permanent, of *low* to *medium* magnitude, *very long* duration, and *regional* geographic extent. Thus, potential impacts are considered *major*.

5.4.2 Solid Wastes, Air Emissions, and Effluents

5.4.2.1 Solid wastes

During offshore operation activities, several types of waste may be generated (see Section 3.5.2.1 for a list). Potential impacts of solid waste on western gray whales are described in Section 5.3.1.1. All solid waste will be sorted, accumulated, and transported for onshore disposal.

Because solid waste will not be discharged to the sea, there will be *no impacts* on western gray whales.

5.4.2.2 Air emissions

Air emissions associated with Sakhalin II operations are not expected to be detectable beyond the immediate area of discharge, as they will rapidly disperse because of their volatility and the high winds in the area. However, emissions can be expected to contribute to cumulative air quality issues related to industrial emissions from Sakhalin Island and any future offshore developments, although they will not accumulate to potential deleterious levels over the duration of the project. Atmospheric emissions could, in theory, affect the health of western gray whales, but emissions of potentially harmful materials will be very small, there will be rapid dispersion of emissions to undetectable levels, and whales spend relatively little time at the surface.

Potential impacts on western gray whales attributable to atmospheric emissions released during operations will be of *low* to *medium* magnitude, *sub-local* geographic extent, and *short* duration. Thus, potential impacts are considered *negligible*.

5.4.2.3 Effluents

Discharges associated with the operations phase of the Sakhalin II project have the potential to impact western gray whales, as well as their habitat and prey. Although there are no records in the literature of impacts on western gray whales or other marine mammals from water discharges from oil or gas production platforms, discharges could potentially cause avoidance of the area, interrupted feeding, and adverse impacts on food resources used by gray whales. However, the PA-A, PA-B, and LUN-A platforms are located 5-9 km from the 20-m depth contour, the approximate outer limit of the known western gray whale feeding area near Piltun Bay.

The water discharges from offshore platforms include clean rainwater, cooling water, greywater and industrial wastewater.

Clean rainwater will not affect western gray whales.

Development drilling will require seawater, most of which will be used as cooling water. Cooling water will be treated to acceptable chlorine and temperature levels, itsvolume will be low, the area of thermal effects is expected to be small, and the heat plume from cooling water likely to be non-detectable beyond 300 m.

Treated sewage and greywater will also become diluted near the platforms and well away from known western gray whale feeding areas.

There will be several different types of industrial wastewater. For treated completion, packer, and workover fluids, hydrocarbon levels are reduced to very low levels, acids are neutralised, and only small volumes are released. Blowout preventor fluids will be glycol-water mixes of low toxicity.

Potential impacts on western gray whales attributable to effluents released during the operations phase will be of *low* to *medium* magnitude, *sub-local* geographic extent, and *short* duration. Thus potential impacts are considered *negligible*.

5.4.2.4 Drilling Muds and Cuttings

Discharges of drilling muds have the potential to impact the marine environment and marine mammals, including western gray whales. Chronic releases of diluted drilling muds can cause water toxicity, smothering of the sea floor, habitat alteration, turbidity, and tainting of the benthos, potentially affecting the health of western gray whales. Discharge of drilling muds and cuttings could also cause avoidance of the area, interrupted feeding, and adverse impacts on food sources for western gray whales.

Drilling muds and cuttings generally will not be discharged, but some discharge will occur at the beginning of drilling and production, when water-based muds and cuttings from the first wells will be discharged to the sea. No oil-based muds and cuttings will be discharged. The discharges will occur at a distance of approximately 7-9 km from the known western gray whale feeding area near Piltun Bay, and the discharges will dilute and disperse rapidly.

Potential impacts on western gray whales attributable to the limited amount of discharge of drilling muds are likely to be of *low* to *medium* magnitude, *sub-local* geographic extent, and *short* duration. Thus, potential impacts are considered *negligible*.

5.4.2.5 Small, Chronic Spills

Accidental, small spills are discussed in Section 5.3.1.4 for the construction phase of the project. Potential impacts during the operations phase are expected to be the same.

Potential impacts of small and/or chronic spills during the operations phase of the project are expected to be of *low* magnitude, *sub-local* geographic extent, and *short* duration. Thus, potential impacts are considered *negligible*.

5.4.3 Noise

Because underwater noise propagates for long distances, the potential zone of influence around a particular noise source can be several km up to or even exceeding 100 km in the case of icebreakers. The 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).

Very loud noises at close range may also cause hearing damage and other physical damage (see Section 5.3.4). Reactions to disturbance may be short or long-term, and may vary from having a negligible impact on an individual whale to having significant impacts

that could affect the survival of the individual or the survival and condition of the entire population.

The impacts of noise on western gray whales are difficult to predict. Gray whales are expected to avoid close proximity to significant ongoing anthropogenic noise, and likely will move temporarily away from vessels and other sources of noise. It is possible that over time, western gray whales may habituate to noise generated by operational activities. If they do not avoid those areas, or approach a source of noise, hearing damage or other physical damage could occur. Furthermore, considering the critically-endangered status of western gray whales and the importance of the northeast Sakhalin area for feeding, any displacement from feeding areas is considered a very serious impact.

Noise will be introduced into the marine environment from the following operations activities:

- drilling,
- platform operation,
- subsea structure maintenance,
- numerous supply vessels used to support the above operations, and
- helicopters.

Those noise sources and more details on noise levels are described in Section 3.5.6. Potential impacts from noise on western gray whales in the study area are discussed below. The text is organised by type of operations activity.

5.4.3.1 Drilling

Baleen whales in general show variable reactions to noise created by drilling rigs. Some baleen whales are less responsive to noise, and if drilling activities are continuous, habituation may occur. Migrating eastern gray whales off the California coast showed reduced swimming speed and slight seaward or shoreward diversions in course when they were exposed to underwater playbacks of drilling noises while migrating off the California coast (Malme *et al.* 1984).

Each Phase 2 platform will be involved in the active drilling of at least 30 wells. Noise will result from (1) platform equipment such as the drill rig, the rotation of the drill stem, and the movement of pipe associated with drilling; (2) the operation of generators, pumps, hydraulic equipment and other large machinery on the platform; and (3) high-pressure air releases, engines and winches. Underwater acoustics programmes conducted during 1999 and 2000 in the PA-A area and near Piltun Bay indicated that noise levels in those areas where western gray whales were present, 6-10 km from the PA-A platform, were generally less than 100 dB re 1 μPa rms (Sobolevsky 2000). That is well below the 160 dB and the 180 dB re 1 μPa rms levels, i.e. the levels thought to cause impacts to feeding behaviour and physiological impacts, respectively, (as indicated earlier) on western gray whales. It is unknown what influence noise in the subsonic range produced during drilling would have on whales.

Impacts are predicted to be of *low* magnitude, *sub-local* to *local* geographic extent, and *very long* duration. Thus, impacts on western gray whales are considered *moderate*.

5.4.3.2 Platforms

In addition to noise generated from drilling of wells, production machinery will create noise. There are very few data on noises associated with production activities (Richardson *et al.* 1995). The gravity bases of the platforms proposed for installation at PA-B and LUN-A are made of concrete. Thus, conduction of production noise to the water will be poor and it is anticipated that noise levels will be relatively low (see Section 3.5.6.2).

Shore observations and boat surveys (Blokhin *et al.* 2001; Weller *et al.* 2000, 2001b) suggest that the general distribution of western 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 that proposed distribution shift are currently unknown, it has been speculated that whales may have moved away from the noise associated with the Vityaz/Molikpaq (platform) 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).

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. Since the placement of the structure in 1998, few gray whales have been sighted within 10 km of the PA-A platform. During systematic aerial surveys in 1998 (Weller *et al.* 2002a), 1999, and 2000 (Sobolevsky 2000, 2001) no gray whales were sighted within 10 km of the Vityaz Complex. Most gray whale sightings during the 1999 and 2000 aerial surveys were in waters close to shore, in water <20 m deep, and 6-10 km from the PA-A platform. However, occasionally some gray whales have been recorded more offshore in waters deeper than 20 m (Sobolevsky 2000).

Potential impacts on western gray whales attributable to noise generated from the platforms are predicted to be of *low* magnitude, *sub-local* to *local* geographic extent, and *very long* duration. Thus, impacts on western gray whales are considered *moderate*.

5.4.3.3 Maintenance of Subsea Structures

Subsea structures will require periodic inspection, cleaning to remove fouling organisms, repairs, and maintenance of corrosion-protection devices and coatings. Maintenance activities will generate noise and potentially disturb western gray whales.

The known western gray whale feeding area that is closest to either licence area is off Piltun Bay in water <20 m deep, ~6 Km from the PA-A platform and ~8 km from the planned location of the PA-B platform. Potential impacts on western gray whales attributable to platform maintenance are predicted to be of *low* magnitude, *sub-local* to *local* geographic extent, and *very long* duration. Thus, impacts on western gray whales are considered *moderate*.

5.4.3.4 Vessels

Reactions of baleen whales to vessels are described in Section 5.3.4.6. During operations, supply vessels will visit each platform approximately once every 10 days. Also, there will be ongoing maintenance and survey vessels working in the area of the platforms on

an *ad hoc* basis. Vessel traffic to and from the offshore facilities during the open-water season has the greatest potential to disturb western gray whales in the nearshore zone; most notably vessels that travel directly through main western gray whale feeding area near Piltun Bay to get to and from the PA-A field. Vessel traffic in the entire project area will be a frequent and at times a continuous source of sound. There are concerns that vessel traffic could interfere with the usual migratory patterns of western gray whales, either by directly or indirectly blocking a migratory route. If migration were delayed or diverted, there could be consequences for individual survival or survival of the entire population.

Overall, noise from vessel traffic during the operational activities is expected to have potential impacts of *low* to *high* magnitude, *local* to *district* geographic extent, and *very long* duration. Thus, potential impacts on western gray whales are considered *moderate*.

5.4.3.5 Helicopters

Helicopters will introduce a source of low-frequency noise in the area. During operations, helicopters will be used as the principal means of transporting personnel on and off the platforms. The expected flight volume is ~150 flights per month or 5 flights per day, 7 days per week. As mentioned in Section 5.3.4.7, whales show variable reactions to aircraft overflights. It is possible that frequent overflights of the western gray whale feeding area by helicopters enroute to the PA-A platform may seriously disturb them.

Potential impacts from noise generated by helicopters associated with the Sakhalin II project are predicted to be of *medium* to *high* magnitude, *very long* duration, and *district* geographic extent. Thus, impacts on western gray whales are considered *moderate*.

5.4.4 Major Oil Spills

Potential impacts on western grey whales of a major oil spill in the area could include (1) direct adverse impacts through contact with the oil and inhalation of toxic vapours, (2) indirect adverse impacts *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 western gray whales feed on, (5) avoidance of the spill area by the whales because of noise and activities associated with clean-up, and (6) collisions between response vessels and whales.

Most marine mammals are not very susceptible to deleterious effects of oil. However, weak or highly stressed individuals may be vulnerable to oiling. Whales exposed to oil are generally not at risk because they rely on a layer of blubber for insulation, and oiling of the external surface does not appear to have any adverse thermoregulatory effects (Kooyman *et al.* 1976, 1977; Geraci 1990; St. Aubin 1990). 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.

Whales could ingest oil and spilled fuel with contaminated water or food, or it could be absorbed through the respiratory tract. If oil is ingested, it can be voided in vomit or

faeces, but some could be absorbed and could cause toxic effects (Geraci 1990). When returned to clean water, contaminated animals can depurate this internal oil (Engelhardt 1978, 1982). However, whales exposed to an oil spill are unlikely to ingest enough oil to cause serious internal damage (Geraci and St. Aubin 1980, 1982). Crude oil could coat the baleen and reduce filtration efficiency; however, effects may be reversible within a few days (see Geraci 1990 for a review).). The flow of water through gray whale baleen coated with several grades of oil was relatively unaffected (Geraci and St. Aubin 1985, Geraci 1990). Effects of oiling of gray whale baleen on feeding efficiency appear to be small (Geraci 1990). Whales present in the study area could also suffer sublethal effects, through oiling of mucous membranes or the eyes if they swim through a slick. As an indirect impact from oil spills, gray whales would be susceptible to ship traffic and noise impacts associated with oil spill cleanup activities.

Eastern gray whales were seen lying in or swimming through oil slicks associated with the 1989 Exxon Valdez Oil Spill along Alaska's south-central coast. Eastern gray whales migrating through areas of natural oil seeps near Santa Barbara, California, often swam through oil (Kent et al. 1983 cited in Moore and Clarke 2002). According to Moore and Clarke (2002), eastern gray whales swimming through oil offshore from California swam faster, stayed submerged longer, and took fewer breaths than whales that did not pass through oil. Reactions of migrating eastern gray whales to the 1969 Santa Barbara Channel oil spill were not documented (Brownell 1971), but no deaths were attributed to the effects of oil pollution (Reeves 1977). No eastern gray whale deaths were attributed to either the Santa Barbara Channel oil spill or to the Exxon Valdez Oil Spill (Moore and Clarke 2002).

Sublethal effects likely to be caused by major oil spills are reversible and are unlikely to cause permanent damage to the animals. Population-level effects are unlikely, as no significant long-term and lethal effects from external exposure, ingestion, or bioaccumulation of oil have been demonstrated.

Because of their low population size and apparent dependence on a few, relatively small areas to obtain their annual food supply, western gray whales are likely to be very susceptible to oil spills because of the effects the spills may have on their source of food. If a major oil spill came ashore in the feeding area off Piltun Bay and smothered or displaced the western gray whale prey that are abundant there, feeding could be hindered or prevented for months, and there could be serious impacts at the population level.

Depending on the time of year, location of the whales within the study area, and type of major oil spill or blowout, the potential impacts of an offshore oil release on western gray whales could be of *low* to *high* magnitude, *regional* geographic extent, and *medium* duration. Thus, impacts on western gray whales are considered *major*.

5.4.5 Impact Summary

Potential impacts during the construction phase of the project are summarised in Table 5-2.

TABLE 5-2. Predicted impacts of the operations phase of the Sakhalin II Project on western gray whales.

Source of predicted impact	Effect	Magnitude	Duration	Geographic extent	Predicted impact before mitigation
Presence of Structures	Short-range avoidance movements	Low to Medium	Short	Sub-local	Negligible
Presence of vessels	Movement away from the area, avoidance of the area and/or obstruction of normal movement patterns, interrupted feeding, and collisions	Low to Medium	Very long	Regional	Major
Air emissions	Health/sublethal effects	Low to Medium	Short	Sub local	Negligible
Effluents-(cooling water, domestic and sanitary waste, industrial wastewater)	Health/sublethal effects	Low to Medium	Short	Sub local	Negligible
Drilling Muds and Cuttings	Health/sublethal effects	Low to Medium	Short	Sub local	Negligible
Drilling noise	Short-range avoidance movements, possible disruption of feeding	Low	Very long	Sub-local to Local	Moderate
Other noise from platforms	Short-range avoidance movements, possible disruption of feeding	Low	Very long	Sub-local to Local	Moderate
Noise from maintenance of subsea structures	Short-range avoidance movements, possible disruption of feeding	Low	Very long	Sub-local to Local	Moderate
Noise from support vessels	Change in behaviour, short-range avoidance movements	Low to High	Very long	Local to District	Moderate
Noise from helicopters	Change in behaviour, short-range avoidance movements	Medium to High	Very long	District	Moderate
Major oil spills	Health/sublethal effects, mortality or oiling of benthos, ingestion of oil	Low to High	Medium	Regional	Major