Environmental Impact Assessment

Sakhalin-2 Project

South Piltun Site Survey
Sakhalin Island

Compiled on behalf of Sakhalin Energy Investment Company Ltd.

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TABLE OF CONTENTS

List of Figures

List of Tables

Acronyms and Abbreviations

.	decimal point (in numbers)
,	thousands separator (in numbers)
~	approximately
±	plus or minus
+	plus
-	minus
↑	increasing
↓	decreasing
>	greater than
<	less than
≤	less than or equal to
%	percent
‰	parts per thousand
2D	two-dimensional
3D	three-dimensional
4D	four-dimensional
α	alpha
ADCP	acoustic Doppler current profiler
ALARP	As low as reasonably practicable
AASM	Airgun Array Source Model
AUV	autonomous underwater vehicle
ß	beta
Bc/kg	black carbon per kilogram
BCS	beyond continental shelf
Bbl/d	barrels per day
BLI	BirdLife International
BOD	Biological oxygen demand
Br	Breeding
°C	Celsius
cd	Conservation Dependent
CITES	Convention on the International Trade in Endangered Species
cm	centimetres
cm/s	centimetres per second
CPA	closest possible approach
CR	Critically Endangered
cu. in.	cubic inch
cu m	cubic metres
D	dermersal
DD	Data Deficient
dB re 1μPa-m	dB referenced 1 microPascal at 1 metre
dB	decibel
DFOC	Department of Fisheries and Oceans Canada
E	east
EFD	Energy Flux Density
EGW	eastern gray whale

EIA	Environmental Impact Assessment
EMP	Environmental Management Plan
EN	Endangered
ENL	Exxon Neftegas Limited
EPA	Environmental Protection Agency
EPB	Environmental Protection Books
°F	Fahrenheit
FSO	floating storage and offloading system
ft	foot/feet
g	grams
GBS	Gravity-based structure
GDP	Gross Domestic Product
g/m^2	grams per square metre
GRP	Gross Regional Product
HESS	High Energy Seismic Survey Team
hr	hour
HR	High-Resolution
HSE	Health, Safety and Environment
HSE-MS	Health, Safety & Environment Management System
HSESAP	Health, Safety, Environmental and Social Action Plan
Hz	hertz
IAGC	International Association of Geophysical Contractors
IBA	Important Bird Area
IBM	Russian Far East Institute of Marine Biology
ID	identification
IFAW	International Fund for Animal Welfare
IFC	International Finance Corporation
IMF	International Monetary Fund
IMO	International Maritime Organisation
in^3	cubic inches
ind/m^2	individuals per square metre
IOPP	International Pollution Prevention
IR	infrared
ISRP	Independent Scientific Review Panel
IUCN	International Union for the Conservation of Nature
IWC	International Whaling Commission
JASCO	JASCO Applied Sciences
JNCC	Joint Nature Conservation Committee
kHz	kilohertz
kg	kilogram
km	kilometre
km/h	kilometre per hour
km^2	square kilometre
kt	knot
kw	kilowatt
l	litres
lc	Least Concern
LFA	low frequency active

LGL	LGL Limited
LNG	Liquefied Natural Gas
London Convention:	Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter
LR	Lower Risk
m	metre
MAC	Maximum allowable concentration
MARPOL	International Convention for the Prevention of Pollution from Ships
MBB	multi-beam bathymetric sonar
Mcf	million cubic feet
MF	mid-frequency
m^3	cubic metre
Mg	Migratory
mg/l	milligrams per litre
mg m^{-3}	milligrams per cubic metre
m^3h^{-1}	Cubic metres per hour
min	minute
MLH	earthquake wave magnitude
ml/l	millilitres per litre
mm	millimetres
MMO	marine mammal observer
MMP	mitigation and monitoring plan
MMS	Minerals Management Service
MoM	Minutes of meeting
MONM	Marine Operations Noise Model
MPE	Maximum Permissible Emissions
Ms	millisecond
m/s	metres per second
m/s/m	metres per second per metre
N	north
NAH	non-aromatic hydrocarbon
NMFS	National Marine Fisheries Service
NOAA	National Oceanographic and Atmospheric Administration
NPIW	North Pacific Intermediate Water
NSF	National Science Foundation
Nt	Near Threatened
NW	north-west
NWS	North-West Shelf
OBC	Ocean Bottom Cable
OCS	outer continental shelf
ORB	Oil Record Book
OSR	oil spill response
OSRP	Oil Spill Response Plan
P	pelagic
PA	Piltun-Astokh
PA-A	Piltun-Astokh-A (or Molikpaq) Platform
PA-B	Piltun-Astokh-B Platform
PA-C	Piltun-Astokh-C Platform

PAM	passive acoustic monitoring
PCDP	Public Consultation and Disclosure Plan
PE	parabolic equation
PN	planktivorous
ppm	parts per million
PS	parasitic
PSA	Production Sharing Agreement
psi	pounds per square inch
PTS	permanent threshold shift
PV	piscivorous
RAM	Range-dependent Acoustic Model
RAM	Risk Assessment Matrix
R/V	Research Vessel
RF	Russian Federation
Rpm	revolutions per minute
RMS	root mean square
S	south
s	second
SALM	Single Anchor Leg Mooring
SAUP	Sea Around Us Project
SBP	sub-bottom profiler
SEIC	Sakhalin Energy Investment Company Ltd.
SEL	sound exposure level
S/N	Signal to Noise ratio
SOPEP	Shipboard Oil Pollution and Emergency Plans
SPL	sound pressure level
spp.	species
SSTF	Seismic Survey Task Force
SURTASS	Surveillance Towed Array Sensor System
T	Threatened
Tcf	Trillion cubic feet
TEO-C	Technical, Economic and Construction Substantiation
TL	transmission loss
Tonnes/yr	tonnes per year
tpa	tonnes per annum
TTS	temporary threshold shift
µg	microgram
µg/l	microgram per litre
UAV	unmanned aerial vehicle
UHR	Ultra-high resolution
U.K.	United Kingdom
U.S.	United States
UNCLS	United Nations Convention on the Law of the Sea
USFWS	U.S. Fish and Wildlife Service
UTM	Universal Transverse Mercator
VEC	Valued Ecosystem Component
VU	Vulnerable
W	west

WB	World Bank
WGW	Western gray whale
WGWAP	Western Gray Whale Advisory Panel
WWF	World Wide Fund for Nature

EXECUTIVE SUMMARY

Background and Survey Description

Sakhalin Energy Investment Company Limited's overarching goal, as set out in their *Statement of General Business Principles*, is "to commercially develop, operate and market the hydrocarbon resources and associated infrastructure governed by the Sakhalin-2 licences for the sustainable benefit of shareholders, the Russian Federation, the Sakhalin Oblast and the wider community".

Sakhalin Energy holds a concession to develop and produce oil and gas from the Piltun-Astokhskoye (PA) field on the northeast shelf of Sakhalin Island (Figure 1). Oil and gas production is currently limited to reserves that are accessible from the existing Astokh and Piltun platforms (*viz*. PA-A and PA-B respectively), located approximately 25 km apart.

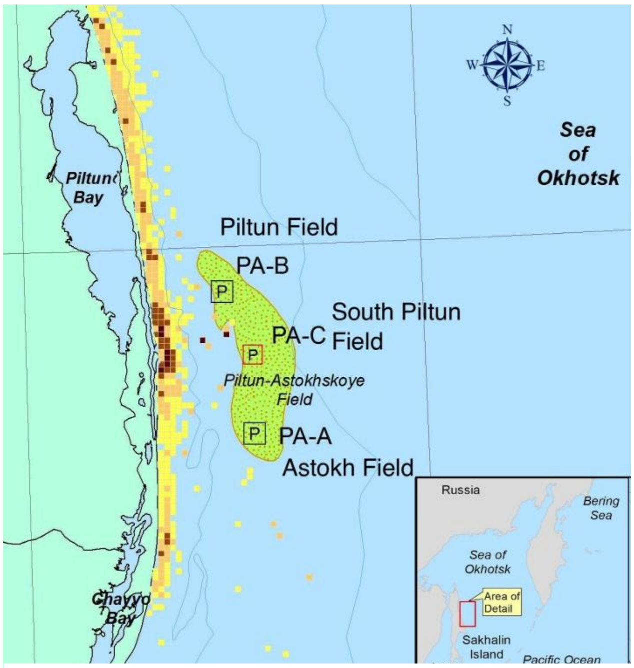

Figure 1. Piltun-Astokhskoye Oil and Gas Field

The South Piltun oil and gas accumulation in Sakhalin Energy's concession is located between the Astokh and Piltun oil fields. The company is undertaking subsurface and engineering studies to determine technically-feasible and commercially-viable development plans for the South Piltun field[1]. The range of development options being assessed includes an additional platform located between the existing PA-A and PA-B platforms, referred to as "PA-C".

In that context, Sakhalin Energy proposes to conduct a site survey to collect data essential for these studies. The survey will acquire:

- High-resolution (HR) and ultra-high-resolution (UHR) 2D seismic data for assessment of shallow gas hazards at proposed platform location;
- Seabed and sub-seabed surveys to identify seabed and shallow buried hazards in the vicinity of the potential platform and along the required pipeline routing;
- Geotechnical coring, sampling and in-situ testing to determine seabed properties for platform structural design calculations.

This information is essential if the option of a PA-C platform is to be confirmed as technically feasible. It is also required to be produced under Russian Federation law.

Within a Health and Safety context, the South Piltun site survey also provides Sakhalin Energy with a valuable opportunity to acquire similar information for the identification of relief well sites for existing platforms. In the very unlikely event of an emergency, in which control of any producing oil or gas wells fails, a jack-up rig may be required to drill emergency relief wells to intersect the faulty well in a section as close as possible to the top of the producing reservoirs. The locations for potential

[1] The results of the feasibility study and concept selection will be reported, when completed, as part of the Impact Assessment (IA) for the overall South Piltun field development, currently expected in 2013.

emergency relief wells also need to be surveyed for shallow gas hazards, seabed obstacles and seabed strength, using exactly the same methods as for the South Piltun site survey.

Following scientific advice (see below) in regard to minimising any impact on gray whales, Sakhalin Energy proposes to conduct the site survey during summer 2012, as early as possible after ice break up and prior to the peak arrival of the gray whales. The 2D seismic acquisition is planned to be completed in 3 weeks, during June to July. As currently planned, the research vessel will mobilize from Korsakov on June 17 and is expected to arrive on-site June 20. An array of 4*40 in^3 airguns is likely to be deployed as seismic source[2], towed approximately 30 metres behind the survey vessel. Seismic hydrophones shall be towed along a single streamer 750 m in length. The dimensions of the proposed 2D survey, at approximately 10km x 6km, are significantly smaller than Sakhalin Energy's 2010 Astokh 4D seismic survey.

Administrative Framework

The proposed site survey falls under the responsibility of Sakhalin Energy's Health, Safety and Environment Management System (HSE-MS). Consequently, it is subject to the Company's policies, standards and procedures. Sakhalin Energy's *Procedure for Impact Assessment* requires that all seismic surveys planned and conducted by the Company undergo full environmental impact assessment (EIA). The impact assessment process laid down in Sakhalin Energy's procedure is aligned with relevant World Bank / IFC guidance and with Russian Federation legislation. According to Russian Federation law, commercial activities in internal marine waters, territorial seas and on the continental shelf may only be performed on condition that a positive State Environmental Expert Review (SEER) conclusion is obtained. Accordingly, Sakhalin Energy's appointed contractors prepared reports for the federal SEER to Russian specifications.

This EIA Report was prepared to conform to the relevant World Bank / IFC guidance. Since the terms of reference differ, the reports vary in structure and content. However, these differences are not material to the general conclusions.

Stakeholder Engagement

Stakeholder engagement is the process of seeking opinions, concerns and requirements of stakeholders while engaging them in systematic, constructive dialogue. According to Sakhalin Energy's Public Consultation and Disclosure Plan, the nature and extent of community engagement is guided by a project's potential interaction with likely stakeholders. During the proposed site survey this is expected to be very limited. Vessels will remain offshore and there is no planned interaction with local communities. Further, the likelihood of any significant interaction with fishermen is also considered low due to the limited use of the PA area by commercial fisheries.

The EIA process defined in Russian law determines the scope of public consultation for that purpose. Accordingly, the EIA reports produced for the Russian authorities describe the details and outcomes of public consultation conducted during 2011. Information from those reports has been summarised in this report. In addition, this World Bank/IFC EIA focuses on stakeholder engagement with international stakeholders, including the IUCN's Western Gray Whale Advisory Panel (WGWAP), a major stakeholder established in 2006. The goal of the WGWAP is the 'conservation and recovery of the Western Gray Whale (WGW) population'. Listed in the Russian Red Book, gray whales found in the western Pacific are also classified as Critically Endangered by the IUCN. Sakhalin Energy resources and actively engages with the Advisory Panel on a frequent and regular basis. The company has committed recently to continue funding the operations of the panel until 2016. The Panel comprises scientists from a range of disciplines recognised by the IUCN as relevant to the conservation of the whales. Observers include representatives from the Russian and Japanese

[2] SIEC is currently investigating the possibility of using 3 X 60 in^3 gun array and will advise following modelling work should this be a more optimum configuration

branches of IFAW (International Fund for Animal Welfare), WWF, Pacific Environment and the independent environmental consultant for Sakhalin Energy's Phase 2 Senior Lenders.

Previous experience with Stakeholders

The WGWAP and their associated seismic survey task force (SSTF) were consulted extensively during Sakhalin Energy's preparation of the, potentially more intrusive, 2010 Astokh 4D seismic survey. That consultation and outputs from it – including a Mitigation and Monitoring Plan (MMP) recognised by the Panel as "the most comprehensive seismic survey MMP for cetaceans to date" – formed the basis of recent engagement to discuss Sakhalin Energy's proposed, less powerful, 2D site surveys. The Astokh 4D seismic survey was carried out under the MMP and no incidents or impacts on gray whales, or any other sea mammal, resulted.

Thus far, six meetings have been held between Sakhalin Energy and members of the WGWAP at which the motivation, scope and parameters for high-resolution 2D seismic data were presented and discussed. A substantial amount of work has been undertaken in support of these meetings, including for example, assessment of survey design options, acoustic modelling and evaluation of noise contours and thresholds in relation to sensitive areas and the optimisation of mitigation plans. Significantly, the full suite of WGWAP recommendations has been incorporated into the mitigation and monitoring plan for the survey (see below).

Issues Scoping

The main focus of the marine seismic survey impact assessments is the potential effects of noise on the marine mammals. However, they were also considered for invertebrates, birds and fish. Scoping for the effects assessment was conducted by reviewing previous environmental assessments for Sakhalin Island and elsewhere, as well as reports focusing on the gray whales. The following key issues have been considered:

- Disturbance and injury to marine mammals
- Disturbance and injury to marine invertebrates, fish and birds
- Effluent discharge, emissions and waste disposal
- Accidental spills, leaks, and dropped objects
- Interaction with other users of the area

Valued ecosystem components (VECs)[3] that were identified during scoping include:

- Baleen whales (mysticetes)
- Toothed whales (odontocetes)
- Seals (pinnipeds)
- Marine invertebrates
- Fish
- Seabirds

Significance Assessment

Impact significance was assessed based on a review of available literature, monitoring data, specialist investigations, conclusions of communications with identified stakeholders, consultation with experts and professional judgment. In evaluating impacts, consideration was given to criteria including magnitude, duration and geographical extent of expected interactions within spatial and temporal

[3] A VEC is defined as a resource or environmental feature that is important to a local human population, or has a national or international profile, or if altered from its existing status, will be important for the evaluation of environmental impacts of industrial activities. The VECs examined during the baseline studies include ichthyoplankton, benthic invertebrates, fish, fisheries, marine mammals, and birds.

boundaries. For this assessment, four ecological impact significance categories were applied for the ecological impact:

- **Major Impact**: affects an entire genetic population/sub-population or species in sufficient magnitude to cause a decline in abundance and/or change in distribution beyond which natural recruitment (reproduction, immigration from unaffected areas) would not return that population or species, or any sub-population or species dependent upon it, to its former level within several generations of the species being affected;
- **Moderate Impact**: affects a portion of a genetic population/sub-population and may bring about a change in abundance and/or distribution over one or more generation(s) of the species affected, but does not threaten the integrity of that population or any sub-population dependent on it. Moderate Impact to the same resource multiplied over a wide area would be regarded as a Major Impact;
- **Minor Impact**: affects a specific group of individuals within a genetic population or sub-population over a short time period (one generation of the species affected or less), but does not affect other trophic levels or the population/sub-population;
- **Negligible or No Impact**: where no significant impact is predicted to occur; the impact is of such small magnitude that it does not require further consideration in the assessment.

Impact Assessment

The following table summarises the aspects, potential impacts and assessed significance (if unmitigated and if mitigated). Further information on the environmental baseline, the biology of receptors and modelling studies to predict effects in support of the assessment is summarised in the subsequent sections.

Aspect	Potential Impact	Significance (if unmitigated)	Significance (if mitigated)
Noise and physical presence of survey vessels	*Gray whales*: disturbance to feeding, weaning, foraging and reproductive potential	Moderate	Minor
	Cetaceans and Pinnipeds: Injury or fatality due to collisions with vessels or deployed equipment	Moderate	Minor
	Cetaceans and Pinnipeds: Temporary Auditory Threshold Shift (TTS), Permanent Auditory Threshold Shift (PTS) and non-auditory physiological effects	Moderate	Negligible
	Marine invertebrates: Injury, fatality or behavioural changes	Negligible	Negligible
	Marine fish: Injury, fatality or spawning disturbance	Minor	Minor
	Seabirds: Injury, fatality or disturbance effects	Negligible	Negligible
Effluent discharge	*Water quality*: Impacts from cooling water, chlorinated water and deck-surface runoff (e.g., sea spray and rain water)	Negligible	Negligible
	Water quality: Impacts on water quality and marine biota from non-accidental release of drainage and sanitary waste water discharges	Negligible	Negligible
Emissions from combustion & incinerators	*Air quality*: Reduction in local air quality	Negligible	Negligible
	Air quality: Contribution to regional / global atmospheric pollution	Negligible	Negligible
Solid and hazardous waste	*Water quality*: Impacts on water quality and marine biota (toxicological effects)	Negligible	Negligible
Accidental spills and leaks	*Water quality*: Small release of harmful substances (e.g., wastes, oil, lubricants, cable fluid) resulting in a decrease in water quality and impact on marine organisms	Negligible	Negligible
	Water quality: Large release of harmful substances (e.g., wastes, oil, fuel) resulting in a decrease in water quality and impact on marine organisms	Minor	Minor
Dropped objects	*Water quality*: Loss of small objects/equipment	Negligible	Negligible
	Water quality: Loss of large objects and cargo causing pollution, impact on marine organisms, and obstruction to other vessels	Minor	Minor
Interaction with other users of the area; use of local resources	Temporary interference with commercial fishing/damage to fishing equipment	Minor	Minor
	Disruption of migratory salmon resource and subsistence fishing	Negligible	Negligible
	Interference with military use of the area	Negligible	Negligible
	Damage to marine archaeology and cultural heritage	Negligible	Negligible
	Hunting of marine mammals	Negligible	Negligible
	Effects on the local social environment and economy	Negligible	Negligible
	Vessel collisions, disturbance or damage to cables and other submarine infrastructure	Minor	Minor

Disturbance and Injury to Marine Mammals

The marine environment is naturally noisy, particularly during storms and earthquakes. Noise is important to marine mammals. They use underwater sounds to communicate and to gain information about their surroundings. Experiments have shown that they can hear and react to many sounds, including sounds from seismic exploration. Marine mammals exposed to highly elevated noise levels may develop temporary or permanent hearing impairment and/or behavioural issues. Additional noise sources, such as airguns and echo-sounders, have the potential to impact upon marine mammals, particularly at close range, metres or tens of metres. Appropriate mitigation measures, such as observers alerting operators to marine mammal presence at distance and the survey being halted until safe to resume, have been used previously by Sakhalin Energy and shown to be successful in avoiding risks to marine mammals from this impact.

Noise Effects in Baleen Whales (Mysticetes)

Seismic sources used for high-resolution shallow gas assessment surveys typically have upper-limit frequency components in the 300-400 Hz range. This frequency range overlaps the lower range of sound produced by most mysticetes. Airguns also produce a small proportion of mid- and high-frequency sounds, although at much lower energy levels. The nominal source outputs of airguns are well within the detection thresholds of mysticetes. Echo-sounders typically operate at frequencies of approximately 11-12 kHz. This frequency range overlaps the estimated auditory bandwidth of mysticetes, but is higher than the sound frequencies known to be produced by most mysticetes. The frequencies and amplitudes of sounds emitted by ship engines, vessel hulls and drillship machinery also overlap the frequencies and thresholds of mysticetes's hearing, although the intensity of vessel sounds would be considerably less than sounds emitted close by airguns and sonar. Five species of baleen whales have been recorded in or near the survey area on the northeast Sakhalin coast: the gray whale, bowhead whale and north Pacific right whale are classified as Category 1 (endangered) in the Red Book of the Russian Federation; the fin whale is classified as Category 2 (vulnerable), while the minke whale is not listed.

Gray whale

Gray whales, *Eschrichtius robustus,* migrate to the east coast of Sakhalin Island to feed through the summer and into the autumn. They start to arrive in June just after ice-break up and their numbers continue to rise, peaking in September before departing the area in October. They have been observed to feed in two areas, one nearshore and the other offshore, several kilometres from the Piltun-Astokhskoye field. Nevertheless, steps must be taken to assess the risks and mitigate any possible impact from the company's activities. Gray whales, although numbering many thousands in the eastern Pacific, number much less in the Sea of Okhotsk and western Pacific. WGWAP's most recently endorsed population modelling estimates (2009) are in the region of 134 individuals, not including calves. Consequently, they are attributed very high conservation status both within the Russian Federation and internationally. Recently, debate renewed as to the provenance of the gray whales off Sakhalin (termed the Western Gray Whales) in the light of studies of their genetics, photo identification records and satellite tagging information. Their genetics require much more study to ascertain the relationships of the individuals and putative groups in the Pacific, to allow for their subsequent definition. The photo and satellite data provide strong and increasing evidence that at least some of the whales of the Sea of Okhotsk overwinter off of California, in Mexico and the USA (where mating and calving take place), raising questions as to whether the two groups are indeed reproductively isolated, as first assumed, or are part of the same genetic population. No other, alternative wintering site has been identified or located for those whales.

Historic aerial, vessel and onshore distribution data were used to estimate the boundary of the Piltun feeding area that contained 95% of the gray whale population in this area during June and July (dotted grey line in Figure 2 below). This boundary in conjunction with detailed acoustic modelling indicated that sound levels >163 dB re 1 uPa-1 .m (rms) – the threshold above which onset of adverse behavioural responses could occur – will not enter the Piltun feeding area and therefore whales in this area will not be exposed to levels above this limit[4].
Acoustic modelling predicted that the radius to the 170 dB re 1μPa2-s per-pulse SEL contour[5] – the precautionary sound pressure threshold above which TTS may occur – will extend less than 200m from seismic source. In other words, marine mammals would generally need to be closer than 200 m to the seismic vessel to be at risk of TTS. Notwithstanding the low likelihood that any mysticetes would occur within this radius, the possibility still exists. Without mitigation, the potential impact of

[4] Modelling studies for the PA-A relief well site survey concluded similar findings.
[5] Precautionary margin translated from 180 dB re 1μPa rms

noise[6] to gray whales (disturbance, short-range avoidance movements, reduced feeding opportunities, possible loss of reproductive potential) was assessed to be of *moderate* significance. With mitigation, it was assessed as *minor*.

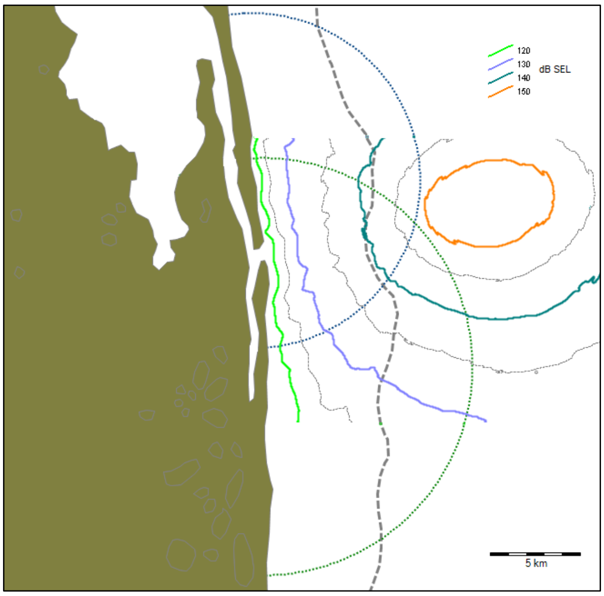

Figure 2 South Piltun 2D Contours to 120dB

Given the status of gray whales in the western Pacific, a comprehensive mitigation plan was developed during extensive consultation with the WGWAP SSTF. Sakhalin Energy has incorporated the full suite of mitigation measures endorsed by WGWAP into the seismic survey plan. Similar mitigation measures were successfully used by Exxon Neftegas Limited in their 3D seismic survey in the Odoptu area in 2001[7] and again by SEIC in 2010. Estimates of gray whale densities in the Piltun feeding area based on historical data also indicated that fewer whales are expected to be in this region during June and July compared to August-September. As noted by the WGWAP SSTF: "*The most effective mitigation measure currently available, by far, is to ensure that the seismic survey is completed as early in the season as possible*". Historic aerial, vessel and onshore distribution data were used to estimate the boundary of the Piltun feeding area that contained 95% of the gray whale population in this area during June and July (dotted grey line in figure opposite). This boundary in conjunction with detailed acoustic modelling indicated that sound levels >163 dB re 1 uPa-1 .m (rms) – the threshold above which onset of adverse behavioural responses could occur – will not enter the Piltun feeding area, and therefore whales in this area will not be exposed to levels above this limit[8].

Acoustic modelling predicted that the radius to the 170 dB re 1μPa^2-s per-pulse SEL contour[9] – the precautionary sound pressure threshold above which temporary auditory threshold shift (TTS) may occur – will extend less than 200m from seismic source; in other words, marine mammals would generally need to be closer than 200 m to the seismic vessel to be at risk of TTS. Notwithstanding the low likelihood that any mysticetes would occur within this radius, the possibility still exists.

Without mitigation, the potential impact of noise[10] to Gray Whale (disturbance, short-range avoidance movements, reduced feeding opportunities, possible loss of reproductive potential, reduced growth, reduced survival) was assessed to be of *moderate* significance.

Other Baleen Whales

Potential impacts of unmitigated noise to the endangered north Pacific right whale, the fin and minke whales have been assessed to be of *moderate* significance. The implementation of mitigation measures, including "ramp-up" procedures and "shutdowns" when whales are detected within a

[6] The dominant noise source would be the planned 2D seismic survey, which in any event has a much smaller noise effect than typical 3D surveys.
[7] The Odoptu block is also located in close proximity to the Piltun GW feeding area, north of Sakhalin Energy's Astokh field. ENL conducted their survey during August-September 2001. Although various publications related to that survey (e.g. Johnson et al., 2007) suggested that no biologically significant or population-level impacts resulted from that survey, WGWAP SSTF advised SEIC to conduct the survey as early in the season as possible.
[8] Modelling studies for the PA-A relief well site survey concluded similar findings.
[9] Precautionary margin translated from 180 dB re 1μPa rms
[10] The dominant noise source would be the planned 2D seismic survey, which in any event has a much smaller noise effect than typical 3D surveys.

defined exclusion zone, will also mitigate impacts for these species. Consequently, the mitigated assessment is *minor*.

Bowhead whales have only been recorded in the region during February and March and therefore no impacts to this species are anticipated.

Noise Effects in Toothed Whales (Odontocetes)

Odontocetes are thought to be more sensitive to the mid- to high frequencies produced by echo-sounders than to the predominantly low frequencies produced by airguns and vessels. Owing to the narrowly focused, generally downward-facing beams of echo-sounders, their intermittent and short pulse signal and the operational speed of the vessel, individual odontocetes are highly unlikely to experience more than a few brief pulse exposures from echo-sounders at worst.

Potential disturbance includes a variety of effects, including subtle changes in behaviour, more conspicuous changes in activities and displacement. In addition, TTS or PTS is possible if animals are exposed to noise levels >180 dB re 1 μPa (rms). However, there seems to be a natural tendency for odontocetes to avoid these higher, seismic source noise levels.

Many of the species present in the region are known to prefer deeper, offshore water. Species that have been encountered closer to shore include Beluga, Harbour porpoise, Dall porpoise, orca, Baird's beaked whale and northern Right whale dolphin. Cuvier's beaked whale also occurs within and near the Astokh project area; this species is classified as Category 3 (rare) in the Russian Red Book.

Numbers of individual odontocetes modelled or estimated to be exposed to >160 dB re 1 μPa (rms) during the survey are small in relation to regional population sizes. The impact to odontocetes from the proposed survey is therefore predicted to be of low magnitude, local in scale and of short duration. The overall unmitigated impact of survey noise on odontocetes is therefore determined to be *moderate*. The mitigated impact is assessed as *minor*.

Noise Effects in Pinnipeds

In general, pinnipeds seem to be more tolerant of exposure to airgun pulses than mysticetes. Like odontocetes, pinnipeds are probably more sensitive to mid- to high-frequency sonar systems (as well as some low-frequency systems). However, the downward-focus of echo-sounder beams and intermittent and short pulse signal, are likely to reduce the exposure of individuals to such noise. Nevertheless, even though animals may tend to avoid uncomfortable levels, they may still be injured through TTS or PTS if they are exposed to high noise levels. Mitigation through the actions of observers can virtually eliminate this risk.

Eastern Sakhalin Island is one of the major reproductive regions for pinnipeds in the Sea of Okhotsk. Six species of pinnipeds occur in the vicinity of eastern Sakhalin Island: ringed seals, largha (or spotted) seals, ribbon seals and bearded seals are closely associated with the ice through the winter-spring season. The northern fur seal and the Steller sea lion are mainly open-water visitors to the area. Of these, only the Steller sea lion is listed in the Russian Red Book.

Impacts to pinnipeds by the proposed survey are expected to include short-term behavioural disturbance and short-term localized avoidance of the area near the active sources. This is expected to have negligible short- and long-term impacts on individual pinnipeds, their habitats, and regional populations within the area of analysis. The impact to pinnipeds by noise from the proposed survey is therefore predicted to be of low magnitude, local or sub-local in scale, and of short duration. The overall unmitigated impact of survey noise on pinnipeds is therefore determined to be *minor*. The mitigated impact is assessed to be *negligible*.

Injury through Entanglement, Ingestion and Ship-Strikes

Entanglements occur when marine mammals become caught in cables, lines, nets, or other objects suspended in the water column. During seismic operations, cables, lines and other objects of the airgun array and hydrophone streamers will be towed behind the survey vessel near the water's surface. Cetaceans and pinnipeds are expected to avoid the noise associated with the seismic vessel during the survey, reducing this risk. Furthermore, risk of entanglement is further likely to be low as the length of the proposed single streamer for the 2D survey is 750 m, compared to 4-5 km multiple streamers of conventional 3D seismic systems.

In the highly unlikely event of a sizeable oil or fuel spill, marine mammals could inhale vapour or ingest oil with contaminated food and water. Some of the ingested oil may be voided but some may be absorbed and could cause toxic effects. In mysticetes, crude oil could coat the baleen and reduce filtration efficiency. However, effects are expected to be reversible. The proposed survey will have an approved oil spill response plan in place to ensure a prompt response to any incident.

There is a possibility that marine mammals could be injured or killed in a collision with a survey related vessel; although this would be highly unlikely in the proposed 2D survey where a single vessel, the size of a fishing boat, will be used to execute the survey at a speed of approximately 2-3 knots. Studies indicate that collisions may have negative impacts, particularly on baleen whales. Data indicate that migrating gray whales appear more susceptible to collisions, compared to other whale species. In the North Atlantic, endangered right whales are also known to be highly susceptible to vessel collisions, experiencing significant mortality and damage from collisions. Collisions have also been reported for other species of mysticetes, including humpback, fin and minke whales. Pinnipeds can probably move quickly enough to avoid collisions with ships. However, when feeding, pinnipeds may be inattentive to vessels. Fur seals are attracted to fishing vessels to feed and some have been killed by the propellers.

The risk of entanglement or collision between vessels, birds, marine mammals is considered extremely unlikely due to the slow operating speed of the seismic vessel and the relatively short length of the single streamer. Consequently, impacts through entanglement, ingestion and vessel strikes were assessed to be of *minor* significance under unmitigated conditions. The use of "ramp-up" procedures and the presence of on-board observers during the survey would minimize the risk of ship strikes and would lead to an assessment of *negligible*.

Disturbance and Injury to Marine Invertebrates, Fish and Seabirds

Marine Invertebrates

Many invertebrates are capable of producing and using sound in territorial behaviour, mating, courtship and aggression. However, studies on the impact of seismic sounds on invertebrates are extremely limited. Pathological, physiological and behavioural effects could occur. Sounds produced by airguns could cause acute injury and perhaps mortality of some invertebrate species, particularly larval and egg stages in very close proximity to the seismic source (i.e. a few metres). Since the proposed seismic acquisition area does not overlap with known critical spawning, migration or rearing areas of marine invertebrates, any risk of mortality of invertebrate eggs, larvae, juveniles, or adults near the airgun source is expected to be *negligible* with respect to the overall invertebrate population. Likewise, the significance of behavioural disturbance among marine invertebrates was assessed to be *negligible*.

Marine Fish

Echo-sounders, such as those used by seismic vessels, operate at frequencies above the known hearing ranges of most marine fish. Therefore, disturbance that would produce population-level effects are unlikely. Airguns have a frequency range that overlaps the frequencies detected by many fish species for which hearing ranges have been studied or surmised.

Pathological, physiological and behavioural effects of seismic sound on marine fish are relatively poorly documented. In theory, sounds produced by airguns could potentially cause TTS or PTS in some species of fish; they would need to be close enough to the source for this to occur. Some studies have reported that mortality of fish, fish eggs or larvae can occur in very close to seismic sources (see above). However, mortality rates caused by exposure to seismic surveys are so low, compared to natural mortality rates, that the impact of seismic surveying on recruitment to a fish stock is regarded as insignificant.

There is general concern in fisheries about the potential reduction in the catchability of fish due to seismic survey operations. Although reduced catch rates have been observed in some fisheries during seismic surveys, the findings of other studies were confounded by other sources of disturbance. The northeast Sakhalin coast supports some subsistence fishing and small-scale commercial fishing in the area is occasional and non-intensive. Salmon fishing is focussed onshore / closer to shore in August and September. Levels of injury, fatality or behavioural changes to fish from the proposed survey are considered to be *minor*.

Seabirds

Frequencies in the range of 1-5kHz generated by the airguns and by the vessels' engines would be audible to seabirds below and above the water. If seismic activity disorientates, injures, kills or otherwise increases the availability of prey species, birds could be attracted to within close range of active airguns. Birds very close to an airgun may be at risk of induced PTS or other injury due to the intense pressure pulses of the airgun discharges at such close range. However, available evidence from other seismic surveys has not shown a pattern of fish (or other prey) kills from airguns and it is considered highly unlikely that marine birds would dive near enough to a sound source. No evidence is available on the physiological effects (e.g. stress) of underwater acoustic sources on seabirds. Levels of injury, fatality or behavioural changes to birds resulting from the proposed survey are considered to be *negligible*.

Other Potential Impacts

In addition to VEC's, this impact assessment also considered potential effects on other users of the marine environment, as well as potential impacts from effluent discharge, emissions, waste disposal, and accidental spills, leaks and dropped objects.

Mitigation Measures

Mitigation measures were developed to avoid or reduce potential adverse impacts of the survey on identified receptors. For receptors where there is uncertainty relating to the magnitude of predicted impacts, monitoring forms part of the mitigation strategy. The impact assessment summary table (above) shows that significance assessments for the mitigated potential impacts range from negligible to minor; as such, these can be managed with standard operating procedures, supplemented where necessary by specification.

The potential, unmitigated impact of the proposed site survey on marine mammals was assessed to be moderate/minor. A detailed mitigation and monitoring programme was developed by the WGWAP Seismic Survey Task Force (SSTF), and approved by WGWAP, to address this concern. The following table summarises the mitigation measures to be implemented with respect to marine mammals.

Pre-Survey Planning	
Design	Site survey area optimised. Gray Whale feeding area boundary (PML) calculated according to the month for which the survey is planned.
Timing	Survey to commence as early as logistically possible in open-water conditions.
Duration	As short as logistically possible.
Equipment	Acquisition equipment to be effective in cold water conditions. Archival acoustic recorders deployed and confirmed functioning.
Survey Conduct	
Exclusion Zone	Exclusion zone around seismic source established at 1,000 m, provided there is no conflict with permit specification. Should poor visibility extend the survey duration to unreasonable levels, then Sakhalin Energy will notify the WGWAP of the need for deviation to allow 500m exclusion zone during poor visibility.
Shutdown	Shutdown to be initiated if a cetacean (excluding porpoises and dolphins), or endangered pinniped is observed in the defined exclusion zone. A precautionary power-down will be initiated if a specified marine mammal is observed to be on a course that will result in its entering the exclusion zone.
Pre-Shoot Observation	MMOs will be required to conduct a 20-minute pre-shoot observation of the full array exclusion zone to ensure no specified marine mammals are present within exclusion zone before start of “ramp-up” procedures from shutdown.

Ramp-Up*	Ramp-up required after more than 20 minutes of inactive source. (*Inactive source* defined as no guns active; if one or more guns are active – e.g. during a line-change – then this is considered an *active source*). Ramp up to occur across a period of time such that a progressively larger gun combination is activated over a period of several minutes.
Line Changes	At least one airgun will remain active during line changes.
Poor Visibility	Seismic operations can continue in periods of poor visibility (night, fog etc.) under certain defined circumstances: To acquire a line in poor visibility, it must have been scanned while shooting an adjacent line in good visibility conditions during the preceding six hours, without any Gray Whale sightings. Operations will be shut down for the low visibility period if whales are sighted during this scan. In poor visibility, operations will not recommence after more than 20 minutes of source inactivity due to the inability to conduct a visual scan.
Monitoring	
Archival Acoustic Monitoring	Two archival acoustic recorders to be installed; one on the 10 m isobath and one on the 20 m isobath for both the PA-C and PA-A relief well site surveys.
Seismic Vessel Visual Monitoring	Four experienced MMOs on the seismic vessel for duration of the survey. Minimum of two active MMOs on the seismic vessel at any given time during ramp-up, shooting, and for the 20 minutes before start of ramp-up. MMOs limited to a maximum 2-hour continuous shift with a minimum of 1-hour between shifts. MMO observation platforms will be located at the highest elevation available on the vessel with the maximum viewable range from the bow to 90 degrees port/starboard of the vessel. Single point authority for shutdown will lie with the senior MMO.
Shore-Based Visual Monitoring	Shore-based behaviour-monitoring teams will be stationed prior, during and post survey of the PA-C and PA-A relief well sites. Locations of the observation stations to be confirmed prior to the survey.

*Considered low impact/importance for the seismic array proposed.

1 INTRODUCTION

1.1 Background

Sakhalin Energy's overarching goal, set out in their Statement of General Business Principles, is "to commercially develop, operate and market the hydrocarbon resources and associated infrastructure governed by the Sakhalin-2 licences for the sustainable benefit of shareholders, the Russian Federation, the Sakhalin Oblast and the wider community".

The South Piltun oil and gas accumulation is located in Sakhalin Energy's concession between the Astokh and Piltun oil fields, on the north-eastern shelf of Sakhalin Island (Figure 1-1). Hydrocarbon reserves in this area have been discovered and appraised, and are ready for development. Sakhalin Energy has been requested by its shareholders to investigate possible options for the development of this field, with an early focus on oil extraction.

Sakhalin Energy is currently undertaking subsurface and engineering studies to determine technically-feasible and commercially-viable development plans for the South Piltun field. Their feasibility study considers alternative concepts – see WGWAP-10 Report (2011) – including the concept of a new platform.

In order to properly prepare the platform option for concept selection, Sakhalin Energy requires:

- High-resolution and ultra-high-resolution 2D seismic data for evaluation of shallow gas hazards;
- Seabed and sub-seabed surveys to identify seabed and shallow buried hazards in the vicinity of the potential platform and along the required pipeline routing;
- Geotechnical coring to determine seabed properties for platform structural design calculations.

This information is essential to confirm if the option of a PA-C platform is feasible. It is also information required in terms of Russian Federation law. The company proposes to conduct this site survey[11] during early summer 2012.

Of all components of the site survey, the 2D seismic survey is expected to produce the most noise – although at levels very much lower than typical 3D seismic surveys. Seismic and seabed surveys use reflected sound waves to acquire information about surface and subsurface features and condition; sound waves produced by sources (such as airguns or sonar) are directed towards the target area (e.g. seabed at the potential location of the new platform), while reflected sound waves are measured by recorders (hydrophones). The generation and recording of seismic data (seismic acquisition) can be achieved using many different receiver configurations, including a tow of hydrophones behind a vessel to record the seismic signal.

[11] Although the focus of this report is the South Piltun site survey, Sakhalin Energy also plans to survey two, small relief well sites per existing platform, viz. PA-A, PA-B, and LUN-A; while seabed surveys and geotechnical coring will be carried out on all sites, 2D seismic is only required for PA-A. Further details are provided in this report.

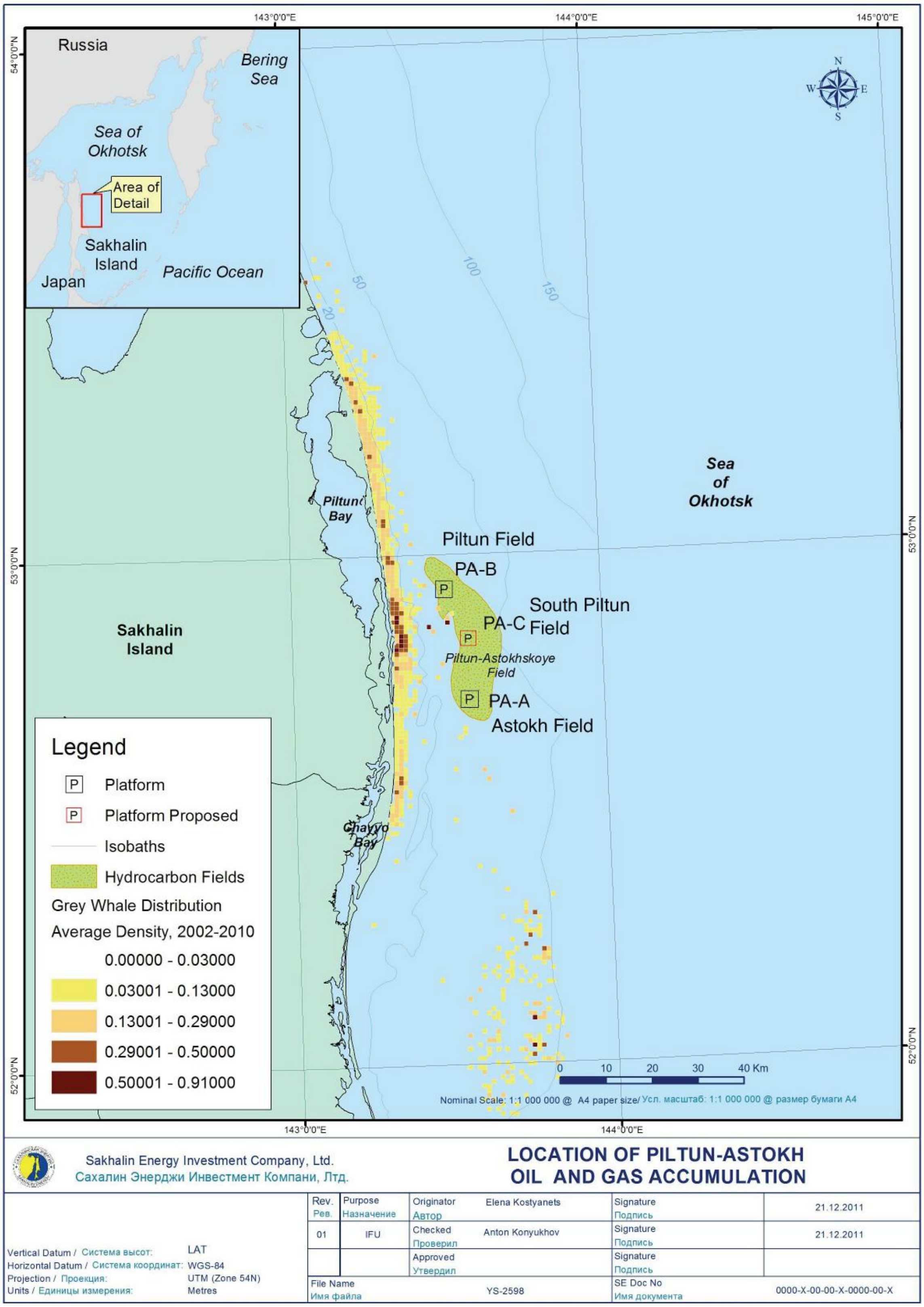

Figure 1-1. Location of South Piltun oil and gas accumulation in relation to existing PA-A and PA-B platforms

Anthropogenic sound in the ocean (from industrial activities such as engineering installations, shipping, sonar, and seismic airgun arrays) contributes to ambient or background levels. Marine animal species are sensitive to certain sound levels and frequencies, and temporary or permanent hearing impairment and/or behavioural responses may occur if they are exposed to strong sounds. Although the impacts of seismic activities on marine mammals are not yet fully understood, precautionary measures should be applied to protect vulnerable species against these potential effects.

The use by marine species of waters off the east coast of Sakhalin Island as migration routes and feeding grounds is an important consideration for offshore activities in this area. Given that Sakhalin Energy's Piltun concession is within relatively close proximity to the near shore feeding area of the gray whale (*Eschrichitus robustus*), particular attention has been paid as to how the survey might affect these whales, which are accorded very high status[12]. Sakhalin Energy has identified potential impacts and minimized these through the implementation of monitoring and mitigation measures.

1.2 Environmental Impact Assessment Premises

The proposed site survey falls under the scope of Sakhalin Energy's Health, Safety, and Environment Management System (HSE-MS) and is subject to controls described in the Company's HSE Policy and associated standards.

Integral to the management system is the Health, Safety, Environment and Social Action Plan (HSESAP, currently Revision 3), concluded between Sakhalin Energy and its Phase 2 Senior Lenders. Under the Common Terms Agreement (CTA), the Company commits to comply in all material respects with the HSESAP.

The option of a new PA-C platform would be classified as a *Project Expansion* (PE) in terms of the company's *Project Expansions HSE Procedure*[13]; the site survey, a separate but related activity, has been classified as a *Permitted Project Expansion* (PPE). The Company is required to submit any environmental impact assessment to the Phase 2 Senior Lenders' independent environmental consultant for review.

Sakhalin Energy's HSE-MS provides a systematic approach to environmental management to ensure compliance with the law. In terms of:

- Item 7 Article 11 under Russian federal law "On environmental review",
- Article 34 of federal law "On internal marine waters, territorial seas and marginal zones of the Russian Federation", and
- Article 31 of federal law "On the continental shelf of the Russian Federation",

Geological and engineering site investigation activities in internal marine waters, in territorial seas, and on the continental shelf [of the Russian Federation] may be performed only on condition that a positive State Environmental Expert Review (SEER) conclusion is obtained. This involves submission of documentation on impact assessment and measures for environmental protection to authorities for their review and approval.

In line with Russian Federation (RF) legislation, Sakhalin Energy's *Procedure for Impact Assessment* requires all seismic surveys planned and conducted by the Company to undergo full impact assessment. The impact assessment process laid down in Sakhalin Energy's

[12] WGW is listed as a critically-endangered population by the IUCN, and as a Category I species in the Red Book of the Russian Federation

[13] http://www.sakhalinenergy.ru/en/documents/4_Project_Expansion_HSE_Procedure_E.pdf

procedure is aligned with the relevant World Bank / IFC guidance, as per Company's *International Requirements for Managing Risk*[14] under the HSESAP.

Thus, for the South Piltun site survey, Sakhalin Energy is required to submit EIA report(s) conforming to RF regulatory requirements to RF authorities for their review and decision, and a separate report conforming to international requirements to the Lenders' Consultant for their review and comment. Since the terms of reference differ, the reports vary in structure and content; however, these differences are not material to the general conclusions.

1.3 Scope of the EIA

The scope of an EIA is defined by the interaction between survey activities and environmental receptors, both spatially and temporally. Environmental issues associated with marine seismic surveys have been widely documented in Environmental Assessments (for example, see SEIC 2003, 2010; L-DEO and NSF 2006; LGL 2003; LGL et al. 2005; MMS 2005, 2006a, 2006b, 2007; UTA and NSF 2006; also see references in Southall et al. 2007 and Chapter 6 of this report). In scoping this impact assessment, the following key issues have been considered:

- Disturbance and injury to marine mammals;
- Disturbance to marine invertebrates, fish and birds;
- Effluent discharge, emissions, and waste disposal;
- Accidental spills, leaks, and dropped objects; and
- Interaction with other users of the area.

The EIA focuses on survey activities that have the potential to result in significant impacts on valued ecosystem components (VECs), and on identifying appropriate measures to avoid and/or minimize those impacts to "as low as reasonably practicable" (ALARP). Activities that may result in minor or negligible impacts will be discussed only briefly. Guidelines of the World Bank (World Bank 1991) and the International Finance Corporation (IFC 2007) have been considered in the preparation of this EIA.

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[14] http://www.sakhalinenergy.ru/en/documents/3_International_Requirements_for_Managing_Risk.pdf

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2 LEGAL AND ADMINISTRATIVE FRAMEWORK

Policies, regulatory instruments, guidelines, and industry standards considered during the planning of the South Piltun Site Survey included:

- Sakhalin Energy's HSE Policy and related standards, procedures and guidelines;
- Relevant international environmental laws and conventions;
- Terms and conditions of the Piltun-Astokh oil and gas field development plan under the Production Sharing Agreement (PSA) between the Government of the Russian Federation and Sakhalin Energy;
- Relevant requirements of the Russian Federation and Sakhalin Oblast environmental legislation;
- International guidelines for impact assessment (World Bank 1999; International Finance Corporation 2007); and
- International environmental, health, and safety guidelines for offshore oil and gas development.

2.1 Sakhalin Energy's HSE Policy, Standards, and Procedures

Sakhalin Energy's General Business Principles state that the company will manage HSE matters as it does any other critical business activity. This is reflected in Sakhalin Energy's HSE Policy and Commitment (Table 2-1), which is the highest-level document in the company's HSE-MS.

The HSE-MS applies to all operations and activities under the direct management control of Sakhalin Energy. It provides a structured framework to ensure that company operations and activities are performed in accordance with legal and other requirements, whilst encouraging continual improvement in HSE performance. Successful implementation of the HSE-MS requires sufficient resources (human, physical and financial), standards that prescribe minimum performance requirements, procedures and work instructions to achieve those standards, clearly defined roles and responsibilities, and personnel and contractors who are competent to fulfil those responsibilities.

The proposed site survey falls under the scope of the HSE-MS and will therefore be carried out in accordance with Sakhalin Energy's Health, Safety, Environmental and Social Action Plan[15], Marine Operating Procedures and Guidelines, Marine Mammal Protection Plan, and its environmental standards including, but not limited to:

- Air emissions;
- Energy management;
- Water use and discharges;
- Waste management and minimisation; and
- Biodiversity.

[15] http://www.sakhalinenergy.ru/en/library.asp

Table 2-1.Sakhalin Energy's HSE Commitment and Policy

Sakhalin Energy Investment Company
Commitment to Health, Safety and the Environment

We are all committed to:

- Pursue the goal of no harm to people;
- Protect the environment;
- Use material and energy efficiently to provide our products and services;
- Develop energy resources, products and services consistent with these aims;
- Publicly report on our performance;
- Play a leading role in promoting best practice in our industries;
- Manage HSE matters as any other critical business activity;
- Promote a culture in which all Sakhalin Energy employees share this commitment.

In this way, we aim to have HSE performance we can be proud of, to earn the confidence of customers, shareholders and society at large, to be a good neighbour and to contribute to sustainable development.

Sakhalin Energy Investment Company
Health, Safety and Environment Policy

The Company:

- Has a systematic approach to HSE management designed to ensure compliance with the law and to achieve continuous performance improvement;
- Sets targets for improvement and measures, appraises and reports performance;
- Requires contractors to manage HSE in line with this policy;
- Will use its influence to promote this or an equivalent policy in company related activities which are not under its direct control;
- Includes HSE performance in the appraisal of all staff and rewards accordingly.

2.2 International Legislation, Standards and Guidelines

This section provides a summary of international legislation and industry standards and guidelines relevant to the proposed seismic survey.

2.2.1 International Conventions and Treaties

There are a number of international environmental conventions and treaties applicable to offshore seismic acquisition. The registration country of the contracted seismic survey vessel may also determine which conventions and treaties are applicable to the programme. The seismic contractor is expected to comply with all applicable statutes in the following international conventions and treaties (listed in order of their date of ratification):

- International Convention for the Prevention of Pollution of the Sea by Oil (1954) as amended (1962, 1969);
- Convention on the Continental Shelf (1958);
- Convention on the Territorial Sea and the Contiguous Zone (1958);
- Convention for the International Council for the Exploration of the Sea (1964);
- International Convention on Civil Liability for Oil Pollution Damage (1969) as amended;
- Convention on Wetlands (1971);
- International Convention on the Establishment of an International Fund for Compensation for Oil Pollution Damage (1971);
- Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (London Convention) (1972);
- Convention on the International Regulations for Preventing Collisions at Sea (1972);
- International Convention for the Prevention of Pollution from Ships (MARPOL) (1973) as amended;
- Convention Concerning the Protection of Workers Against Occupational Hazards in the Working Environment Due to Air Pollution, Noise and Vibration (1977);
- International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (1978) as amended;
- Convention on the Conservation of Migratory Species of Wild Animals (1979);
- International Convention on Long Range Transboundary Air Pollution (1979);
- United Nations Convention on the Law of the Sea (UNCLS) (1982);
- Convention on Conditions for Registration of Ships (1986);
- International Convention Relating to Intervention on the High Seas in Cases of Oil Pollution Casualties (1987);
- Montreal Protocol on Substances that Deplete the Ozone Layer (1987);
- International Convention on Oil Pollution Preparedness, Response and Co-Operation (1990);
- International Convention on Environmental Impact Assessment in a Transboundary Context (1991);
- European Convention on the Protection of Archaeological Heritage (1992);
- United Nations Framework Convention on Climate Change (1992);
- Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal (1992);
- Convention on Biological Diversity (1992); and
- International Convention on Liability and Compensation for Damage in Connection with the Carriage of Hazardous and Noxious Substances by Sea (1996).

2.2.2 International Standards and Guidelines

International financiers, commercial banks and export credit agencies are increasingly emphasizing good environmental performance in their covenants for lending. A number of financial institutions, including the World Bank (WB) and the International Finance Corporation (IFC), have developed safeguard policies, guidelines and compliance requirements on social as well as environmental management and protection issues (World Bank 1991; IFC 2007a). As a company committed to high levels of corporate governance and sustainable business, Sakhalin Energy is guided by the following international standards and guidelines in conducting this EIA and in developing HSE performance requirements for the seismic survey:

- International Association for Impact Assessment (IAIA) Principles of Environmental Impact Assessment, 1999;
- WB Environmental Assessment Sourcebook, 1991 (and updates);
- WB Pollution Prevention and Abatement Handbook, 1998;
- IFC's Performance Standards on Social & Environmental Sustainability, 2006;
- IFC's Guidance Notes: Performance Standards on Social & Environmental Sustainability, 2007b;
- IFC and WB Environmental, Health, and Safety General Guidelines, 2007c;
- IFC and WB Environmental, Health, and Safety Guidelines for Offshore Oil and Gas Development, 2007a; and
- International Association of Geophysical Contractors (IAGC) Environmental Manual for Worldwide Geophysical Operations, 2001.

Moreover, various organisations have established standards and guidelines for the protection of marine resources that are relevant to the Astokh survey:

- Joint Nature Conservation Committee (JNCC) Guidelines for Minimising Acoustic Disturbance to Marine Mammals from Seismic Surveys, 1998; and the associated Guidance Note for Minimising Acoustic Disturbance to Marine Mammals from Seismic Surveys, 2000;
- Standards of the International Maritime Organisation (IMO) relating to the prevention and control of oil pollution by vessels; and
- The World Conservation Union (IUCN) relating to biodiversity protection and the identification and classification of threatened species (IUCN Red List of Threatened Species, 2007). The IUCN also serves as an advisory authority through the auspices of the Western Gray Whale Advisory Panel (WGWAP).

2.3 Production Sharing Agreement

The Sakhalin-II Production Sharing Agreement (PSA) between the Russian Federation (RF) and Sakhalin Energy is the legal basis for the development of the Piltun-Astokh oil field. The PSA was concluded in June 1994, before the enactment of the Federal Law "On Production Sharing Agreements" of 30 December 1995 No. 225-FZ (as amended, the "PSA Law"). Although the PSA Law came into force after the original PSA agreement between the RF and Sakhalin Energy, the PSA Law contains relevant clauses in its Article 2.7, and Sakhalin Energy is committed to the development of the PSA License Areas (including the Piltun-Astokh area) in compliance with the requirements stated below:

> *"The works under the agreement shall be accomplished in compliance with requirements of the legislation of the Russian Federation … concerning the safe conduct of works, and protection of the subsoil, the natural environment and the health of the population. In this respect, the agreement shall stipulate the investor's obligations for taking of measures aimed at preventing harmful effects of*

the said works on the natural environment, as well as to eliminate the consequences of such effects."

The PSA agreement states that the Sakhalin Project shall be implemented in accordance with laws, regulations, decrees, and other governmental acts applicable to the territory of the RF, officially enacted, and publicly available. Activities under the PSA will be conducted in accordance with environmental standards that are defined in the PSA as:

"design, construction and operation codes, standards and industry practices, and environmental, health, and safety norms, policies, and practices, generally accepted in the international oil, gas, pipeline, and LNG industries."

2.4 Russian Federation Legislation

2.4.1 Federal Legislation

The Russian Federation has defined a number of requirements for the management of resources and the protection of flora and fauna, and establishes liability for damage to protected species and to their living environment. The following documents provide the basis for these requirements:

- Federal Law "On Protection of the Environment," 10 January 2002, No. 7-FZ affords protection to "elements of nature" including state natural reserves and parks, natural monuments, objects or species that are of special nature conservation, scientific, historic, cultural, aesthetic, recreational, sanitary, or other importance, rare soils, vegetation, animals, and other organisms and their habitats, the continental shelf and offshore economic zone of the RF, as well as traditional places of residence and economic activity of the indigenous nations of the RF;
- Federal Law "On Wildlife," 24 April 1995, No. 52-FZ;
- Federal "Water Code of the Russian Federation," 03 June 2006, No-74-FZ (the "Water Code");
- Federal Law "On Air Protection," May 4, 1999, No. 96-FZ;
- Federal Law "On Specially Protected Natural Areas," 14 March 1995, No. 33-FZ defines special requirements that apply to operational activities on protected sites;
- Federal Law "On the Continental Shelf of the Russian Federation," 30 November 1995, No. 187-FZ;
- Federal Law "On the Maritime Waters, Territorial Seas and Contiguous Zone of the Russian Federation," 31 July 1998, No. 155-FZ;
- Federal Law "On Exclusive Economic Zone of the Russian Federation," 17 December 1998, No. 191-FZ;
- Federal Law "On Ecological Expert Review," 23 November 1995, No. 174-FZ defines the process for realisation of a planned economic activity within environmental constraints;
- Order No. 372 of 16 May 2000 that approves *Regulations on Assessment of Environmental Impact of Planned Business- and Other Activities in the Russian Federation*. Sections III and IV of the said Regulations contain the requirements for ensuring public awareness and participation in EIA and holding public consultations.
- Order of the RF State Committee of Environment Protection "On validation of the Resolution for Environmental Impact Assessment on Planning Economic or Other Activities in the Russian Federation," 16 May 2000, No. 372.

This regulatory framework also provides for the creation of the "Red Book" (Resolution of the RF Government "On the Red Data Book of the Russian Federation," 19 February 1996, No. 158), which lists protected plants and animals. Under Russian Federation law, the economic use of any species identified in the Red Book is not allowed. Any activity that may cause the death, reduction in numbers, or deterioration of the living environment of a species identified in the Red Book is also prohibited.

The Red Data Book of the Russian Federation (Iliashenko and Iliashenko 2000) provides an assessment of the rarity and status of native species, grouped within the categories outlined below:

- Category 0: represents species that inhabited RF territory in the past, but whose presence has been unconfirmed for the last 50 years and the species is viewed as probably extinct;
- Category 1: represents endangered species whose abundance has decreased to critical levels, where they are considered to be under threat of extinction in the near future;
- Category 2: represents vulnerable species whose numbers are constantly decreasing and that could be moved to Category 1 in the near future;
- Category 3: represents rare species where population numbers are low and the species inhabits a limited territory or is sporadically distributed over a larger area;
- Category 4: represents species of uncertain status that have small populations where detailed information on population numbers is difficult to estimate;
- Category 5: represents rehabilitated and rehabilitating species whose numbers and distribution has recovered or is recovering due to adopted protective measures. Category 5 species are considered to be close to stable and require no additional urgent measures to ensure their survival.

A Red Book has been developed specifically for Sakhalin (Law of the Sakhalin Region "On the Red Book of the Sakhalin Oblast," 16 March 1999), and a Commission has been established for the conservation of rare and endangered species of animals, plants and mushrooms.

Several RF laws pertain to social welfare and the protection of human health; those relevant to the site survey include:

- Federal Law "On the Guarantees of Rights of Indigenous Ethnic Minorities in the Russian Federation," 30 April 1999, No. 82-FZ; and
- Federal Law "On Territories of Traditional Use of Natural Resources by Ethnic Minorities of the North, Siberia, and Far East of the Russian Federation," 7 May 2001, No. 49-FZ.

2.4.2 Regional Legislation of the Sakhalin Oblast

Any activity undertaken within the Sakhalin Oblast must comply with the requirements of the following laws, regulations and decrees:

- Sakhalin Oblast Law "Regulations of the Sakhalin Oblast," amended 1 April 2008, No.270 that states basic principles of environmental management;
- Sakhalin Oblast Law "On Development of Specially Protected Natural Territories of Sakhalin Oblast," 21 December 2006, No. 120-FZ that regulates the establishment, protection, and use of specially protected natural territories of the Sakhalin Oblast and defines the economic activities permissible within these sites;
- Sakhalin Oblast Law "On the Red Book of the Sakhalin Oblast," amended 28 December 2007, No. 131-OL provides for the regional Red Data Book that regulates activities related to the protection and preservation of endangered species;
- Decree of the Governor of Sakhalin Oblast "On initiation of the regulation procedure on the use of water biological resources that are allotted for Sakhalin Oblast in accordance with established procedures," dated 12.10.2001, No.392;
- Resolution of the Governor of Sakhalin Oblast "On establishment of the coefficient for

indexing charges and wages for pollution of the environment," dated 27.12.2000, No. 479-r;

- Decree of the Governor of Sakhalin Oblast "On the approval of the list of wildlife objects listed in the Red Book of Sakhalin Oblast," dated 29.05.2000, No. 230;
- Point 8 of the Decree of the Governor of Sakhalin Oblast "On the provisions for the utilization of water bodies of Sakhalin Oblast," dated 17.06.1998, No. 252 (updated 17.07.2003, No.38), and
- Decree of the Governor of Sakhalin Oblast "On Actions for the Creation of the Conditions for Preservation of Traditional Modes of Living and Development of Traditional Branches of Economy of the Indigenous Population of the North," 2 March 2001, No. 99.

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3 DESCRIPTION OF SITE SURVEY

3.1 Introduction

This chapter provides context to oil and gas developments in the Sakhalin region as a background to Sakhalin Energy's motivation for the high-resolution 2D seismic acquisition, seabed survey data acquisition, and geotechnical coring activities (together referred to as "site survey"). In addition, a description of proposed survey activities is provided and the main sources of potential environmental impact are introduced.

3.2 Sakhalin Island Oil and Gas Resources[16]

Russia is the largest producer in the world, following Saudi Arabia's OPEC-induced cuts in 2009/2010. It also boasts the world's largest commercial gas reserves and is the second largest global gas producer, behind the oil US.

Population	140 million (2011)
Liquid Reserves (Remaining)	94.62 billion barrels (1/1/2011)
Liquid Production	10457 thousand b/d (2011)
Liquid Reserves/Production	24.8 years
Gas Reserves (Remaining)	808.67 tcf (1/1/2011)
Gas Production	64.63 bcf/d (2011)
Gas Reserves/Production	34.3 years

Source: Wood Mackenzie

Russia has around 2,600 oil and gas fields, of which about 1,800 are oil fields, 400 oil and gas fields and nearly 400 gas fields. Wood Mackenzie estimates that Russia has remaining commercial reserves of 95 billion barrels of liquids and 810 tcf of gas at 01/01/11, based on fields which are currently onstream, under development or being actively worked on by participants. Beyond that, Russia has massive reserves which have been classified by Wood Mackenzie as technical (i.e. with no current development plans in place and/or significant uncertainty over development plans and timing). Wood Mackenzie estimate Russia's technical reserves at 65 billion barrels of liquids and 623 tcf of gas. Moreover, there is extensive 'yet-to-find' potential throughout the country.

In 2009 Russia became the world's largest oil producer and maintained this position throughout 2010-2011. In 2010, oil production grew by 2.8% to 10.1 million b/d. In 2011, the rate of production increase slowed down to 1.3% with an average output of 10.23 million b/d. In March 2012, Russia reached production of 10.36 million b/d.

Sakhalin Island, off Russia's Far Eastern coast has oil reserves estimated at 12 billion barrels and natural gas reserves estimated at approximately 90 trillion cubic feet (Energy Information Administration 2007). The island is surrounded by a number of license blocks; those that have been awarded are designated Sakhalin I through Sakhalin VI. Of these, only Sakhalin I and Sakhalin II have progressed to production (Figure 3-1).

[16] Wood Mackenzie Country Overview April 2012

3.2.1 Sakhalin 1

The Sakhalin I project began in 1975 with the discovery of the Chaivo and Odoptu fields. Further exploration identified the Arkutun-Dagi field that was incorporated into Sakhalin I. In 1995, the Sakhalin I consortium was formed between two Rosneft subsidiaries (viz. Sakhalinmorneftegaz and RN Astra), SODECO, ONGC Videsh, and Exxon Mobil, with Exxon Neftegaz Limited (ENL) as the field operator. The first phase of this project comprised the development of the Chaivo field, with subsequent phases involving development of the Odoptu and Arkutun-Dagi fields.

Commercial production began in the Chaivo field in October 2005, and by February 2007 the field was producing around 250,000 bbl/d of oil and 140 mcf of natural gas. Production is fed to the port of DeKastri, where natural gas enters the Russian distribution network, and crude oil is exported to international markets, mainly in East Asia.

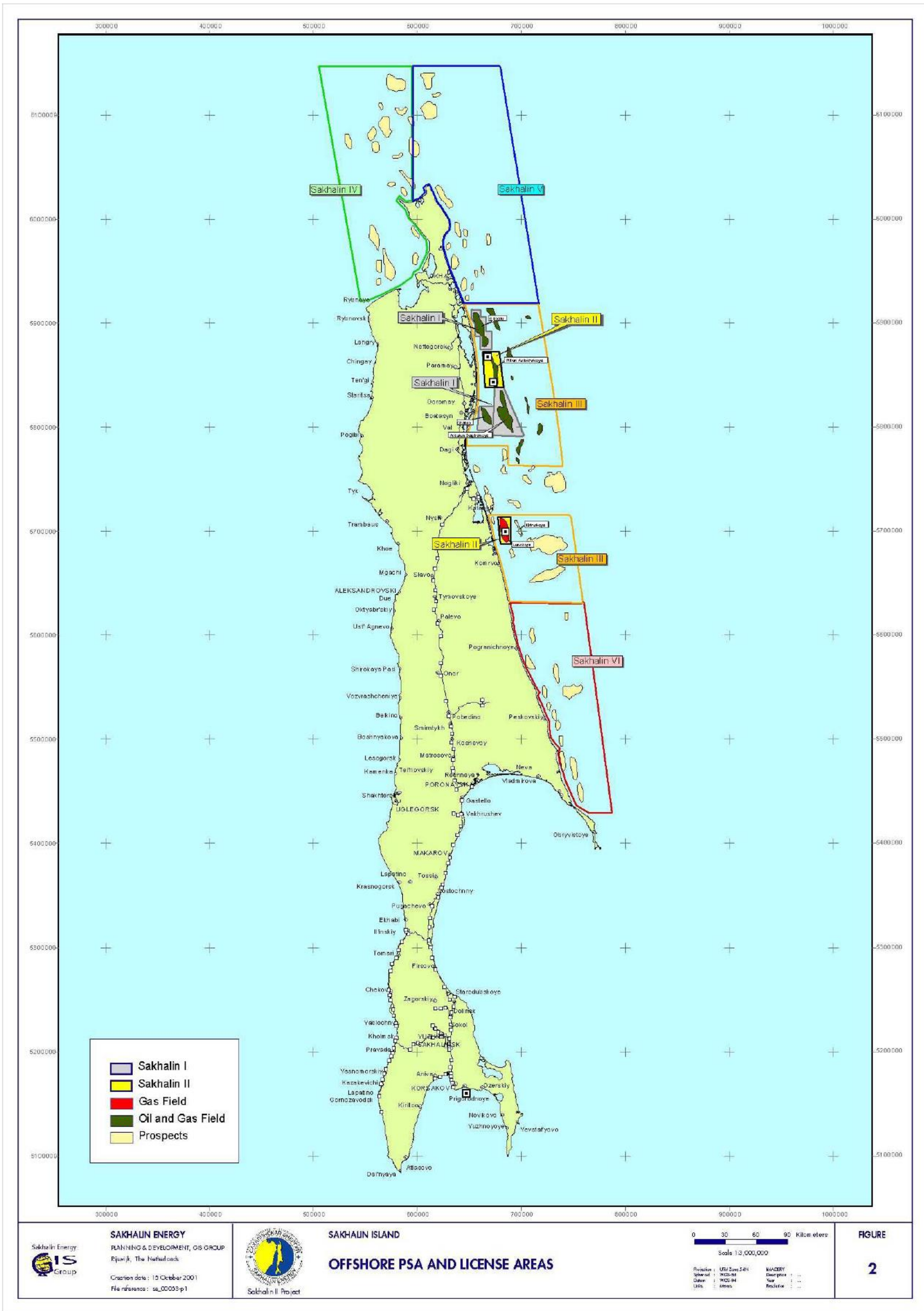


Figure 3-1. Map of offshore oil and gas concessions, Sakhalin Island

3.2.2 Sakhalin 2

The Sakhalin 2 project was initiated in 1991, when the Russian Federation and Sakhalin Oblast Administration invited international companies to tender proposals for the development of the Piltun-Astokhskoye and Lunskoye fields. The tender was won by a consortium comprising the Marathon Oil Company, McDermott, and Mitsui, and was later joined by Royal Dutch Shell and Mitsubishi. In 1994, the consortium established the Sakhalin Energy Investment Company (Sakhalin Energy) to oversee the development. In the same year, Sakhalin Energy signed a Production Sharing Agreement (PSA) with the Russian Federation.

In 1997, McDermott sold their share in the project to the remaining shareholders, and in 2000, Shell took over Marathon Oil's share. In February 2007, Gazprom purchased 50 percent plus one share in Sakhalin Energy. The current consortium comprises Gazprom (50 percent plus one share), Royal Dutch Shell (27.5 percent, less one share), Mitsui (12.5 percent), and Mitsubishi (10 percent).

The Sakhalin 2 development has progressed in phases. Phase 1 involved the Piltun-Astokh-A (PA-A, or 'Molikpaq') platform and associated tankering facilities (now discontinued). Phase 2 of the project (including PA-B and LUN-A platforms, the Onshore Processing Facility, the pipeline system, LNG Plant, and offshore Tanker Loading Unit) allowed all year round production from both the Piltun-Astokhskoye and Lunskoye fields.

In July 2005, SEIC estimated that Sakhalin II's recoverable reserves were 17.3 Tcf of natural gas and one billion barrels of liquids. During Phase 1, the project produced around 80,000 bbl oil per day during the ice-free summer months; since commissioning of Phase 2, the project has been producing approximately 60 cargos of oil (each 700,000 bbl) per year and 150 cargos of LNG (each 145,000 m^3 produced gas) per year.

3.2.3 Other Sakhalin Projects

Sakhalin III comprises four blocks and is believed to contain 5.1 billion barrels of oil and 46 Tcf of natural gas. The Ayashsky, Kirinksky, and East Odoptu blocks had been held by an Exxon Mobil-led consortium, but that tender was cancelled by the Russian Federation in January 2004. A Rosneft-Sinopec consortium is planned to develop the fourth block (Veninsky) within Sakhalin III, while Gazflot (a Gazprom subsidiary) is appraising the structures in the Kirinksky block.

The Sakhalin IV blocks (Pogranichny and Okruzhnoye) have reserves estimated at 880 million barrels of oil and 19 Tcf of natural gas. The primary project developers are BP (49 percent) and Rosneft (51 percent). Exploratory drilling and 3-D seismic exploration has taken place within these blocks.

Sakhalin V (Kaigansko-Vasyukansk) has estimated reserves of 4.4-5.7 billion barrels of oil and 15.2-17.7 Tcf of natural gas. The primary project developers are Elvary Neftegaz Limited (a subsidiary of BP) (49 percent) and Rosneft (51 percent). Exploratory drilling and 3-D seismic surveys have also been conducted within the license area.

GazpromNeft has an exploration licence for the Lopukhovsky block (located between Sakhalin IV and Sakhalin V) with forecasted reserves of about 800 million barrels of oil. Sakhalin VI (Pogranichny) has estimated reserves of 600 million barrels of oil. The primary project developers are Petrosakh and Alfa Eco. Three blocks in the Sakhalin VI license area have still to be awarded.

3.3 Motivation for South Piltun Site Survey

The motivation for the site survey pivots on the results of Sakhalin Energy's ongoing studies to potentially develop untapped oil and gas accumulations in the South Piltun structure located in Sakhalin Energy's Piltun-Astokhskoye license area.

3.3.1 Ongoing Studies to Develop the South Piltun Area

Sakhalin Energy is evaluating the possible development of the South Piltun oil and gas accumulation, located in the central part of the Piltun-Astokh (PA) field, between Sakhalin Energy's PA-A and PA-B platforms, in their concession on the northeast coast of Sakhalin Island.

Oil and gas production from the PA field is limited to reserves that are accessible from the existing southern and northern platforms (*viz*. PA-A and PA-B, respectively). Sakhalin Energy is now undertaking subsurface and engineering studies to determine technically-feasible and commercially-viable development plans for the central oil and gas accumulation – the South Piltun field – in the Piltun-Astokh area.

A feasibility study was carried out, and is followed by a concept select phase (mainly engineering studies). The results of these studies will be reported, when completed, as part of the Impact Assessment (IA) for the overall South Piltun field development. The range of development options being assessed includes an additional platform located between the existing PA-A and PA-B facilities, referred to as PA-C.

The site survey is required to provide essential data for these engineering studies, Russian Federation Project approvals, and the future IA for the field development. The survey will provide:

- High-Resolution (HR) and Ultra-High-Resolution (UHR) 2D seismic data for evaluation of shallow gas hazards for locating a platform;
- Seabed surveys to identify seabed hazards in the vicinity of the potential platform and along the required pipeline routing;
- Geotechnical coring to determine seabed properties for platform structural design calculations.

The following sections describe these objectives for the survey in more detail.

3.3.2 Location for Potential Platform "PA-C"

As part of ongoing evaluation, Sakhalin Energy has identified at least two potentially suitable locations for a new (potential) PA-C platform in the South Piltun, based on the following key considerations:

a. All subsurface targets for well trajectories need to be in drilling reach of the platform, within achievable technical specifications and without excessive safety risk of drilling hazards due to long-reach wells;

b. The platform locations and the drilling trajectories must be safe in particular with regards to the presence in pockets of shallow gas and shallow layers beneath the seabed filled with gas. Drilling operations through those shallow gas accumulations has caused repeatedly in the industry well control incidents with loss of human life, platform destruction and severe environmental pollution.

Identified notional location for the PA-C platform are in water depths between 30 m and 40m.

Sakhalin Energy examined available seismic data for evidence of shallow gas in the South Piltun area; a complete set of 3D seismic data was acquired for the whole Piltun-Astokh license area by *Nordic Explorer* during July – August 1997.

Sakhalin Energy felt that the 1997 3D seismic data were sufficient to give an indication of gas in strata deeper than 200 m. They used these data to identify likely accumulations of shallow gas – presenting an unacceptable hazard to structures that might be placed in this area – along the crest of the South Piltun structure (Figure 3-2 and Figure 3-3). Reservoirs as shallow as 250 m below sea level are filled with gas, which migrated upwards along faults seen on the 3D seismic. Options of locating the planned platform at this zone where the shallow gas hazard is severe were therefore rejected, and the preferred location was established.

3.3.3 Need for High-Resolution 2D Seismic Data

The 1997 3D dataset was acquired at a spacing of 300m between sail lines, in water of 30 to 50 m deep. While this line spacing is considered sufficient to examine strata deeper than 200 m, it is too coarse to cover the very shallow subsurface; gaps in the illumination occur, visible as jitter at the sea bed in Figure 3-3 and as white stripes in Figure 3-4. Consequently, the 1997 seismic data are not sufficient to assess the risk of shallow gas in strata between seabed and a depth of approximately 200 m. High-resolution 2D seismic is therefore needed, acquired with a finer spacing of 50 - 100 m between neighbouring sail lines. The acquisition of a high-resolution 2D seismic data is mandatory by Russian Federation legislation and is International Oil Industry standards. Its main purpose is to minimize the risk of locating a platform above a shallow gas accumulation.

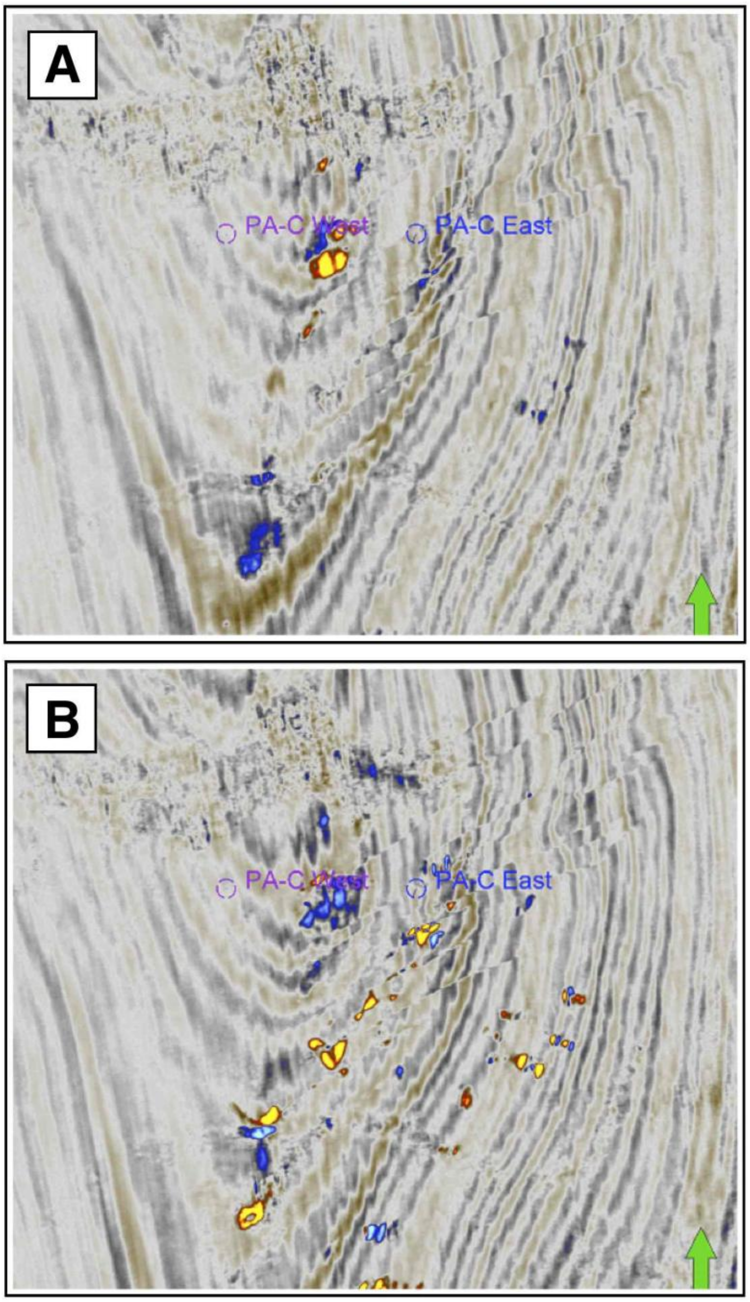


Figure 3-2. **Time slice (data at equal time) through the 1997 PA 3D seismic data (A) at 276 ms TW, or about 250 m depth below sea level, and (B) at 296 ms TWT, or about 265 m depth below sea level. The brown and white colours represent reflections of seismic waves at acoustic interfaces of a normal shale/sand sequence. Blobs in yellow/red and blue are indicative of shallow gas accumulations. Sharp lines in the data (mostly in N55°E direction) are expression of faults. (North is to the top).**

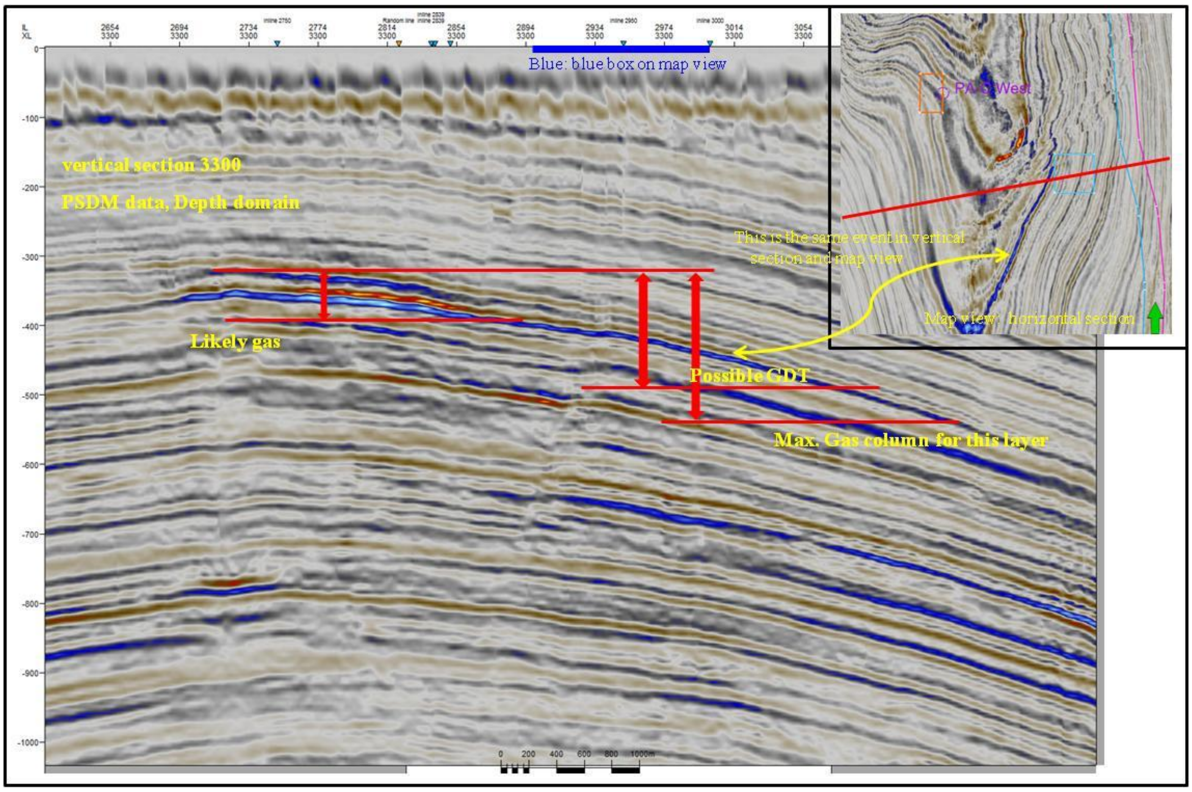


Figure 3-3. Vertical seismic section (WSW->ENE) at the potential PA-C platform location through the existing Piltun-Astokh 3D seismic data after PSDM reprocessing. Vertical axis is depth is in ms below sea level, horizontal scale as per scale bar. The location of the potential platform is indicated in blue. The inset shows the general South Piltun structure on a horizon slice at reservoir level. Shallow gas is visible in isolated pockets and in shallow reservoirs with bright yellow/orange and blue colours to the West of the planned location, at the crest of the South Piltun structure.

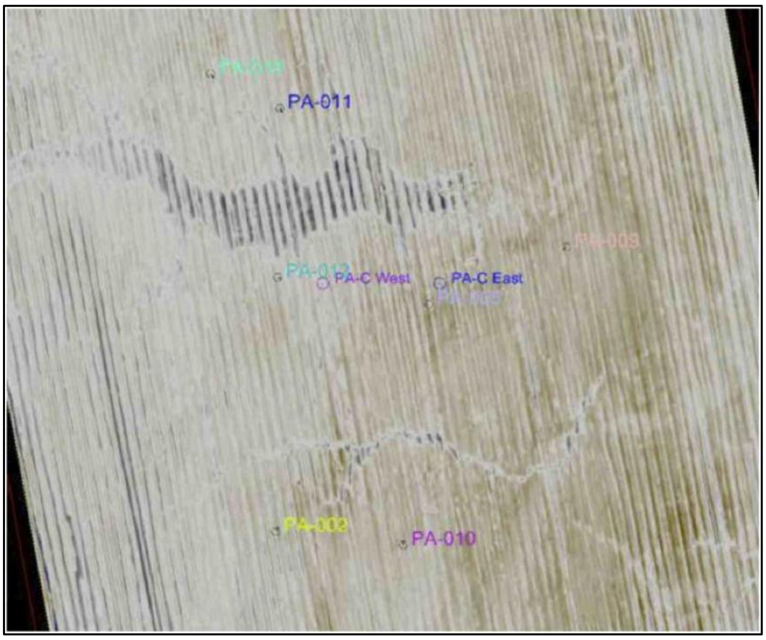


Figure 3-4. Time slice (data at equal time) through the 1997 PA 3D seismic data

at about 50 m depth. The white stripes correspond to area of no coverage. The brown and white colours represent reflections of seismic waves at acoustic interfaces of a normal shale/sand sequence. One large and some smaller channels are visible. (North is to the top).

3.3.4 Need for Seabed Survey Data

Once it is acquired, evaluation of the HR and UHR 2D seismic data will allow Sakhalin Energy to either (a) confirm that the nominal location of the potential PA-C platform is suitable with respect to shallow gas hazard, or (b) identify an alternative, safer location. Thereafter, seabed survey data is required for a smaller area, 2 km x 2 km, with the updated platform location at its centre. The seabed survey data will allow Sakhalin Energy to assess the seabed for obstacles. Acquisition and analysis of this survey data is mandatory according to Russian Federation legislation, not only at the potential platform location, but at all locations of possible infrastructure, i.e. routes of eventual pipelines. The seabed survey data will allow Sakhalin Energy to confirm the potential platform location, or to update the location again using both HR 2D seismic and seabed survey data sets.

3.3.5 Need for Geotechnical Data

Once the location of the potential PA-C platform has been determined, as described in §3.3.3 and §3.3.4, the strength of the substrate needs to be tested to assess if it can support an eventual platform, and to further inform design criteria. For this, samples of the seabed and shallow sub-strata need to be taken in a pattern specific to the selected platform concept. This geotechnical data is an absolute requirement for the proper design of the potential PA-C platform, and is mandatory by Russian Federation law and by international standards for engineering design.

3.4 Motivation for Relief Wells Site Surveys

The main focus of this EIA Report is the South Piltun Site Survey. However, Sakhalin Energy recently proposed to use the opportunity to also acquire high-resolution 2D seismic survey data for relief wells for existing platform sites.

In the very unlikely emergency event in which well control failure occurs in any of the producing oil or gas wells, in conjunction with inaccessibility of the respective producing platform (PA-A, PA-B, LUN-A), a Jack-Up rig may be required to drill emergency relief wells to intersect the faulty well in a section as close as possible above the producing reservoirs.

The locations for potential emergency relief wells also need to be surveyed for shallow gas hazards, seabed obstacles, and seabed strength, using exactly the same methods as for the South Piltun site survey. Sakhalin Energy has determined that two independent locations per platform should be surveyed for possible usage as drilling locations for relief wells.

3.5 Survey Methodology

This section describes the overall scope, methodology, timeline and relevant technical details of the site survey.

3.5.1 Overall Activities of the Site survey

The full list of field activities (South Piltun and Relief Wells) to be conducted in relation to site survey in summer 2012 contains the following elements:

a. High-Resolution (HR) 2D seismic and Ultra-High Resolution (UHR) 2D seismic

around the PA-C proposed platform location at the locations of two relief wells for the PA-A (Molikpaq) platform17

b. Onshore behaviour monitoring of gray whales before, during and after the HR / UHR seismic

c. Passive monitoring of the seismic-generated sound levels in the sea with 2 acoustic buoys before, during and after the HR / UHR seismic

d. Seabed survey measurements

Around the potential PA-C platform location (updated after evaluating the HR / UHR seismic)
At the locations of 2 relief wells each for the PA-A, PA-B and LUN-A platforms
Along the potential pipeline route(s)

e. Soil investigation (geotechnical coring)

At the PA-C proposed platform location (updated after evaluating the HR seismic)
At the locations of 2 relief wells each for the PA-A, PA-B and LUN-A platforms

f. Soil investigation (shallow soil sampling to 3 m depth) along the proposed pipeline route

g. Environmental monitoring

Along the proposed pipeline route from PA-C to the processing point for the oil and gas from South Piltun
Optional: At the PA-C proposed platform location[18]

h. Installation of sea and ice current meters at proposed PA-C platforms for Metocean data collection, if required[19]

[17] During design and construction of Sakhalin 2 Phase 2 Project, Sakhalin Energy acquired high resolution 2D seismic data for areas around PA-B and LUN-A platforms; thus HR 2D seismic data are not required for these relief well locations. However, Sakhalin Energy does not have the necessary HR 2D seismic data for Phase 1 (Molikpaq), which was not part of the data received from Marathon.

[18] Sakhalin Energy completed environmental baseline monitoring (benthos, sediment, and water characterisation) at the nominal PA-C location in 2010. Environmental baseline monitoring only needs, in terms of RF requirements, to be repeated in 2012 if the final platform location is substantially different to the current, notional location.

[19] Only after Sakhalin Energy has selected the concept for a potential platform at the PA-C location, can a decision be made whether continuous sea and ice current measurements are required for the future platform design. If required, Sakhalin Energy will install respective metering systems at both neighbouring PA-A and PA-B platforms.

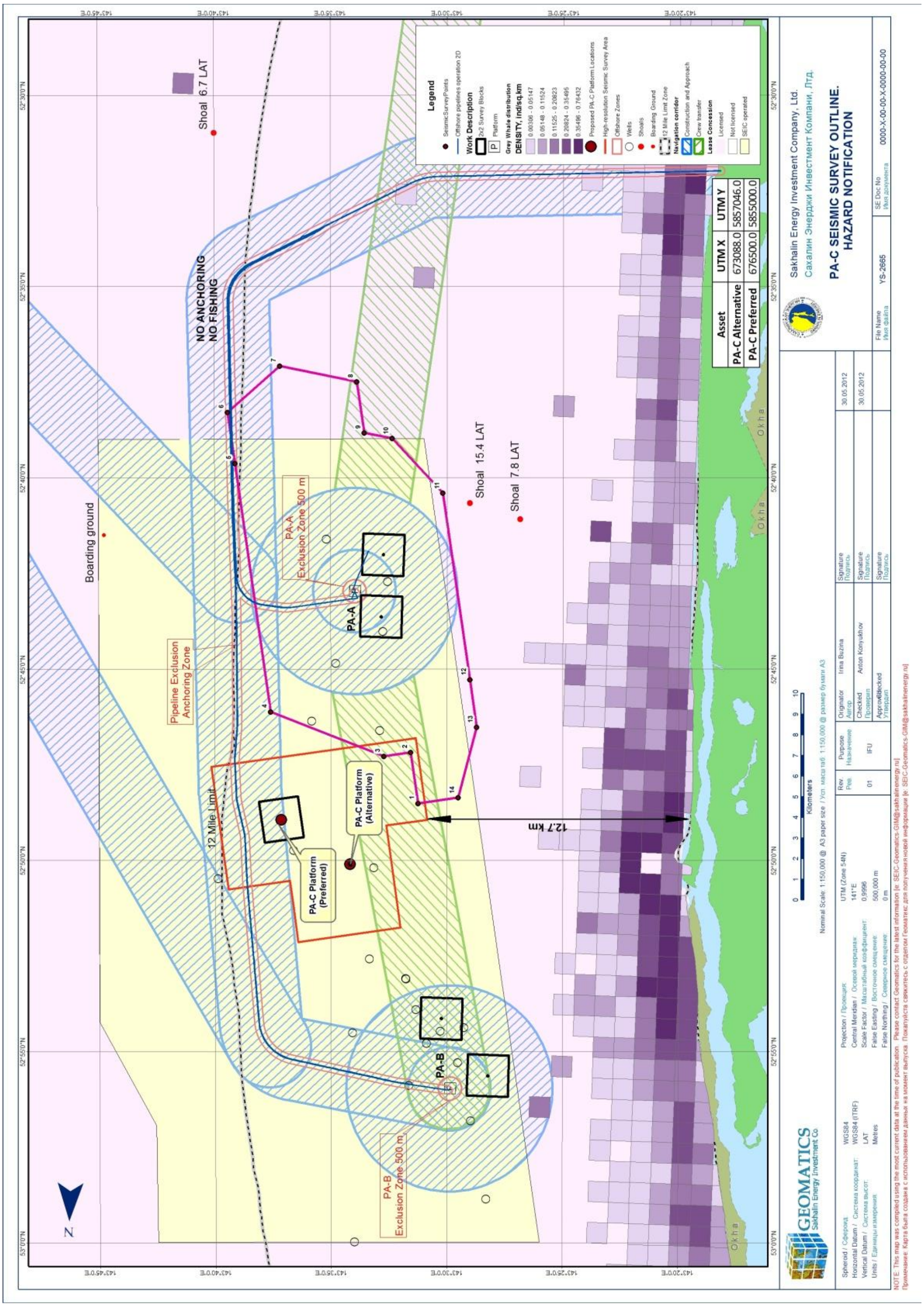


Figure 3-5. Location of the site survey. The outline of the planned HR 2D seismic is shown as red outline area, centred at the nominal location of the possible PA-C platform. Stations of the environmental baseline survey carried out in 2010 are given as black dots. For comparison, the outline of the Astokh 4D seismic survey acquired in 2010 is given in purple.

3.5.2 Location of Activities

Figure 3-5 provides an overall map of the locations of planned activities in relation to the Gray Whale feeding area. The main area of activities for the site survey is polygon (comprising some 627 line km) located in the South Piltun area, to the north of the Astokh field and to the south of the Piltun field. The boundary of the acquisition area for the South Piltun high-resolution 2D seismic is defined by the following UTM coordinates (UTM54N, WGS84):

Easting (m)	Northing (m)
675458.111	5860908.847
675979.055	5857954.423
678933.479	5858475.368
679975.368	5852566.521
670127.290	5850830.040
669432.698	5854769.271
671402.313	5855116.567
670534.072	5860040.606

The area of vessel activity will extend several kilometres beyond the actual survey acquisition area to accommodate for the required line turns; all other marine activities listed in §3.5.1 and related to the South Piltun site survey are carried out in the area given above. Figure **3-7** shows the location of the UHR 2D survey area within the South Piltun HR area.

Figure 3-9 shows the location of HR 2D acquisition lines for two Molikpaq relief wells, while Figure 3-10 shows planned seabed surveys of alternative pipelines routes. These are further discussed in the following sections.

Other activities associated with relief well location surveys for PA-A, PA-B and LUN-A are located in the vicinity of those platforms.

3.5.3 High-Resolution and Ultra-High Resolution 2D Seismic

It is expected that, of all components of the site survey, the 2D seismic survey will produce the highest sound levels – although still very much lower than typical 3D seismic surveys.

Seismic acquisition in general varies according to its objectives, local surface conditions, and subsurface characteristics. It involves employing the correct source (both type and intensity), configuration of receivers, and orientation of receiver lines with respect to geological features. This ensures that the highest signal-to-noise ratio can be recorded for the given objective, that the resolution is appropriate, and that extraneous effects can be minimized, or distinguished and removed through processing.

The planned HR 2D seismic survey would be conducted from a single vessel that tows both the seismic source and the receiver apparatus at very shallow (2.5 m) depth below the water surface. The vessel-type would be a dedicated site survey vessel (smaller than conventional seismic vessels) that will travel at 2-4 knots during acquisition (Table 3-1).

The seismic source would be an array of 4 individual airguns[20] fired simultaneously to project a high-amplitude seismic-acoustic pulse into the ocean bottom; (see Table 3-1). The airgun's energy is concentrated below 300 Hz, with a rapid decrease in amplitude with increasing frequency between 250 and 500 Hz. The intensity of the sound is dependent on the size of the array in use (see below). The airguns are activated periodically, about every 6.25 m (about every 5 seconds). The resulting sound wave is reflected by the underlying rock layers to receiver equipment, and relayed to the recording vessel. The receiver equipment consists of one streamer of 750 m length, and contains 120 sensitive hydrophones for detecting echoes of the seismic pulse reflected from sub-bottom features.

The sound levels produced by a seismic array broadly scale with its volume. Sakhalin Energy conducted real-time measurements of sound produced by 70 in^3 and 150 in^3 airguns during their 2010 Astokh 4D survey offshore Sakhalin Island. Those measurements were used as input to sound modelling for the proposed 2012 high-resolution 2D Seismic (JASCO 2011), and formed the basis for the HR 2D survey-monitoring program developed jointly by Sakhalin Energy and the WGWAP (see Chapter 8). The results of the sound modelling study are described in detail in Chapter 6, §6.3.

The sound levels produced by the high-resolution 2D seismic will be significantly lower than those produced by a conventional seismic survey; the HR 2D survey will use a small array of 3 airguns with a small total volume of 180 in^3 (3 x 60 in^3), which would be less than $^1/_{16}$ of the total volume of 2,620 in^3 used by Sakhalin Energy in the 2010 Astokh 4D seismic (Table 3-1). As per best industry practice, and in line with a recommendation of the WGWAP, Sakhalin Energy will use an airgun array, instead of a single airgun with the same volume. For the ultra-high resolution 2D seismic, a single airgun with a volume of maximum 25 in^3 will be used, and hence the produced sound will be lower than that produced by the HR 2D Seismic.

Moreover, the activities to be carried out during the 2012 South Piltun HR 2D seismic survey are much smaller in dimensions than the Astokh 4D seismic survey conducted in 2010. Key parameters are compared in Table 3-1.

As already mentioned, the HR and UHR 2D surveys will require only one vessel for geophysical and seabed survey operations. The surveys will be acquired using conventional HR / UHR seismic methodology. A compressor system onboard the vessel will supply the pressurized air for the airguns; the above described airgun array will be deployed together with a receiving system consisting of one hydrophone streamer. As the array is towed along the survey lines and data are recorded, received survey data will be transferred to the master vessel's onboard processing system.

[20] SIEC is currently investigating the possibility of using 3 X 60 in^3 gun array and will advise following modelling work should this be a more optimum configuration

Table 3-1. Key parameters for comparison of the 2012 South Piltun 2D High-resolution Seismic survey and the 2010 Astokh 4D Seismic survey

	2012 HR 2D Survey	2010 4D Survey
Seismic vessel tonnage (brutto)	2,833 tonnes	6,051 tonnes
Number of airguns in array	4[21]	2 arrays of 33 each, alternatively shooting
Total volume of airgun array (in^3)	160	2,620
Pressure (psi)	2,000	2,000
Shot interval (m)**	6.25	12.5
Vessel speed during acquisition (knts)	2.0 – 4.0	4.5 – 5.5
Streamer length (m)	750	6 x 4,600
Tow depth – airgun (m)	2.5	6
Tow depth – hydrophone (m)	2.5	7
Survey duration***	20 days	18 June - 2July
Number of support vessels	0	2

** This influences the speed of the vessel
*** 2012 HR 2D = estimated duration depending on standby (technical, weather, fog, Gray Whale protection); 2010 4D = actual duration

The seismic receivers will be encapsulated in a conventional streamer, with a length of only 750 m. This short streamer used for HR 2D seismic will allow shorter line-turns, and hence a reduction – compared to typical 3D seismic – in total duration of the acquisition.

Four marine mammal observers (MMOs) will be hosted on the 2D seismic vessel during the survey; the function of the MMOs would be to enable timely detection of marine mammals (specifically gray whales and endangered pinnipeds), so that shut-down of operations can be effected if these marine mammals are spotted within a safety radius as per the mitigation and monitoring programme agreed with the WGWAP – see Chapter 8. As further agreed with the WGWAP, two buoys equipped with hydrophones will be deployed before the start of the survey at the 10 m and 20 m isobaths for passive measurement of background noise and the noise produced by the 2D seismic acquisition. Shore-based operations will consist of behavioural monitoring of Gray Whale before, during and after the survey.

The HR 2D seismic area at the potential PA-C site comprises a series of separate sail-lines of different spacing: close to the nominal platform location the sail-lines are spaced 50m apart, while further away they are spaced 400 m apart; the coarser sail-line spacing further away from the centre optimizes effort and hence survey duration.

Figure 3-6 shows the outline area for South Piltun HR 2D acquisition as currently planned. The survey will be acquired in a sequence subject to tidal, current, weather and marine mammal monitoring constraints. The survey will be conducted in shallow water depths of 20 to 40 m; as per marine safety requirements, the seismic vessel will also operate a low-energy echo-sounder throughout the survey.

[21] SIEC is currently investigating the possibility of using 3 X 60 in^3 gun array and will advise following modelling work should this be a more optimum configuration

The survey will start at sail-lines closer to the proposed platform location. Onboard seismic data processing will enable Sakhalin Energy to obtain images of the most important lines near the notional platform location during the acquisition of the survey, and hence allow opportunity for further optimization of the survey pattern during acquisition.

Ultra-high-resolution 2D seismic data will be acquired in a 2 km by 2 km square centred at the potential PA-C platform location (Figure **3-7**) as updated by HR 2D results. The UHR 2D survey is a subset of the HR 2D survey; UHR line spacing being 50 m and 100 m. The line pattern as currently planned is shown in Figure 3-8.

Only for the survey on the Astokh relief well locations, a small set of high-resolution 2D seismic lines need to be acquired. The required line pattern is given in Figure 3-9. No UHR data acquisition is needed. For the Piltun and Lunskoye relief well locations, high-quality High-resolution 2D seismic was available and an assessment of the shallow gas hazards could be completed.

3.5.4 Seabed surveys

The seabed surveys will provide three-dimensional images of the seabed and shallow subsurface profiles. This technique is defined by international industry standards and guidelines and by Russian federation Regulations for Offshore Site Investigations (SP11-114-2004).

Seabed surveys of the potential South Piltun platform site, and the PA-A, PA-B and LUN-A relief well locations, will cover a standard 2 km x 2 km area per site, in accordance with Shell guidelines for seabed surveys of platforms and marine drilling rigs.

Figure 3-10 shows proposed export pipeline route for the potential PA-C platform currently under consideration by Sakhalin Energy; the route follow the existing pipeline route corridor. Seabed surveys will be conducted along the proposed pipeline route from the nominal location of potential South Piltun platform to potential tie-in location (Figure 3-10); seabed survey of pipeline route will have 1km width.

The seabed survey will be conducted after the HR 2D seismic survey, using the same vessel. Sensors to be used include multibeam echo sounder (MBES), single-beam echo sounder (SBES), sub-bottom profiler (SBP), side-scan sonar (SSS) and Magnetometer. Sound generated during the seabed survey would be in the upper part of the 30-210 kHz frequency range, which is considered to be outside the frequency range that might cause major disturbance to gray whales.

Models of Sub Bottom Profiler that could be deployed are detailed in Table 3-2 and these are reviewed in a submission to WGWAP Noise task Force and reported in JASCO Applied Sciences (2011) “Review of acoustic footprints of low frequency geotechnical sounding and coring operations – Zizheng Li (Editor: Racca)

Li and Racca observe that for the sub bottom profielrs, the laterally propagating sound levels can be expected to be significantly lower than the levels in the downward direction normally listed in the specs. This is even more so because the energy is more effectively focused in a narrower beam. Typically the tools have sound threshold radii that exhibit the following when operating: 160dB at 5m radius in ramping down; 150dB at about 20m and 140dB or less at 75m

Based on measurements of a variety of SBPs performed in Camden Bay, off Beechey Point (both in the Beaufort Sea) and in the Chukchi Sea, Li and Racca report that the Sub Bottom Profilers consistently had much smaller radii to threshold levels than a 2x10 in^3 airgun array and even a single 10 in^3 airgun.

The Kongsberg SBP300 has significant higher levels in the main beam than conventional SBPs, but the energy is focused in a very small footprint (about 30m at 37m depth)

Given that operations will be well within the shutdown zone (500m-1000m) specified for the seismic then the noise impact for the sub bottom progfielrs will be of negligible impact

Table 3-2. Overview of the suite of Sub Bottom Profiler equipment with operating frequencies and output power

	Seismic survey			
№	Type of equipment	Model	Operating frequency	output power
1	Sub Bottom Profiler 1	SIS-1625	1 - 10 kHz	4 KW
2	Sub Bottom Profiler 2	AA201	NA	212-215 dB re 1 mPa at 1 meter
3	Seismic Energy Sourse	CSP-D	NA	50-2400 J
4	Digital multichannel seismic system		300Hz	NA
	Analog survey			
№	Type of equipment		Operating frequency	output power
1	Multy Beam Echo Sounder	SeaBat 8125	455 kHz	NA
2	Single Beam Echo Sounder	EA 600	200 kHz	NA
3	Side Scan Sonar	SIS-1625	400 kHz	NA

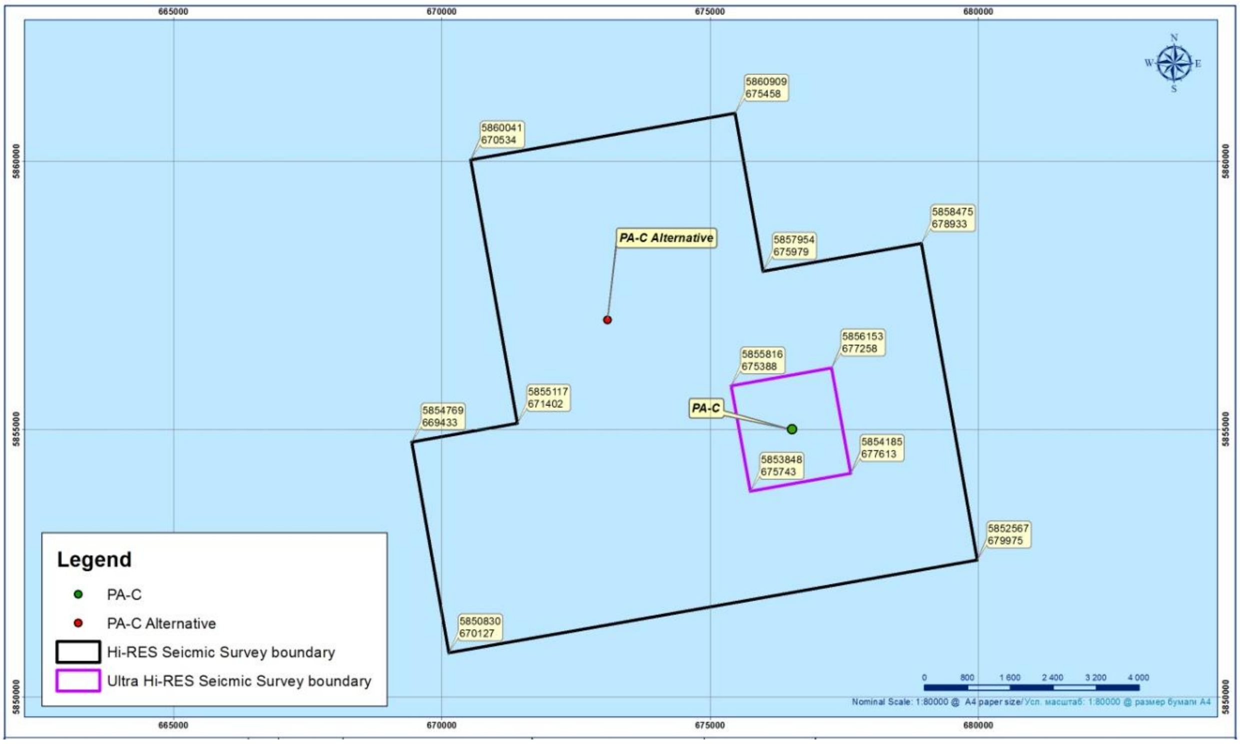


Figure 3-6. HR 2D seismic survey area is shown as polygon with black outline; locations of the nominal and alternative PA-C platform are indicated.

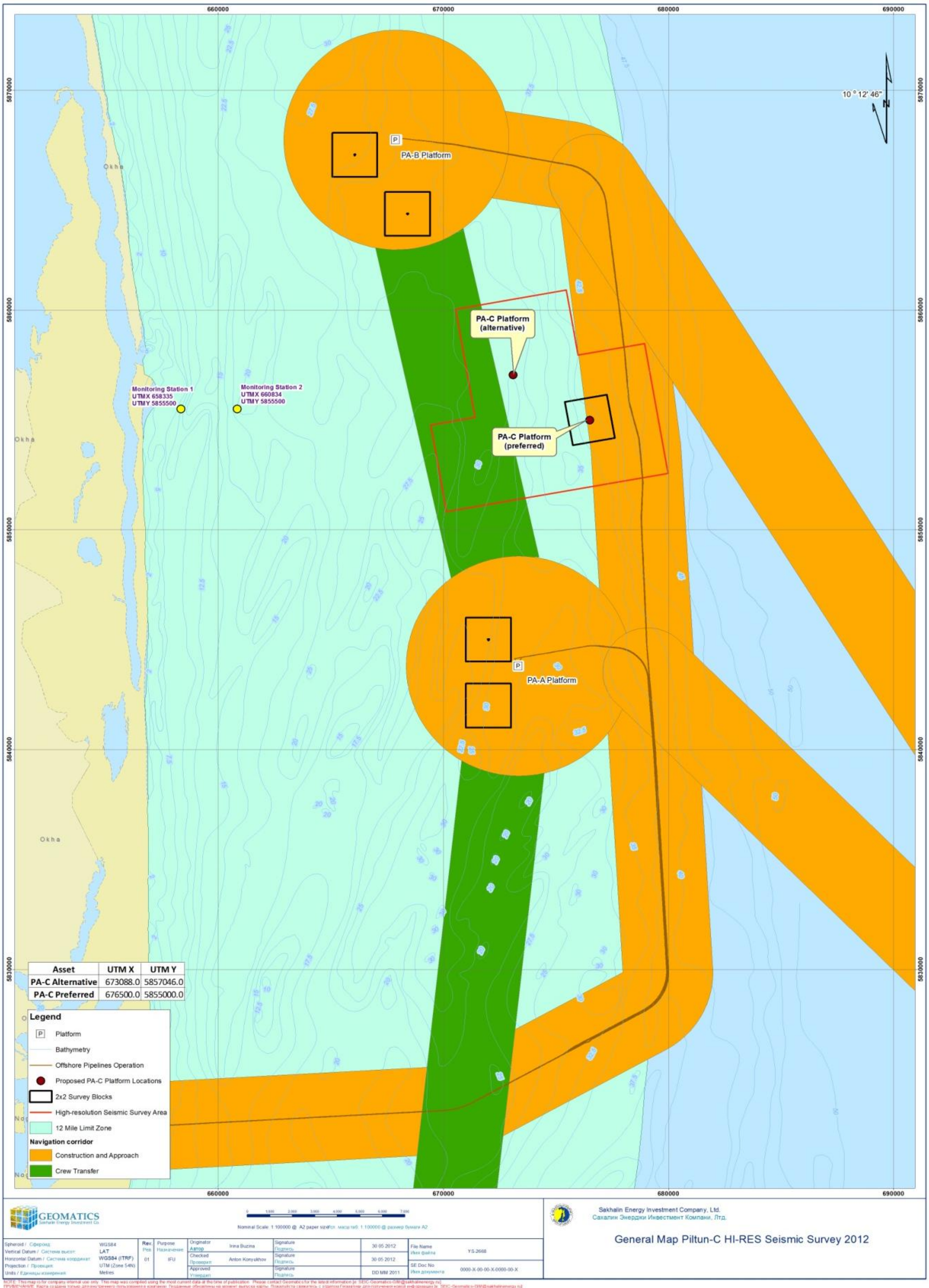


Figure 3-7. **South Piltun 2D seismic survey area in relation to existing infrastructure, navigation corridors, and acoustic monitoring buoys.**

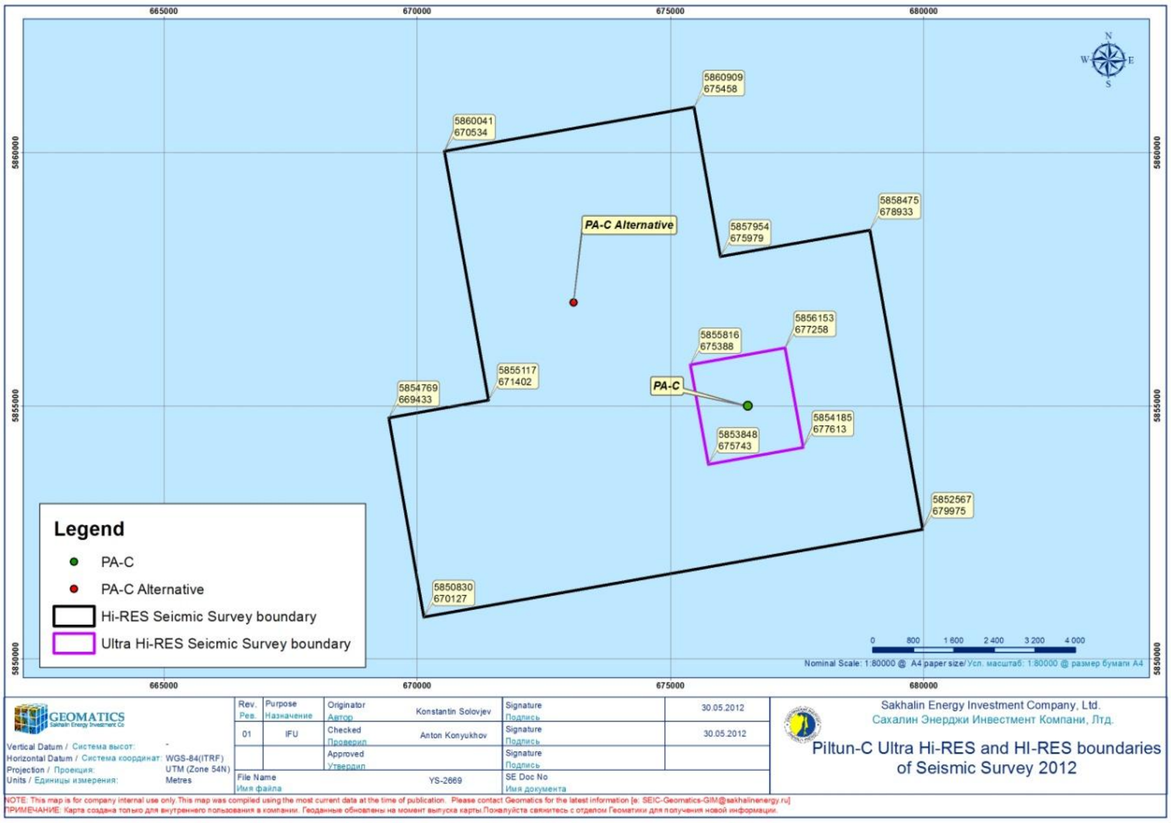


Figure 3-8. South Piltun UHR 2D seismic survey.
Purpul Outline is 2 km x 2 km. The locations of the nominal PA-C platform and alternative are indicated.

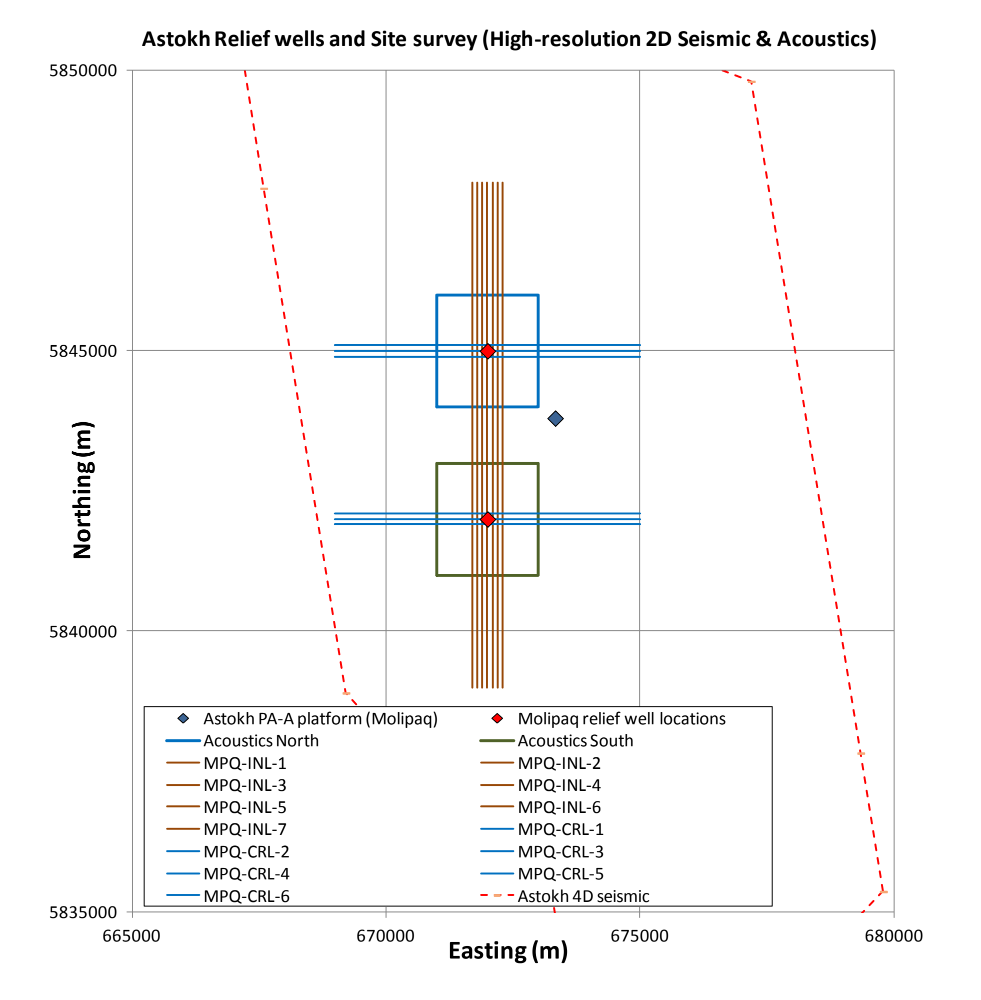


Figure 3-9. Line pattern for HR 2D seismic survey for Astokh relief wells.
The map shows the locations of the Molikpaq platform (blue diamond), the planned relief wells (red diamonds), the planned HR 2D seismic (brown S->N inlines and blue E->W crosslines), the 2km x 2km areas for seabed survey measurements (squares around the relief well locations) and a portion of the Astokh 4D seismic area (dotted red line)

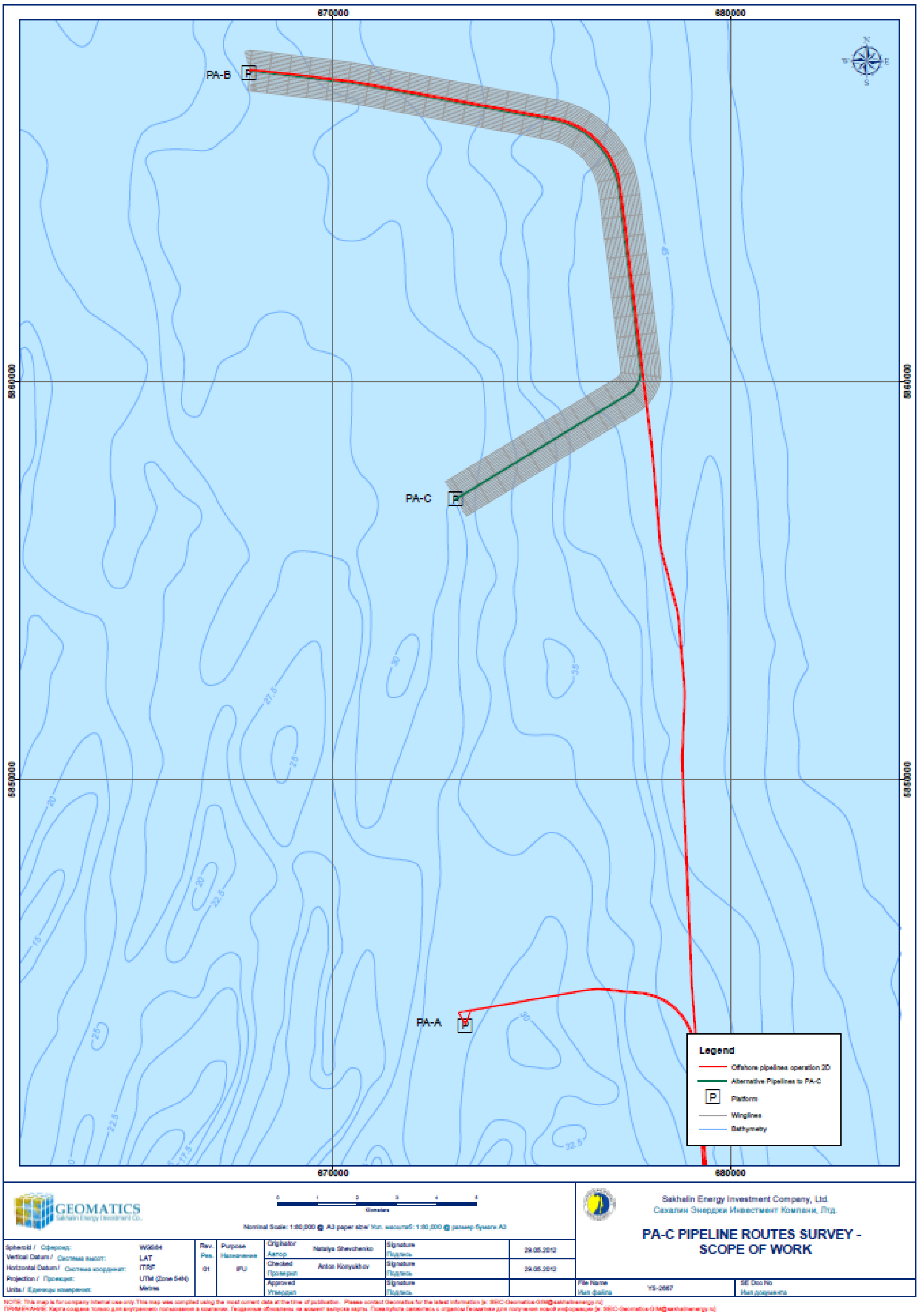


Figure 3-10. PA-C alternative pipeline routes.

3.5.5 Geotechnical Sampling and In-situ Testing

Geotechnical seabed and substrate sampling shall be performed at the location of the potential PA-C platform, at the locations of the potential relief wells for PA-A, PA-B and LUN-A and along the proposed export pipeline route. The PA-C borehole pattern is based upon the concept for a potential platform structure and the location will be finalized only after the results of the HR / UHR 2D seismic and seabed surveys are available.

At the current notional location for the PA-C platform, seismic data qualitatively indicate that the geo-mechanical properties (e.g. strength of the seabed) are similar to those at the PA-B platform. Notional, worst-case coring patterns (i.e. most extensive coring) for the platform location and relief well locations are shown in Figure 3-11 and Figure 3-12, respectively.

The maximum number of sampling boreholes for the proposed PA-C platform location will be:

Geotechnical site investigation for the proposed Gravity Base Structure shall comprise:

- 1 borehole (BH) to a depth of 150 m, including combined sampling Seismic/ Piezo CPT
- 4 BH's to a depth of 60 m, including combined sampling and CPT
- 12 BH's to a depth of 30 m, continuous sampling or CPT
- 6 BH's to a depth of 15 m, Continuous Seismic CPT- PCPT/sampling
- 4 BH's to a depth of 15 m, Continuous PCPT (Piezo Cone Penetration Tests)

Over the top 15 m, continuous sampling /PCPT testing is required to assist in the identification of weak layers that could be critical to the stability of a gravity based structure. At larger depths the sample/ in-situ testing intervals (distance between bottom and top of sample/ in-situ testing) shall not be larger than one meter.

The maximum number of cores for the PA-A, PA-B and LUN-A relief well locations will, for each relief well, be:

- 5 boreholes of 30 m depth

The geotechnical program is expected to start in mid-August at the relief well locations, and beginning September at the PA-C platform location. Coring will be performed by a dedicated vessel, which will be anchored during the operation. The main noise source will be the vessel’s engines; coring the soft strata of the seabed via rotary mechanism will generate far less noise than that generated by conventional oil and gas well drilling. Coring will use seawater for drilling, and cuttings will be discharged to the seabed[22].

Furthermore, shallow soil samples will be taken at a lateral sampling frequency of 1 km, and to a depth of 3 m only, along the routes of the potential pipeline from PA-C location.

The obtained cores and samples will be analyzed according to both Russian and International standards in onshore laboratories situated in the Russian Federation.

[22] According to Sakhalin Energy’s Standard for Water Use and Discharges (under the HSE-MS approved by their Lenders): “No drilling cuttings or residual muds and completion and workover fluids shall be disposed into the sea”. However, Sakhalin Energy has motivated that this zero-discharge policy is intended to address drilling of oil and gas production and water injection wells, not geotechnical coring. They contend that the type and amount of geotechnical coring waste would be minimal and consistent with natural material in the area.

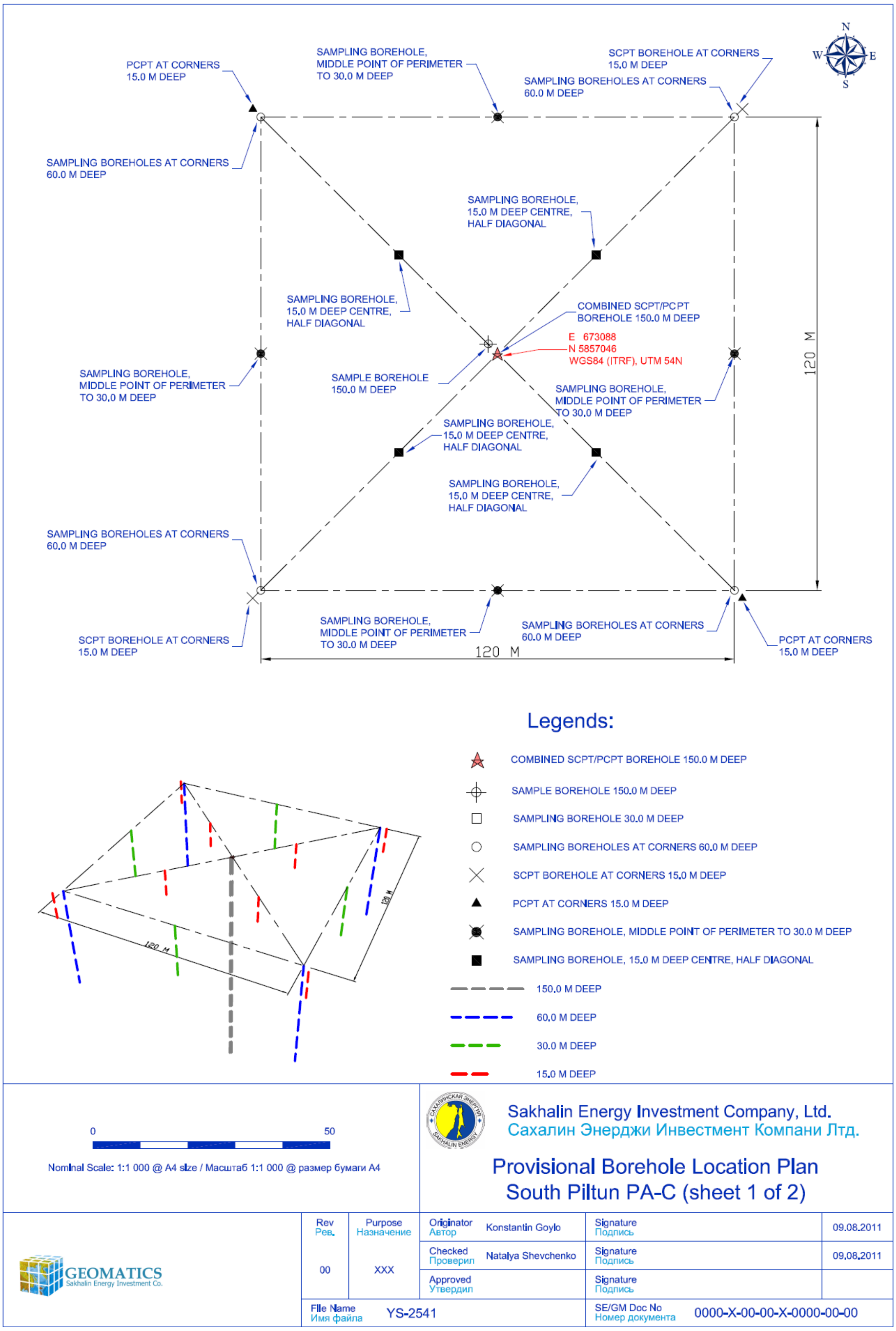
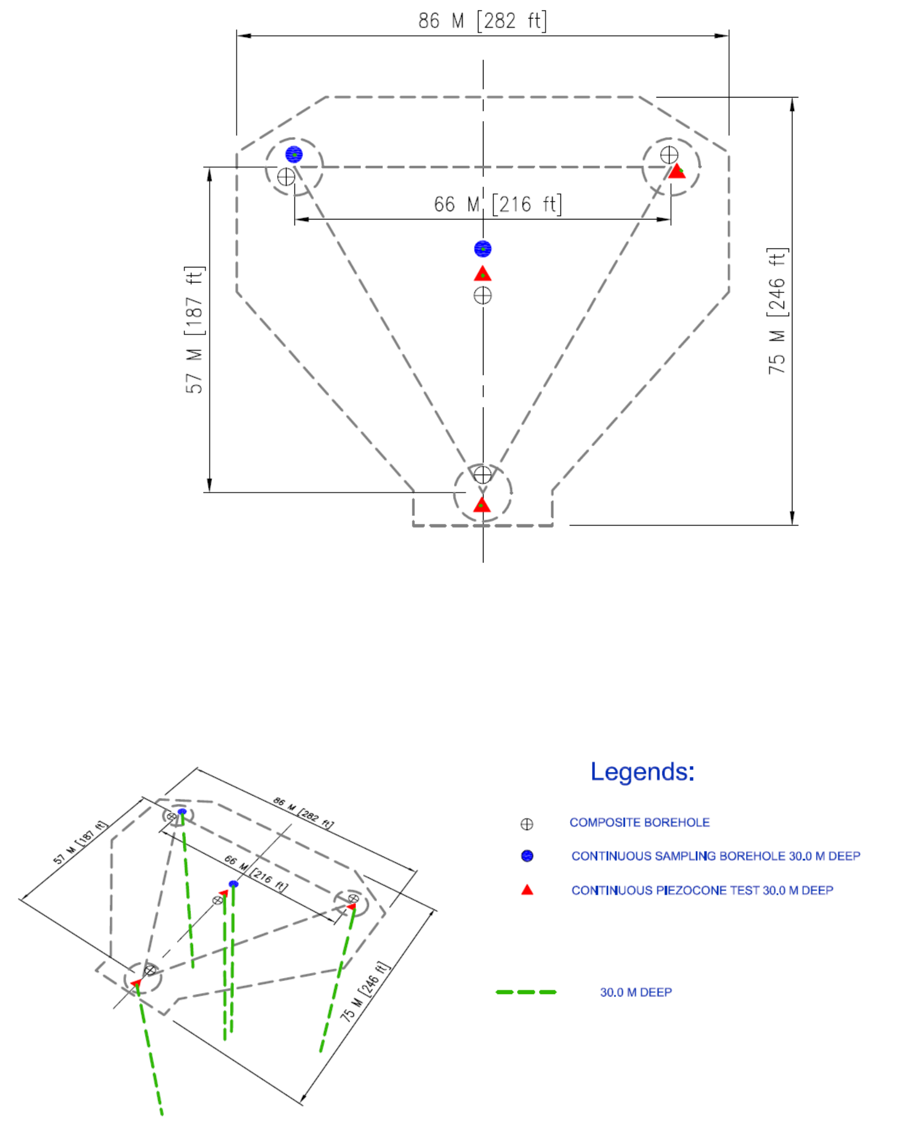


Figure 3-11. Notional borehole pattern at the PA-C location for a 4-leg GBS.



0 50

Nominal Scale: 1:1 000 @ A4 size / Масштаб 1:1 000 @ размер бумаги A4

Sakhalin Energy Investment Company, Ltd.
Сахалин Энерджи Инвестмент Компани Лтд.

Provisional Borehole Location Plan
South Piltun PA-C (sheet 2 of 2)

	Rev Рев.	Purpose Назначение	Originator Автор	Konstantin Goylo	Signature Подпись	09.08.2011
GEOMATICS Sakhalin Energy Investment Co.	00	XXX	Checked Проверил	Natalya Shevchenko	Signature Подпись	09.08.2011
			Approved Утвердил		Signature Подпись	
	File Name Имя файла	YS-2541		SE/GM Doc No Номер документа	0000-X-00-00-X-0000-00-00	

Figure 3-12. Notional borehole pattern at the relief well locations for a 3-leg jack-up rig.

3.5.6 Other

In 2010, monitoring of seawater, sediments and benthos communities was conducted in the PA-C survey area; these data are required by Russian Federation law as a baseline for future, post-construction environmental monitoring if the project were approved. Similar monitoring need only to be repeated in 2012 if the final platform location is substantially different from the current notional PA-C location.

However, baseline monitoring has not yet been completed for pipeline routes, and Sakhalin Energy proposes to complete these surveys in 2012.

Clarity on the need for additional metocean data will be obtained only after Sakhalin Energy has selected the concept for a potential platform at the PA-C location; continuous current measurements could be required for the future platform design. If required, Sakhalin Energy will install respective metering systems at both neighbouring PA-A and PA-B platforms.

3.5.7 Schedule of Activities

The site survey was originally planned for 2011, this survey had been postponed until 2012 because the necessary permits were not available for the contractor to start as early as WGWAP had recommended; postponement allowed an earlier start in the ice-free season. Furthermore, postponement of the site survey would allow survey of the relief well locations to be added to the scope of work.

The site survey is planned in a sequential manner, to enable the evaluation of the acquired data, and to obtain technically correct decisions for the subsequent operations.

The start of the work depends mainly on ice conditions in the Sea of Okhotsk. Considering previous experience (e.g. during the start-up of the Astokh 4D seismic), and the late ice melt in 2011, a realistic, technically-feasible start date of about 25th June has been scheduled for the HR 2D seismic survey (Table 3-2).

Table 3-2. Timetable of activities

Period (2012)	Activity
18 Jun – 22 Jul	Gray Whale behavioural monitoring by onshore teams, and underwater noise measurements using acoustic buoys (see Chapter 8)
25 Jun – 15 Jul	HR & UHR 2D Seismic Surveys
16 Jul – 08 Aug	Seabed surveys of PA-C platform and pipeline, and of PA-A, PA-B and LUN-A relief well locations
15 Aug	Decision on PA-C & relief well geotechnical coring locations
16 Aug – 30 Sep	Geotechnical sampling at PA-C platform, pipeline and PA-A, PA-B and LUN-A relief well locations
01 Sep – 30 Sep	Environmental Baseline Survey

The HR & UHR 2D seismic activities are planned to be completed as early in the season as possible, before gray whale numbers reach their summer maximum (see Chapter 8). During the survey period, a total of **20 days** actual source activity is anticipated.

3.6 Environmental Aspects

Sakhalin Energy carried out a *Hazard Identification and Risk Assessment* according to the hazard and risk classifications of its HSE management system. The result of the Hazard Identification and Risk Assessment provided a source of information during the scoping process of this EIA.

Seismic, seabed (sonar), and geotechnical surveys, and the operation of associated vessels, can result in a range of environmental impacts. Information from previous impact assessments (Lunskoye 3D 2003; Astokh 4D 2010), risk assessments, stakeholder engagement reports (e.g. WGWAP and SSTF), and unpublished information were used to identify key environmental aspects in the first instance. A full assessment of potential impacts on the environment is provided in Chapter 6.

3.6.1 Noise

The main noise sources during the survey will be airguns and to a lesser extent, sonar; relative to these, vessel noise and noise associated with drilling during geotechnical coring is expected to be minimal.

The characteristics of noise from airguns and sonar are discussed extensively in Chapter 6. The characteristics of noise from vessels and geotechnical coring are discussed briefly below.

The primary sources of sound from all vessel classes are propeller cavitation, propeller singing, and propulsion or other machinery (Richardson et al. 1995). Noise from propeller cavitation results from two types of vortex cavitation known as tip-vortex and hub-vortex, and from two types of blade surface cavitation, back and face. Propeller singing occurs when vortex-shedding frequencies reinforce a resonant vibrational frequency of a propeller blade, resulting in a strong tone between 100 and 1000 Hz. Noise from propulsion machinery arises from within the vessel and is transmitted to the water via the hull. Secondary noise sources include rotating shafts, gear reduction transmissions, reciprocating parts, gear teeth, fluid flow turbulence, and mechanical friction (Richardson et al. 1995), as well as pumps, non-propulsion engines, generators, ventilators and compressors, flow noise from water passing along the hull, and bubbles breaking in the wake.

Vessel noise is a combination of narrowband “tonal” sounds at specific frequencies and “broadband” sounds with energy spread continuously over a range of frequencies (Richardson et al. 1995). Levels and frequencies of both tonal and broadband sounds tend to be related to vessel size, but are also affected by vessel design and speed. Large vessels create stronger and lower-frequency sounds due to their greater power, large drafts, and slow-turning engines and propellers. Medium to large vessels have dominant tones up to ~50 Hz. Broadband components, caused by propeller cavitation and flow noise, may extend to 100 kHz, peaking at 50-150 Hz (Ross 1976 in Richardson et al. 1995). Pumps and compressors on the vessel can produce tones at frequencies up to several kilohertz.

Typically, seismic survey vessels are small (less than 100 m in length). Their propellers generally have four blades (3 m diameter) and turn at ~160 rpm. The blade-rate tone for such propellers is 10-11 Hz. If the propellers are in nozzles (cowlings), the radiated noise is reduced at some frequencies (Richardson et al. 1995). Broadband source levels for most small ships are ~170-180 dB re 1 μPa (Richardson et al. 1995).

As already discussed in Section 3.5.5, coring the soft strata of the seabed via rotary mechanism will generate far less noise than that generated by conventional oil and gas well drilling. According to EIA document produced by SVAROG in relation to geotechnical activities, spectral density of noise produced from coring operations in the water stays within the frequency range of up to 0.5 kHz and the noise limit of 70 dB relative to 1kPa (adjusted to 1m).

JASCO performed dedicated measurements of acoustic levels from a geo-technical coring operation in the Chukchi Sea, in water depth of about 40 m.[23] The coring was conducted from a specialized vessel, the *Synergy*, equipped with Dynamic Positioning (DP) thrusters that were used both to maneuver the vessel to the coring location and to hold station while coring was performed.

The acoustic footprint from the coring operation was found to be dominated by the DP thrusters noise, and during the measured activity the levels were in fact somewhat higher when the vessel was on DP without coring than during an actual coring operation. The radius to 120 dB re 1 µPa rms was 1.8 km for the vessel in active coring mode and 2.3 km while on DP without coring.

Effluent generated during the site survey is likely to include:

- Gray water from sanitation, cleaning and laundry;
- Drainage such as bilge water and contaminated runoff;
- Process and cooling water; and
- Black water from sewage and medical facilities.

In general, uncontrolled effluent discharge to the marine environment may cause pollution and impact vulnerable receptors. Typically, survey vessels are equipped with oil/water separators, bilge water and sludge tanks, and associated treatment systems. Release is not permitted unless the effluent meets permissible discharge criteria. Operators of survey vessels are required to comply with legal requirements including MARPOL. Potential effects of effluent discharge are discussed in Chapter 6, §6.8.

3.6.2 Waste Disposal

Wastes generated during the site survey are likely to include minor amounts of:

- Drilling cuttings and residual muds / sediments from geotechnical coring; volume estimated to be maximum 55 m3 of drilling cuttings / sediment. Muds will be sea-water based. In an unlikely scenario, but if necessary, a bio-degradable vegetable gum might be added to stabilize borehole walls;
- Hazardous wastes such as used oil (e.g. lubricants, hydraulic fluids, cable/streamer oils etc.), lithium batteries, fluorescent tubes, contaminated material (e.g. spent containers, oil filters, oily rags, personal protective equipment etc.), and medical waste (e.g. sharps, swabs, dressings, samples, expired drugs etc.);
- Solid, non-hazardous wastes such as paper, plastics, glass, wood and metal; and
- Organic waste (e.g. food, cooking oil, and sewage solids etc.).

In general, inappropriate waste disposal can pollute the receiving environment and impact biological receptors. Vessels usually incinerate, where permissible, the majority of non-reusable waste. Recyclables and wastes unsuitable for incineration may be stored onboard and disposed of at appropriate licensed facilities on return to port. All contractors will be required to manage and dispose waste in accordance with MARPOL and relevant national legislation. Potential effects of waste management are discussed in Chapter 6, §6.8.

[23] Hartin K.G., L.N. Bisson, S.A. Case, D.S. Ireland, and D. Hannay. (eds.) 2011. Marine mammal monitoring and mitigation during site clearance and geotechnical surveys by Statoil USA E&P Inc. in the Chukchi Sea, August–October 2011: 90-day report. LGL Rep. P1193. Rep. from LGL Alaska Research Associates Inc., LGL Ltd., and JASCO Research Ltd.

3.6.3 Atmospheric Emissions

Sources of emissions from the planned activity include waste incineration and fuel combustion through operation of propulsion systems, generators and incinerators. Table 3.3 provides estimated emission levels based on emissions for MV "Mariner".

Table 3-3. Estimated vessel emissions to the atmosphere (SEIC 20012).

Parameter (Kg/day)	Sailing	Moored & Drilling	In Port of Standby at location
Carbon dioxide (CO_2)	18191	8396	4197
Nitrogen oxides (NOx)	342	158	79
Sulphur dioxide (SO_2)	25	11	6
Carbon monoxide (CO)	42	19	10
Hydrocarbons	1.7	0.8	0.4

3.6.4 Spills, Leaks, and Dropped Objects

If liquid-filled streamers are deployed during the survey, collision or snagging of the streamer equipment could result in releases of fluid from the streamer segments; rupturing one cable section could result in the loss of up to 100-200 litres. During the course of an average survey, some of the lead weights used to hold the streamer equipment at the correct depth in the water column could be lost. The plastic streamer depth control units (commonly known as "birds") could also be lost during a survey, although this seldom occurs. No streamers losses are expected, due to the use of inflatable devices that are activated if the equipment sinks to an unacceptable depth. Tailbuoy losses are rare during surveys, but are possible. Potential effects of spills, leaks and dropped objects are further discussed in Chapter 6, §6.9.

The survey vessels shall comply with MARPOL and are required to have an International Oil Pollution Prevention (IOPP) certificate as well as a Shipboard Oil Pollution Emergency Plan (SOPEP). While the vessels will be equipped to deal with onboard spills and other minor spills (e.g. as a consequence of offshore bunkering), they will not have the capacity to deal with spills caused by major tank rupture should a vessel run aground or collide with another vessel. To minimise the likelihood of such occurrences, vessels will utilise bathymetric sonar. In addition, an oil spill response plan will be in place for the planned activity that includes availability and timely deployment of adequate emergency response resources.

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4 STAKEHOLDER ENGAGEMENT

4.1 Introduction

Stakeholder engagement is the process of seeking opinions, concerns and requirements of stakeholders and engaging them in systematic, constructive dialogue. It forms an integral part of the impact assessment process and comprises three main activities:

- Disclosure of information about the proposed activity, the assessment of potential environmental impacts, and measures to mitigate negative effects;
- Consultation, which involves engaging people and soliciting their views on proposed activities. It also entails how information obtained during the engagement process is used; and
- Participation, which is a voluntary and collaborative approach to define environmental issues and management objectives, evaluate outcomes, and develop solutions.

Stakeholders include those persons or groups who have an interest in, are affected by, or are in a position to influence Sakhalin Energy's activities. The company has been informing and consulting various stakeholders about Sakhalin II activities since work began in 1992. Sakhalin Energy has taken into account the guidelines and recommendations for public consultation and information disclosure published by the IFC, as well as relevant international conventions and Russian Federation legal requirements in developing its own Public Consultation and Disclosure Plan (PCDP) (SEIC 2008). Stakeholders addressed in that plan include:

- Communities that are directly affected by an activity;
- Other communities on Sakhalin Island;
- Marginal communities including indigenous groups;
- International stakeholders;
- Community and other non-governmental organisations (local, regional, international);
- Interest groups such as academic and research institutes; and
- The media (local, regional, national and international).

4.2 Stakeholder Engagement Plan

As mentioned in §1.2 of this EIA Report, industrial activities in offshore waters of the Russian Federation may only be performed under a positive SEER conclusion. The law defines the application process, and Sakhalin Energy duly appointed an independent Russian contractor to prepare the necessary documentation, including an EIA according to Russian requirements, for submission to the authorities. Under that process, the authorities decided what scope of public consultation was required for review and decision-making.

According to Sakhalin Energy's PCDP, the nature and extent of community engagement is guided by a project's potential interaction with affected communities. During the proposed site survey, vessels will remain offshore, and there is no planned interaction with local communities. Nevertheless, procedures approved by the authorities of Nogliki and Okha districts required engagement with the public through press advertisements and meetings (see §4.5).

Given the limited use of the area by commercial fisheries, the likelihood of any significant interaction with fisherman is also considered low. Nevertheless, the local fisheries authority participated in the RF EIA process (see §4.5), and fishermen known to operate in the vicinity will be notified prior to the commencement of the survey so that they might avoid the area during the brief period of operations.

The RF EIA Reports provide the details and outcomes of their public consultation; these are summarised in §4.5 below. To avoid duplication, the current "international-style" EIA report focuses on stakeholder engagement with international stakeholders, including the IUCN's Western Gray Whale Advisory Panel.

4.3 Consultation with the Western Gray Whale Advisory Panel

In 2004, Sakhalin Energy requested that the World Conservation Union (IUCN) establish an Independent Scientific Review Panel (ISRP) to evaluate knowledge about the gray whales and to provide recommendations to Sakhalin Energy on appropriate measures to adopt during implementation of its planned offshore activities. In September 2005, the ISRP recommended the establishment of a longer-term advisory panel, and in October 2006, the IUCN established the Western Gray Whale Advisory Panel (WGWAP). The objective of WGWAP is to provide independent, scientific and technical advice to industry, government and civil society with respect to human activities on the conservation and recovery of the WGW population, particularly in areas of oil and gas development.

The WGWAP comprises 11 prominent international scientists from a range of disciplines. Observers to the WGWAP include representatives from the Russian and Japanese branches of IFAW (International Fund for Animal Welfare) and WWF (World Wide Fund for Nature), and Pacific Environment (an international NGO); thus, participating NGOs are also informed during engagements with the WGWAP.

4.3.1 Historical Astokh 2010 4D Seismic Survey

The WGWAP is recognised as a significant stakeholder for activities on the northeast shelf of Sakhalin Island, and has been consulted often for expertise and guidance during the Sakhalin 2 Phase 2 Project. During planning of the 2010 Astokh 4D Seismic Survey, engagement of the Panel commenced early, in 2007, allowing adequate time for complex considerations such as survey methodology, whale density analysis, acoustic modelling, and monitoring and mitigation measures. That engagement remains relevant to the proposed 2012 2D seismic survey (the focus of this report) because the issues are similar, and because the extensive discussion held and the decisions reached during planning of the 2010 survey provide a solid foundation for current planning of the 2012 2D seismic survey.

The scope of involvement of the WGWAP during survey preparations was broad and unrestricted. Focus areas included:

- Survey design, including acquisition area and timing;
- Acoustic modelling to predict noise exposure during the survey;
- Delineation of the Piltun feeding area;
- Verification of acoustic predictions against acoustic measurements;
- Definition of noise thresholds as the basis for mitigate measures;
- Design and implementation of a monitoring programme.

A summary of consultation carried out for planning of the 2010 4D survey is provided in

Table 4-1.

Table 4-1. Summary of consultation undertaken during preparation for the 4D survey.

Occasion	Synopsis
2nd WGWAP Meeting April 2007, St. Petersburg	Sakhalin Energy's proposal for the Astokh survey was presented along with a preliminary impact assessment and summary mitigation plan. The WGWAP proposed the establishment of a collaborative Seismic Task Force (STF) to further assess the survey's impact and improve mitigation and monitoring plans.
1st Seismic Task Force Meeting June 2007, Den Haag	A week-long collaborative session that focussed on developing a suite of science-based mitigation and monitoring measures for the survey.
3rd WGWAP Meeting November 2007, Lausanne	The findings of the STF were presented to the WGWAP along with news that SEIC was to postpone the survey to 2009 to avoid any potential safety concerns associated with oil export vessels in the vicinity. WGWAP recommended that the STF re-convene to further refine plans.
2nd Seismic Task Force Meeting March 2008, Lausanne	A second collaborative workshop that focused on improving noise thresholds and acoustic model verification. A final, comprehensive mitigation and monitoring plan was proposed for inclusion in the EIA.
4th WGWAP Meeting April 2008, Lausanne	The report of the STF was presented to and endorsed by the WGWAP, who acknowledged the thorough work undertaken with respect to seismic surveys and cetaceans in advance of field operations.
5th WGWAP Meeting December 2008, Lausanne	A review of various aspects of the proposed survey, including the impact assessment, acoustic modelling, Gray Whale density mapping and finalisation of the perimeter monitoring line. The Terms of Reference for a dedicated Task Force monitoring workshop were confirmed.
3rd Seismic Task Force Meeting February 2009, Vancouver	Workshop convened with additional external specialists to develop a monitoring plan that will ensure that data collected is sufficiently robust to assess the effects of seismic on Gray Whale.
6th WGWAP Meeting April 2009, Geneva	A review of the Gray Whales mitigation and monitoring plans was presented and endorsed by the WGWAP. However, due to decreased numbers of Gray Whales reported off Sakhalin Island in 2008, the Panel recommended that the planned Sakhalin Energy seismic survey be postponed, pending results of Gray Whale monitoring during 2009. Sakhalin Energy accepted the panel's recommendation to postpone the survey until 2010.
PML meeting, Seismic Survey Taskforce sub-group. October 2009, Geneva	Workshop convened to develop statistical methodology to integrate opportunistic and systematic Gray Whales survey data in calculation of the Perimeter Monitoring Line (PML).

Occasion	Synopsis
4th Seismic Task Force Meeting December 2009, Geneva	A review of outstanding issues was conducted, including agreement on location of PML, use of ice-data to determine earliest start date, use of towers for behaviour monitoring, the designation of operational “scenarios” to provide guidelines for the use of the observation vessel for behaviour monitoring, and a proposal to allow an “A” line to transition into a “B” line for the portions of that line that were not predicted to exceed 156dBSEL shoreward of the PML.
7th WGWAP Meeting December 2009, Geneva	Preliminary results from 2009 distribution monitoring showed similar numbers of whales using the Piltun feeding area as compared to 2007. The panel made no recommendation for further postponement of the seismic survey and continued to work with Sakhalin Energy on finalizing the monitoring and mitigation plans.
5th Seismic Task Force Meeting April 2010, Geneva	A review of outstanding issues was conducted, including agreement on behaviour sampling protocols, a contingency plan in the event of failure of the shore-based acoustic stations, the role of an independent observer and plans for post-survey analyses.
8th WGWAP Meeting April 2010, Geneva	Final results from 2009 distribution monitoring were presented that confirmed the preliminary findings reported in December 2009, i.e., similar numbers of Gray Whales used the Piltun feeding area as compared to 2007. The panel made no recommendation for further postponement of the seismic survey and continued to work with Sakhalin Energy on finalizing the monitoring and mitigation plans.

In addition to meetings and other engagements listed in

Table 4-1, post-survey meetings between Sakhalin Energy and the WGWAP were, and continue to be held, to discuss monitoring data recorded during the survey; for example, see SSTF-6 Report[24], SSTF-7 Report[25], WGWAP-9 Report[26], and WGWAP-10 Report[27].

4.3.2 WGWAP Engagement for Proposed 2D Seismic Survey

Six meetings have been held between Sakhalin Energy and members of the WGWAP to date at which the motivation, scope and parameters for high-resolution 2D seismic data were presented and discussed. Details of agreed mitigation and monitoring requirements for the 2D survey are stated in SSTF-6 and SSTF-7 Reports, which can be downloaded from the IUCN’s WGWAP website. Table 4-2 summarises the details of the meetings.

24 http://www.iucn.org/wgwap/wgwap/task_forces/seismic_survey_task_force/
25 http://www.iucn.org/wgwap/wgwap/task_forces/seismic_survey_task_force/
26 http://www.iucn.org/wgwap/wgwap/meetings/wgwap_9/
27 http://www.iucn.org/wgwap/wgwap/meetings/wgwap_10/

Table 4-2. Summary of WGWAP consultation undertaken during planning for the 2D survey.

Occasion	Synopsis
SSTF *ad hoc* meeting October 2010, Copenhagen	Preliminary discussion of proposal by Sakhalin Energy to conduct 2D survey for new South Piltun platform. It was agreed that the baseline should be the MMP developed for the 2010 survey.
6th SSTF Meeting December 2010, Geneva	Presentation by Sakhalin Energy on survey rationale, scope and parameters. The SSTF made recommendations for the MMP.
9th WGWAP Meeting December 2010, Geneva	Recap of survey rationale, scope and parameters. WGWAP recommended that Sakhalin Energy review options of a single airgun versus an array; also recommended that the monitoring programme outlined in Annex 6 of the WGWAP-9 Report be implemented.
7th Seismic Task Force Meeting May 2011, Geneva	Update by Sakhalin Energy on survey plans. Sakhalin Energy agreed to implement array of 4 smaller guns to minimise the footprint and provide a more directional downward projection. SSTF noted that the proposed 2D survey was considerably smaller and quieter than the 2010 4D survey. SSTF raised concerns about the planned late start of the survey; Sakhalin Energy has since proposed to start the survey earlier in the season.
10th WGWAP Meeting May 2011, Geneva	WGWAP recognised that the planned 2D seismic survey was of significantly smaller scale and thus likely to have less impact on the whales than the 2010 Astokh 4D survey; WGWAP welcomed the fact that Sakhalin Energy has adopted the monitoring and mitigation measures provided in the SSTF-7 Report; stressed that the most important mitigation measure is to begin as early in the season as ice conditions allow when fewest whales are present.
Noise Task Force 1 November 2011, Vancouver	Sakhalin Energy discussed the MMP that had been developed for the planned 2011 2D survey; the 2011 survey had been postponed until 2012 because the necessary permits had not been obtained in time to allow the contractor to start as early as WGWAP had recommended; postponement until 2012 will allow earlier start in the ice-free season. Sakhalin Energy also informed the SSTF that, in response to the BP Macondo well incident (United States), the Company was reviewing its emergency preparedness and was planning relief well surveys, including a small HR 2D survey for PA-A. (Report not yet available on WGWAP website).

4.4 Expression of NGO Concern

At the tenth meeting of the WGWAP in May 2011, the World Wildlife Fund for Nature (WWF) submitted – on behalf of a group of 20 NGOs – a statement of concern about the Sakhalin II oil and gas project. Their concern focuses on the option of a third platform, and points to Equator Principles for comprehensive environmental impact assessment and action plan.

Their letter requests that "*all activities relating to the third platform be halted, including seismic surveys planned for summer 2011, until a comprehensive EIA for the entire third platform and associated subsea pipeline project has been developed, shared in a transparent and consultative manner, and endorsed by the appropriate bodies*".

Sakhalin Energy has stated (see WGWAP-10 Report[28]) that an environmental impact assessment for development of the South Piltun field is currently scheduled to be undertaken in 2013; in line with Sakhalin Energy's HSESAP commitments, the South Piltun Development EIA will conform to international standards, including an assessment of cumulative impacts. To properly prepare that EIA, a site survey is required in 2012 to collect essential, environmental, geophysical and geotechnical information – information that is also required in terms of Russian Federation law.

The proposed 2D seismic survey is significantly smaller and will create less noise than larger historic 3D surveys. Provided that the mitigation measures and monitoring programme, as agreed between Sakhalin Energy and the WGWAP, are implemented, there should be no adverse impacts to the WGW population.

Notwithstanding the relatively low noise levels of 2D surveys as described in Chapter 6 of this report, it should also be noted that, by postponing the 2D survey until 2012, Sakhalin Energy has been able to meet the WGWAP's "most important mitigation measure – to begin as early in the season as ice conditions allow when fewest whales are present".

4.5 Summary of Stakeholder Engagement During Russian EIA Process[29]

4.5.1 Regulatory Requirements

Public participation in formal EIA is required by RF legislation:

- Article 3 of Federal Law No. 7-ФЗ (dated 10 January 2002) On Environmental Protection (as amended 27 December 2009) requires respect for public's right to reliable environmental information, and involvement of public in the decision-making process regarding their statutory rights for favourable environment;
- Federal Law No. 174-ФЗ (dated 23 November 1995) On Environmental Expert Review (as amended 17 December 2009) defines the rights of people and public organisations during the decision-making process regarding business- and other activities impacting public interests;
- Further to the requirements of Federal Law On Environmental Expert Review, the RF State Environmental Committee issued Order No. 372 of 16 May 2000 that approves the *Regulations on Assessment of Environmental Impact of Planned Business- and Other Activities in the Russian Federation*. Sections III and IV of the said Regulations contain the requirements for ensuring public awareness and participation in EIA and holding public consultations.

[28] http://www.iucn.org/wgwap/wgwap/meetings/wgwap_10/

[29] Regulatory approvals are issued to the entity (in this case, contractor) that may execute the activity. Where more than one contractor may be under consideration (e.g. during tender), each contractor would require separate approval.

4.5.2 Public Engagement Process, March-May 2011 : ZAO ROMONA

The planned site surveys would take place within license areas that adjoin two municipal districts of the Sakhalin Oblast: Okha City District and Nogliki City District. In accordance with Order 372 on *Approval of Provisions for EIA in the Russian Federation*, notices of public consultation were submitted to, and approved by local authorities of Nogliki and Okha.

Public consultations were undertaken accordingly, with focus on identification of key issues related to the Programme's potential impacts on environmental and social receptors.

- ***Phase 1 – Ensuring public awareness about planned project activities***.
  Notices were placed in *Sakhalinskiy Neftyanik* and *Znamya Truda* (local newspapers) during March 2011, regarding the availability of *EIA Terms of Reference* for initial public consultations. The EIA ToR documents were made available:
  In the reading room of the Okha Central Library, 17 Lenina Street, Okha;
  In the reading room of the Nogliki Central Library, 5A Pogranichnaya Street, Nogliki;
  At www.ecoalliance.ru.
  Interested parties were invited to submit questions / proposals by phone, or in writing at the libraries. One respondent believed that the ToR were adequate; three other respondents had no comments / questions.

- ***Phase 2 – Notification about EIA process, date and venue of public meetings***.
  Notices were placed in *Rossiyskaya Gazeta* (federal gazette) *Sakhalinskiy Neftyanik* and *Znamya Truda* (local newspapers) during April 2011, regarding the availability of *draft EIA materials and questionnaire forms* at:
  The Okha Central Library;
  The Nogliki Central Library;
  Websitewww.ecoalliance.ru.
  Press advertisements provided contact details (company names, addresses, telephone and facsimile numbers, and email addresses), and invited interested parties to contact EIA contractors about questions, comments and proposals. Four respondents believed that the draft EIA materials were "full" and "ok".

- ***Phase 3 – Public meetings***.
  Pubic discussions were held in Okha and in Nogliki on 20 May 2011.

  Minutes of Okha meeting concluded that "technological and environment protection solutions assumed by ZAO ROMONA comply with the requirements of the current legislation". Nine opinions polls were submitted during the meeting; no negative comments towards the proposed project were received. Minutes of the meeting are stamped as approved by Head of Okha Urban District Municipality.
  Minutes of the Nogliki meeting indicate that no opinion polls were completed at this meeting. However, the minutes refer to engagement held on 6 May 2011 with the fishery managers at the municipality administration. According to the minutes, EIA materials were carefully considered and the following conclusion was made:

  > *"Having studied the [EIA] materials and information provided by experts for protection, ichthyology, and monitoring of water biological resources and habitat, nature use supervision, as well as representatives of indigenous Arctic ethnic groups and the representative of Nogliki District Fishery Managers Association, we hereby suggest that the schedule of the seismic exploration works at the adjacent offshore zone be shifted to October-November 2011 due to unacceptably high negative impacts on reproduction of pacific salmons and fishery during 2011 fishing season.*

Considering that the main salmon run in north-east Sakhalin has a seasonal character (once in two years) performing seismic exploration works during this odd (salmon) year would affect both the fish stock and its field operations. Therefore, the fishing entities would suffer direct losses from the impossibility of fishing at their fishing sites caused by seismic exploration works. Moreover, damage compensation to the fishing entities is not specified in the submitted materials."[30]

[Note that the seismic survey was not completed in 2011; it was postponed until 2012. Subsequent engagements took place in the Autmn of 2011 culminating in meetings held 6th, 7th and 8th December 2011 where these issues were resolved – specifically highlighting that salmon mass migration on the North-East coast of Sakhalin should begin in the third week of July and Seismic works will be completed by then.]

4.5.3 Public Engagement Process, August-December 2011: SVAROG

In accordance with Order 372 on *Approval of Provisions for EIA in the Russian Federation*, plans for public consultation prepared by the second EIA contractor were submitted to, and approved by local authorities of Nogliki and Okha.

Public consultations were undertaken accordingly.

- ***Phase 1 – Ensuring public awareness about planned project activities***
  Press advertisements and locations of materials
  Announcements about the start of EIA and the availability of draft EIA ToR were published in the following newspapers:
  Rossiiskaya Gazeta №185 (5561) dated August 23rd, 2011
  Gubernskie Vedomosti №152-153 (3839-3840) dated August 23rd, 2011
  Znamya Truda №69 (8857) dated August 25th, 2011 (Nogliki newspaper)
  Sakhalinsky Neftyanik №67 (19810) от 27.08.11. (Okha newspaper)

  Draft EIA ToR was available at the following locations from 22 August 2011:
  Okha Library-branch #13, 19 Dzerzhinskogo Street, Okha;
  Reading room of Nogliki District Central Library, 5A Pogranichnaya Street, Okha;
  Reading room of Sakhalin Regional Universal Research Library, 78 Khabarovskaya Street, Yuzhno-Sakhalinsk;
  Website address http://www.svarog.ru/

  Interested parties were invited to submit questions / proposals by phone, or in writing at the libraries. Five questionnaires were completed at Okha library; no negative comments / concerns on specific issues were registered.

  Engagement with Local Municipalities
  Nogliki

  Letter from SVAROG to Nogliki district administration (No. 179-09/2010 dated 14 September 2011) informing the administration about the EIA process and intent to conduct public hearings following phase 1 (draft technical assignment, ToR) and phase 2 (draft EIA materials) of the public participation process. Reply from Head of Nogliki Municipality (letter No. 17-2740 dated 3 October 2011) accepting the notice, and identifying their focal point for participation in public hearings, with due signature authority for the final protocol.

[30] Baseline information for indigenous people and traditional trades and commercial fisheries is provided in §5.12.3 and §5.12.4 respectively. Impact assessment of the proposed site survey on commercial fishing activities and on subsistence fishing and hunting is presented in §6.7.1 and §6.7.2, respectively. Main fishing sites for salmon are onshore / much closer to shore than the offshore location of the site surveys.

Okha
Letter from SVAROG to Okha district administration (No. 178-09/2010 dated 14 September 2011) informing the administration about the EIA process and intent to conduct public hearings following phase 1 (draft technical assignment, ToR) and phase 2 (draft EIA materials) of the public participation process. Reply from Head of Okha Municipality (letter No. 07-17/2266 dated 23 September 2011) accepting the notice, and identifying their focal point for participation in public hearings, with due signature authority for the final protocol.

- ***Phase 2 – Notification about EIA process, date and venue of public meetings***
  Press advertisements and locations of materials
  Announcement about availability of the preliminary version of EIA to the public were published in the following newspapers:
  Rossiiskaya Gazeta №243 (5619) dated October 28th, 2011
  Gubernskie Vedomosti №196 (3883) dated October 28th, 2011
  Znamya Truda №69 (8857) dated November 3rd, 2011 (Nogliki newspaper)
  Sakhalinsky Neftyanik №85 dated October 29th, 2011 (Okha newspaper)

  Draft EIA was made available from 4 November through 5 December 2011 at the following locations:
  Reading room at Okha Central Library, 17 Lenina Street, Okha;
  Reading room at Nogliki District Central Library, 5A Pogranichnaya Street, Nogliki;
  Reading room at Sakhalin Regional Universal Research Library, 78 Khabarovskaya Street, Yuzhno-Sakhalinsk;
  Web site of Geotochka: http://www.geotochka.ru/
  In addition the information was also published at Okha municipality web-site www.adm-okha.ru, in accordance with specific request from Head of Okha Municipality in his letter No. 07-17/2266 dated 23 September 2011

- Public submissions
  Six responses to draft EIA materials were submitted by the public in Nogliki, and three in Okha. Summary of comments as follows:

  Some concern that the seismic survey may impact young fish, and that some noise and vibration from borehole drilling (coring) may impact salmon.
  Suggestion that proponent should consider alternative methods of seismic acquisition that may be more favourable.
  Comment that EIA is complete and comprehensive, and includes all details on impact to marine biota. The materials also considered migration periods of salmon. If possible, minimize impact from the seismic survey activities.
  Question: Will visual monitoring be effective for monitoring of marine mammals in the area of works?
  Question: What will be the percentage of work for local people?

- ***Phase 3 – Public meetings***
  Okha and Nogliki Public Hearings
  Pubic discussions were held in Okha and in Nogliki on 6 and 7 December 2011, respectively. Attendees were informed about the background to the meetings, and were invited to comment. No negative comments were received. Protocols (minutes) were duly signed by SVAROG and authorized persons from municipalities.

  Meeting with Sakhalin Indigenous Minorities Council

In addition, SVAROG officially requested Chairperson of Sakhalin Indigenous Minorities Council to organize a meeting with the Council members to inform them specifically about the proposed project. The meeting was held on 8 December 2011, attended by Council, SVAROG, GeoPoint and Sakhalin Energy.

Key points of the meeting (translation from the original MOM):

The works would commence as early during the 2012 ice-free season as possible; it is planned to complete the seismic survey (the activity producing most noise) by the middle of July. The activities will be conducted at a distance of 17 km - 25 km from the coast within the Piltun-Astokhskoye and Lunskoye License Areas.

According to information from scientific and research institutes, the salmon mass migration on the North-East coast of Sakhalin should begin in the third week of July. According to the works schedule, the noisiest aspects of the site survey should be completed by that time; thereafter, geotechnical components (e.g. core samples collection) are scheduled.

Council expressed wish that all site survey activities should be completed by 5 September, prior to the salmon run; proponents assured that Council that the works were scheduled to be conducted within the shortest period depending on weather conditions.

The EIA process was discussed: environmental impact assessment documentation was prepared, public hearings were conducted, and the documents would be shortly submitted for the state environmental expert review.

Council wished to be informed about the outcome of the state environmental expert review; proponent agreed to do this.

Council proposed that a follow-up meeting should be held with local communities in Nogliki in May 2012, prior to commencement of works; the proponent, Sakhalin Energy, agreed.

The parties agreed that should Council advance any other questions, they would submit them to Sakhalin Energy in writing.

Conclusion:

Participants of the meeting agreed that discussion had been fruitful, and constructive proposals had been made.

Position of Indigenous Minorities representatives towards proposed site survey activities was not negative.

MoM was signed by SVAROG and Chairperson of Sakhalin Indigenous Minorities Council.

All recommendations received, by Sakahlin Energy Investment Company, as a result of the public consultations, have been taken on board by the responsible parties and used as input to the planning of the activities for offshore survey operations.

4.5.4 Public Engagement Process, 2011: Russian Federation Fishery Authority

The RF Fishery Authority (FAR) and its Expert Commission (TsUREN) have been engaged as part of review of the Svarog EIA whereby they have been provided all essential information on the Project itself, its execution schedule, potential impact on environment and marine bio-resources, mitigation measures.

Svarog in the close cooperative efforts with the Company addressed their questions and comments on the matter and received the positive approvals from both - FAR and TsUREN.

4.6 Other Engagement

A final draft of this impact assessment report will be submitted to the Lenders' Independent Environmental Consultant ENVIRON, in compliance with the Company's HSESAP requirements and to the Lenders directly. The report will also be published on Sakhalin Energy's external website.

Particpants in the Western Gray Whale Advisory Panel were advised at meeting #11 (February 2012) about the intention for publication of the EIA.

In addition the Lenders' Independent Environmental Consultant - ENVIRON has advised that the Non Technical Summary of the EIA should be made available to the local communities in Russian via the website and the Company's local information centres.

Finally, Svarog conducted two further "engagements" on 2nd and 3rd June with local fisheries authorities and indigenous people.

4.7 Literature Cited

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5 BASELINE ENVIRONMENTAL CONDITIONS

5.1 Introduction

This chapter provides contextual information on the existing physical and biological environment of the survey area, focusing on those components that may be impacted by, or that may impact on the proposed survey operations. Environmental baseline descriptions include:

- Climate and meteorology;
- Hydrology and oceanography;
- Seabed chemistry, morphology and sedimentology;
- Physical environment relating to sound;
- Coastal landscape;
- Geological environment and seismic stability;
- Marine invertebrates and fish communities;
- Marine mammals;
- Marine and coastal birds;
- Protected areas; and
- The human environment.

The Sea of Okhotsk is a large basin on the western margin of the Pacific Ocean. It is 2,500 km in length from southwest to northeast and 1,500 km wide. It has an area of approximately 1.5 million sq km, an average depth of 821 m, and a maximum depth of 3,520 m. It is the second largest sea in the Pacific Ocean region. The sea is bordered by Sakhalin Island and Asia to the west, Siberia to the north, the Kamchatka Peninsula to the northeast, the Kuril Islands Arc to the southeast and the Japanese island of Hokkaido to the south (Figure 5-1). Sakhalin is separated from Hokkaido by the La Perouse Strait (also known as the Soya Strait), which is 60 km wide at its narrowest.

The baseline-study area includes a 50-km offshore zone around the perimeter of the survey area plus the known near shore and offshore gray whale feeding grounds as well as the presumed corridor for whale movement between the two (Figure 5-1).

A Valued Ecosystem Component (VEC) approach has been used in this EIA. A VEC is defined as a resource or environmental feature that is important to a local human population, or has a national or international profile, or if altered from its existing status, will be important for the evaluation of environmental impacts of industrial activities. The VECs examined during the baseline studies include ichthyoplankton, benthic invertebrates, fish, fisheries, marine mammals, and birds.

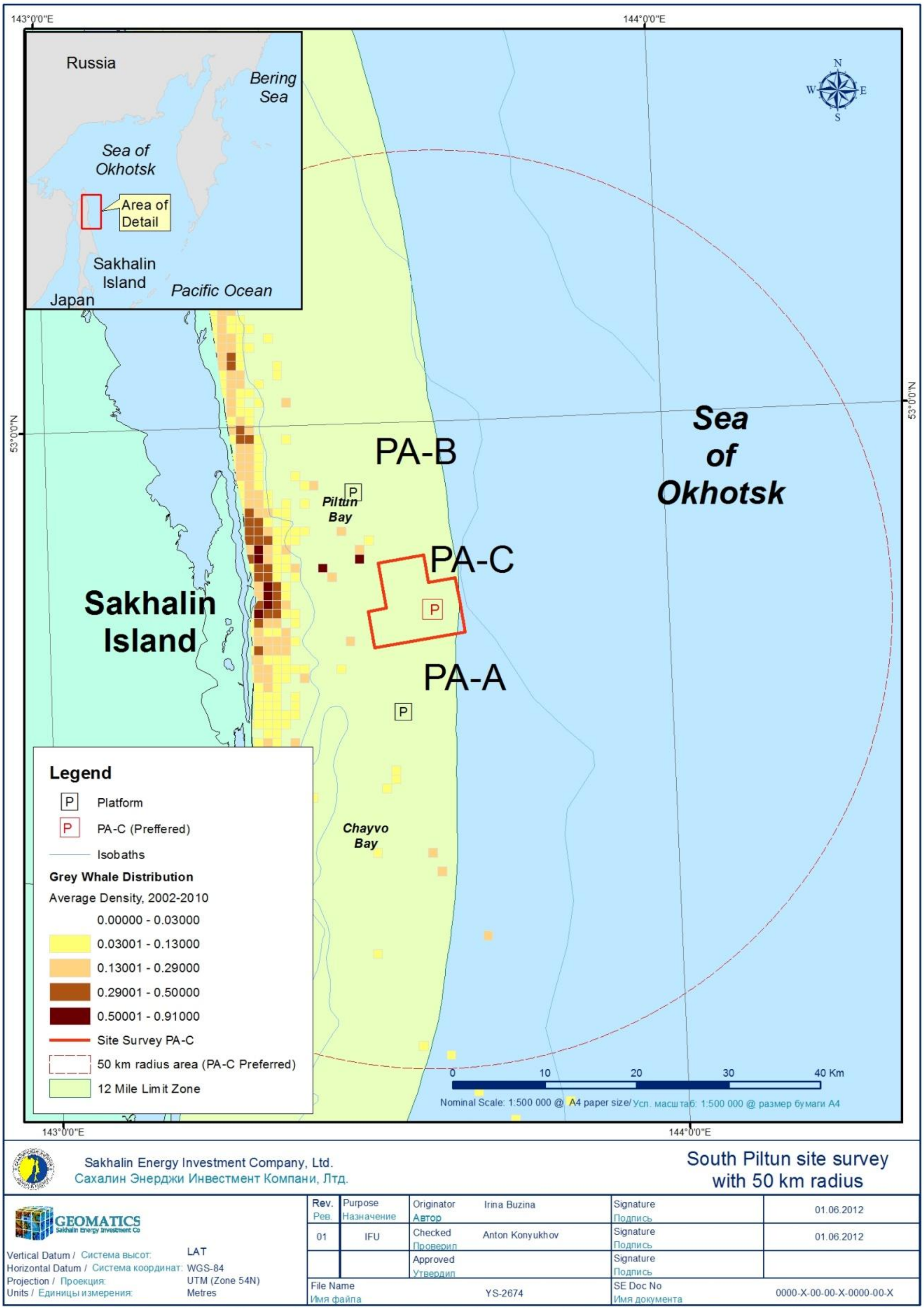


Figure 5-1. Location map and baseline area.

5.2 Climate and Meteorology

5.2.1 The Sea of Okhotsk

The Sea of Okhotsk is situated in the monsoon climatic zone of the temperate latitudes. It is also considered to be a sub-Arctic sea due to the influence of the seasonal Siberian High[31], which determines the severity of winters in the region (US NODC 2001). These two opposing meteorological trends result in a mixed climate, with mild summers influenced by minor tropical cyclones and the Soya current[32]. The climate to the south of the sea is considered to be warmer than the regional average, with colder climates experienced towards the north. January experiences the coolest temperatures, when the minimum temperature averages -23 °C; the warmest months are July and August, when typical maximums of 18°C are observed.

The Sea of Okhotsk is considered to be one of the world's roughest seas. Coastal zones often experience strong windstorms, with average wind speeds of 20-25 m/s recorded (SEIC 2002a, TEO-C Volume 7 Book 1-EIA: Chapter 1).

The **winter monsoon** arrives in the Sea of Okhotsk in October and persists until April. The combination of winter monsoon conditions in the south and polar conditions in the north produces strong northerly or north-westerly winds blowing out of the atmospheric high pressure cell over Siberia from October to April. These conditions produce average wind speeds of 4.1-7.6 m/s and storms often develop (SEIC 2002a, TEO-C Volume 2A Book 8-EPB: Chapter 6). On the coast, annual maximum wind speeds during the winter monsoon have been recorded up to 38 m/s during deep cyclones. Precipitation is relatively low in this region. Sea ice is extensive in all but the southern margins. In winter, navigation on the Sea of Okhotsk becomes difficult, or even impossible, due to the formation of large ice floes, because the large amount of freshwater from the Amur River lowers the salinity and raises the freezing point of the sea. The distribution and thickness of ice floes depends on many factors: the location, the time of year, water currents, and the sea temperatures.

Spring is characterised by a decrease in wind speeds, relatively low levels of precipitation and an increase in fogginess and low-lying cloud.

Summer monsoons arrive between May and September, and result in an increase in precipitation and long-lasting heavy fogs around coastal areas. The occurrence of sea fogs increases during the summer months. Air temperatures rise slowly in coastal zones owing to the melting of sea ice. The foggiest period usually lasts from May to September in coastal zones, with an average of nine to 18 days of fog per month towards the south, and three to six days per month in other areas. Cyclones and rainstorms may be experienced during this period. Prevailing winds are from the south and southeast with average wind speeds of 3.2-4.9 m/s (SEIC 2002a, TEO-C Volume 2A Book 8-EPB: Chapter 6). The stormy conditions persist into autumn, when cyclones, high winds, high precipitation and occasional hailstorms may occur.

5.2.2 Sakhalin Island

Generally speaking, Sakhalin Island is influenced by a moderate monsoonal climate, characterised by cold winters and warm, rainy summers. The climate varies considerably as a result of the large latitudinal extent of the island and the influence of the Sea of Okhotsk on the eastern coast. The local climate is cooler and harsher than other locations at the same latitude due to the cooling effect of the Siberian continental monsoon system during the winter and of

[31] The Siberian High is an area of high pressure which forms over Siberia in winter, and which is particularly apparent on mean charts of sea level pressure (National Snow and Ice Data Centre, Arctic Climatology and Meteorology 2002).
[32] An extension of the Tsushima Current that flows northward from the Japan Sea into the Okhotsk Sea via the La Perouse Strait.

the cold waters of the Sea of Okhotsk in the summer. Summer monsoons bring wet ocean air with considerable precipitation in the summer and autumn. Parts of the eastern coast of Sakhalin are colder than other areas as cold-water currents influence them, while the southwest is subject to the warmer Tsusima Current.

The long-term average air temperature in January in the north of the island varies between -18 to -25°C, while in the south of the island it ranges from -6 to -12°C. Winter generally lasts 5-7 months and summer 2-3 months. The average air temperature in August in the north of the island ranges from +11 to +16°C, while in the south it ranges from +16 to +20°C (Sakhydromet 1998). Fog frequently occurs in the coastal zone in the summer season. Autumn may be characterised by frequent typhoons and storms. Annually, average precipitation in the central part of the island is 500-750 mm, in the north it is over 400 mm (rising to 1000-1200 mm in mountainous areas) and 1000 mm in the south. The majority (65 to 78%) of precipitation falls between April and October, with September generally being the wettest month as this is normally the period of most intensive cyclone activity. The Sakhalin region experiences some 100 cyclonic depressions each year concentrated in late summer and early autumn (SAIC 2002a, TEO-C Volume 7, Book 1 EIA). These cyclones originate in the equatorial zone. The majority of these cyclones do not exert a significant effect on the marine environment to the northeast of the island.

5.2.2.1 Climate Conditions in the North-east and the Piltun-Astokh Fields

The Piltun-Astokh area is located in the north Sakhalin climate zone. The winters are long and cold, with temperatures often falling below -30°C and staying below 0°C for approximately 200 days a year. Air temperature starts to rise above zero towards the end of April to the beginning of May, causing sea ice in coastal regions to begin to drift, although the air temperature may fall below 0°C during the spring and summer months. Summers are cool with average air temperatures from July to October of 9°C to 10°C offshore, and humidity levels of 84 to 93%. August is the warmest month, with average offshore temperatures of 12°C and maximum temperatures of 19°C.

The average annual precipitation level in the area is 600 mm, with September to October being the wettest months and January-February the driest. Precipitation between November and April falls mainly as snow. Humidity levels of 70 to 78% are normal in winter. Fog can be observed for approximately 80 days per year; frequent fogs are experienced on the northeast coast of the island in the Okha and Nogliki districts during the summer months (SEIC 2002a, TEO-C Volume 2A & 2B Book 8, Chapter 4). Average annual wind speeds on the coast vary from 3.9 to 4.4 m/s (SEIC 2002a, TEO-C Volume 2A & 2B Book 8-EPB: Chapter 4) with westerly to north-westerly winds prevailing during the winter and south to south-easterly winds during the summer. Maximum wind speeds of 4 to 7 m/s from the north and northwest are experienced during winter, with peak winds of 37 to 40 m/s.

5.2.3 Air Quality

Background atmospheric pollution levels in Sakhalin Island and the surrounding area are generally low, with occasional short-term peaks caused by forest fires, shipping sources, or from regional urban centres. On a local scale, urban areas, such as the regional capital Yuzhno-Sakhalinsk, and industrial areas, such as coal-fired power station sites, record peak pollution levels (SEIC 2002a, TEO-C Volume 7 Book 1-EIA: Chapter 1). The pollution dispersion capacity of the region is generally moderate due to the windy meteorological conditions. Calm periods and inversions can occur during any season, but are more common in the winter when the recurrence of inversion conditions is between 66 to 76% (SEIC 2002a, TEO-C Volume 7 Book 1-EIA: Chapter 1). The fewest inversions occur in July. The existing air quality in the Piltun-Astokh area can be considered good given the low number of sources of atmospheric pollution in north-eastern Sakhalin Island and the moderate pollution dispersion capacity.

5.3 Hydrology and Oceanography

5.3.1 Water Masses and Circulation

Satellite infrared images of the Sea of Okhotsk reveal strong and persistent summertime fronts in sea surface temperature. In most cases, fronts are surface signatures of transition zones between stratified waters of the deep central Sea of Okhotsk and vertically well-mixed waters associated with strong tidal activity. The coldest, most saline bottom water occurs at depths of 150-200 m on the North-West Shelf (NWS) and extends southeast (Martin et al. 1998 cited in Rogachev et al. 2000). Dense water polynyas occur along the Northern Shelf of the Sea of Okhotsk (Yasuda 1997; Martin et al. 1998 cited in Rogachev et al. 2000).

The general circulation of the Sea of Okhotsk is cyclonic, resulting in the formation of the Okhotsk Gyre in the centre of the sea (Figure 5-2). In the southern Sea of Okhotsk, circulation is anticyclonic and comprises two or four large eddies 100-150 km wide (Sapozhnikov et al. 2001). An important hydrographic feature of the sea is the outflow of Okhotsk intermediate waters[33], through the Bussol and Krusenshterna passages into the North Pacific, which is considered to be a possible source of the North Pacific Intermediate Water (NPIW). Water exchange with the Japan Sea occurs through La Perouse Strait while Pacific waters enter the sea through the straits of the Kuril Islands (Komex 2002). The Amur River enters the sea through the Sakhalin Gulf and Tatar Strait. The Amur is the only large river in Siberia that drains into the Sea of Okhotsk rather than the Arctic Ocean. The outflow into the sea provides 68% of the sea's freshwater supply together with sediment load, and influences sea ice formation, currents and marine productivity (Komex 2002). The East Sakhalin Current transports low salinity water derived in part from the Amur River around the northern tip of the island and then southwards along the east Sakhalin coastline.

[33] Okhotsk intermediate waters are formed in a layer from 150-200 m to 500-800 m depth (Komex 2002).

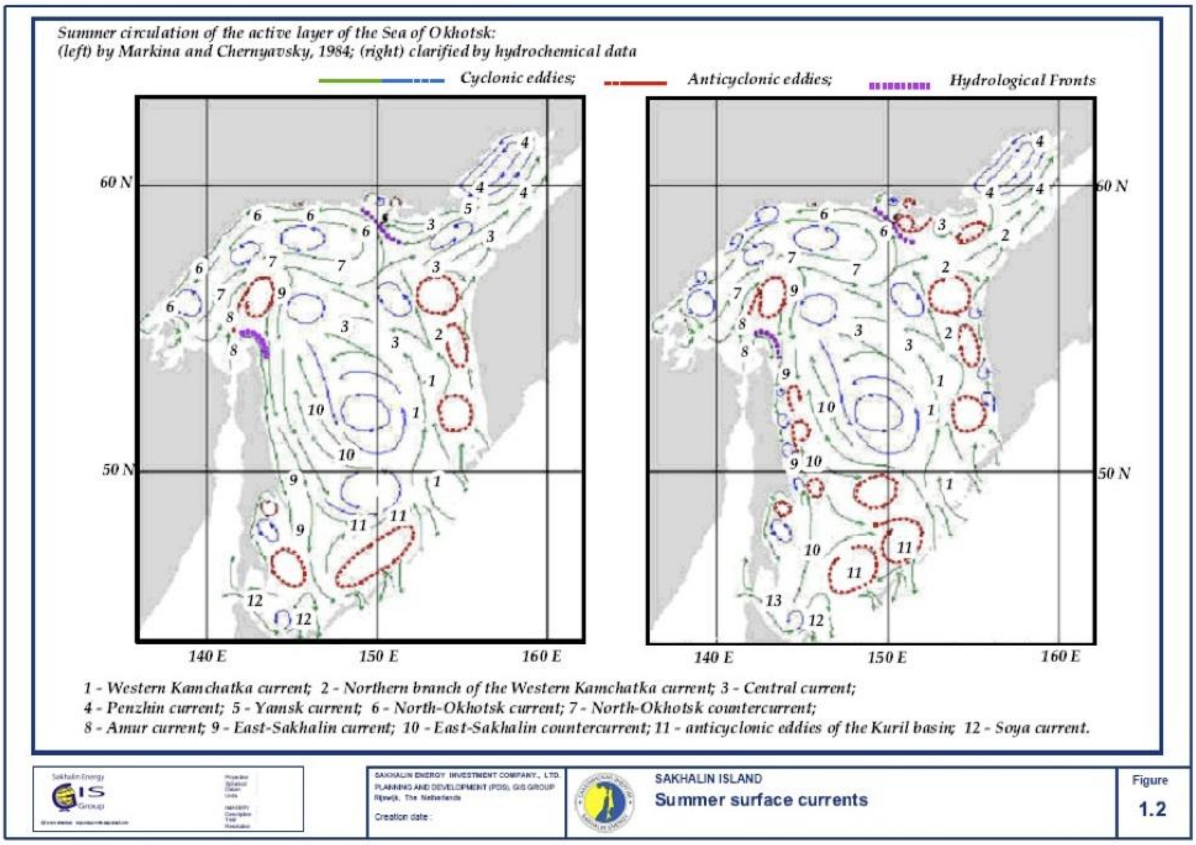


Figure 5-2. Summer surface currents in the Sea of Okhotsk.

5.3.2 Tide and Current Patterns

The Sea of Okhotsk is an area where tidal and current dynamics are generally poorly studied and documented. Analysis of the tidal energy budget in the Sea of Okhotsk and in other regions shows that a small area may play an extremely important role in the dissipation of tidal energy. For example, the total energy dissipated in the Sea of Okhotsk is greater than the energy dissipated in the Arctic Ocean (Kowalick and Polyakov 1998 cited in Rogachev et al. 2000). The numerical model of Kowalick and Polyakov (1998) shows that the largest tides occur in the north-eastern part of the Sea of Okhotsk, where there is a maximum tidal range of 13 m. Smaller but significant tides occur along the NWS, where tidal amplitudes increase to the west.

Tides are principally diurnal off the north-eastern coast of Sakhalin Island. Tides range between 1.7 and 2.2 m high. Currents associated with daily tidal events are most pronounced between 5-10 km and 20-25 km offshore (SEIC 2002a, TEO-C Volume 2A & 2B Book 8-EPB: Chapter 6). The formation and break-up of seasonal sea ice affect surface currents and water column temperature stratification (thermocline). Over the summer monsoon period (from June to August), south-easterly and southerly currents are primarily observed off the northeast Sakhalin coast, with average wave heights of 0.8-1.1 m.

In the Piltun-Astokh area the prevailing currents are southerly (Figure 5-2) with average aggregate surface currents between 0.6 and 0.8 knots and predominantly in a south to south-western direction during ice-free periods (SEIC 2002a, TEO-C Volume 2A Book 8-EPB: Chapter 6). Average near-bottom currents of 0.3 knots are primarily directed north to south.

Maximum currents reach 2.9 knots and 2.5 knots at surface and near bottom depths, respectively (SEIC 2002a, TEO-C Volume 7 Book 1-EIA: Chapter 1). These strong near-bottom currents are responsible for the large-scale transport of sediments on the shelf and the resultant formation of a variety of bed forms (e.g. large sand waves, sand banks and sorted gravel deposits). Spring surface currents are 0.1-0.2 knots arising from the East Sakhalin current from a westerly direction (SEIC 2002a, TEO-C Volume 7 Book 1-EIA: Chapter 1). During summer, surface currents between depths of 10-20 m are orientated north north-west, with current speeds increasing by 0.1 knots on average with depth. The prevailing direction of water flow moves east during the autumn and current speeds reach between 0.5-0.6 knots offshore.

5.3.3 Wave Climate

The development of cyclonic activity in the southern part of the Sea of Okhotsk in winter can produce significant wave heights of 14 to 15 m with an 11 to 12 s period. In spring, the wave energy decreases, resulting in significant wave heights of 9 to 11 m with a 9 to 11 s period. In the summer, significant wave heights are generally less than 7 m with a 6 to 8 s period (SEIC 2002a, TEO-C, Volume 2B, Book 8, Section 6). Autumn sees the significant wave heights increase to 11 to 12 m with a period of 9 to 11s. Southern and north-western areas may experience extremes of wave height and storm events throughout the year.

Around the Piltun-Astokh area, significant wave action is experienced during the ice-free season between May and December. During summer, significant wave heights reach 3-4 m, increasing in September to a maximum of 4-5 m (SEIC 2002a, TEO-C Volume 2A & 2B Book 8, Chapter 6). With the onset of the winter monsoon, wave heights reach a maximum of 5-6 m in December, originating from a northerly wind direction.

5.3.4 Water Temperature

Over the winter months, the temperature of the southern area of the Sea of Okhotsk falls as low as -1.5°C in the coastal zone, with a temperature increase offshore to the east towards the outer boundary of the Kamchatka continental shelf. Offshore temperatures rise to a maximum of 8 to 9°C in northern areas, and 12 to 13°C in southern areas at the height of summer warming intensity (during August). In the far southern areas cold Pacific water with a temperature of 9 to 10°C flows along the south-western Kamchatka coast.

Water temperatures in the surface layers of the Piltun-Astokh area feature seasonal variations, with average minimum winter temperatures of -1.7°C and average summer temperatures of 10.7°C (SEIC 2002b). As expected, this range decreases with water depth, and the bottom water layer at approximately 30 m depth has a seasonal average temperature variation of approximately -1.8 to 1.5 °C (Table 5-1).

Table 5-1. Annual average water temperature data for the Piltun-Astokh area.

Water Depth (m)	Water Temperature °C			
	Max Monthly Average	Min Monthly Average	Maximum	Minimum
0	10.7	-1.7	18.1	-1.7
10	6.8	-1.8	12.2	-1.9
20	2.1	-1.8	10.4	-1.9
30	1.5	-1.8	8.0	-1.9

The formation of a stable thermocline does not usually occur until sometime after ice melt and the cessation of spring storms. By late June, the longer day lengths and higher air temperatures warm surface seawaters and create a strong thermocline at depths of 10-20 m (SEIC 2002a, TEO-C Volume 7 Book 1-EIA: Chapter 1). This upper water layer (surface to 20 m depth) forms a separate water mass in summer. With the onset of cooler temperatures and stormy weather in autumn the thermocline begins to break down and is usually absent by October. Water temperatures then continue to decline to winter minimums.

5.3.5 Salinity

Salinity ranges 31-32‰ at the surface and 31-32.7‰ at a depth of 30 m, and seasonally is generally at its minimum in May to June due to advection of fresher water from the East Sakhalin current. Upwelling of saline waters results in increased salinity during the summer months, which then falls again in October as the upwelling ceases (SEIC 2002a, TEO-C Volume 2A & 2B Book 8-EPB: Chapter 6). Additional factors contributing to salinity minima include:

- Peak influx of Sakhalin east coast rivers in spring;
- Sea ice melt in spring; and
- Peak precipitation in September and October.

During the winter months, the formation of sea ice causes salinity concentrations to increase, raising the density of the surface waters, whilst melting in spring releases cold freshwater thereby reducing the density of surface waters. In the Piltun-Astokh area, the complex frontal zone where estuarine and upwelling inputs interact, a sharp decrease in salinity of up to 3-5‰ and temperature peaks of up to 10°C occur (SEIC 2002a, TEO-C Volume 7 Book 1-EIA: Chapter 1.

5.3.6 Sea Ice Formation

5.3.6.1 Sea of Okhotsk

In the Sea of Okhotsk, sea ice formation begins towards the end of October in the predominantly freshwater estuaries of Penzhinski Bay. By December, ice starts to form on the open sea, gradually extending southwards and by January, ice generally covers the Kamchatka coast and reaches as far as the southern coast of Sakhalin Island. The peak of ice cover in the Sea of Okhotsk is March-April, when the majority of the continental shelf zone is covered with drift ice. Only the southernmost areas of the sea avoid complete ice cover, being partially covered or ice-free under average winter conditions. During severe winters, drift ice masses may be driven by winds towards the Kuril Islands, where channels can be blocked until the ice melts. There are, on average, 280 days a year when ice covers the northern areas of the sea, whereas the southern coasts of Kamchatka and the Kurils are covered by ice for a maximum of 90 days a year (SEIC 2002a, TEO-C Volume 7 Book 1-EIA: Chapter 1). Sea ice melt typically commences in April with the development of cyclonic conditions. The ice boundary rapidly retreats northwards and by the end of June the sea and coastal areas are generally free from ice cover.

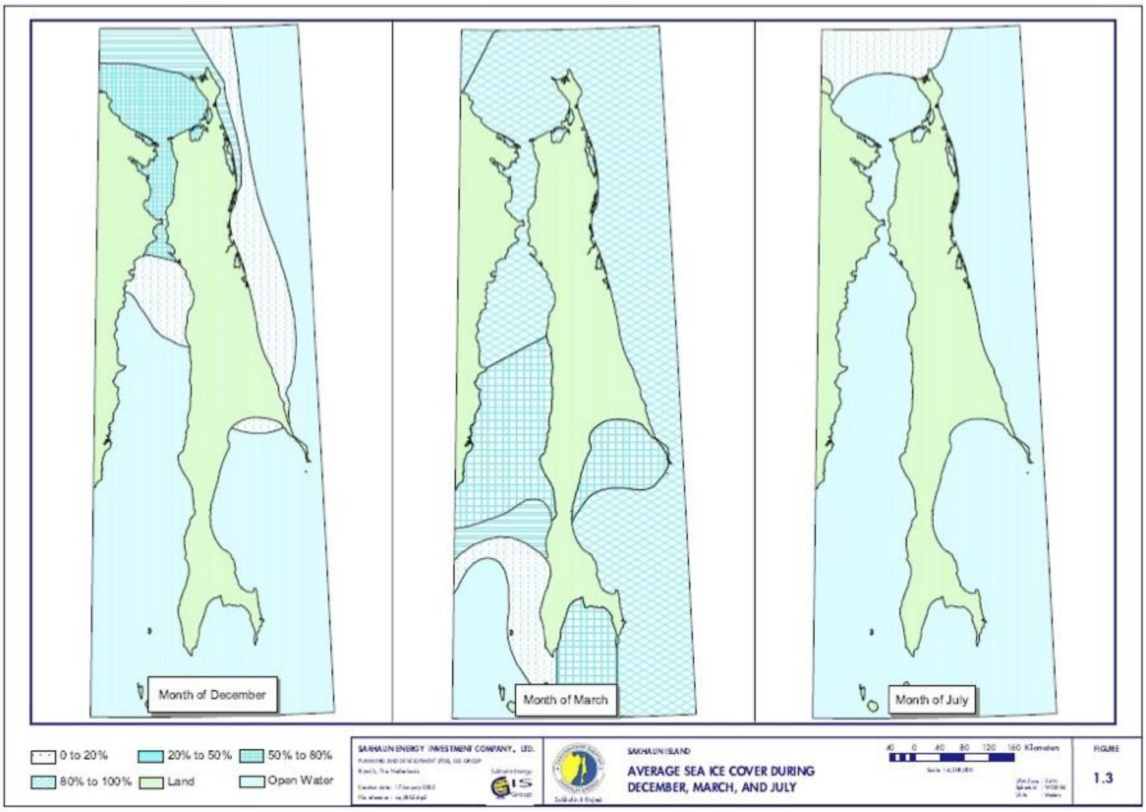


Figure 5-3. Average ice cover during the months of December, March and July.

5.3.6.2 Piltun-Astokh Area

Ice volumes on the north-eastern Sakhalin Shelf are generally high during the winter period (Figure 5-3). Ice formation begins at the end of November, with peak ice cover occurring in March and persisting until early June. The average duration of ice cover in the vicinity of the Piltun-Astokh area is 187 days (SEIC 2002a, TEO-C Volume 2A and 2B Book 8, EPB: Chapter 6). Initial ice formation, coastal ice ridges and temperatures below 0°C, combine to create favourable conditions for the formation of shorefast ice. This shore ice retreats from the coast during early April/late May and drifts along the shelf boundary. Average ice thickness increases from 0.4 m in January to 1.2 m in May, although deformation usually occurs in this area, increasing the volume of ice in some locations to up to 1.5 m thickness during the winter period (SEIC 2002a, TEO-C Volume 3.1.1 and 3.1.2, Book 8, EPB: Chapter 6). Maximum sheet ice thickness recorded in the Piltun-Astokh area is 2.1 m. The overall thickness of the pack ice is 3 to 4 m, with ice keels[34] of 10 to 15 m (SEIC 2002a, TEO-C Volume 2B Book 8, EPB: Chapter 6). Extreme ice keels may reach 20 m depth, but these are considered to be rare (SEIC 2002a, TEO-C Volume 2A and 2B Book 8, EPB: Chapter 6). Ice formations with a deep keel may reach the Piltun-Astokh area from January to May. Keels on the undersides of ice ridges can be driven by the wind, gouging long trenches into the sea floor as they move. Ice gouging is generally observed in water depths shallower than 10 m, but may occur in up to 20 m of water. Fast ice may be present in the vicinity of the field from January to April with average widths of between 1 and 3 km and is frequently broken up by winds. The pack ice in the region of north-eastern Sakhalin is dynamic and is in near continual motion because of winds, currents and tides. Maximum drift speeds observed at the Piltun-Astokh area are 0.2 m/s and are generally experienced during January to February (SEIC 2002a, TEO-C Volume 2A Book 8, EPB: Chapter 6). The movement of drift ice starts from Sakhalin Bay in December to the shelf region on the northeast coast and through the field. Movement is generally south-easterly in direction, coinciding with the East Sakhalin current, with occasional movements to the north, east and west. Cyclical tidal drift may be observed on shorter timescales.

An important feature of the ice cover is the periodic appearance of polynyas, which are bands of thin ice or open water that run parallel to the coast between shore ice and the thicker pack ice offshore. Polynyas normally have a duration of several days or weeks, and are usually formed from January to March. They are formed again during May when shore ice recedes from the coast and the ice breaks up and begins to thaw. These features have been regularly observed in the Piltun-Astokh area, and are related to wind direction. Conversely, strong winds from the northeast or east push the drifting pack ice up against the coast and generate more ice ridges and hummocks. Many of these thickened pieces of ice become grounded and often persist until the ice pack breaks up in spring.

5.3.7 Gas and Fluid Venting

The Sea of Okhotsk has the highest potential methane production rate in the northern hemisphere, largely because the shelf areas around Sakhalin Island form part of an extremely active methane and fluid-venting zone (Komex 2002). The methane, which forms reservoirs in contact with the seafloor can have a direct exchange with the atmosphere via the water. The predominant control on the release rate of this methane is the seasonal sea ice cover, which regulates gas exchange. There are a number of active gas and fluid vents in the Sea of Okhotsk that support deposits of mineral precipitates associated with the vented substances. Carbonate deposits, which are generally associated with cold vent sites have been observed as well as barite deposits that are also associated with cold vent sites. These vent sites have

[34] Ice keels occur when two sheets of ice collide and force a mass of ice downwards to form a ‘keel’ like structure below the sea surface.

been found in large quantities in the Derugin Basin where a large number of chimneys, edifices and blocks of several metres in height have been formed on the sea floor (Komex 2002). The stability of the gas reservoirs in the Sea of Okhotsk is dependent on fault zones and fissures in the sea floor sediments, and on fluctuations in deep-sea temperatures and sea level. Methane is widely found as hydrate deposits on the shelf and slope areas of the sea. These methane hydrate deposits are known as clathrates and their stability has significant implications for the atmosphere and global climate, as methane has a high global warming potential.

5.3.8 Marine Water Quality

Marine water quality data are available for spring and summer months when there is no ice cover; data have been taken from surveys carried out between 1995 and 2000 in the Piltun-Astokh area.

5.3.8.1 Oxygen Concentrations and Distribution

In the waters around the Piltun-Astokh area, surface water oxygen concentrations are approximately 8-8.5 mg/l in the spring and 6.5-7 mg/l in the summer, equivalent to 105% and 100% saturation respectively. Oxygen concentrations then decrease with depth in the water column, falling to a minimum level of 5.5 to 6 mg/l (approximately 75% saturation). Horizontal concentrations are generally uniform (SEIC 2002a, TEO-C Volume 2A & 2B Book 8, EPB: Chapter 6). Maximum oxygen concentrations exceeding 9 mg/l (more than 115%) are observed in spring and summer at approximately 20 m depth, and are thought to relate to phytoplankton blooms.

Data collected by FERHRI during October 2010 in the vicinity of the proposed PA-C area recorded limits of 6.738-7.042 ml/l, with profiles that usually decreased with depth.

5.3.8.2 Biological Oxygen Demand

Biological oxygen demand (BOD) can be used as an indicator of the degree of organic matter in the water column. Available data show a trend of increasing BOD with water depth in the Sakhalin region, with BOD1[35] ranging from 0.15 to 0.30 ml/l and BOD5[36] increasing from 1.26 to 2.12 ml/l (SEIC 2002a, TEO-C Volume 2A & 2B Book 8, EPB: Chapter 6). The BOD levels indicate that there are low levels of organic content.

During October 2010, BOD5 in the vicinity of the proposed PA-C area ranged 0.215 to 0.655 ml/l, with no consistent pattern with respect to depth; FERHRI considered these to be typical values for the Sakhalin shelf.

5.3.8.3 pH Levels

In the Sakhalin region, pH is relatively constant and generally decreases from 8.2 in the surface waters to 8.0 to 8.1 in waters of 50 to 100 m depth (SEIC 2002a, TEO-C Volume 2A & 2B Book 8, EPB: Chapter 6). In the Piltun-Astokh area, pH values are similar, with a pH of 8.15-8.35 at a depth of 20 m decreasing to an almost constant value of 8.1 between 50-100 m; seasonal fluctuations in pH show a slight increase from summer to autumn, with surface water pH values increasing from 8 to 8.2 from August to September (SEIC 2002a, TEO-C Volume 2A Book 8, EPB: Chapter 6).

[35] Biological Oxygen Demand over one day resulting from the consumption of organic matter
[36] BOD5 measures the oxygen consumed by heterotrophs as they consume organics over a five-day period. BOD5 is used as an indirect measure of the concentration of organic matter in water.

5.3.8.4 Nutrient Concentrations

Nutrient concentrations recorded in the Piltun-Astokh area are presented in Table 5-2. Lateral distribution patterns of nutrients are influenced by an influx of silica and nitrites from the Amur River and lagoonal waters along the north-east coast (SEIC 2002a, TEO-C Volume 7 Book 1-EIA: Chapter 1). In offshore waters, nitrate and phosphate concentrations are lowest in surface waters during the spring and summer due to the consumption of nutrients by phytoplankton, but increase with depth. Nutrient concentrations measured at the PA-C site in 2010 were similar to those measured pre-2002 in the general PA area.

Table 5-2. Seawater nutrient concentrations.

Nutrient	Piltun-Astokh Area*		PA-C Site**	
	Surface	Bottom	Surface	Bottom
Nitrate (µg/l)	52-64	135-158	80-98	87-111
Nitrite (µg/l)	1.27	3.87	3.7-4.6	3.8-5.5
Ammonia (µg/l)	3.4-46.6	10.9-48.4	38-113	13-139
Phosphate (µg/l)	10-21	16-24	31-37	35-42
Silica (µg/l)	259-532	264-360	n/a	n/a

* From SEIC 2002a, TEO-C Volume 2A Book 8: Chapter 6
** From FERHRI survey, October 2010

5.3.8.5 Suspended Particulates

Concentrations of suspended particulates show only a small vertical variation in the Piltun-Astokh area with 2.0 to 4.0 mg/l observed between 0 to 15 m depth, and 4.0 to 6.0 mg/l recorded in the bottom layers. This marginal increase is due to the mobilisation of seabed sediment by bottom water currents (SEIC 2002a, TEO-C Volume 7 Book 1-EIA: Chapter 1). No significant seasonal variation has been observed.

During October 2010, concentrations of suspended particulates in the vicinity of the proposed PA-C area ranged 3.85 to 8.00 mg/l (average 5.35 mg/l), with profiles that generally increased with depth.

5.3.8.6 Contaminant Concentrations

Seawater analyses indicate that the Piltun-Astokh area has no major pollution sources. On a wider scale, Sakhalin's marine environment is generally defined as unpolluted to lightly polluted. There are, however, a small number of significantly polluted sites relating to coastal development and point source release of untreated sewage and fishing wastes (SEIC 2002a, TEO-C Volume 7 Book 1-EIA: Chapter 1). Untreated industrial and household sewage wastes from Sakhalin coastal developments represent a significant discharge into the Sea of Okhotsk. Table 5-3reports the general findings of the Piltun-Astokh area seawater analyses together with corresponding Russian standards for "Maximum Permissible Concentrations" (MPCs) where these are available.

Table 5-3. Seawater contaminant trends and concentrations.

Contaminant (µg/l)	Piltun-Astokh (pre-2002)*	PA-C Site (2010)**	MPC (µg/l)
Arsenic	<1.1 - 1.38	< 1.0	10
Barium	8.8 - 30.2	3.5 - 19.0	2,000
Cadmium	<0.01 – 0.046	0.023 - 0.066	10
Chromium	<0.5	< 1.0	-
Copper	0.03 – 0.29	0.25 - 0.98	5
Iron	1.8 - 31	2.44 - 15.80	50
Lead	0.19 – 1.12	0.05 - 0.34	10
Mercury	0.005	< 0.01	0.5
Zinc	0.24 – 2.84	0.43 - 12.10	50
Phenols	0 – 4.0	0.6 - 0.9	-
Petroleum hydrocarbons	2.5 - 30	<3.0 - 27.5	50
Detergents	0 - 35	5 - 33	100

* SEIC 2002a, TEO-C Volume 7 Book 1-EIA: Chapter 1.
** FERHRI survey conducted in vicinity of proposed PA-C site during October 2010.

On the whole, contaminant concentrations are broadly comparable with values reported in the literature for unpolluted oceanic water (Bryan 1984), though certain metals such as lead and zinc are present in slightly higher concentrations. All heavy metal concentrations recorded during June 2001 at the PA-A platform did not exceed MPCs (SEIC 2002a, TEO-C Volume 2A & 2B Book 8, EPB: Chapter 6).

Levels of petroleum hydrocarbons in seawater recorded during pre-2002 surveys at the PA-18 exploration well fluctuated between 2.5 and 30 µg/l, with an average of 12.9 µg/l (SEIC 2002a, TEO-C Volume 2A Book 8, EPB: Chapter 6). Concentrations did not reduce with increasing depth. Survey results from the PA field indicated that maximum concentrations were observed in the intermediate water layer (12.8 µg/l), with minimum concentrations in the surface layer (7.5 µg/l) and high levels in the bottom layer of 11.5 µg/l (SEIC 2002a, TEO-C Volume 2A Book 8, EPB: Chapter 6). Petroleum hydrocarbon concentrations of between 10-30 µg/l are characteristic of the northeast Sakhalin shelf, which do not exceed the MPC value of 50 µg/l (SEIC 2002a, TEO-C Volume 2A Book 8, EPB: Chapter 6). The Piltun-Astokh area contained levels of hydrocarbons that do not exceed the MPC (SEIC 2002a, TEO-C Volume 2A & 2B Book 8, EPB: Chapter 6).Table 5-3 also compares concentrations of seawater contaminants measured in October 2010 in the South Piltun area to concentrations for the PA area measured pre-2002. Significant differences are not evident.

5.4 Seabed Chemistry, Morphology and Sedimentology

5.4.1 Bathymetry and Seabed Features

The Sea of Okhotsk comprises two distinct zones: the Kamchatka continental shelf with insular shoals (e.g. sand banks or sand bars) and the deeper seabed, incorporating a complex region of basins, troughs and ridges.

The Kamchatka continental shelf covers 40% of the total area of the Sea of Okhotsk and runs from Penzhinski Bay in the north to the First Kuril Strait in the south (Figure 5-9). The shelf is gently sloping, and in some areas level. The boundary is conventionally marked along the 200 m isobath.

The remaining, and deeper, 60% of the sea area consists of a series of basins, troughs and ridges. The highest ridges and banks are the Academy of Science Rise, the Institute of Oceanography Rise, the Kashevarov Bank and the St. Iona Bank (Komex 2002). The largest basins are the Derugin, TINRO and Kuril basins. The Piltun-Astokh area is located within the

Derugin Basin, which lies northeast of Sakhalin Island and has a maximum depth of 1,780 m. The deepest basin is the Kuril Basin, which is a backarc basin, reaching depths of 3,500 m, and is associated with the volcanically active Kuril Islands. This area of the Sea of Okhotsk is a subduction zone, playing a significant mass transfer and cycle role for the sea (Komex 2002).

Geological investigations were conducted in the Piltun-Astokh area during 2000 (PECO 1998, 2000a, 2000b). The seabed is characterised by uneven relief and has an average slope angle of 2° (PECO 1998). Large and medium sized sand bars stretch from the southwest to the northeast, although these are mainly concentrated in the western and central part of the Piltun-Astokh area (PECO 1998). These features have heights of 1-2.5 m above the seabed. The largest sand bar is more than 4,000 m in length, whilst the majority vary in length between 500 and 1,500 m; their widths range from 150-400 m. Boulders, up to approximately 3 m in diameter are scattered throughout the field, the closest to the PA-B platform being located approximately 230 m away (PECO 1998). Between the PA-B and PA-A platforms, the seabed is characterised by a series of four east-west orientated sand bars and associated depressions with a gradient to the east of 4° (PECO 2000b). Three palaeo-channels occur in the area and reach depths of 15 m below the seabed in the PA-B platform area.

5.4.2 Seabed Sediments

Surface sediments in the Piltun-Astokh area comprise fine-grained sands, which form above ridges in the north-western and central parts of the field (SEIC 2002a, TEO-C Volume 2A Book 8-EPB: Chapter 5). Coarse sand and gravels occur in the southeast area of the field and are associated with the flat seabed. Sand, gravel and possible clay outcrops occur mainly in the northeast field area where a basal gravel horizon lies very close to the seabed surface. This gravel horizon lies at the base of a relatively thin and intermittent layer of Holocene sands that cover both the underlying bedrock and Quaternary formation infill of paleo-channels (PECO 2000a). Bedrock is represented by interbedded clays, loams and sands, while the infill of the palaeo-channels is composed of soft clays.

5.4.3 Seabed Contamination Analysis

5.4.3.1 Heavy Metal Content

Heavy metals in marine sediments are usually associated with fine sediments (<63 μm) as fine particles of clay and silt have a large surface area to volume ratio and more readily adsorb metals to their surface. Sites in the Piltun-Astokh area were sampled during cruises in 1995-1998 (SakhNIRO), the results of which are reported in the TEO-C, Vol 2A and 2B, Book 8 (SEIC 2002a). Table 5-4 shows minimum- and maximum-recorded concentrations of heavy metals in sediments from the Piltun-Astokh area. These values are comparable with or below the concentrations typical for unpolluted areas of the shelf of the Russian Far East and fall within general background levels (SakhNIRO 1998). Single extremely high concentrations of chromium and lead appear erroneous and should probably be rejected.

Table 5-4. Metal concentrations in sediments from the Piltun area.

Metal	1998 Data	1995 Data	Background (SakhNIRO)	2010 Data	Background (FERHRI)
Aluminium	1.18 – 6.33 %	1.22 – 4.46 %	7.2 %	257-954 µg/g	228-2420 µg/g
Arsenic (µg/g)	2.7 – 10.0	3.0 – 14.8	7.7	1.72-2.58	1.25-12.9
Barium (µg/g)	241 – 817	276 – 721	460	1.04-3.09	0.94-29.6
Cadmium (µg/g)	<0.010 – 0.23	<0.010 – 0.12	0.17	0.003-0.015	0.002-0.029
Chromium (µg/g)	0.9 – 279.0	1.4 – 58.9	72	1.09-4.82	0.15-29.2
Copper (µg/g)	0.5 – 6.2	0.6 – 6.1	33	0.47-2.39	0.11-1.53
Iron	0.15 – 1.53 %	0.16 – 1.45 %	4.1 %	1360-4610 µg/g	824-4160 µg/g
Mercury (µg/g)	0.001 – 0.016	0.001 – 0.047	0.19	0.005-0.012	0.005-0.009
Lead (µg/g)	5.2 – 28.2	5.7 – 13.8	19	0.82-1.63	0.76-3.48
Zinc (µg/g)	2.4 – 38.8	3.3 – 26.6	95	1.39-6.29	0.3-12.9

Data were acquired during 2010 in the area of the proposed PA-C platform (FERHRI). Different background levels were reported by SakhNIRO and FERHRI based on their respective datasets; both are provided for comparison.

5.4.3.2 Radionuclide Activity

Radionuclide activity analysis of Piltun-Astokh area sediments indicate that α (‘alpha’) and ß (‘beta’) radiation levels are within the normal expected range for uncontaminated sediment, i.e. 50.9-75.9 Bc kg for α-radioactivity, and 60.1-110.1 Bc/kg for ß-radioactivity, with an average value of 93.0 Bc/kg (SEIC 2002a, TEO-C Volume 2A Book 8-EPB: Chapter 5).

5.4.3.3 Hydrocarbons

There is currently no norm for a maximum permissible level of non-aromatic hydrocarbon (NAH) content in sediments in Russia. Dutch guidelines specify a target value of 50 µg/g and an intervention value of 5,000 µg/g for mineral oil in terrestrial soil.

By comparison, TPH values in bottom sediments near the PA-C, as a whole, varied within <0.5—6.1 µg/g, averaging 1.7 µg/g (FERHRI 2011[37]). Background concentrations of hydrocarbons in sediments of the northeast shelf of Sakhalin Island average 19.6 µg/g (range 15-24 µg/g) in pelite and aleurite silts, and 11.1 µg/g (range 6-16 µg/g) for terrigenous sands (Nemirovskaya, 2004).

5.5 Coastal Landscape

The coastline of Sakhalin Island can be divided into three types:

- Steep coastlines with low mountains terminating at the shore, predominantly in the mid-latitudes of the island;
- Flat coastlines with lakes and shallow bays, predominantly along the Sakhalin Shelf to the north of the island; and
- Intermediate undulating coastlines punctuated by bays and river mouths (SEIC 2002a, TEO-C Volume 7 Book 1-EIA: Chapter 1).

The shore of northeast Sakhalin is characteristic of a flat coastline with lakes and shallow bays. Here, barrier spits comprise narrow, long landforms of fine sand that separate coastal bays

[37] FERHRI 2011. Results on background ecological survey in the area of installation of the South Piltun platform (PA-C).

from the Okhotsk Sea. Spits on the northeast coast include Nabilsky and Chaivo (35-45 km long, 3.0-3.5 km wide), and Piltun Spit (60 km long and 0.6-1.0 km wide; SEIC 2002a, TEO-C Volume 2A Book 8-EPB: Chapter 5).

The low-lying coastline adjacent to the Piltun-Astokh area comprises narrow inlets, shallow lakes and bays including those at Piltun, Chaivo, Lunsky, Nabilsky and Nivsky. There are no major watercourses in the vicinity of the Piltun-Astokh area. The large shallow bays have permanent inlets, some of which are over 10 km long (Piltun and Nabilsky) and 1-2 km wide (Nyivo and Anuchin). Active erosion from tidal currents has resulted in the deepening of some inlet bottoms relative to the floor of the bay and the adjacent seabed (SEIC 2002a, TEO-C Volume 2A & 2B Book 8-EPB: Chapter 5).

The extent of coastal habitat/vegetation is generally delineated by the surf splash-zone or highest tidal limit. However, saline influence may extend further inland owing to the effects of salt spray and the presence of numerous brackish water bodies within the coastal sandbar complex associated with Piltun and Chaivo Lagoons. The vegetation of the second coastal ridge has developed over a relatively long period of time without significant saline influence and therefore resembles non-maritime plant communities. In the Piltun-Chaivo area this vegetation community comprises Dahurian larch (*Larix gmelinii*) and Japanese stone pine (*Pinus pumila*) on the sandy coastal ridges. The second coastal ridge is separated from the first ridge by numerous depressions with damp and wet transitional areas. The first coastal ridge consists of relatively recent sand deposits, sometimes comprising significant areas of open sand. The vegetation community is typified by Japanese rose (*Rosa rugosa*) and mixed-herb species such as saw-wort (*Saussurea sachalinensis*), wormwood (*Artemisia opulenta*), seaside ragwort (*Senecio pseudoarnica*), sea-pea (*Lathyrus japonicus*) and other meadow herbs. Mobile and semi-fixed dunes occur along the immediate coastline above the mean high water mark. These support species of lyme grass (*Elymus* spp.), large-head sedge (*Carex macrocephala*), tree-lupin (*Thermopsi lupinoides*), Bei Sha Shen (*Glehnia littoralis*) and oyster plant (*Mertensia maritima*).

Within the “coastal zone” between the first and second ridges, water-bodies (brackish immediately adjacent to the shore) are surrounded by peat bogs with *Sphagnum* spp. and mixed grass communities. Sedges such as Lyngbye’s sedge (*Carex cryptocarpa*) or mixed-herbs and reedgrass (*Calamagrostis* spp.) occur, along with coastal species such as the umbellifer (*Angelica gmelinii*), Scots lovage (*Ligusticum scoticum*) and marsh pea (*Lathyrus palustris*). The water-bodies within the wetland complex support some aquatic macrophytes, notably pondweed (*Potamogeton* spp.) and eelgrass (*Zostera* spp.) in the brackish waters of the main lagoons (FESU 2000).

5.6 Geological Environment and Seismic Stability

5.6.1 Sea of Okhotsk and Sakhalin Island

The Sea of Okhotsk region is seismically unstable and earthquakes occur regularly. Northern Sakhalin experiences predominantly crustal earthquakes with focal depths of 0 to 35 km. Earthquakes with wave magnitude (MLH) of approximately 5.0 and greater are associated with large basement faults, and 90% of major earthquakes occur in areas of fault intersection (SEIC 2002a, TEO-C Volume 2B Book 8-EPB: Chapter 5). Smaller earthquakes with MLH equal to or smaller than 4.5 have a less predictable distribution throughout the area.

5.6.2 Piltun-Astokh Area

The Piltun-Astokh area is located on the Piltun-Astokh mega-anticline, a part of the Odoptinsk anticlinal zone that extends along the shelf of northeast Sakhalin for a length of approximately 150 km and down to a depth of 17 km (SEIC 2002a, TEO-C Volume 2A Book 8-EPB: Chapter

5). The Piltun-Astokh mega-anticline combines three structures, the Piltun brachyanticline, southern Piltun polyanticline and Astokh brachyanticline.

The survey area encompassed the southwest slope of the Piltun structure and part of the flexure dividing the Piltun and Astokh structures (PECO 2000a). The PA-B platform is located on the Piltun structure or Piltun brachyanticline. Shallow gas anomalies are present in the northeast part of the Piltun-Astokh area (PECO 2000a). These anomalies appear to be associated with faulting of the Piltun structure. However, these are more than 700 m from the platform location (PECO 2000a). The southern slope of the Piltun structure is broken by a number of southwest northeast trending faults. Evidence of a fault with both horizontal and lateral movement has been identified at the south-western edge of the Piltun.

5.7 Physical Environment and Marine Sound

The ocean can be a very efficient conductor of acoustic energy, so that underwater sounds are capable of propagation over long distances in the deep ocean in particular; for example, signals from a low frequency sound projector at Heard Island in the Indian Ocean were detected more than 20,000 km away (Munk et al. 1994). However, shallow water environments are normally much less conducive to long-range sound propagation, due mainly to the important attenuating influences of seabed and sea surface, and the lack of a deep ocean sound channel (Urick 1975).

The noise-conducting ability of shallow, coastal water is highly dependent on the sound speed profile, water depth, seabed properties[38], sea-surface properties, and the frequency of the noise (Urick 1975). Different combinations of these factors can result in very good or very poor sound conduction, and need to be considered in baselines for impact assessment (see Chapter 6).

5.7.1 Sound Speed Profiles

The sound speed profile of a water column is a key parameter influencing underwater sound propagation. The speed of sound is dependent on the temperature of the water; higher temperatures lead to higher sound speeds (Clay and Medwin 1977); baseline information on water temperature in South Piltun is presented under Section 5.3.4 of this report. In the Piltun-Astokh region, it is common for solar heating of surface waters in summer to create profiles that have higher sound speed near the surface than near the bottom (Borisov et al. 1994). These summer profiles cause sound waves to refract (propagate on a curved path) downward away from the surface. And downward refraction causes more sound interaction with the bottom, resulting in increased bottom loss.

5.7.2 Bathymetry

An important feature of sound propagation in coastal water is that shallow water depths define a low-frequency limit, the “low-frequency cut-off”, below which sounds are rapidly attenuated (Urick 1975)[39]. As water gets shallower, it supports propagation of higher-frequency sounds; a water column will never support propagation of sound at wavelengths greater than four times the depth. The *actual* low-frequency cut-off is, however, generally higher than this theoretical

[38] Whereas deep-water sound can travel significant distances before interacting with bottom or surface, shallow water sound reflects off these surfaces quite frequently; hard seabeds such as rock tend to reflect more acoustic energy back into the water than soft seabeds such as mud.

[39] Acousticians have shown that the low-frequency cut-off can be explained mathematically in terms of modes of vibration in the sea. The modes are analogous to resonance of sound in organ pipes; as an organ pipe gets shorter and narrower it supports only higher frequency modes of vibration.

limit, and is dependent on the compressional sound speed of the seabed materials[40]; see Section 5.7.3. The cut-off frequency is not necessarily a hard limit; rather it defines the frequency at which a gradual transition from worse-to-better sound transmission occurs with increasing frequency.

5.7.3 Geoacoustic Properties

The rate at which sound level decreases with distance from the source is closely related to geoacoustic properties of the seabed in shallow water. For the purpose of modelling the transmission of sound from a source, five geoacoustic parameter profiles have to be known: sediment density, compressional wave speed, compressional wave attenuation, shear wave speed, and shear wave attenuation (Jensen et al. 1994).

No direct measurements of these parameters in the Piltun-Astokh region are available, except for the results of some coring studies that could not be taken as being representative of the overall geological properties of the region. Consequently, a base set of values for these parameters was taken from published information on geoacoustic properties of the seabed (Hamilton 1976, 1980). These parameters are summarized in Table 5-5.

Table 5-5. Nominal geoacoustic parameters of the seabed for the Piltun-Astokh region.

Parameter	Nominal Value
Compressional speed (at seabed surface)	1652 m/s
Compressional speed gradient	1m/s/m
Compressional attenuation	0.14 dB/λ
Density	1722 kg/m3
Shear speed	150 m/s
Shear attenuation	13.6 dB/λ

The nominal values in Table 5-5 were obtained as follows: compressional wave attenuation coefficient and sediment density are based on values for sandy-silt on the continental terrace for terrigenous sediments (Hamilton 1980, Tab. IB). The shear wave attenuation coefficient is based on the average of values for diluvial sand and clay (19.8 dB/λ) and for diluvial sand (7.4 dB/λ) (Hamilton 1980). Using these assumptions, the following parameters were postulated for the entire region: density 1772 kg/m3; compressional wave attenuation 0.14 dB/λ; compressional wave speed gradient 1m/s/m; shear wave attenuation 13.6 dB/λ. The compressional wave speed and shear wave speed could not be estimated with sufficient accuracy to ensure reliable model outputs without some form of measurement based tuning. These parameters were therefore chosen based on fitting model predictions with dedicated transmission loss measurements (Hannay and Racca 2005). This yielded average optimized values of 1652 m/s (at the seafloor) for compressional speed and 150 m/s for shear speed.

[40] Sounds with frequencies above the low-frequency cut-off are influenced in a substantially different way to sounds below the cut-off. For frequencies above the cut-off, one or more “vibration modes” may be excited; these modes can provide a very efficient sound-conduction mechanism in the shallow sea environment. In general, however, there exists an “optimal” sound propagation frequency in shallow water environments that is inversely related to the water depth (Jensen et al. 1994). Above this optimal frequency, scattering due to seabed and sea-surface roughness start to disrupt the modes. This effect is a function of the physical size of the seabed unconformities relative to the sound wavelength, and therefore disruption increases with frequency. Consequently, in shallow marine environments, an increase in transmission loss occurs with increasing frequency.

5.7.4 Ambient Noise

Ambient sound is a relevant component of the acoustic footprint when predicting impact potential of additional noise sources. Figure 5-4 provides an example of a measured spectral profile of mainly natural, ambient noise measured by an underwater acoustic recorder at a control station to the north of the Piltun-Astokh region, in September 2003 (Kruglov and Rutenko 2004).

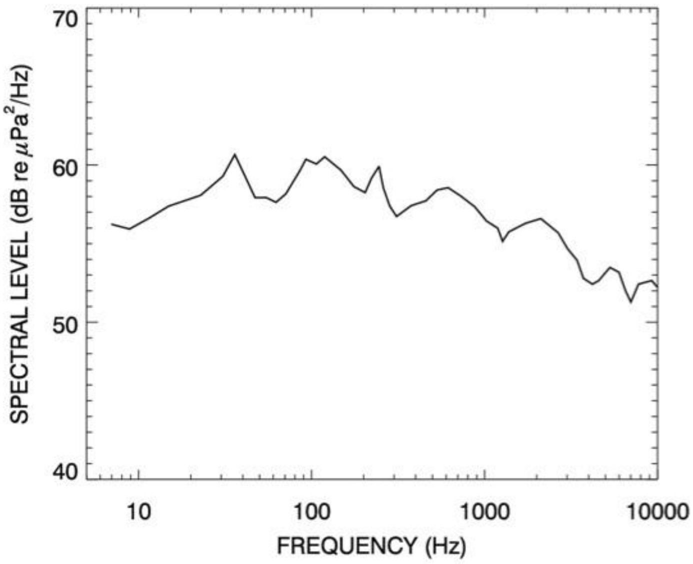
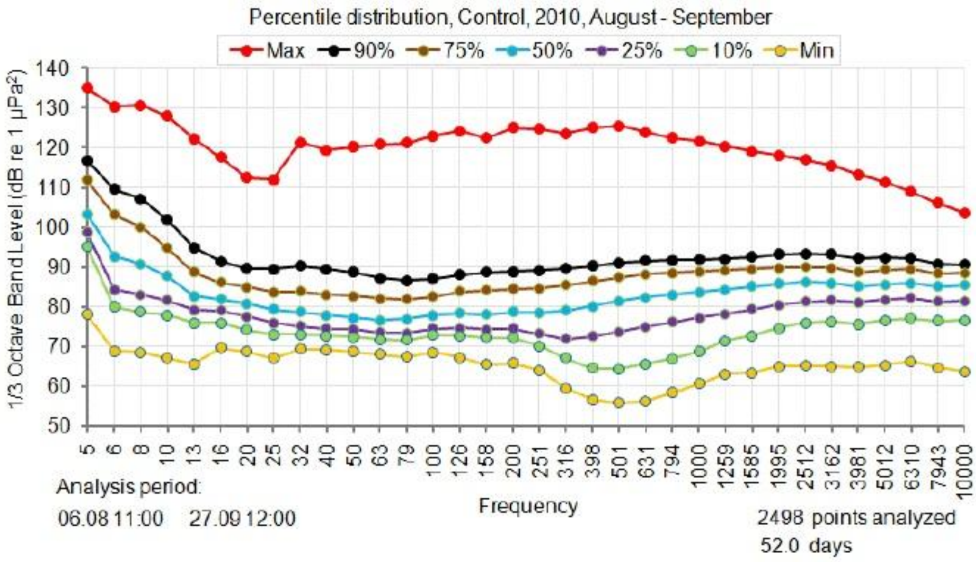


Figure 5-4. Spectral profile of ambient noise north of the Piltun-Astokh region.

More recent ambient noise data[41] is depicted in Figure 5-5, which shows percentile plots for the frequency distribution of ambient noise during August – September 2010[42]. The northern-most AUAR station ("Control") is located significantly to the north of the Sakhalin-1 and Sakhalin-2 projects, in the northern-most reaches of the Piltun feeding area, while the Piltun AUAR station is located in the nearshore – within the notional feeding area – approximately abeam the proposed location for the south Piltun development. The latter provides a geographically and temporally representative dataset for baseline ambient noise.

[41] From Borisov et al, 2011. Acoustic & Hydrographic Studies on the North East Sakhalin Shelf, 27th July to 5th October 2010. Downloaded from http://www.iucn.org/wgwap/wgwap/meetings/wgwap_10

[42] Ambient data during July 2010 were not reported presumably because the Astokh 4D seismic survey occurred during that period.



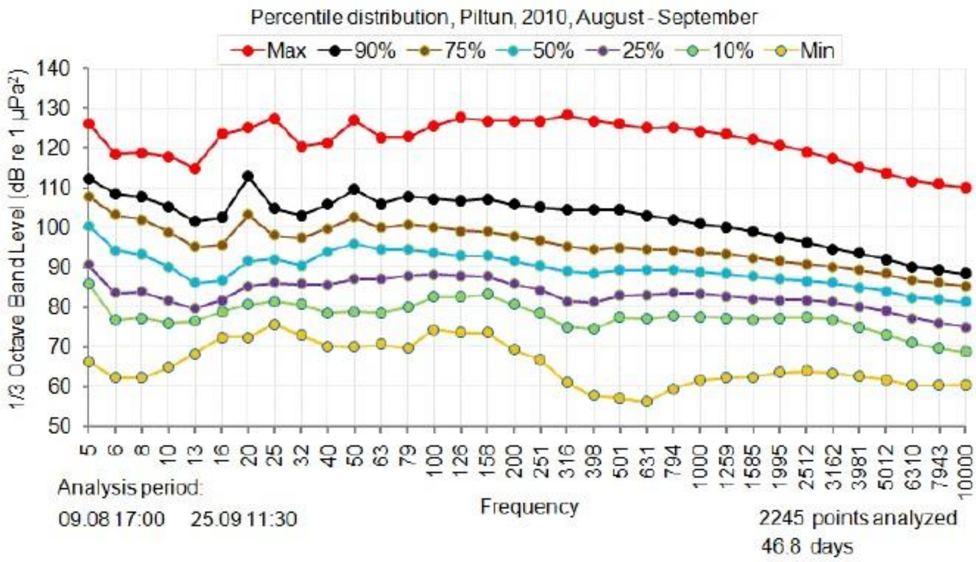


Figure 5-5. Power spectral density percentile plots of sound pressure level at Control and Piltun acoustic monitoring stations, Aug-Sep 2010. Coordinates for the Control AUAR station are 53°25.982N 143°11.108E, and for Piltun AUAR station are 52°49.328N 143°24.890E. Both stations are 20 m depth. A seismic survey occurred during this period in the Lebedinskoye field[43].

Anthropogenic sound sources expected to contribute to ambient noise in the Piltun-Astokh region at the time of the planned site survey (summer 2012) include:

- Industrial noise from operating PA-A and PA-B platforms;
- Drilling activities from PA-B platform;
- Support and supply vessels associated with operational and drilling activities.
- Annual survey and inspection of subsea assets, seabed survey of pipelines and platform 500m zone, comprising multibeam echosounding (MBES) and side scan sonar (SSS), duration approximately 20 days.

[43] A Sakhalin-5 seismic survey was carried out during August-September 2010 at the Lebedinskoye field to the north of Odoptu. Even though some industrial noise from the Lebedinskoye survey may be incorporated in the ambient data for the Control station, the 90% power spectral density percentile level at 15 Hz was no greater than 94 dB re 1 µPa2.

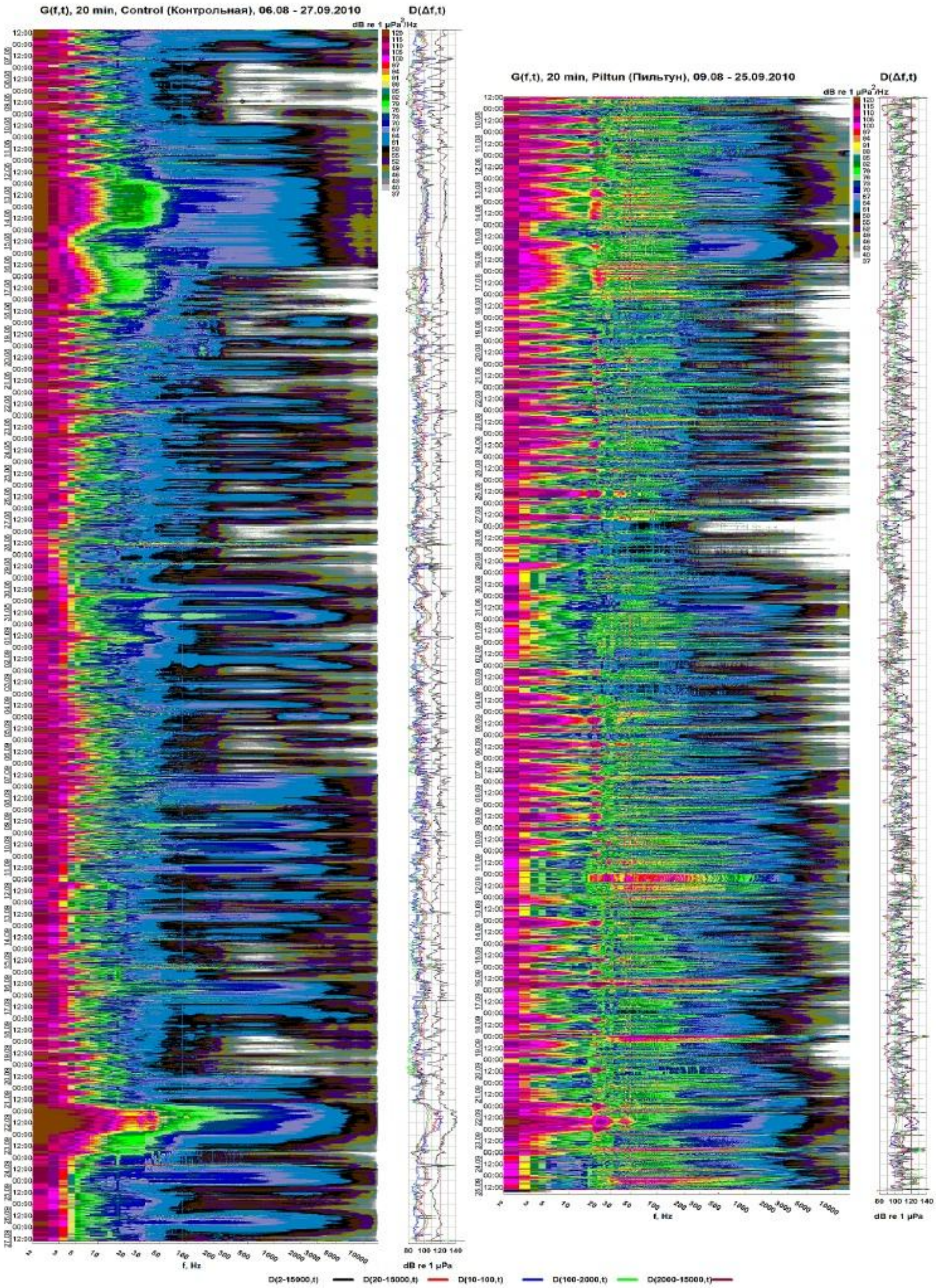


Figure 5-6. Sonogram of acoustic data recorded at the Control and Piltun monitor stations.

Figure 5-6 compares sonograms of acoustic data recorded at the Control and Piltun monitor stations during August to September 2010, allowing visualization of anthropogenic contribution to ambient noise at the Piltun monitoring station (Borisov et al., 2011). It is likely that the 20-300 Hz acoustic noise recorded almost continuously at the Piltun station was generated by the *Smit Sibu*, the standby vessel for the Molikpaq and PA-B platforms, which was stationed between these platforms, across from the Piltun acoustic monitoring station.

Figure 5-6 also shows the effect on ambient noise of two powerful cyclones that hit the area during 10-15 August and during 21-22 September, causing storm-driven waves and swells. Wind gusts, rain and storm-induced surface waves caused broad-band acoustic noise up to 15 kHz, and orbital motion of the water particles. During these periods, the power spectral density level for frequencies below 20 Hz exceeded 115 dB re 1 μPa^2/Hz and sound pressure levels as high as 140 dB re 1 μPa^2/Hz in the 10-100 Hz frequency range. Additionally, low-frequency (20-30 Hz) narrow band components are present in the spectra due to resonant vibrations of, for example, the hydrophone suspension. These noises are also well defined during tidal currents (Borisov et al., 2011).

Natural and anthropogenic noise together provide the ambient noise 'backdrop' against which new sources (e.g. seismic surveys) should be assessed. The extent to which underwater acoustics (level and frequency) of an additional source deviate from the ambient acoustics local to a receptor is relevant to the determination of potential impacts to that receptor (Richardson et al. 1995).

5.8 Marine Plankton, Invertebrates and Fish

The Sea of Okhotsk is one of the richest seas in the world, supporting a high level of productivity and species diversity. The following sections describe the main species / groups that occur and contribute to the marine and coastal biodiversity of the Sea of Okhotsk and the north-eastern coast of Sakhalin Island in the vicinity of the Piltun-Astokh area. Information on hearing physiology of marine invertebrates and fish is presented in Chapter 6, §6.5.1 and 6.5.2.

5.8.1 Plankton Communities

5.8.1.1 Phytoplankton

Phytoplankton are capable of photosynthesis (i.e. primary producers) and include cyanobacteria, diatoms, desmids and dinoflagellates.

During the summer months when the Sea of Okhotsk is free of ice, primary productivity rises rapidly and is dominated by silicaceous plankton (Komex 2002). Populations are unevenly distributed due to sea currents but are concentrated around the Kamchatka Peninsula and in the northern areas of Sakhalin Island (NOAA 2002). The offshore areas to the north and north-east of Sakhalin Island are characterised by large spring and summer phytoplankton blooms, which may be evident until October, and autumn diatom blooms where diatom biomass can reach 5000 to 10,000 mg/m^3 (Komex 2002). The estimated annual production of cyanobacteria and protozoa in the Sea of Okhotsk is 5.2 x 10^9 and 2.1 x 10^9 tonnes respectively (NOAA 2002).

The phytoplankton community in the Piltun-Astokh area is also the most productive, abundant and largest in terms of biomass on the north-eastern shelf (SEIC 2002a, TEO-C Volume 2A Book 8-EPB: Appendix F1). Plankton surveys undertaken by local scientific institutes (DVNIGMI and SakhUGMS) during 1998-2000 recorded average biomass during the summer of 4180-5389 mg/m^3, and 675.5-1425 mg/m^3 during the autumn (SEIC 2002a, TEO-C Volume 2A Book 8-EPB: Appendix F1). Sporadic observations of winter biomass in the area (including other parts of the Sea of Okhotsk) indicate that phytoplankton biomass ranges 50 to 60 mg/m^3 (SEIC 2002a, TEO-C Volume 2A Book 8-EPB: Appendix F1).

Phytoplankton in the Piltun-Astokh area comprise between 70 and 110 species. Diatoms (*Bacillariophyta*) are the most abundant species in the surface and intermediate layers, whereas below the pycnocline dinoflagellates (Dinophytes) are the most diverse species (SEIC 2002a, TEO-C Volume 2A Book 8-EPB: Appendix F1). The diatoms exhibiting the greatest species diversity include the genera *Chaetoceros*, *Thalassiosira* and *Navicula*, whereas the *Peridinia* with the greatest number of species include *Protoperidinium* and *Gymnodinium*.

The phytoplankton community in the vicinity of the proposed PA-C platform in October 2010[44] included 100 species: 49 species of Dinophyta, 44 of Bacillariophyta (Diatoms), two Chlorophyta, one Chrysophyta, two Cryptophyta, and two Haptophyta.

Some species occasionally dominated samples. For example, some samples comprised 100% *Ceratium longipes*, other samples comprised 97% *Thalassiosira punctigera* and *Thalassionema frauenfeldii*, others 85% *Thalassiosira bramaputrae*, others 82% *Paralia sulcata*, and others 91% *Plagioselmis punctata*.

Dinophytes and diatoms dominated abundance and biomass: their average abundance was 2.42×10^3 cells/l and 3.98×10^3 cells/l, respectively; while average biomass was 123.8 mg/m^3 and 35.0 mg/m^3, respectively. There were no clear patterns to the distribution of phytoplankton in the PA-C area.

5.8.1.2 Zooplankton

Zooplankton are heterotrophic plankton that range in size from small protozoans to larger metazoans. They include holoplanktonic organisms, with life cycles completely within the plankton form, and meroplanktonic organisms that have only part of their life cycle (e.g. eggs, or larvae) in the plankton form.

Ecologically important protozoan groups include the foraminiferans, dinoflagellates, and radiolarians; important metazoan groups include some cnidarians (e.g. jellyfish), crustaceans (e.g. copepods, krill), chaetognaths, certain molluscs, and chordates such as salps and juvenile fish. This range reflects a wide range in feeding behaviour among zooplankton groups, including filter feeders and predators that feed on bacterioplankton, other zooplankton, phytoplankton, and detritus.

Thus, zooplankton play an important role in aquatic food webs as a food resource for higher trophic levels (including fish), and in biogeochemical cycles (e.g. carbon). Since they are typically small, zooplankton can respond rapidly to increases in phytoplankton abundance, for instance during spring blooms.

In the Sea of Okhotsk, zooplankton communities are dominated by the copepods *Pseudocalanus minutus*, *Oithina similes*, *Metridia ohkotensis*, *Metridiapacifa*, *Calanus crisatus*, *Calanus* plumchrus, *Calanus glacialis*, and the crustaceans *Thysanoessa raschii*, *Thysanoessa longipes*, *Thysanoessa inermis* and *Euphasia pacifica*. The total annual zooplankton production in the Sea of Okhotsk has been estimated at approximately 3×10^9 tonnes (NOAA 2002).

In the Piltun-Astokh area, neritic copepod species[45]inhabiting the brackish-freshwater areas of the shallow inlets and bays dominate coastal zooplankton assemblages (DVNIGMI 2002). Zooplankton in the area of the PA-B platform are also predominantly neritic, with elements of a pelagic community (DVNIGMI 2002); they are characterised as a relatively mature community with a high percentage of predatory plankton (SEIC 2002a, TEO-C Volume 2A Book 8-EPB:

[44] FERHRI 2011. Results on background ecological survey in the area of installation of the South Piltun platform (PA-C) (Final Report). Prepared by SE Far Eastern Regional Hydrometeorological Research Institute for Sakhalin Energy

[45] e.g. *Pseudocalanus minutus*, *Eurytemora herdmani*, *Centropages abdominalis*, and species of the genus *Acartia*

Appendix F1). Average zooplankton abundance was 23,112 organisms/m^3 (SEIC 2002a, TEO-C Volume 2A Book 8-EPB: Appendix F1); the predominant species were epipelagic copepods *Oithona similis* (8,170 organisms/m^3) and *Pseudocalanus minutus* (1,726 organisms/m^3) and pelagic species, *Metridia okhotensis* (4,885 organisms/m^3). Monitoring activities during 2000 indicated that the coastal waters of the central part of the region (between Piltun and Lunskiy Bays) are relatively barren compared to the north and south of Sakhalin Island.

The zooplankton community, excluding ichthyoplankton, sampled in the vicinity of the proposed PA-C platform during October 2010 included eight groups of holoplankton and six groups of meroplankton. Holoplankton were represented by 25 species, of which 16 were copepoda[46]. Other holoplankton included species of Cladoceran, Appendicularia and Pteropoda. The abundance of holoplankton ranged 3,620 to 23,916 ind/m^3, with an average of 11,452 ind/m^3; abundance was greater at control stations to the north of the proposed PA-C area. Spawning of average intensity was recorded for copepods *Pseudocalanus newmani*, *Oithona similis*, *Acartia longiremis* and *Eurytemora herdmani*. Spawning was also noted for Appendicularia and Pteropoda.

The abundance of meroplankton, represented by larvae of bivalvia and barnacles, ranged 73 to 882 ind/m3, with an average of 402 ind/m3, and appeared to play a relatively minor role among zooplankton. Zooplankton biomass was dominated bypteropod *Limacina helicina* (34.3 %), and copepods *P. newmani* (22.4 %) and *O. similis* (21.3 %). No patterns were noted for distribution of zooplankton diversity or biomass at the PA-C site.

In general, zooplankton in the PA-C area in 2010 were neritic; a few open ocean representatives included *Eucalanus bungii*, *Neocalanus plumchrus*, *Tomopteris septentrionalis*. This reflects a weak interaction of planktonic community of the survey area with epipelagial community of deep-water areas of the Okhotsk Sea.

5.8.2 Benthic Communities

The benthic fauna of the shelf system of north-east Sakhalin has been investigated by a number of researchers since the early 1980s, notably Koblikov (1982), Averintsev et al. (1982), Borets (1985), Dulepova and Borets (1990), Kussakin et al. (2001), and Fadeev (2002, 2003, 2004, 2005, 2006, 2007). Their work showed that species composition and the distribution of benthic communities on the shelf are largely controlled by sediment type and water depth.

Variable biomass and diversity values have been recorded in these studies. Averintsev et al. (1982) observed large populations of the common sand dollar (*Echinarachnius parma*) in water depths of 15-120 m, covering an area of over 13,000 km^2, (i.e. about 40% of the shelf area). The *E. parma* community is associated with fine sand and with muddy sand in areas of relatively high current activity, with numbers decreasing as the mud content of the sediment increases towards the south of the shelf (reflecting a reduction in current strength).

Data from Dulepova and Borets (1990) and Borets (1985) show that the shelf area of north-eastern Sakhalin differs from other parts of the Sea of Okhotsk due to the relatively high abundance of sand dollars and amphipods. Their survey revealed that amphipods comprised 7.5% of total biomass, while in other parts of the Sea of Okhotsk values for these crustaceans ranged from 0.7% (on the Pritauyiskii shelf) to 2.5% (in Terpeniya Bay).

The mean biomass of benthos on the shelf area (to a depth of 100 m) has been calculated at 500g/m^2, with values varying with sediment type and the presence/absence of certain key species (e.g. *E. parma*). Relatively high biomass is reported for depths to 100 m in the north and central shelf. Koblikov (1982) presented a mean benthic biomass value of 428.6 g/m^2 for

[46] FERHRI 2011. Results on background ecological survey in the area of installation of the South Piltun platform (PA-C) (Final Report). Prepared by SE Far Eastern Regional Hydrometeorological Research Institute for Sakhalin Energy

the shelf area between Schmidt Cape in the north to the Cape of Lunskii Bay in the south. This figure is comparable with that reported by Kussakin et al. (2001) who quoted a range of 200 to 500g/m^2 for this area, of which sand dollars comprised 58% biomass, crustaceans 12.3%, bivalve molluscs 7.4% and polychaetes 4.9%.

A number of specific survey programmes to examine benthic diversity in the nearshore Piltun area have been undertaken since 1998, including an investigation of benthic communities in and around the area where the PA-A platform has been constructed.

Data from these surveys indicate that sediments within the Piltun-Astokh area primarily fine to medium grain sands with areas of fine and medium gravels. Annual perturbations of the benthos from ice-scour in water depths to 20 m (January to April) and storm waves create an unstable physical environment that may be responsible for the dominance of opportunistic species such as the cumacean *Diastylis bidentata*, and suggests that the benthic fauna is adapted to physical change with annual cyclicity.

The 1998 characterisation survey (CSA 1998; SakhNIRO 1999a) obtained 67 benthic sediment samples from stations in the Piltun area and along two initially proposed pipeline routes. The most numerous taxa recorded from this survey were amphipods (38 species) and polychaetes (31 species) and, to a lesser extent bivalve molluscs (18 species). The total faunal abundance varied from 80 to 106,400 individuals per square metre (ind/m^2) with *Diastylis bidentata* being particularly abundant (contributing over 50% of the macro-infaunal abundance at 65 of the 84 stations). Bivalves accounted for 26% of the total faunal density (excluding cumaceans). By far the most numerous bivalve species was *Mysella kurilensis* (tumida) observed at a maximum density of 13,440 ind/m^2. The sand dollar *E. parma* accounted for 14% of the total abundance, with numbers at some stations exceeding 1000/m^2. Polychaetes accounted for 8% of total abundance, while actinids (sea anemones) – the most dominant species being *Halcampa* sp. and *Epiactislewisii* – accounted for 3% of the total benthos.

The total biomass varied from 10 to 17,062g/m^2 with *E. parma* predominating (67-99% of the total biomass),then *D. bidentata*. These two species, along with the priapulid worm *Priapulus caudatus*, were the most frequently encountered animals in the sediment samples taken in the Piltun area (CSA 1998; SakhNIRO 1999a).

A survey conducted in 2001 (reported in FERHRI 2003) recorded faunal communities similar to those reported by SakhNIRO (1999), with polychaetes (48 species) and amphipods (46 species) dominating and bivalves (17 species) also forming a significant component of the fauna.

In autumn 2010, 112 species of macrobenthos belonging to 19 faunistic groups were recorded in benthic samples taken in the area of the proposed PA-C platform[47]. Amphipoda (38 species) and polychaeta (31 species) dominated in terms of diversity. Eleven species of bivalves and seven species of gastropods were also present.

In general, Cumacea, Amphipoda, Actiniaria, Mysidacea and Polychaeta exhibited the highest frequency-of-occurrence and abundance in the PA-C area. Benthos abundance was dominated by cumacean D*. bidentata,* mysid *A. grebnitzkii,* amphipods, and two polychaetes, *O. limacina* and *G. capitata.*

Echinoidea dominated biomass. Highest biomass values (2,711.2 ± 969.9 g/m^2) were recorded at control stations, 10 km north of the proposed PA-C site; within the PA-C area, average benthos biomass was lower, 694.2 ± 606.3 g/m^2. The sand dollar *Echinarachnius parma* contributed most of this biomass: 97.8% at control stations, and 90.5% in the PA-C area.

[47] FERHRI 2011. Results on background ecological survey in the area of installation of the South Piltun platform (PA-C) (Final Report). Prepared by SE Far Eastern Regional Hydrometeorological Research Institute for Sakhalin Energy

Only one type of benthos community structure was identified in the PA-C area, dominated by *E. parma*. Sand dollars have low calorific value, and are not a preferred food source of gray whales. Further discussion of gray whale food resources can be found in Section 5.9.1 below.

5.8.3 Fish Communities

The Sea of Okhotsk supports a significant variety of fish; the northeast Sakhalin area alone is host to some 101 species. Fish densities vary temporarily and spatially; their distribution is complex and requires reliable and consistent databases to evaluate long-term trends, seasonal and short-term fluctuations. Research programmes have been established by the Russian government to support the commercial fishing industry in the region.

Acoustic and trawl surveys were carried out to assess commercial stocks of finfish and shellfish off northeast Sakhalin between September and October 1998, and between September and November 1999 (SAKHNIRO 1999b, 2000). Results showed that, in general, wall-eye pollock (*Theragra chalcogramma*) was the dominant species (51% of catch) off north-eastern Sakhalin. However, within the Piltun-Astokh area, great starry flounder (*Platichthys hstellatus*) was dominant (53%). The surveys also document two crab species, six shrimp species, and five gastropod species. The survey area and sample size was limited; therefore, it is not possible to extrapolate the survey findings to assess fish populations over the wider area.

Walleye pollock (or mintai) is one of the main commercial fish species in the area. It inhabits the entire basin of the Sea of Okhotsk, migrating along the Kamchatka and northern seacoasts. Spawning varies according to location and climate. There are considered to be three main spawning areas viz. the western Kamchatka shelf, Shelikhov Bay and the central sea (Lebed elevation). There is also a smaller spawning ground on the eastern coast of Sakhalin Island, where spawning occurs at the end of May to the beginning of June. Mintai yearlings remain close to the original spawning areas, being both spatially and seasonally stable until their second year when the sexually immature fish begin significant seasonal migrations within the sea. These migrations continue throughout maturation into adulthood.

Trawl surveys in 2001 identified a total of 26 species of fish belonging to 21 genera and 13 families in the Piltun-Astokh area. Seven species from the *Cottidae* (sculpins) family and six from the *Pleuronectidae* (flounders) family were recorded, while the *Osmeridae* (herrings), Gadidae (cods), and *Hexagrammidae* (greenlings) families were each represented by two species. The great starry flounder, Pacific herring (*Clupea pallasi*), four-spotted flounder (*Hippoglossina oblonga*) and saffron cod (*Eleginus gracilis*), which were seen in more than half the trawler catches (58.33 to 83.33%) were the most common fish species recorded in the north-east Sakhalin shelf region. Other species of commercial fish (walleye pollock and capelin (*Mallotus villosus*), smelt (*Osmeridae* sp.) and greenling were less frequently recorded (SEIC 2002a, TEO-C Volume 2A Book 8-EPB: Appendix F1).

Fish recorded in coastal lagoons of the area reflected the variable salinity of these water-bodies. Resident species include the blenny (*Acantholumpenus mackayi*), eelpout (*Zoarces elongatus*), several species of stickleback, and starry flounder. The lagoons are also used by a number of migratory species, such as Japanese smelt (*Hypomesus nippoensis*), East Siberian char (*Salvelinus leucomaenis*) and rudd (*Tribolodon* spp.), and the young of marine species such as saffron cod and pacific herring.

In the summer to autumn period, a number of migratory salmon species, char (*Salvelinus krascheninnikovi*) and East Siberian char (*Salvelinus leucomaenis*) occur in the shelf waters of northeast Sakhalin. The salmon species include pink or humpback salmon (*Oncorhynchus gorbuscha*), chum or dog salmon (*Oncorhynchus keta*), silver (coho) salmon (*Oncorhynchus kisutch*), cherry salmon (*Oncorhynchus masu*) and the Sakhalin taimen (*Hucho perryi*). Salmon are of significant commercial, livelihood, and cultural significance on Sakhalin Island and the spawning distributions in the rivers on the island are relatively well known. The migration routes between freshwater breeding areas and marine feeding areas, however, are not fully known but it is likely that salmon from the rivers on the east coast of Sakhalin Island migrate through the coastal waters of northeast Sakhalin to offshore waters to the south. Together pink and chum salmon constitute approximately 95% of the total commercial salmon catch on Sakhalin Island, with cherry salmon and silver salmon making up the rest.

Pink salmon is a typical anadromous fish (those that spend most of their lives in the ocean but migrate to fresh water to spawn) with a unique two-year life cycle, shorter than other salmon species. Adult pink salmon leave marine waters in the late summer and early autumn, their migration normally coinciding with the summer mean water flow period and ending near the autumn flow increase. The seaward migration of pink salmon fry occurs in northeast Sakhalin from the beginning of May until the beginning of July. The chum salmon spawning runs occur in autumn in the north-eastern part of the island and takes place in the river basins of the north-east between the end of August and November. The spawning of chum salmon is rather prolonged and spawning fish may be observed as late as March. Fry remain in the rivers for a few months and when they reach 38-40 mm in length they begin migrating to the sea, where they typically spend a couple of months in estuarine, tidal and near shore waters prior to moving out into the open ocean. Fish spend one winter feeding in oceanic waters before migrating back to their natal rivers.

Silver salmon are more numerous than cherry salmon in the rivers of north-eastern Sakhalin. Silver salmon undertakes its spawning migration later than all of the other Pacific salmon species. The spawning migration can be highly protracted and continue from early September through to mid-December in some seasons. Once hatched, young fish normally spend 2-3 years in the upper reaches of the river systems before beginning their seaward migration, typically in June-July with the majority migrating to the open sea by August. SakhNIRO (2000) report, using collated survey data, that the bulk (90%) of initial migrants from the river systems of northeast Sakhalin are three-year-old fish. Once at sea, silver salmon spend a year feeding prior to returning to their natal rivers for spawning. The cherry salmon occurs in small numbers in Sakhalin rivers and is the first migratory Pacific salmon to appear in coastal waters, normally in June in northern Sakhalin with mass migration upstream occurring during late July to early August in northern Sakhalin. The duration of the river-dwelling stage of this species appears to be dependent on diet and generally during the second year in freshwater the juvenile population divides into smolts, which undertake migration to the open sea, and parrs that remain in the river for another year. Some individuals achieve sexual maturity without leaving the rivers. The cherry salmon migration in northern Sakhalin occurs at an older age (three years) compared with that in many other regions of the range, where the bulk of juveniles leave the rivers during the second year of life (SakhNIRO 2002). Cherry salmon smolts, among which females prevail, spend a large amount of time in the near shore zone where they feed on crustaceans and small fish, before moving offshore into open waters.

The Sakhalin taimen is a rare species of salmon that occurs in Sakhalin, the Amur Basin and northern Hokkaido. It is listed in the Russian Federation Red Data Book and is classified by the IUCN as Critically Endangered (IUCN 2007). On Sakhalin it appears to be generally distributed in rivers of the central and northern part of the island and occurs rarely in the small to medium-sized rivers of the south (SakhNIRO 2000). Its main habitat is the lower and estuarial areas of large rivers, brackish-water lagoons, estuarial cut-offs, and bays, although spawning takes place in upstream sections of rivers. Taimen spend winter in the estuarial sections of rivers and normally begin to winter in mid-October through to November depending upon the weather. After wintering, mature individuals spend a short time offshore before they begin moving up-river. Spawning coincides with spring floods, at the end of April or beginning of May. After spawning (May-June), individuals migrate back to estuaries and coastal areas. Eggs hatch during early summer and young fish normally stay in the river systems for 2-5 years. The IUCN

(2007) estimates the global population at 12,806-78,925 with 1591-12,024 on Sakhalin Island (including the Kuril Islands).

5.9 Marine Mammals

Two major groups of marine mammals live around Sakhalin Island: Cetaceans (whales and dolphins) and Pinnipeds (seals and sea lions). At least 20 species likely occur in the PA license area, including 14 species of cetaceans and 6 species of pinnipeds (Table 5-6 and Table 5-8).

Most marine mammals are seasonal inhabitants. The northern and north-eastern Sakhalin coast and surrounding areas are summer feeding grounds for many species (e.g. gray whales), while other cetaceans (e.g. bowhead and beluga whales) and pinnipeds may be more abundant during winter or during early spring due to their association with sea ice.

This section provides baseline information on species composition, status, distribution, abundance, and seasonal dynamics of marine mammals of the Sakhalin Island and Sea of Okhotsk region and, specifically, in the vicinity of the PA field. It also provides detail on the gray whales. Information on marine mammal hearing is included in Chapter 6, Section 6.4.1.

5.9.1 Cetaceans

The following fourteen species of cetaceans are known to occur in the Sea of Okhotsk and may occur in the vicinity of north-east of Sakhalin Island:

- Gray whale (*Eschrichtius robustus*)
- North Pacific right whale (*Eubalaena japonica*)
- Bowhead whale (*Balaena mysticetus*)
- Fin whale (*Balaenoptera physalus*)
- Minke whale (*Balaenoptera acutorostrata*)
- Beluga/White whale (*Delphinapterus leucas*)
- Sperm whale (*Physeter macrocephalus*)
- Orca/Killer whale (*Orcinus orca*)
- Baird's beaked whale (*Berardius bairdii*)
- Dall's porpoise (*Phocoenoides dalli*)
- Harbour porpoise (*Phocoena phocoena*)
- Pacific white-sided dolphin (*Lagenorhynchus obliquidens*)
- Short-beaked common dolphin (*Delphinus delphis*)
- Bottlenose dolphin (*Tursiops truncatus*)

Four of these species, viz. bowhead whale, North Pacific right whale, fin whale and gray whale, have been greatly impacted by decades of mechanized, unregulated, and in some instances, illegal commercial whaling. Five species are currently listed in the Red Book of the Russian Federation, and six species are listed as Endangered, or Vulnerable in the IUCN Red List of Threatened Species (2007).

Cetaceans most likely to be encountered near the PA field during summer-autumn include gray whales, minke whales, orcas, and Dall's and harbour porpoises. Beluga whales are most likely seen during their spring migration. Sightings of endangered cetaceans (excluding gray whale) from the Sakhalin Energy database are shown in Figure 5-7, and sightings of non-endangered cetaceans are shown in Figure 5-8.

Table 5-6. Cetacean species potentially found in the vicinity of Sakhalin Island (Green highlighted species are most likely to be encountered near the Piltun-Astokh area)

Taxon (SubOrder, Family)	Taxon (Species, Common Name)	Region of Maximum Abundance	Season of Maximum Abundance	Local Abundance	Activity	Total Numbers in Sea of Okhotsk	Russian Red Book Category* 1 (2000)	IUCN Classi-fication*2 (2004)
Baleen Whales - Mysticetes								
Balaenidae	*Balaena mysticetus*, Bowhead Whale	Nabil Bay, near the ice edge	February – March	50—100	Winter-ing	300–400	1	LR-cd
	Eubalaena japonica, North Pacific Right Whale	Sea around Terpeniie Point	July – September	150–200 off Terpeniie Point	Feeding	Up to 800	1	EN-D
Balaenopteridae	*Balaenoptera acutorostrata*, Minke Whale	Sea along the entire east coast of Sakhalin Island	June – September	3,000– 3,500 off eastern Sakhalin Island	Feeding	Up to 19,000		LR-nt
	Balaenoptera physalus, Fin Whale	Sea around Terpeniie Point	June – September	400–600	Feeding	~ 2,700	2	EN-A1abd
	Balaenoptera musculus Blue Whale	-	June-September	Few	Feeding	Few dozen	1	En-A1abd
	Megaptera novaeanglia Humpback Whale	-	June-September	Unknown, few	Feeding	~15	1	VU-A1ad
Eschrichtidae	*Eschrichtius robustus*, Gray Whale (western)	East of Piltun and Chayvo Bays	June – September	50–120 at Chayvo and Piltun bays and north	Feeding	<150	1	CR-D
Toothed Whales - Odontocetes								
Monodontidae	*Delphinapterus leucas*, Beluga (White Whale)	Sea along the northeast coast of Sakhalin Island and Tatar Strait	May – June	400– 500 off NE Sakhalin	Feeding	20,000–25,000		VU-A1abd
Phocoenidae	*Phocoena phocoena* Harbor Porpoise	East coast of Sakhalin Island and Sakhalin Bay	Summer	Common	Feeding	Common		VU-A1cd
	Phocoenoides dalli, Dall Porpoise	Sakhalin Island	June – September	3,500 – 4,000 off eastern Sakhalin	Feeding	20,000–25,000		LR-cd
Delphinidae	*Lagenorhynchus obliquidens*, Pacific White-sided Dolphin	Tatar and La-Perous Straits	Summer	Up to 2,000	Feeding	Up to 5,000		LR-lc
	Tursiops truncates, Bottlenose Dolphin	South Sakhalin Island	Summer	Unknown	Feeding	Few		DD
	Delphinus delphis,	Southeast Sakhalin	Summer	Unknown	Feeding	Few		LR-lc

Taxon (SubOrder, Family)	Taxon (Species, Common Name)	Region of Maximum Abundance	Season of Maximum Abundance	Local Abundance	Activity	Total Numbers in Sea of Okhotsk	Russian Red Book Category* [1] (2000)	IUCN Classi-fication*2 (2004)
	Common Dolphin	Island						
	Lissodelphis borealis, Northern Right Whale Dolphin	East of Terpeniie Bay and La Perouse Strait		Unknown	Feeding	Few		LR-lc
	Orcinus orca, Orca (Killer Whale)	Entire Sakhalin Island	June – October	300-400	Feeding	1,500–2,000		LR-cd
	Globicephala macrorhynchus, Short-finned Pilot Whale	Tatar Strait	Summer	Unknown	Feeding	Few		LR-cd
Ziphiidae	*Berardius bairdii*, Baird's Beaked Whale	Along the east coast of Sakhalin Island	June – October	250 – 300	Feeding	1000–1500		LR-cd
	Ziphius cavirostris, Cuvier's Beaked Whale	La-Perouse Strait	Summer	Unknown	Feeding	Few	3	DD
Physeteridae	*Physeter macrocephalus*, Sperm Whale	Sea around Terpeniie Point and Cape Aniva	June – September	200 – 300	Feeding	~1,000		VU-A1 bd

*1 Category 1: endangered species whose abundance has decreased to critical levels, under threat of extinction in near future.
Category 2: vulnerable species whose numbers are constantly decreasing, could be moved to Category 1 in near future.
Category 3: rare species where population numbers are low, species inhabits limited territory or sporadically distributed over larger area.

*2 Codes for IUCN classifications: EN = Endangered; VU = Vulnerable; Lr-lc = Lower Risk-Least Concern

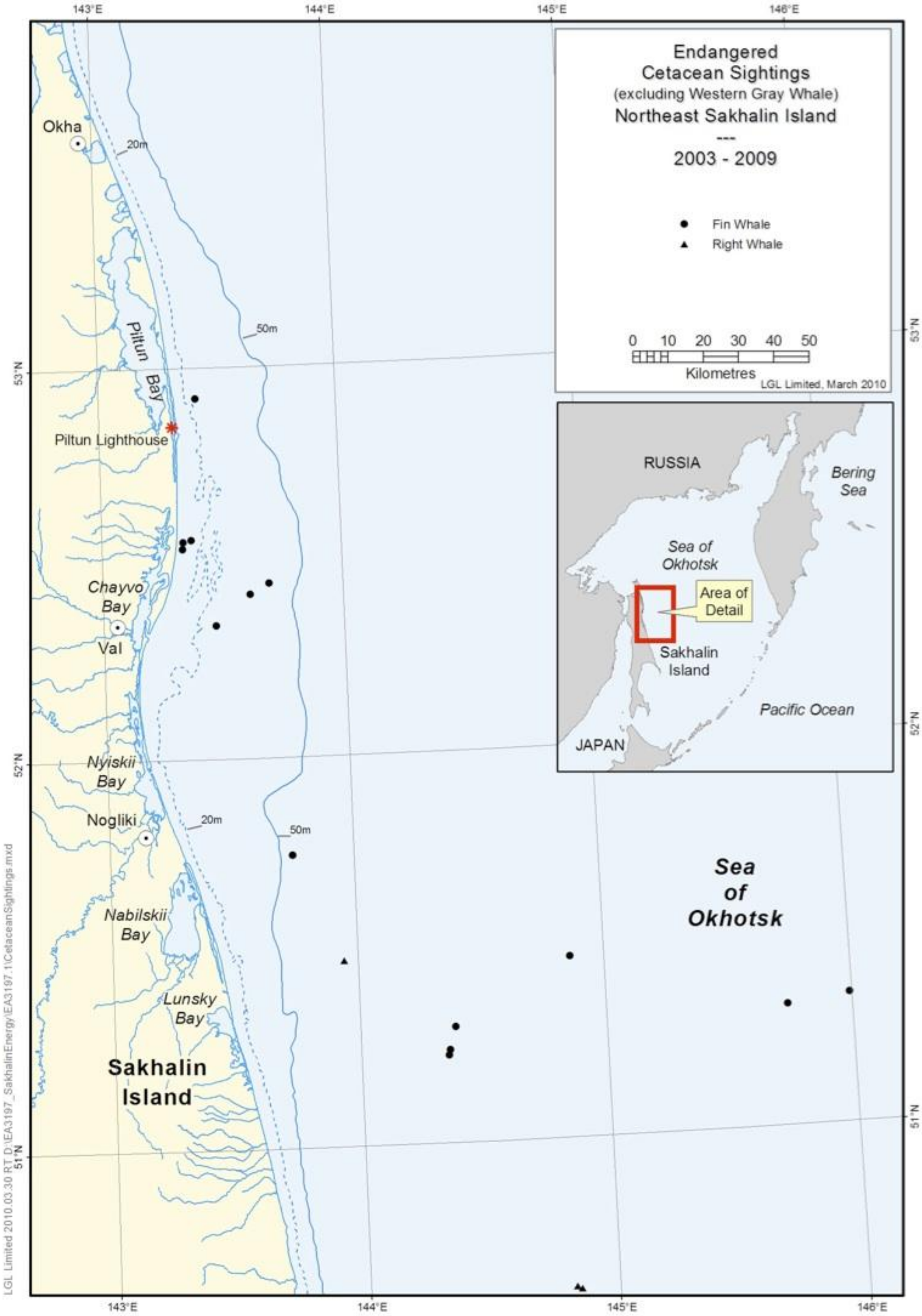


Figure 5-7. Sightings of endangered cetacean species (excluding gray whales) from the supply vessels (Sakhalin Energy MMO database, 2003-2009).

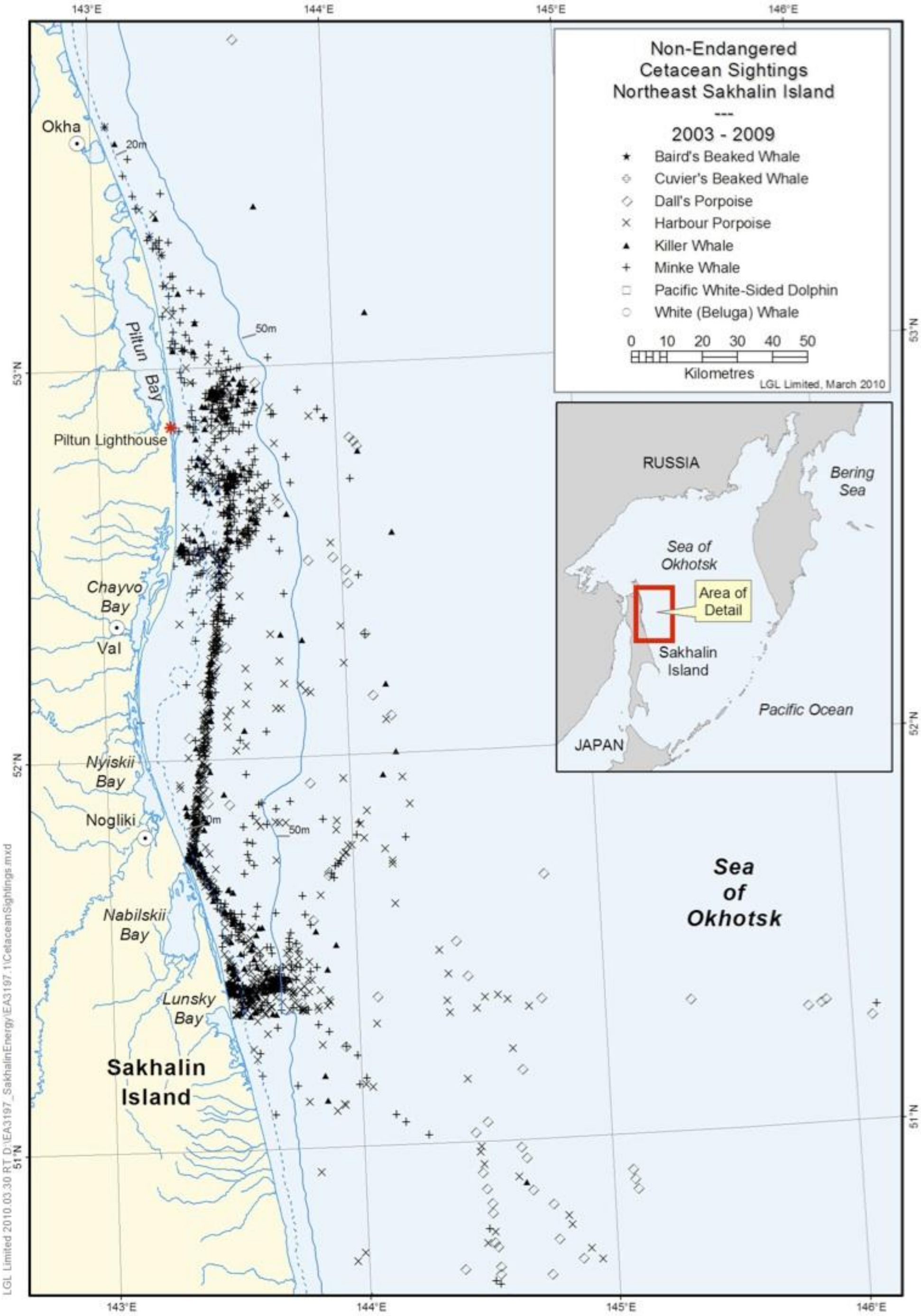


Figure 5-8. Sightings of non-endangered cetacean species from the supply vessels (Sakhalin Energy MMO database, 2003-2009).

5.9.1.1 Gray whale (Eschrichtius robustus)

Status

According to historical data, two distinct populations of Gray whales occur along the eastern and western margins of the North Pacific: (1) the Eastern North Pacific or Chukchi-Californian-population and (2) the Western North Pacific or Okhotsk-Korean population (Jones et al. 1984).

The Gray Whale is listed as a Category I species in the Red Book of the Russian Federation[48](Krasnaya Kniga RFZ 2001), and as a Critically Endangered species (extremely high risk of extinction) by the IUCN (Hilton-Taylor 2000; IUCN 2007). The IUCN classification was based on the small population size and low number of mature, reproductively active individuals (IUCN 2001).

Distribution - *Winter Breeding Areas*

A long-held belief that Western Gray Whales over-winter along the south coast of the Korean Peninsula has not been substantiated (Rice 1998). It was subsequently proposed that Western Gray Whales winter breeding grounds are in the South China Sea[49], possibly along the coast of Guangdong province and/or around Hainan Island, although specific calving sites have never been observed (Rice 1998; Blokhin and Blokhin 2006; Jones and Swartz 2002, 2009; Weller et al. 2008). Three recent studies (WGWAP-10 Report, 2011) have provided important insight to the extent of Gray Whale wintering areas:

1. Satellite tracking in 2010 and 2011 showed that all three Gray Whales tagged offshore Sakhalin during summer 2010-2011 migrated eastward in winter to the west coast of the United States, near Oregon, and then southward to Mexico, the recognized winter grounds of the eastern population.
2. Comparison of photo-ID records found that twenty one whales photographed offshore Sakhalin Island have also been photographed among the eastern population offshore North America.
3. Genetic studies found that two adult gray whales sampled off Sakhalin in 1998 and 2004 were genetically matched to two whales sampled off southern California in 1995.

A total of twenty three Gray Whales have thus far been matched to records from the east coast of North America. This evidence presents interesting and significant questions about the extent of wintering and breeding or feeding areas of the Gray Whale, but it should be interpreted within the context of other data that indicate some Gray Whales may migrate southward during the winter (see Migration Routes below).

***Distribution -* Summer Feeding Areas**

Gray whales have been recorded in Sakhalinskaya Bay, Ulbanskii, Shelikhov, Akademiia and Tugurskii bays, the coastal waters of Sakhalin Island, Penzhinskaya and Gizhiginskaya bays in the northern Sea of Okhotsk, and in the waters west of Kamchatka (Figure 5-9). However, it is not documented that all of these areas can serve as sustainable feeding grounds of Gray Whale (Krupnik 1984; Yablokov and Bogoslovskaya 1984; Perlov et al. 1997).

Regionally, the northeast coast of Sakhalin Island and three bays on the west coast of the Kamchatka peninsula support feedings areas that are regularly used by Gray Whale during the summer.

[48] See Section 2.4.1 for category definitions
[49] See Section Migration Routes for Western Gray Whale

Two important, distinct summer feeding areas for Gray Whale are located off the northeast coast of Sakhalin Island (Blokhin et al. 1985, 2002, 2003a, 2003b, 2004a, 2004b; Berzin et al. 1988, 1990; Vladimirov 1994; Blokhin 1996; Sobolevsky 2000, 2001; Weller et al. 2000, 2001, 2002a, 2002b, 2003, 2004, 2005, 2006, 2007; Meier et al. 2007; Yazvenko et al. 2007a,b; Vladimirov et al. 2005, 2006a, 2006b, 2007, 2008, 2009, 2010).

Figure 5-10 shows the location the "Piltun Feeding Area" and the "Offshore Feeding Area" in relation to oil and gas industry infrastructure. The Piltun feeding area is particularly important; Sakhalin whales have a high fidelity for this area and the majority of Gray Whale mother-calf pairs have been recorded here. The feeding area comprises a narrow strip (3-6 km wide, and about 100 km long) on the Sakhalin coast adjacent to the large and highly productive Piltun Lagoon (Labaj and Pecheneva 2001). The Offshore feeding area is located approximately 30-40 km seawards of Chaivo Bay in waters 30-65 m deep (Maminov and Yakovlev 2002; Meier et al. 2007).

The presence of other Gray Whale feeding areas have been identified along the east coast of Kamchatka (Vertyankin et al. 2004; Yakovlev and Tyurneva 2008; Yakovlev et al. 2007, 2009, 2010, Tyurneva et al. 2010). Photo-ID studies were conducted at Khalaktyrsky Beach south of Cape Nalycheva (53°11' N, 159°42' E) along the eastern coast of Kamchatka Peninsula in 2004. From 2006-2009, two additional locations were included: Olga Bay (54°34' N, 160°57' E), and Vestnik Bay (51°28' N, 157°34' E).

The distance from Olga Bay in the north to Vestnik Bay in the south is about 600 km; Khalaktyrsky Beach is located in between (Figure 5-9). In general, the eastern Kamchatka shoreline is rocky, but at these three locations the shoreline resembles the coast adjacent to Piltun Bay, with slightly curving sandy beaches~23 km long (Vestnik Bay), ~25 km long (Khalaktyrsky Beach) and ~50 km long (Olga Bay); small rivers flow into them. The depths of the Kamchatka feeding areas ranges from 5 to 20 meters, similar to the Piltun feeding area. In all three locations, the northern part of each bay has a cape extending into the sea (cape Olga, cape Nalycheva, and cape Zholty).

The photo-ID studies[50] show that Gray Whale move between the Piltun and Offshore feeding areas during feeding seasons, presumably opportunistically in response to general food availability. Furthermore, some whales photographed feeding off the southern Kamchatka Peninsula in 2004 and in 2006, have at other times been observed feeding along north-eastern Sakhalin Island (Vertyankin et al. 2004; Yakovlev et al. 2007), showing that whales not only move between the Piltun and Offshore feeding areas in Sakhalin, but also move between Sakhalin and Kamchatka. Additional photo-ID studies conducted in Vestnik and Olga Bays (Kamchatka) during 2008 and 2009 substantiate these observations (Yakovlev et al. 2009, 2010; Tyurneva et al. 2010). See Section on Movement Patterns for Gray whale, below.

Regional Distribution within the Sea of Okhotsk

Over the past two decades gray whales have been observed in the Sea of Okhotsk elsewhere than Piltun and Kamchatka (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, 2000, 2003; Weller et al. 2001; Meier et al. 2007; Yakovlev et al. 2009). Data obtained in 2005 suggest that during summer, some gray whales move along the Sakhalin coast to the north and around Elizaveta Cape, and possibly feed along that route (Figure 5-9). In September 2005, a small group of feeding gray whales was recorded in Severny Bay west of Elizaveta Cape, at depths of 20-30 m; one individual of this group was new to the IMB photo-ID catalogue (Yakovlev and Tyurneva 2006). A group of several gray whales travelling along the coast was

[50] Photo-ID studies conducted by the Institute of Marine Biology, Russian Academy of Sciences in the Piltun-Astokh area since 2002, and in the Kamchatka areas since 2006, have been extensively examined for movement patterns.

also seen in 2005 about 30 km north of Okha (Yakovlev and Tyurneva 2006). Three of these whales were also observed feeding in the Piltun area in 2005.

Gray whales that have been observed on the Sakhalin coast have occasionally been encountered in other parts of the Sea of Okhotsk, for example, in the Shantar Islands area (Burdin 2002, pers. comm.; Weller et al. 2003; Frolov 2005, pers. comm.). One gray whale was observed near Magadan (Blokhin 2001, pers. comm.). In 2000, a gray whale was sighted in the Shantar Island Archipelago, and the same animal was sighted off Paramushir Island south of Kamchatka (Weller et al. 2003). In 2006, two individuals were observed feeding in waters off Kamchatka and Sakhalin Island during the same summer feeding season (Yakovlev et al. 2007). In 2007 there were already 7 whales met near Kamchatka and Sakhalin during the same season (8 whales – 2008; 10 whales – 2009). In 2010 a total of 25 whales were sighted moving from Kamchatka to Sakhalin.

Figure 5-9. The Sea of Okhotsk—known locations of the summer range of the Gray whale.

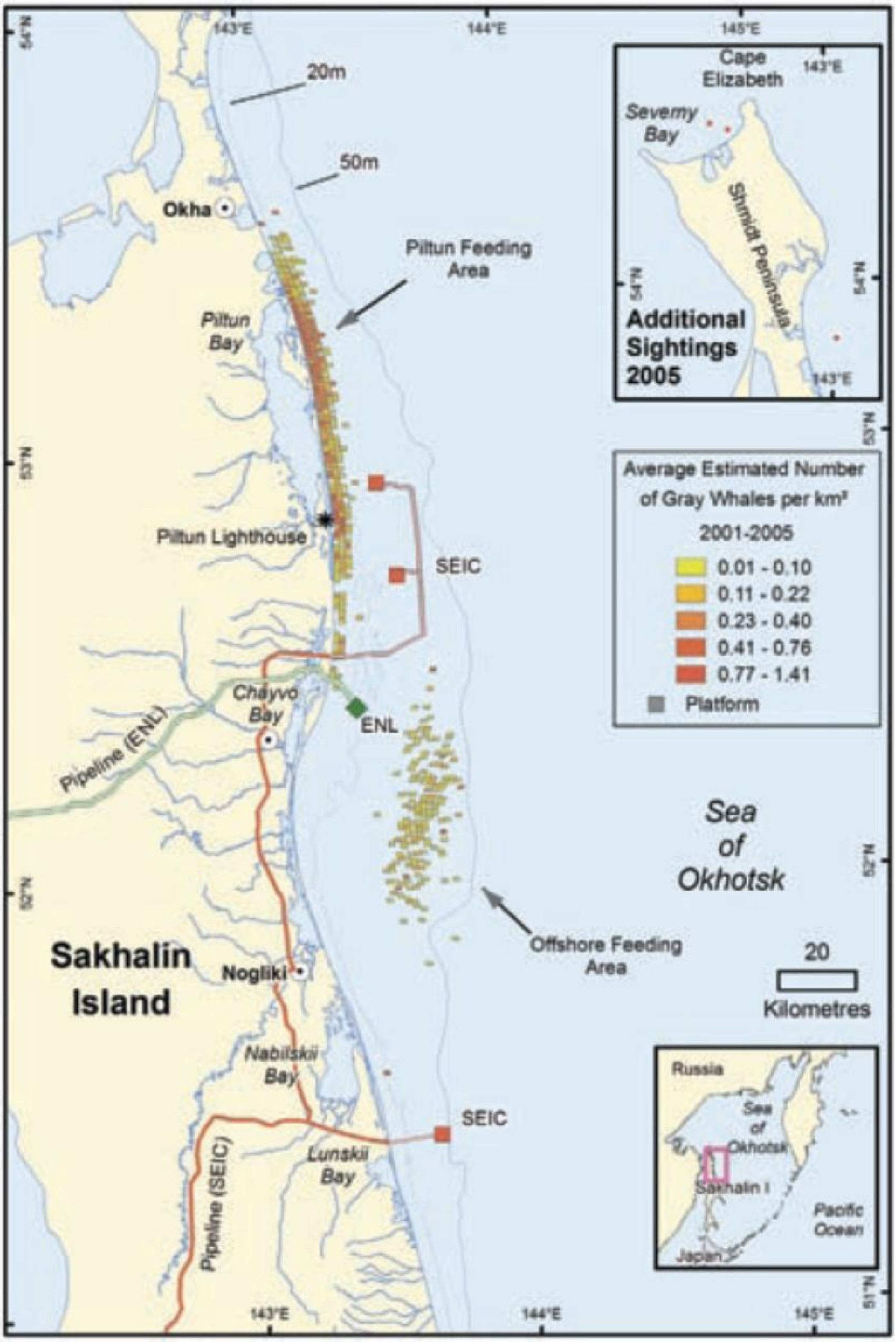
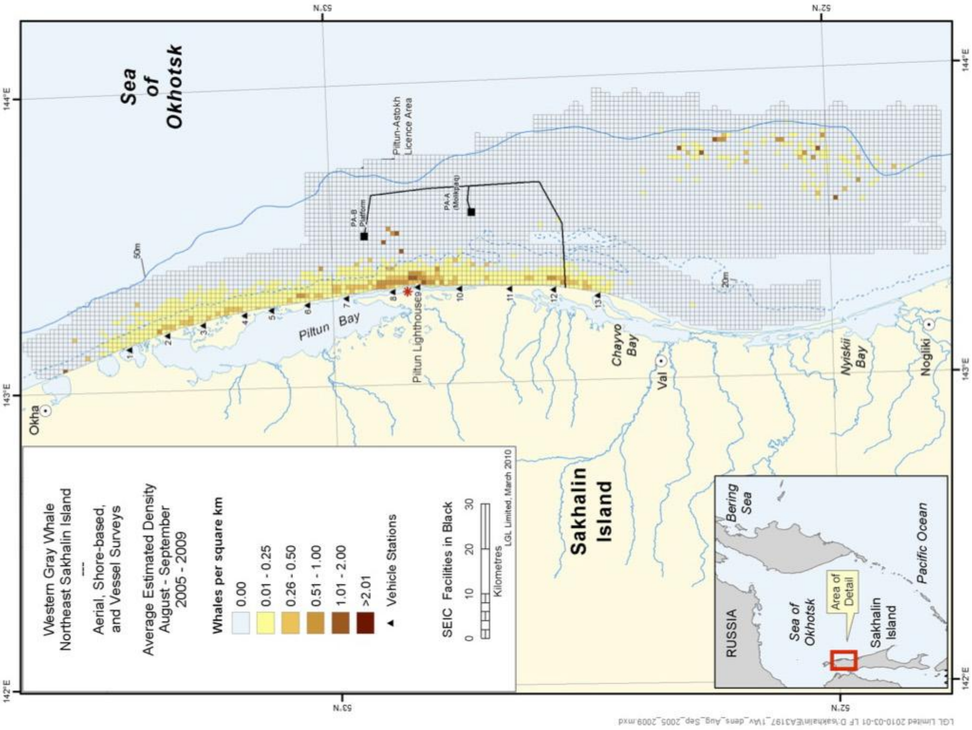


Figure 5-10. Location of Piltun and Offshore feeding areas, Sakhalin Island.



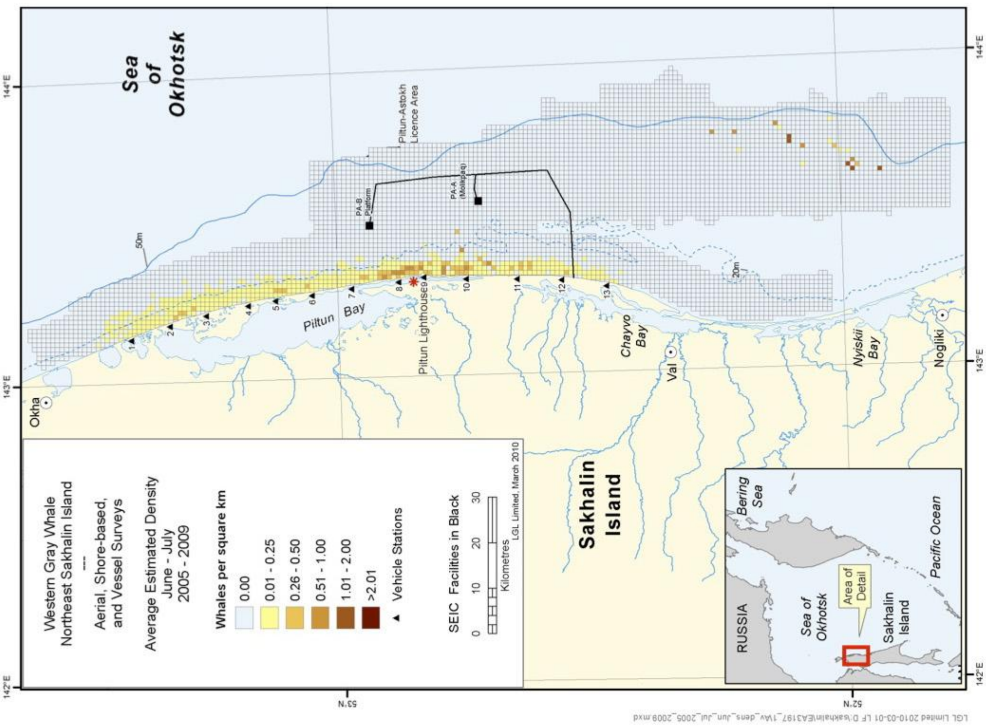


Figure 5-11. Summer Gray Whale distribution on the northeast Sakhalin shelf. Average estimated density at a 1km^2 resolution based on 2005-2009 aerial, vessel, and shore-based observations during (A) June-July and (B) August-September.

Movement Patterns – Sea of Okhotsk and Kamchatka

Gray whales show seasonal and annual variability in their distribution and abundance in the Piltun and Offshore feeding areas (Blokhin et al. 2003a, 2003b, 2004a, 2004b; Gailey et al. 2004, 2005, 2006, 2007; Maminov 2003, 2004; Würsig et al. 1999, 2000; Vladimirov et al. 2005, 2006a, 2006b, 2007, 2008a, 2008b, 2009, 2010; Meier et al. 2007).

No whales have been recorded in the region during four months of January to April, when ice cover is extensive. The general pattern is as follows: small numbers of whales begin to arrive in the area in May, increasing in numbers during June and July; the abundance of whales fluctuates during the summer with highest numbers of whales observed in August and September; and numbers slowly decline during October and November as the whales begin their backward migration.

During the feeding period, Gray Whales do not form dense aggregations in the Piltun feeding area, but scatter along the coast, occasionally forming clusters. The exclusion is the area off the Mouth of Piltun Bay where the number of Gray Whales is high during the whole season. Observed group sizes range from two to ten whales, but most whales are sighted alone or in pairs (Blokhin et al. 2003a,b, 2004a,b; Maminov 2004; Gailey et al. 2005, 2006, 2007, 2008, 2009, 2010; Weller et al. 1999, 2004; Yakovlev and Tyurneva 2004a,b, 2005, 2006; Yakovlev et al. 2007, 2009; Vladimirov et al. 2005, 2006a,b, 2007, 2008a,b, 2009, 2010).

Similar group sizes have also been observed in the Offshore feeding area (Maminov 2004; Yakovlev and Tyurneva 2004a,b, 2008, 2009, 2010), although in 2007 the largest group of 12 animals was recorded in the Offshore feeding area. The distribution of these clusters of gray whales changes both within and between feeding seasons (Gailey et al. 2005, 2006, 2007; Tyurneva et al. 2006, Meier et al. 2007, Vladimirov et al. 2005, 2006a,b, 2007, 2008a,b, 2009, 2010). Group size and aggregations of feeding eastern gray whales have been correlated with the abundance of prey present in a location (Dunham and Duffus 2001, 2002).

Results from the photo-identification studies have shown frequent movements of Gray Whales between the Piltun and Offshore feeding areas, with some whales moving over 20 km within a 50 km^2 area (Tyurneva et al. 2006, 2010; Yakovlev and Tyurneva 2003, 2004a, 2004b, 2005, 2006, 2008; Yakovlev et al. 2007, 2009, 2010). In 2009, 39 individual Gray Whales were recorded in the Offshore feeding and of these, 24 were observed only in this area;85 individuals were recorded in the nearshore Piltun area and of these, 66 were only recorded there (Yakovlev et al. 2010).

As mentioned above, photo identification studies have shown within and between year movements between Kamchatka and Sakhalin (Tyurneva et al. 2010). In 2009, 10 of the 11 whales photographed in Vestnik Bay (Kamchatka) were recorded off Sakhalin Island later in the season; and 8 of 64 whales identified in Olga Bay (Kamchatka) were spotted near Sakhalin later that year, with one of these whales found dead on a sandy beach near Chayvo Bay (Yakovlev et al. 2010). From the 205 whales known to feed near Sakhalin, 137 were met near Kamtchatka as well.

Seasonal shifts in distribution are likely to occur as whales deplete their prey resource (i.e. top-down effects) or as the biomass and quality of prey fluctuates throughout the season (i.e. bottom-up effects). Gray whales along the eastern Pacific coast have been observed to travel within and between feeding areas and to change prey types within and between seasons, partly in response to the distribution and abundance of prey (Darling et al. 1998; Dunham and Duffus 2001, 2002; Meier 2003).

Migration Routes

Until very recently, the popular view was that, once beyond Sakhalin, Gray Whales migrate south through the Sea of Japan, around the Korean Peninsula, through the Yellow Sea, East China Sea and then into the South China Sea (Wang 1984; Zhu 2002).The record of a young female (observed off Sakhalin in summer 2006) that died after being caught in a set net on the Pacific coast of Honshu, Japan, in January 2007 appears to support this view (Weller et al. 2008). Records of other deaths and strandings provide evidence, Figure 5-12.

Figure 5-12. Gray whale strandings (circles) and reported deaths (squares). Red symbols are reports since 1990[51] while blue symbols are reports before 1990. The green square represents a museum specimen.

[51] Excluding record of stranded / dead WGW at Chaivo, Sakhalin in 2009.

However, more recent evidence raises important questions about the extent of Gray Whale migration routes.

After initial, related proposals were discussed in Tokyo in December 2003, satellite tagging of Gray Whale commenced[52] near Piltun offshore Sakhalin Island in 2010. Only one tag was deployed in 2010: on 4 October, a 13-year-old male that had regularly been seen offshore Sakhalin Island after first seen as a calf there in 1997, was tagged on the left side. The whale called "Flex" was 11-12 m in length, in good condition with no signs of emaciation and no unusual concentrations of external parasites.

The whale remained near the coast of Sakhalin Island coast and within 45 km of the tagging site for the first 68 days. In mid-December, he crossed the Sea of Okhotsk to the west side of the Kamchatka Peninsula, then around the southern end of the peninsula and departed the east coast of Kamchatka in early January 2011. He crossed the western and central Bering Sea in one week. Upon arrival at the shallow eastern shelf of the Bering Sea, the whale proceeded south through the eastern Aleutian Islands, crossed the Gulf of Alaska and continued south along the coasts of Washington and Oregon, remaining 20-25 km from shore. His last satellite location was 20 km off Siletz Bay, Oregon (~45ºN), on 5 February. This meant that he was present during the last part of the southbound migration of gray whales through the area.

Six more tags were deployed on whales near Sakhalin in August-September 2011. Four tags stopped to transmit their signals while the whales were staying near Sakhalin. The remaining two tagged animals left Sakhalin in December and started to migrate eastward, repeating the migration route of the whale "Flex" which was tagged in 2010. One tag stopped working when the whales crossed the Gulf of Alaska. The remaining tagged whale, a female called "Varvara", reached the west coast of North America and went down to Mexico where she was re-tagged with permission of IWC. Varvara stayed in the bays Baja California till March 2012, when she began to move back northward.

Satellite data showed that these long-range movements were very direct, suggesting purposeful migration rather than 'wandering'. During the travel segments in the Bering Sea and North Pacific Ocean, the whale's average speeds were >6.5 km/h, much higher than those usually observed for migrating gray whales in the eastern North Pacific (Reports of the Ninth (December 2010) and Tenth (May 2011) meetings of the WGWAP, http://www.iucn.org/wgwap/).

Therefore, satellite tagging, photo-ID, and genetic analyses have shown that at least a part of the gray whales (23 individuals) recorded offshore Sakhalin Island migrate eastward to the North American coast where they are known as Eastern Pacific gray whales.

Abundance and Reproduction

Between 2002 and 2010, 205 individual Gray Whales were identified according to the Institute of Marine Biology catalogue (Yakovlev et al. 2010), although not all of these animals are confirmed alive or present each year. Population modelling of photo-identification data collected from 1995 to 2008 concluded an estimated median non-calf population size of 134 individuals for 2009[53], with 90% confidence limits 120-142; the median estimate of the number

[52] Funded jointly by Sakhalin Energy Investment Company Limited and Exxon Neftegas Limited, with contracting and administration through the IWC and IUCN. The work was conducted by the A.N. Severtsov Institute of Problems in Ecology and Evolution of the Russian Academy of Sciences (IPEE RAS) and Oregon State University Marine Mammal Institute in collaboration with the University of Washington, Sakhalin Research Institute of Fisheries and Oceanography, and Kronotsky State Nature Biosphere Reserve.

[53] In April 2010, Cooke reported to the 10th meeting of the WGWAP his population assessment based on photo-ID data from both the IMB and Russia-US teams collected data offshore Sakhalin Island during 2002-2008 and 1994-2008, respectively;

of mature females in 2009 is 33 with 90% confidence limits of 29-38 (Cooke et al. 2010). In support of Cooke's estimate, photo-ID studies identified 138 whales (including 9 calves and 1 possible calf) in Sakhalin and Kamchatka during 2009 (Yakovlev et al. 2010)[54]. The estimated annual adult and calf survival rates were 0.985 and 0.69 respectively based on 1994 to 2008 data, while the estimated annual population growth rate was 5.0% over the 1994-2008 data series (Cooke et al. 2010). The calving rate has been found to increase in recent years, with intervals shortened from three to two years (Cooke et al. 2008). This 2-year interval is comparable with that for eastern gray whales.

Recovery also may be threatened by anthropogenic activity, probably throughout its range. Although the Gray Whale has been officially protected from commercial whaling since 1938, some whaling continued for at least two decades. Poaching in their southern range (Baker et al. 2002; Brownell and Kasuya 1999) and incidental catches in fisheries off southern China, Korea and Japan have also been reported (Kato 1998; Kim 2000; Zhu and Wang 1994). From 2005-2007, four females were killed in trap nets with a fifth female found stranded on the Pacific coast of Japan (Kato et al. 2005, Brownell et al. 2007, Weller et al. 2007, Cooke et al. 2008). Cooke et al. (2008) project that the loss of one female per year will likely cause the female population to decline to extinction (i.e. a >25% probability of population decline and a 10% probability of female population extirpation by 2050). Currently, the Fisheries Agency of Japan is exploring actions to mitigate anthropogenic effects (Brownell 2007).

In August 2009, a 5-year old male gray whale was found dead on the beach near Chayvo Bay. This individual was seen in 2009 on the east coast of Kamchatka. The cause of death could not be established but there were no indications of a ship strike (IUCN 2009).

The majority of cow/calf pairs in the Piltun feeding area have been observed within 2 km of shore (Vladimirov et al. 2006b, 2007, 2008, 2009, 2010; Meier et al. 2007). No cow/calf pairs have been observed in the Offshore feeding area or in any other area where gray whales have been sighted in any of the years from 2001 to 2007 (Yakovlev and Tyurneva 2003, 2004a,b, 2005, 2006, 2008; Yakovlev et al. 2007). In 2008 however, Yakovlev et al. (2009) recorded, for the first time, one cow-calf pair offshore eastern Kamchatka (the cow was observed offshore Sakhalin in previous years), and in 2009 seven additional cow-calf pairs were recorded in Kamchatka; four of these seven cows had been seen offshore Sakhalin in other years (Yakovlev et al. 2010). The number of Gray Whale calves seen between 1997 and 2009 varies considerably and ranges from two in 1997 to a maximum of 11 in 2003 (Weller et al. 2006). Six (and two possible) calves were seen in 2007 (Yakovlev and Tyurneva 2008), four (and two possible) calves in 2008 (including one calf observed off the east coast of Kamchatka) and nine (and one possible calf) in 2009 (of which five and one possible calf were identified only in the Piltun area, two in both Piltun and Kamchatka, and two in Kamchatka only (Yakovlev et al. 2010)).

Cooke's previous estimates were based only on the Russia-US catalogue. Accordingly, Cooke reported that the estimated population size in 2009 (excluding calves) was 131 animals (90% Bayesian confidence interval 120-140), of which 33 (CI 29-38) are estimated to be reproductively mature females. The estimated annual survival rate is 0.69 (CI 0.58-0.78) for calves and 0.985 (CI 0.977-0.991) for non-calves. The estimated age at sexual maturity is 9.0 years (7.7-11.2).

[54] It must be emphasized that modelling estimates and photo-ID records are limited by the scope of survey effort; the population may be larger if other significant feeding areas exist, undiscovered.

Food Resources

Gray whales feed[55] predominantly on benthic organisms in water < 80 m deep (Zenkovich 1934, 1937; Tomilin 1971; Mizue 1951; Pike 1962; Rice and Wolman 1971; Zimushko and Lenskaya 1970; Thomson and Martin 1983; Nerini 1984; Würsig et al. 1986). They consume their prey by ploughing into the sediment, extracting benthos by suction into the mouth, and expelling sediment through their baleen plates (Ray and Schevill 1974; Oliver et al. 1983, 1984). Occasionally, they might feed on swarms of epibenthic and nektonic organisms in the water column and on the surface, and less commonly on fish when benthic sources are inadequate or when fish biomass is greater than the benthic source (Nerini 1984; Dunham and Duffus 2001, 2002).

The Piltun and Offshore feeding areas on the northeast coast of Sakhalin Island hold significant food resources for the western population of gray whales. Intensive, annual surveys have been carried out since 2002 to understand the ecology of Gray Whale food resources in these areas.

The benthic studies under the Joint Western Gray Whale Monitoring Programme led by Dr Valery Fadeev (Marine Biology Institute, Far East Branch, Russian Academy of Sciences) began in 2001 with a pilot study of 10 diving transects in the north-eastern Sakhalin coastal zone, from Niyskiy Bay in the south to Tront Bay in the north, including four transects in the area offshore of Piltun Lagoon. The resulting data demonstrated that, at depths of 5 to 15 m, the area is characterized by high abundance of gray whale prey, primarily amphipods and isopods (Fadeev 2002). Subsequently, the benthic monitoring has included:

- Sampling at fixed stations according to grids within the Piltun[56] and Offshore feeding areas (2002-2010);
- Random sampling at sites where whales were observed feeding within the Piltun and Offshore feeding areas[57] (2002-2010);
- Sampling at control stations located outside of the Piltun and Offshore feeding areas (2002 only).

Location of the sampling stations in relation to geographical features is shown in Figure 5-13. Benthic samples were collected with a van Veen grab (0.2 m^2); epibenthic and plankton samples were collected with an epibenthic net and Jedi net, respectively; and underwater video was also taken to learn more about the local environment and feeding behaviour (Fadeev 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010).

These studies provide benthic data from wide areas along the coast between Piltun and Chaivo Bays, for water depths between 10-50 m; very limited sampling was conducted in water <10 m deep so that inferences about benthic communities at those depths should be treated with caution. Starting in 2004, sampling in waters <10 m was conducted from a small zodiac and with the use of divers (Fadeev 2005, 2006, 2007, 2008) and with a Petersen grab since 2009 (Fadeev 2010).

[55] Gray whales are seasonal feeders. During the summer, they feed to accumulate energy reserves that largely sustain them throughout the winter. Notwithstanding, eastern gray whales are known to feed during their migration when food is opportunistically encountered and it is likely that western gray whales utilize food resources encountered along their migration route.
[56] Geographically, the "Intermediate feeding area" located adjacent to Chaivo Bay is a southward extension of the Piltun area; therefore, it is currently considered part of the Piltun feeding area in distribution studies despite being considered separately for benthic studies. The Intermediate area was sampled for benthic studies in 2002 and in 2007-2010.
[57] Extended to include whale-feeding sites in Olga Bay, eastern Kamchatka, in 2009 and 2010.

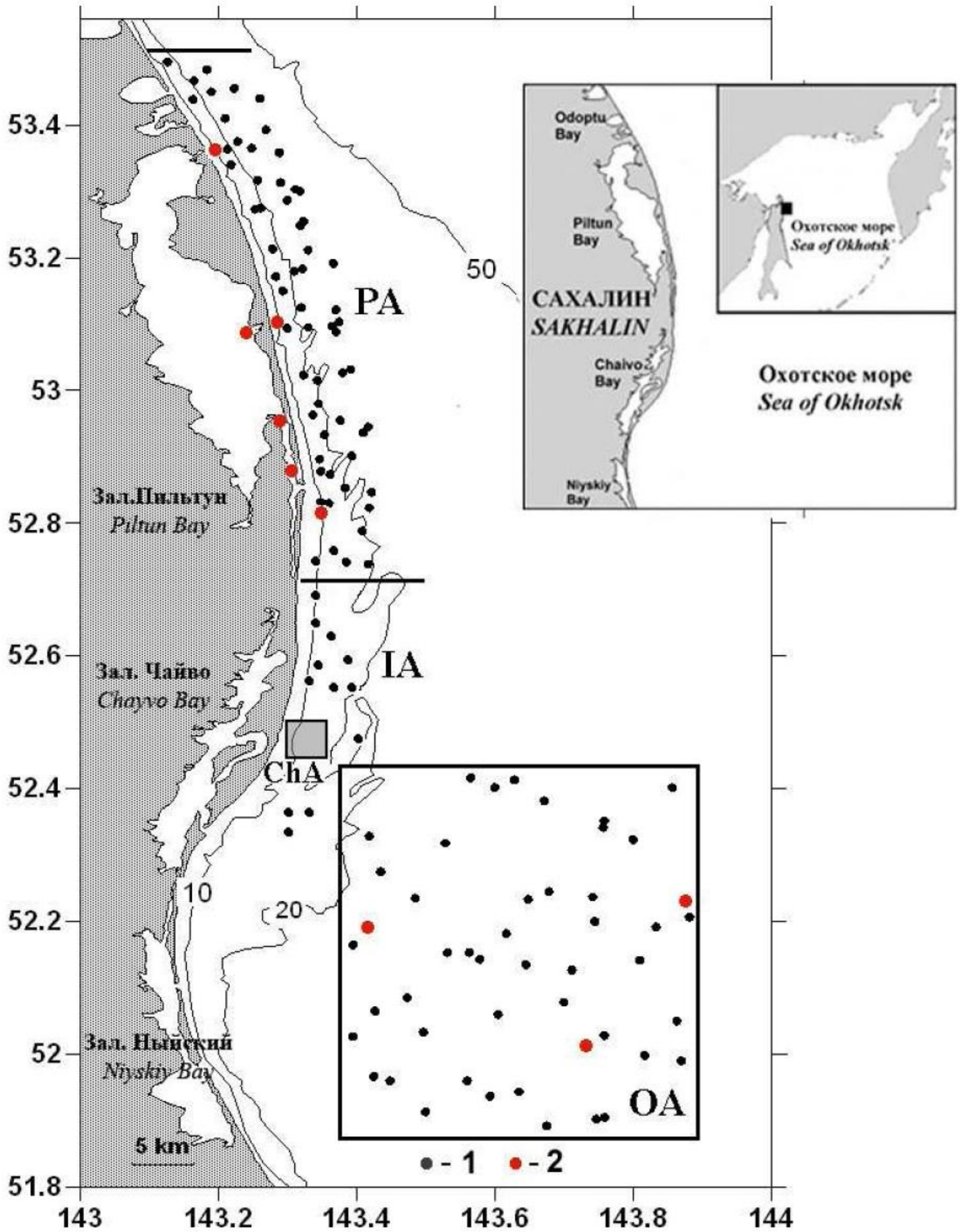


Figure 5-13. Locations of Sakhalin benthic survey stations in 2010.
Key: PA = Piltun Feeding Area; IA = Intermediate Area; OA = Offshore Feeding Area; ChA = Chayvo Subarea; 1 = benthic station; 2 = station for collection of animals and sediments for analysis of isotope and molecular biomarkers in 2006-2008[58].

[58] From Fadeev, V.I. Benthos Studies In Feeding Grounds Of The Okhotsk-Korean Gray Whale Population, 2010 - Methods And Analyses. Chapter 4 In: 2011. Western gray whale research and monitoring program in 2010, Sakhalin Island, Russia. Volume I: Background and methods. (http://www.iucn.org/wgwap/wgwap/meetings/wgwap_10/)

Piltun Feeding Area

Prey studies conducted throughout the Piltun area since 2001 demonstrate high but patchy prey abundance. The Piltun feeding area contains abundant potential gray whale food, including small crustaceans (e.g. swarming amphipods and isopods), polychaete worms, and bivalve molluscs (Sobolevsky et al. 2000; Fadeev 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010). In 2010, the average total biomass of benthos in the Piltun feeding area was 414.8±124.3 g/m^2. The average biomass of amphipods (preferred Gray Whale prey) in the Piltun area was 35.2±7.7 g/m2 in 2010. More than 90% of the abundance of amphipods was due to two species: *Monoporeia affinis* (> 60% of total amphipod biomass) and *Eogammarus schmidti* (> 30%). The highest biomass of amphipods recorded within the narrow (<20 m isobaths) line along the north-east coast of Sakhalin adjacent to Piltun and Chayvo Bays. Behind the 20-m isobaths most of biomass comprises sand dollars (up to 95%) that are not typical prey for gray whales. High biomass of amphipods is also recorded for the Offshore Feeding Area but represented by other species of amphipods than in Piltun Feeding Area.

The distribution of amphipod biomass along the coast of the Piltun feeding area showed similar trends in 2002- 2009; zones of maximum biomass were associated with the coastal waters, and the amphipod distribution has a distinctly aggregated nature.

Temporal variation in amphipod biomass in the shallow waters of Piltun area is evident: a statistically significant biomass decrease occurred in 2006 compared to 2002-2005. Amphipod biomass rise observed in 2007-2010 has not yet reached the maximum biomass values of 2002-2003 (statistically significant differences still remain). In 2009-2010, amphipod biomass, the main feeding component for gray whales in the Piltun area, reached the level of 2004-2005 (no statistically significant differences in biomass values). (Fadeev 2011).

The cause(s) of temporal variation in amphipod biomass in the Piltun area are not known. Fadeev points to the possible influence of nearshore dynamics in temperature and sea ice cover.

Temperature is expected to affect amphipod recruitment, growth, and feeding, resulting in changes to their life cycle duration; e.g. the dominant species in the Piltun area, *Monoporeia affinis*, has a two-year life cycle in cold waters and a one-year life cycle in warmer waters (Segestrale 1967), while *Ampelisca macrocephala*, which inhabits the Offshore area, lives for 5-6 years in the cold waters of the Bering Sea, but for only 2-3 years in the temperate waters of Denmark (Kannewoff 1969; Highsmith and Coyle 1991). Lowest bottom temperatures in the Piltun feeding area for the period 2004-2010 occurred in 2010 (Fadeev 2011).

Sea ice dynamics could also impact coastal biota; ice conditions varied substantially in the Piltun area during 2004-2010. Figure 5-14 indicates the position of the ice edge during the first ten days of June each year. The northeastern Sakhalin coastal zone was free of ice in June 2004 and 2005, but was covered in 10-point ice almost to the mouth of the Piltun lagoon in early June 2006. In 2007-2010, ice remained near Chaivo Bay, but there was open coastal water from the Piltun lagoon northward (Fadeev 2011).

Ice cover could affect the ecology of *Monoporeia affinis* through influence on hydrology and primary production. Phytoplankton are reported to play an important role in the diet of this species (Sarvala 1991; Van de Bund at al. 2001). In an environment with an ice regime, such as the northeast Sakhalin shelf and associated coastal bays and lagoons, the intensity and duration of spring bloom of phytoplankton may be influenced by the availability of light and seeding as the ice persists or retreats. A sharp increase in growth rates of *M. affinis* has been shown to follow the spring bloom of phytoplankton in the Baltic Sea, where food availability affected growth to a greater degree than temperature (Lehtonen 1996; Lehtonen and Andersin 1998).

In summary, Fadeev (2011) states: “The lowest abundance of *M. affinis*, the most likely principal component of Gray Whale diet, occurred in 2006. The distinguishing features of the hydrological and climatic conditions in 2006 were: (a) a decrease in the summer temperature of bottom waters, and (b) an anomalous ice cover duration”.

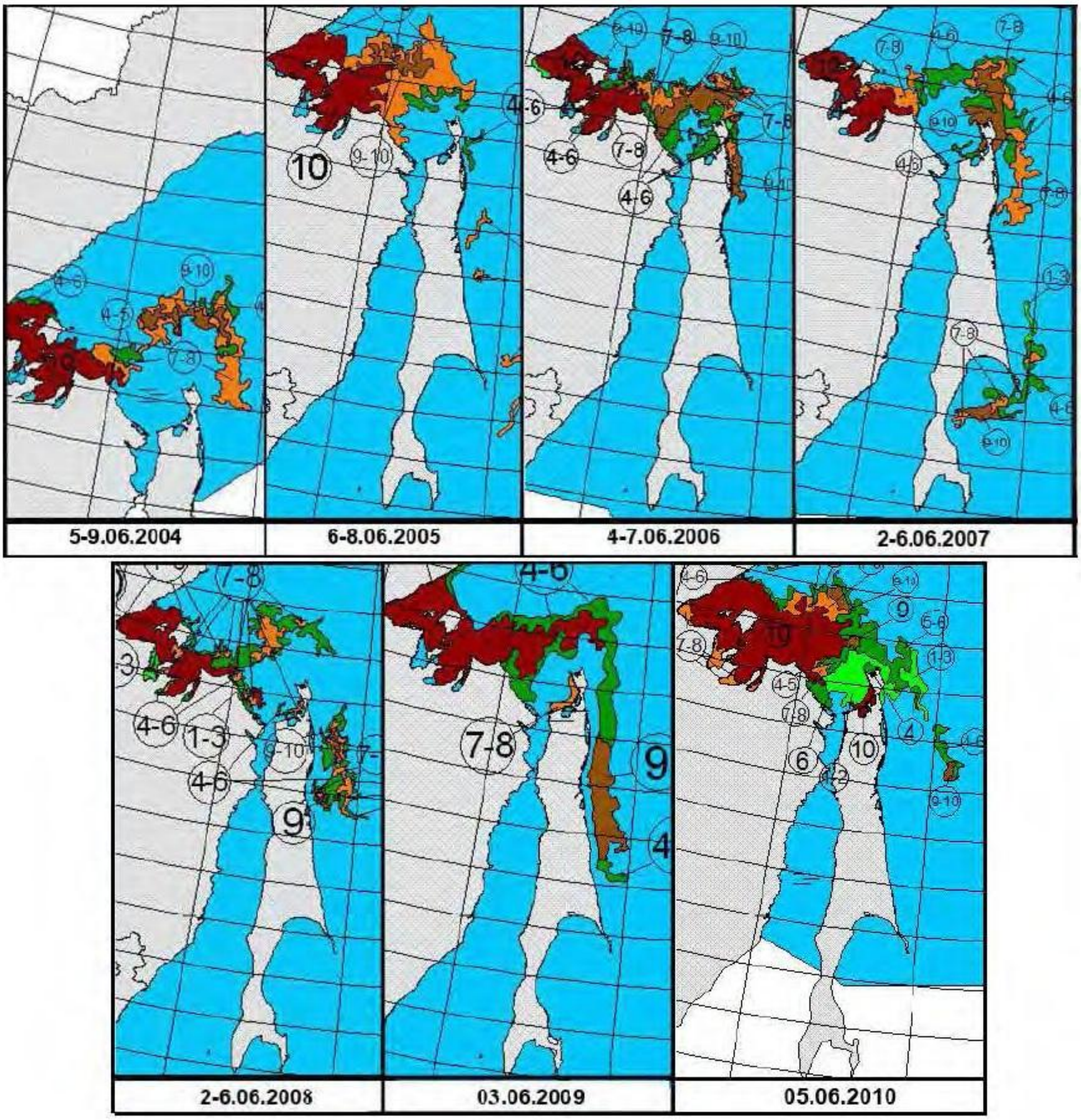


Figure 5-14. Sea ice cover during the first ten days of June 2004-2010 in the region of northeastern Sakhalin (Fadeev 2011; http://www.aari.nw.ru).

The prey distribution corresponds with the distribution and abundance of Gray Whale sightings in both the Piltun and offshore feeding area; waters typically not used by gray whales for feeding were characterized by lower concentrations of potential gray whale prey or by unsuitable species for feeding, e.g. sand dollars (Blokhin et al. 2004a,b; Fadeev 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010; 2011; Vladimirov et al. 2006a, 2006b, 2007, 2008, 2009).

Offshore Feeding Area

Studied for the first time in 2002, the Offshore feeding area is highly productive, dominated by benthic ampeliscid amphipods that live in tubes, sticking up 10-15 cm from the sediment surface, creating a tube forest or carpet along the ocean bottom. This feeding area is comparable in species composition and richness to eastern gray whale feeding areas in the Bering and Chukchi seas (Fadeev 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011).

The average total benthos biomass in the Offshore area in 2010 was 578.6±123.3 g/m^2, which was not significantly different to 2009. As in previous years, the groups with a biomass contribution occurrence greater than 50% were amphipods, cumaceans, bivalve molluscs, marine worms and sea anemones. The biomass of amphipods – the most important component in the diet of whales in the Offshore area – was 206.2±53.7 g/m^2 (Fadeev 2011).

Spatially, the biomass of amphipods of the Offshore feeding area increases eastwards, i.e. from shore toward deeper water, with a maximum of 975 g/m2. Temporarily, biomass of forage benthos was stable during 2002-2010, and no major year-to-year variations were observed; whales fed in a depth range of 41-61m every year in a zone of high abundance of major prey, *Ampelisca eschrichti* (Fadeev 2011).

The numbers of Gray Whales using the Offshore feeding area varies from one year to the next. The highest number of Gray Whales were observed in the Offshore area in 2001, 2002, 2003, 2007 and 2008, with relatively fewer observed in 2004, 2005, 2006 and 2009 (Blokhin et al. 2002, 2003a, 2003b, 2004a, 2004b; Maminov 2003, 2004; Vladimirov et al. 2005, 2006a, 2006b, 2007, 2008a, 2008b, 2009, 2010; Meier et al. 2007).

The lower numbers of whales in the offshore feeding area in 2004-2006 were not attributed to a lower concentration of prey in that area. Instead, the benthic data suggest that the prey conditions in the Piltun feeding area were more favourable in those two years, as evidenced in the northern parts of the feeding area where whales were observed in deeper waters around the 20 m isobath concurrent with high prey concentrations (Fadeev 2006, 2007; Vladimirov et al. 2006a, 2006b, 2007).

Condition of Gray Whales

Systematic photo-identification surveys of Gray Whales present off Piltun Bay were conducted during 1997- 2010 (Würsig et al. 1999, 2000; Weller et al. 2000, 2001, 2002b, Yakovlev and Tyurneva 2003, 2004a, 2004b, 2005, 2006, 2007, 2008; Yakovlev et al. 2007, 2009, 2010).

Since 1999, some whales were observed to be emaciated[59], or ‘skinny.’ Seasonal fluctuations in the fat stores of baleen whales are considered normal during the breeding/calving season and particularly for cows nursing calves (Perryman and Lynn 2002). However, both the US-Russian and the IMB photoID teams have encountered skinny whales during each year of their studies (Table 5-7); in 2007, 14 animals (including six nursing cows) were identified as being underweight, and most sightings of underweight animals occurred early in the season (Yakovlev and Tyurneva 2008). The Russian photo ID team was also able to document

[59] No dead WGW have been encountered on the northeast coast of Sakhalin Island since surveys began, with the exception of a stranded whale found on the beach near Chayvo Bay in September 2009. The stranded whale had been identified in July 2009 in Olga Bay, Kamchatka and had a physical body condition of class 2, which is rather common early in the feeding season (Yakovlev et al. 2010).

improvement in body condition of skinny whales and nursing cows as the feeding season progressed[60].

Table 5-7. Percentage of "skinny" whales observed offshore Sakhalin Island by the US-Russian and IBM photo-identification teams during 1999-2007 (Yakovlev and Tyurneva 2008, Yakovlev et al. 2009, 2010).

	US-Russian Team			IBM Team		
Year	Number of Skinny Whales	Number of Individuals Observed	Percentage Skinny	Number of Skinny Whales	Number of Individuals Observed	Percentage Skinny
1999	16	69	23.2			
2000	30	58	51.7			
2001	21	72	29.2			
2002	9	76	11.8			
2003	3	75	4.0	15	82	18.3
2004	5	93	5.4	11	96	11.5
2005	14	93	15.1	10	118	8.5
2006	4	79	5.1	20	126	15.9
2007*				14	131	10.6
2008*				20	98	20.4
2009*				19	111	17.1

* US-Russian team data were not available for these years.

Similar signs of emaciation were displayed during the same period by eastern gray whales. Many apparently undernourished 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 died in the wintering lagoons of Baja California than in 1999 (LeBoeuf et al. 2000). Fortunately, high mortality in eastern gray whales was not documented during winter 2000-2001 or during the 2001 northward spring migration (Brownell et al. 2001).

The causes of emaciation in both North Pacific populations of gray whales are not clear, but several lines of evidence suggested over-exploitation of the food supply (Moore et al. 2001) and/or a possible large-scale climatic/oceanographic regime shift that affected productivity in the North Pacific region (LeBoeuf et al. 2000; Moore et al. 2001; Grebmeier et al. 2006). The cause is considered most likely to be a complex cumulative time variable effect. However, in the case of the gray whale population, it is highly unlikely that a population of approximately 130 whales has simply over-exploited its food supply.

5.9.1.2 North Pacific Right Whale (Eubalaena japonica)

North Pacific right whales were formerly classified as North Atlantic right whales (*E. glacialis*). However, genetic studies recognise that the North Pacific population is a separate species (Rosenbaum et al. 2000). North Pacific right whales are listed as Endangered (Category 1) in the Red Book of the Russian Federation (Krasnaya Kniga RFZ 2001), and as Endangered by the IUCN (IUCN 2007). The IUCN designation is likely to change to Critically Endangered with the reclassification of the North Pacific population as a separate species. Right whales are particularly susceptible to collisions with ships because they are slow, spend considerable time at the surface, and utilise some habitats in the vicinity of major shipping lanes (Clapham et al. 1999). Ship strikes are a significant cause of mortality for North Atlantic right whales, and it is

[60] It should be noted that the US-Russian team does not include lactating females in reported numbers of skinny whales, while the IBM team does include them.

possible that right whales in the North Pacific are also vulnerable to this threat. Entanglements of right whales have been reported in the Sea of Okhotsk (Brownell 1999; Bukhtiyarow 2001 in Burdin et al. 2004; V.S. Strygin pers. comm. in Burdin et al. 2004). However, due to their rare occurrence and scattered distribution it is not possible to assess the threat of ship strikes and/or entanglements to the North Pacific right whales at this time.

North Pacific right whales were once abundant in the Sea of Okhotsk. Prior to industrial whaling, the number of individuals in the region was ~10,000 animals. However, over-exploitation from the 1840s to the 1920s drastically reduced the numbers of this species. At one time, population levels were so low it was thought that the species had become extinct. All right whales were protected from commercial whaling in the 1930s, and in 1946, the International Whaling Commission (IWC) declared the North Pacific population completely protected. Those measures resulted in a slow increase in the total population numbers, until by the 1970s there were perhaps 200 to 400 individuals throughout the North Pacific range. Current population estimates for the species are largely speculative and range from 100 to the low thousands, however, most authorities tend toward the lower end of this range (Brownell et al. 2001). It has been proposed that as many as 800 to 900 right whales inhabit the Sea of Okhotsk (Vladimirov 1994) and that 150 to 200 animals stay in waters off the east coast of Sakhalin Island during summer and autumn.

Migratory patterns of the North Pacific stock are unknown, although it is thought that the whales migrate from high-latitude feeding grounds in summer to more temperate waters during the winter, possibly offshore (Braham 1984; Clapham et al. 2004). In the eastern region of Sakhalin Island, North Pacific right whales have been reported occasionally, and they may rarely move through, or adjacent to, the Piltun Astokh field. Sporadic sightings in the past 30 years have indicated that the whales use various locations throughout the Sea of Okhotsk (Kuzmin and Berzin 1975), including Sakhalin Island's eastern coast. In 1967, approximately 70 North Pacific right whales were observed in the area of Terpeniie Bay, and solitary animals were seen along Sakhalin Island up to its northern tip (Berzin and Vladimirov 1989). Recently, solitary individuals and small groups of North Pacific right whales have been reported off the east coast of Sakhalin Island (Shuntov 1994). In 1992, nine North Pacific right whales were observed far offshore to the south of Piltun Bay. The same year, seven whales were observed in the area between the northern end of Sakhalin Island and Cape Terpeniie, and in 1993, two individuals were observed in the area east of Cape Terpeniie. One was sighted about 95 km off Lunsky Bay in 1992 (Myashita and Kato 1998 in Brownell et al. 2001), and one individual was found stranded in Lunsky Bay in 1939 (Tomilin 1957 in Brownell et al. 2001). In 2005, during Sakhalin Energy construction activities, two right whales were observed at Lunskoye area on 13 October, at a distance of 2,000 m from the vessel. Figure 5-7illustrates recent sightings near the project area (SEIC MMO database, 2003-2007).

5.9.1.3 Bowhead Whales (Balaena mysticetus)

Bowhead whales are listed as Category 1 “Endangered” in the Red Book of the Russian Federation (Krasnaya Kniga RFZ 2001). The IUCN categorizes the species generally as “Lower Risk-Conservation Dependent,” but also designates distinct populations independently (IUCN 2006). The Sea of Okhotsk population is classed as Endangered (IUCN 2007).

There has been some difficulty in assessing the historical distribution and abundance of bowhead whales in the Okhotsk Sea. Right whales and gray whales were sometimes misidentified as bowhead whales, and whaling records maintained during the short period of time this stock was hunted were incomplete (Bockstoce and Botkin 1983). Whales in this stock were discovered by commercial whalers in 1848 (Bockstoce 1986), but intensive hunting did not begin until 1852 when whales in the Bering Sea stock were no longer as plentiful in "traditional" whaling areas (Bockstoce and Burns 1993). By 1860, the Okhotsk Sea stock was severely depleted, and whalers had already resumed whaling in the Bering Sea (Bockstoce 1986). Mitchell estimated the pre-exploitation size of the population to be 6500 based on a total estimated catch of 3506 whales (Mitchell and Reeves 1982). Ross (1993) suggested that this estimate may be too high for the reasons stated above and offered "a conservative, though mostly speculative, compromise" of 3000 as a minimum population estimate.

In the north-eastern Okhotsk Sea, whalers found bowhead whales in Penzhinskaya Gulf and Gizhiginskaya Gulf, while in the southwest they were found in Tauyskaya Bay. Farther south, the best whaling grounds were within the gulfs and bays south of the Shantarskiye Islands and west of Sakhalin Island.

Fedoseev (1984) observed bowhead whales deep in the ice north of Sakhalin Island in 1969, 1981, and 1983; in addition, he observed one east of Sakhalin Island in 1981 and another a little over 200 km south of Tauyskaya Bay in 1982.

Berzin et al. (1991) noted that by mid-November, bowhead whales were no longer found in the Shantarskiye region, despite the waters being ice-free. Almost all of the areas where summer concentrations of bowhead whales occurred in the past are still occupied today. As recent as August 1995, during joint Russian-American surveys, a few dozen bowhead whales were observed in a feeding aggregation south of the Shantarskiye Islands. Berzin et al. (1990) estimated the population in this area to be at least 250-300 animals. An estimate of abundance of 300-400 was made for the entire Okhotsk Sea based on data collected since 1979 (Vladimirov 1994). However, "no quantitative data are available to confirm" these estimates. There is some speculation as to whether animals found during the summer in the north-eastern Okhotsk Sea form a distinct population from those in the Shantarskiye region. The winter distribution of both of these groups is unknown.

During February and March, 50 to 100 bowhead whales may be present close to the ice edge along the north and east coasts of Sakhalin Island (Vladimirov 1994). In April 2007, 2 bowhead whales (a cow and calf) were observed along the edge of the ice southeast of Tyuleniy off Sakhalin Island's east coast (ENL, pers. comm., 2007).

5.9.1.4 Fin Whales (Balaenoptera physalus)

Fin whales are listed as Vulnerable (Category 2) in the Red Book of the Russian Federation (Krasnaya Kniga RFZ 2001), and classified as Endangered by the IUCN (IUCN 2007). The fin whale used to be one of the most numerous species of great whales. The population was drastically reduced by intensive whaling, but has since gradually increased in size and at present is estimated to number approximately 2700 individuals in the Sea of Okhotsk (Vladimirov 1994), of which 400 to 600 inhabit the waters of eastern Sakhalin Island during the summer and autumn. Fin whales feed on fish, cephalopods, and planktonic crustaceans. Some individuals are present year round in the Sea of Okhotsk. They move into the area from the Pacific Ocean through the straits in the Kuril Islands and from the Sea of Japan through La Perouse Strait.

In 2005, during Sakhalin Energy construction activities, a total of 19 fin whales were observed (SEIC 2006). Most of them occurred far offshore, near the navigational corridors used by vessels in transit. Although they are predominantly a pelagic species, it is possible that fin whales may be observed in the vicinity of the PA field, as individuals sometimes occur in shallow water both along the coast and offshore (Perlov et al. 1996, 1997). Figure 5-7illustrates sightings near the project area (SEIC MMO database, 2003-2007).

5.9.1.5 Minke Whales (Balaenoptera acutorostrata)

Minke whales are designated as Lower Risk/Near Threatened by the IUCN (IUCN 2007). They are the most numerous of the baleen whales remaining in the Okhotsk Sea. They are widely distributed and tend to remain in large bays, where they feed mainly on crustaceans and fish, although their diet varies greatly with the season.

Minke whales are found along the entire east coast of Sakhalin Island. They are usually encountered in Terpeniie and Sakhalin bays (Sobolevsky 1984). About 19,000 individuals occur in the Sea of Okhotsk (Buckland et al. 1992; Vladimirov 1994), and 3000 to 3500 are estimated to inhabit the area east of Sakhalin Island, and are commonly seen in the PA field. Minke whales are noted for their curiosity around ships (Perrin and Brownell 2002). Figure 5-8illustrates recent sightings near the project area (SEIC MMO database, 2003-2007).

5.9.1.6 Sperm Whales (Physeter macrocephalus)

Sperm whales are not considered endangered in the Sakhalin region but are listed as Vulnerable by the IUCN (IUCN 2007). They occur throughout the eastern and southern areas of the Sea of Okhotsk, but the waters offshore the Kuril Islands appear to be the centre of distribution for this species in the region.

During the summer and autumn period, the total population of sperm whales within the Sea of Okhotsk is estimated to be 1000 individuals (Vladimirov 1994). Sperm whales mainly feed on cephalopods, but also eat some fish. Approximately 200 to 300 sperm whales are believed to inhabit waters seasonally along eastern Sakhalin Island; they are most frequently seen around Cape Terpeniy, Cape Aniva and adjacent waters. Because of the absence of focused research, most observations are anecdotal and often unreliable (Perlov et al. 1996, 1997).

Sperm whales are unlikely to be encountered in the PA field area, as they are a deep-water species that is rarely seen over continental shelves, i.e. inshore of the shelf break.

5.9.1.7 Orca / Killer Whales (Orcinus orca)

Orcas, or killer whales, are designated as Lower Risk/Conservation Dependent by the IUCN (IUCN 2007). They have been recorded throughout almost all salt-water and some fresh-water areas, including many long inlets, narrow channels and deep embayments. These animals possess a complex vocal repertoire with variation in signals between populations and social groups (Deecke et al. 1999, 2000; Miller and Bain 2000; Thomsen et al. 2001; Yurk et al. 2002).

They are found throughout the Sea of Okhotsk, especially along the coasts. This species is frequently encountered in the vicinity of the Kuril Islands, western Kamchatka, and in the northern and southern parts of the Sea of Okhotsk. In total, 2500 to 3000 animals are estimated to inhabit the Sea of Okhotsk (Vladimirov 1994). Orcas occur along the entire eastern coast of Sakhalin Island at a total number estimated to be as high as 300 to 400 animals.

Orcas have been well studied in the northeast Pacific, offshore British Columbia and Alaska. Two groups of orcas are described, viz. residents and transients, based on morphology, ecology, genetics, and behaviour (Baird et al. 1992; Hoelzel et al. 1998; Baird 2001; Yurk et al. 2002). Residents live in large pods of six to 50 animals and prey mostly on fish, in particular, salmon (Ford et al. 1998; Saulitis et al. 2000; Anon 2004). Transients form small pods of two to four animals and feed on marine mammals such as seals, sea lions and porpoises, and also sea turtles, sea birds, as well as sea and river otters (Baird and Dill 1995, 1996; Ford et al. 1998; Baird and Whitehead 2000; Saulitis et al. 2000).

Orcas are likely to be observed in the PA field, and have been observed regularly during shore, aerial, and vessel-based distribution surveys (Sobolevsky 2000, 2001; Razlivalov 2004; Shulezhko et al. 2004; Sakhalin Energy Marine Mammal Observers Sightings Database 2006). Most sightings were of single individuals or small groups up to 30 individuals. Figure 5-8illustrates recent sightings near the survey area (SEIC 2007, MMO database, 2003-2007).

5.9.1.8 Beluga /White Whales (Delphinapterus leucas)

Belugas, also known as white whales or *belukhas*, are designated as Vulnerable by the IUCN (IUCN 2007), but are not considered endangered in the Sakhalin region. Belugas have a circumpolar distribution in the northern hemisphere. In the summer, belugas are associated with estuaries where animals moult. In autumn they are driven away from bays and estuaries by ice to winter primarily in polynyas near the edges of pack ice or in areas of shifting ice. They are abundant throughout the Sea of Okhotsk, although their distribution is variable. There are principally three populations of belugas in the Sea of Okhotsk (Perlov et al. 1996, 1997):

- Sakhalin-Amur population (7,000 to 10,000 individuals);
- Shantar population (3,000 to 5,000); and
- North-Okhotsk population (about 10,000).

The total number of belugas inhabiting the Sea of Okhotsk during the summer and autumn is estimated to be 20,000 to 25,000 individuals (Vladimirov 1994). Belugas do not permanently inhabit the waters off eastern Sakhalin Island, but are present in relatively small numbers (400 to 500 individuals) in the waters off north-eastern and northern parts of the island during their spring migration.

Areas where belugas are known to form large and stable concentrations are Sakhalin Bay, bays in the Shantarskie Islands, and Gizhiginskaya and Penzhinskaya bays. These areas are a significant distance from the eastern coast of Sakhalin Island, but observations made more than a century ago indicated the existence of belugas in Terpeniie Bay and in the Poronai River. Arsen'ev (1939) reported that in the 1930s, belugas were sometimes observed along the eastern coast of Sakhalin Island. Adult animals mostly feed on fish, whereas young animals also feed on invertebrates.

TINRO scientists conducted numerous surveys of the eastern coast of Sakhalin Island in the 1980s, and belugas were only found in 1989 when approximately 100 animals were observed among large ice floes near and southeast of Cape Elizabeth, at the northern tip of the island (Perlov et al. 1996, 1997). On 2 June 1989, up to 30 individuals were found in Nyiskii Bay, and about 50 animals moving northwards were seen north of the bay (between Chaivo and Piltun bays). Nyiskii Bay is likely to be the southern limit of the distribution of this species in the Sea of Okhotsk (Perlov et al. 1996, 1997).

Belugas are only expected to be seen off north-eastern Sakhalin Island during their spring migration and should not be encountered during the proposed survey. Figure 5-8illustrates recent sightings near the project area (SEIC 2007, MMO database, 2003-2007).

5.9.1.9 Dall's Porpoises (Phocoenoides dalli)

Dall's porpoise is designated as Lower Risk/Conservation Dependent by the IUCN (IUCN 2007). It is endemic to the Northern Pacific and one of the most numerous species of cetaceans in the Sea of Okhotsk (20,000 to 25,000 individuals). They rarely form large concentrations, and feed on schooling fishes and cephalopods. Although sometimes seen near land, Dall’s porpoises are most often observed far offshore in waters > 180 m deep. The western North Pacific population of Dall’s porpoise follow a well-defined annual migration in which the Japanese population moves northward to summer in the Sea of Okhotsk and around the Kuril Islands.

About 3500 to 4000 individuals occur in waters along the entire eastern side of Sakhalin Island, (Shuntov 1995). Dall’s porpoises are apparently more common south of Cape Terpeniie. In 1965 to 1971, A.E. Kuzin and A.S. Perlov regularly observed Dall’s porpoises southeast of Terpeniie Bay during the spring and summer, and east of Aniva Bay during the autumn and winter. Most observations have occurred between those two bays (Kuzin et al. 1984). Surveys in September 1990 revealed the presence of several groups of Dall's porpoises north and northeast of Cape Elizabeth. Twenty-one groups totalling 80 animals were recorded on 11 September, and 13 groups of 70 individuals were recorded on 12 September. In 1993, Dall's porpoises were seen singly and in small groups (three to five animals) between Terpeniie Bay and Aniva Bay. Shuntov (1995) observed them in and around Terpeniie Bay, and east of Aniva Bay, while. Sobolevsky (2000) observed them often in Terpeniie Bay and to the northeast of Cape Terpeniy.

Dall's porpoises are unlikely to be commonly encountered in the vicinity of the PA field, as they prefer deep, offshore waters (Jefferson 2002). However, Dall's porpoises have been sighted in shallow (~ 20m) waters off Piltun Bay. Figure 5-8illustrates recent sightings near the project area (SEIC 2007, MMO database, 2003-2007).

5.9.1.10 Harbour Porpoises (Phocoena phocoena)

Harbour porpoises are designated as Vulnerable by the IUCN (IUCN 2007). The harbour porpoise is a fairly abundant species and prefers shallower, inshore waters of the continental shelf (Bjørge and Tolley 2002). In the Sea of Okhotsk, the species inhabits waters near the Kuril Islands, along the west coast of Kamchatka, along the east coast of Sakhalin Island, in Sakhalin Bay, and north of the Shantarskie Islands (Perlov et al. 1996, 1997). Sobolevsky (2000) reported seeing single individuals and small groups in coastal areas adjacent to Lunsky Bay. Numerous sightings of harbour porpoise have been recorded in waters along Piltun Bay by Sakhalin Energy marine mammal observers. Harbour porpoises are expected to be observed within the PA field. Figure 5-8 illustrates recent sightings near the survey area (SEIC 2007, MMO database, 2003-2007).

5.9.1.11 Baird's Beaked Whales (Berardius bairdii)

Baird's beaked whales are not considered endangered in the Sakhalin region but are designated as Lower Risk/Conservation Dependent by the IUCN (IUCN 2007). Baird's beaked whales are endemic to the North Pacific. The eastern and western Pacific populations are migratory, arriving at the continental slope in summer and autumn. They can usually be found in deep waters over the continental slope, but they do occur in shallow waters in the Sea of Okhotsk (Kasuya 2002). Approximately 1000 to 1500 animals occur in the Sea of Okhotsk along the islands of the Kuril archipelago, the coast of Kamchatka, east Sakhalin Island, in Sakhalin Bay, near Shantarskie and Ion islands, and in the southern part of the Sea of Okhotsk. About 250 to 300 individuals occur in waters along the southern part of Sakhalin Island, mainly in Aniva Bay and east of Cape Aniva. Recent observations of this species are scarce, and most of them have been made in the southern part of the Sea of Okhotsk near the southern coast of Sakhalin Island, in La Perouse Strait, and east of Cape Terpeniy (Perlov et al. 1996, 1997). In winter-spring 2007 and early winter 2008, observers reported >30 Baird's beaked whales (during 13 separate sightings) in heavy ice conditions along Sakhalin's south-east and north-east coast (ENL, pers. comm., 2007). Figure 5-8 illustrates recent sightings by Sakhalin Energy near the survey area (SEIC 2007, MMO database, 2003-2007).

5.9.1.12 Pacific White-sided Dolphins (Lagenorhynchus obliquidens)

Pacific white-sided dolphins are not rated in the Red Book of the Russian Federation and are classified as Lower Risk/Least Concern on the IUCN Red List of Threatened Species (IUCN 2007). This species is among the most numerous inhabiting the north-western part of the Pacific Ocean. They are often found in large groups (average of 90) but sometimes concentrate in groups of up to 3000 individuals (Waerebeek and Würsig 2002). They appear to be most common in the southern part of the Sea of Okhotsk, along the Kuril Islands, at Cape Aniva, and in La Perouse Strait (Perlov et al. 1996, 1997). Pacific white-sided dolphins are mostly pelagic, moving offshore in spring and summer in rough synchrony with movements of anchovy and other prey (Waerebeek and Würsig 2002). They do not appear to be common in shallow waters along the northeast Sakhalin coast and are likely uncommon in the PA field. Figure 5-8 illustrates recent sightings near the survey area (SEIC 2007, MMO database, 2003-2007).

5.9.1.13 Short-beaked Common Dolphins (Delphinus delphis)

Short-beaked common dolphins are classified as Lower Risk/Least Concern on the IUCN Red List of Threatened Species (IUCN 2007). They are found throughout the temperate and tropical waters of the Pacific. This species is highly gregarious and may be seen in groups of more than 1000 animals; it is the most common dolphin in offshore waters (Perrin 2002). The world population is believed to be several million strong. Short-beaked common dolphins occur in the southern part of the Sea of Okhotsk, along the Kuril Islands and in waters along the west coast of Kamchatka. This species also inhabits the waters east of Sakhalin Island and north of the Shantarskie Islands (Perlov et al. 1996, 1997).

5.9.1.14 Bottlenose Dolphins (Tursiops truncatus)

Bottlenose dolphins are classified as Data Deficient on the IUCN Red List of Threatened Species (IUCN 2007), and are fairly uncommon in the Sea of Okhotsk. They occupy the southern half of the Sea of Okhotsk and may be found up to the central Kuril Islands, and from Cape Terpeniie south to Cape Aniva and Aniva Bay (Perlov et al. 1996, 1997). Bottlenose dolphins are primarily coastal, but also occur over the continental shelf, especially over the shelf break (Wells and Scott 2002).

Bottlenose dolphins are unlikely to be found in the PA field area but do occur further to the south.

5.9.2 Pinnipeds

Eastern Sakhalin Island is one of the major reproductive regions for pinnipeds in the Sea of Okhotsk. The total number of pinnipeds in this area has not changed significantly since the 1980s (Perlov et al. 1996). Six species of pinnipeds occur in the vicinity of eastern Sakhalin Island. Four species of true or ice seals viz. ringed seals (*Phoca hispida*), largha or spotted seals (*Phoca largha*), ribbon seals (*Histriophoca fasciata*) and bearded seals (*Erignathus barbatus*), are closely associated with the ice through the winter-spring season. Two species of eared seals, viz. the northern fur seal (*Callorhinus ursinus*) and the Steller sea lion (*Eumetopias jubatus*), are mainly open-water visitors to the area. Although sea otters were reported from southern Sakhalin Island in the 1960s, they have not been seen near Sakhalin Island in recent years. Species accounts are given below, and the information is summarised in Table 5-8. Pinniped distributions are shown in Figure 5-15and Figure 5-16. Pinniped sightings from Sakhalin Energy's MMO database (SEIC 2007) are illustrated on Figure 5-17 (non-endangered pinnipeds) and Figure 5-18 (endangered pinnipeds).

Table 5-8. Pinnipeds present off the east coast of Sakhalin Island.

Taxon (Family, Species, Common Name)	**Region of Maximum Abundance**	**Season of Maximum Abundance**	**Local Abundance in License Areas**	**Activity**	**Estimated Total Number in Sea of Okhotsk**	**Russian Red Book Category *1**	**IUCN Classification*2**
Phocidae							
Phoca hispida, Ringed seal	Entire east coast of Sakhalin Island, peaks in Lun'sky Bay to Cape Elizabeth	March-May on ice; August-Oct on coast	5,000-7,000	Pupping, Molting, Feeding	540,000		LR-1c (1996)
Erignathus barbatus, Bearded seal	Entire east coast peaks in Terpeniie Bay	March –May	1,000-2,000	Pupping, Molting	180,000		
Histriophoca fasciata, Ribbon seal	Entire east coast peaks in Terpeniie Bay and north up to Lun'sky Bay and Levensh-tein Point	April – May	50-100	Pupping, Molting	350,000		LR-1c (1996)
Phoca largha, Largha or Spotted seal	Entire east coast peaks between Terpeniie Bay and Lun'sky/ Chayvo Bays	March-May – on ice; August–October on the coast	3,000-4,000	Pupping, Molting, Feeding	180,000		LR-1c (1996)
Otariidae							
Eumetopias jubatus, Steller's sea lion	Robben (Tiulenii) Island off Cape Terpeniie	May – November	900-1,000	Pupping, Molting, Feeding	8,500–9,500	2	EN-A1b (1996)
	Kamen' Opasnosti Rock in La Perouse Strait	March – November	700–900	Molting, Feeding	8,500–9,500	2	
Callorinus ursinus, Northern fur seal	Robben (Tiulenii) Island	June – September	70,000-80,000	Pupping, Molting, Feeding	100,000–120,000		VU-A1b (1996)

*1 Category 1: endangered species whose abundance has decreased to critical levels, under threat of extinction in near future.
Category 2: vulnerable species whose numbers are constantly decreasing, could be moved to Category 1 in near future.
*2 Codes for IUCN classifications: EN = Endangered; VU = Vulnerable; Lr-lc = Lower Risk-Least Concern

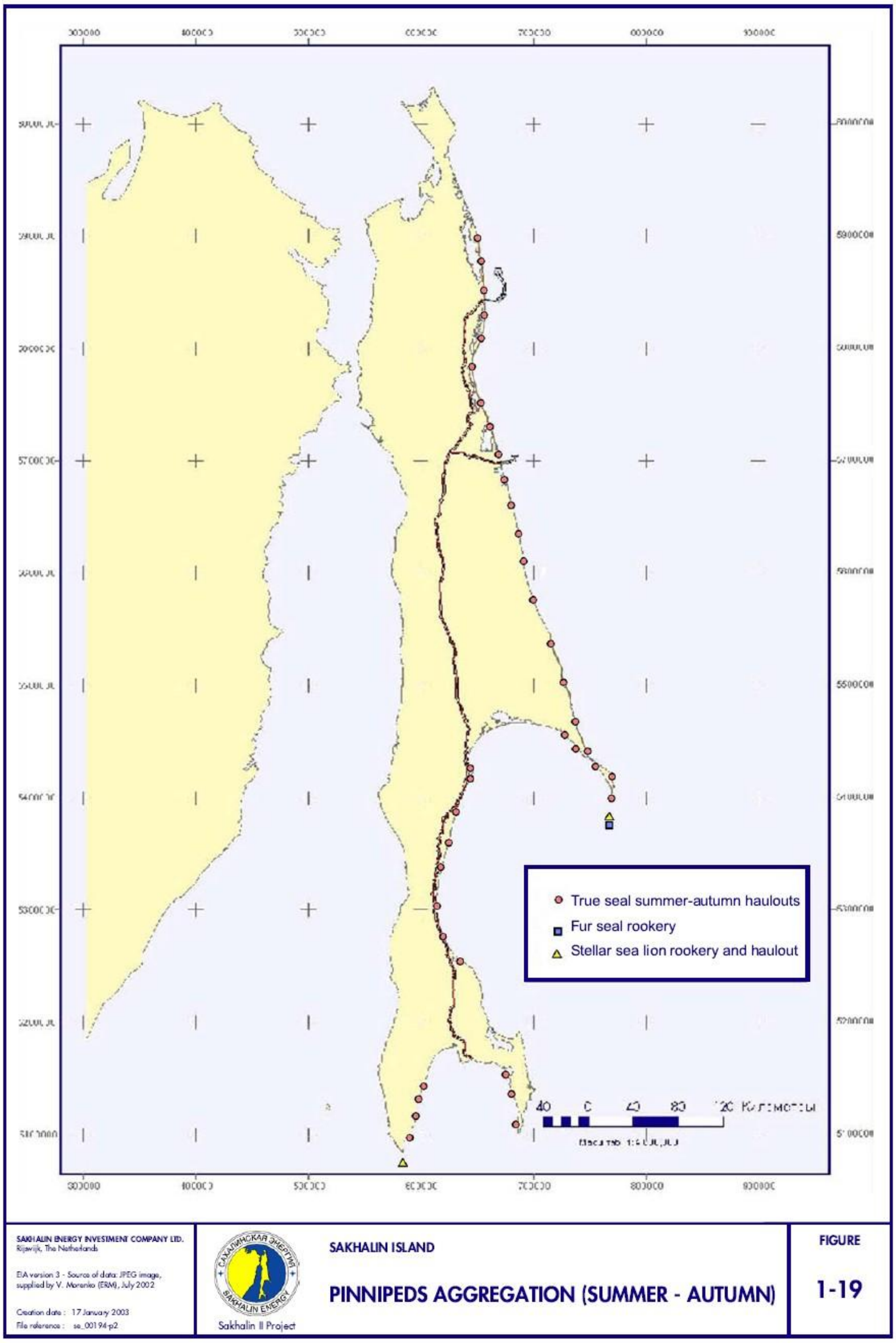


Figure 5-15. Pinniped aggregations (Summer-Autumn) (ERM 2003).

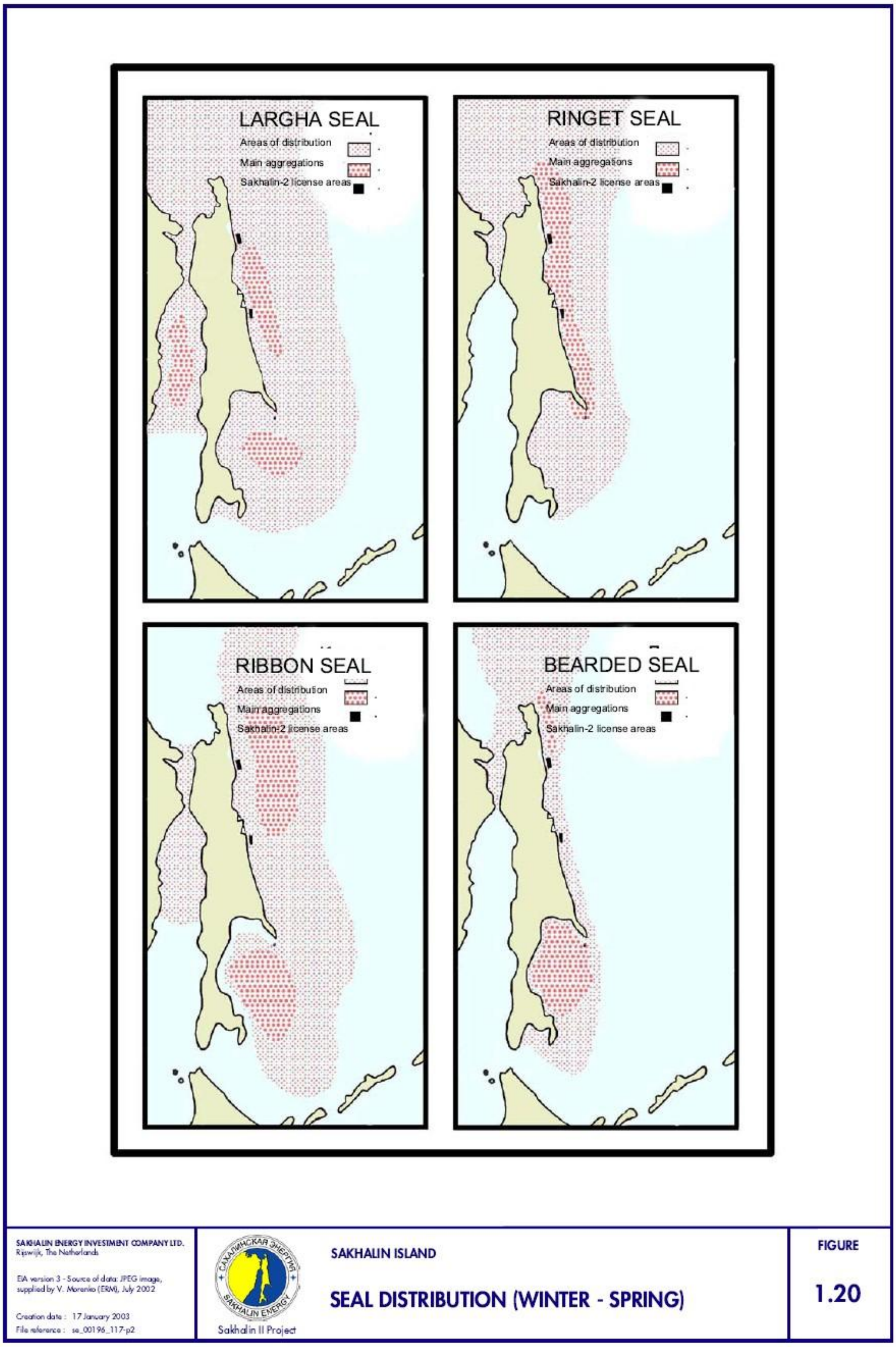


Figure 5-16. Seal distribution (Winter-Spring) (ERM 2003).

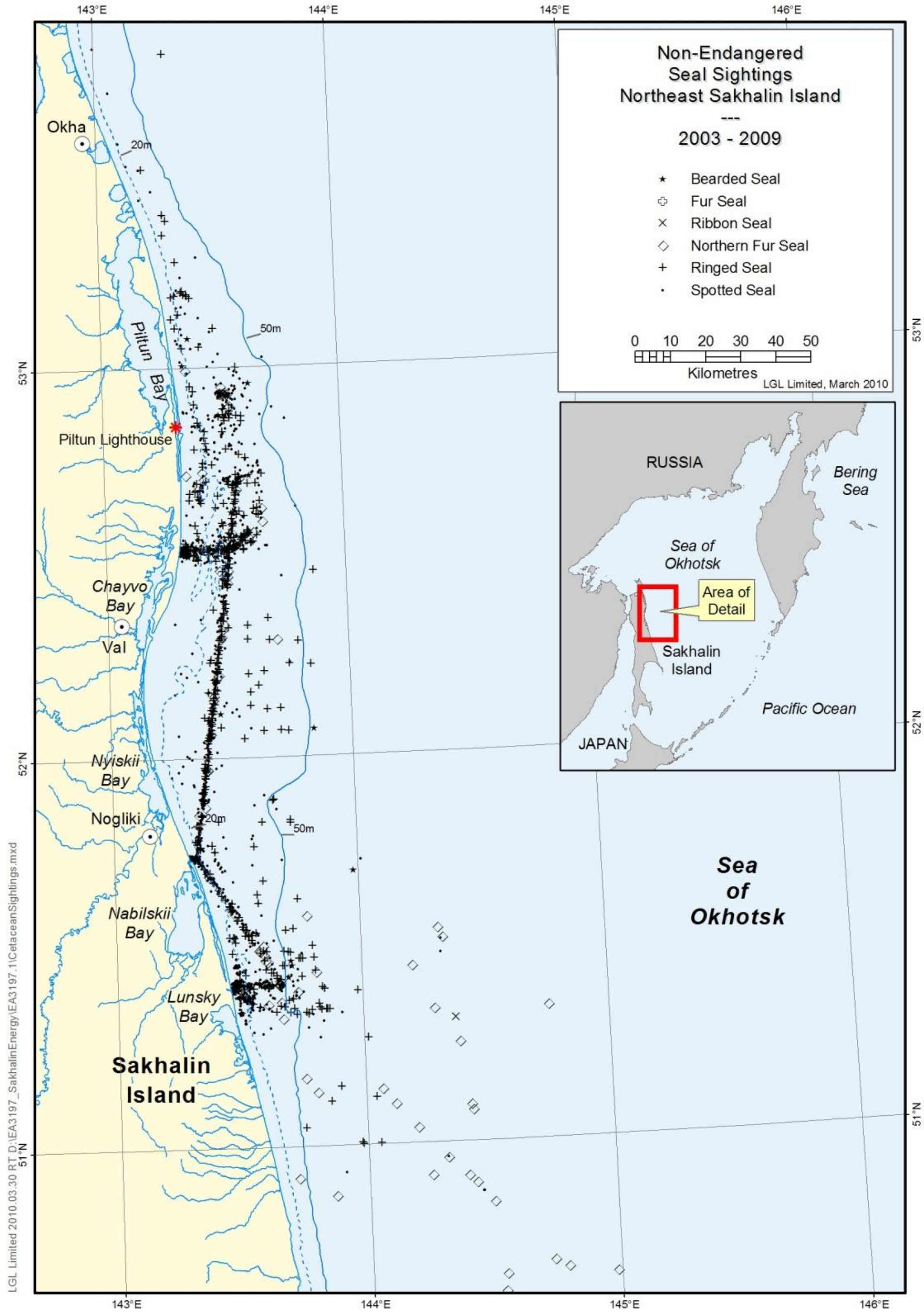


Figure 5-17. Non-endangered pinniped sightings from the supply vessels (Sakhalin Energy MMO Programme, 2003-2009).

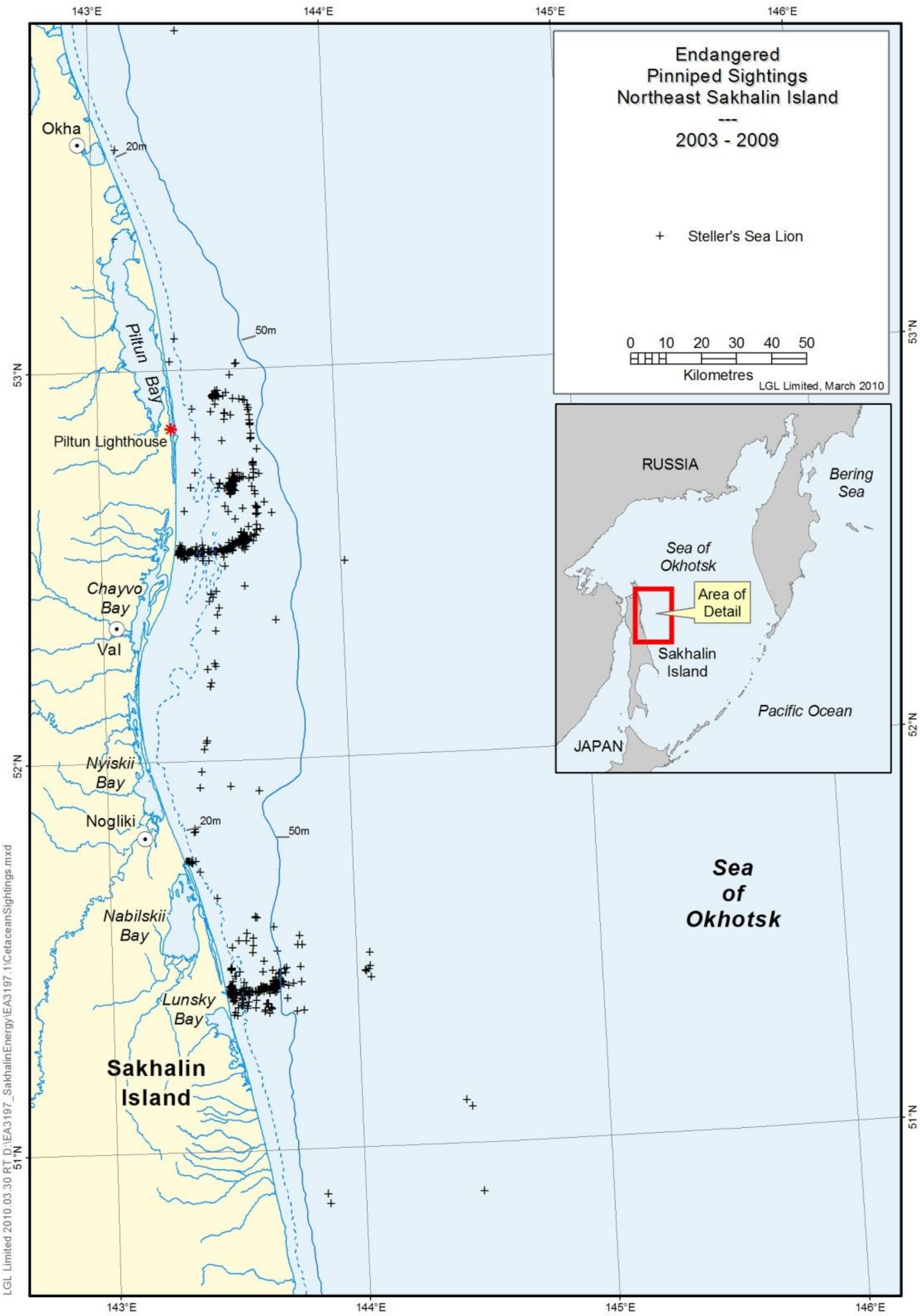


Figure 5-18. Endangered pinniped sightings from the supply vessels (Sakhalin Energy MMO Programme, 2003-2009)

5.9.2.1 Ringed Seals (Phoca hispida)

Ringed seals are generally regarded as the most numerous northern pinniped. The subspecies (*P. hispida ochotensis*) is classified as Lower Risk/Least Concern on the IUCN Red List of Threatened Species (IUCN 2007), and is harvested from the Sea of Okhotsk. Ringed seals are not listed in the Red Book of the Russian Federation (Krasnaya Kniga RFZ 2001). Sealing was unregulated between 1955 and 1968 and the average annual catch during this time was about 78,500 ringed seals (Fedoseev 2000). Since then sealing has been restricted and is now subject to compliance monitoring and scrutiny by scientific review committees. The species is abundant within the Sea of Okhotsk and is found along the entire eastern coast of Sakhalin Island (Fedoseev 2000).

From aerial surveys conducted between 1968 and 1990, it is estimated that the average population within the Sea of Okhotsk was approximately 750,000, with the waters of eastern Sakhalin Island supporting a multi-year average of approximately 130,000 (Fedoseev 2000). Between year variation in the Sea of Okhotsk population was low, about 20% (Fedoseev 2000), but two surveys along the eastern coast of Sakhalin Island in 1968 and 1969 showed greater fluctuations in numbers. In 1968 and 1969, respectively, the estimated ringed seal populations were 28,500 and 138,000 on north-eastern Sakhalin Island, and 15,000 and 40,000 on south-eastern Sakhalin Island (Fedoseev 1971). More recently, a ‘most likely average value’ of 140,000 to 180,000 has been used by the Russian Federation to calculate a total admissible catch for eastern Sakhalin Island (V. Vladimirov, pers. comm. 2007).

Ringed seals breed, whelp and moult on the ice, often forming large concentrations during the winter to spring months. As the ice thickens in late autumn and winter, ringed seals maintain openings in ice more than 2 m wide to breathe. As snow accumulates over breathing holes the seals may excavate lairs. Ringed seals in the Sea of Okhotsk give birth on shore-fast ice, not in lairs as they do in other areas. The highest densities of breeding adults are found on stable land-fast ice, while non-breeders concentrate on the moving pack ice. Ringed seals also remain in the region during the open water period and are found hauled out on land and in near shore waters during the summer. During the spring, summer, and autumn, ringed seals spend most of their time swimming and feeding among the ice floes. Ringed seals are often described as being cautious and easily disturbed by human activity (Burns and Harbo 1972; Burns and Frost 1979; Alliston 1981; Nowak 1999).

The species has been observed regularly within Nyisky, Lunsky, Chaivo and Piltun bays, predominantly at the mouths of estuaries, rivers, straits and channels connecting north-eastern Sakhalin Island’s lagoon habitats with the sea (Grachev 2006). In summer 1999, ringed seals were present at some rookeries (traditional locations of annual breeding aggregations) and scattered along the coast in the area surveyed from Niysky Bay to Piltun Bay (Sobolevsky 2000). In 2000, their distribution was similar in the larger area surveyed (Lunsky Bay to Piltun Bay), but their numbers had increased in Chaivo and Piltun bays (Sobolevsky 2001). Aggregations of between 20 and 70 individuals are often recorded. Figure 5-17 illustrates sightings of ringed seals in the Sakhalin Energy MMO database, 2003-2007 (SEIC 2007).

The species’ main food sources consist of euphausiid shrimps, walleye pollock fry, Pacific herring, Asian smelt and sand lance. Shrimp and crabs represent a lesser constituent (Nikolaev and Skalkin 1975).

5.9.2.2 Largha Seals (Phoca largha)

Largha seals, also known as spotted seals, are classified as Lower Risk/Least Concern on the IUCN Red List of Threatened Species (IUCN 2007) and are harvested from the Sea of

Okhotsk. This species is not listed in the Red Book of the Russian Federation. They are considered to be abundant within the Sea of Okhotsk and have been observed off the north-eastern coast of Sakhalin Island throughout the year; they are closely associated with the ice during much of this time (Sobolevsky 1984).

Based on ten years of aerial surveys conducted between 1968 and 1990, estimated numbers in the Sea of Okhotsk ranged from 180,000 to 240,000, with about 15 to 20% in the waters of eastern Sakhalin Island (Fedoseev 2000). Two surveys along the eastern coast of Sakhalin Island in 1968 and 1969 showed that largha seal numbers were fairly stable during that period: 12,000 to 13,000 animals, of which 4,000 individuals occurred in Terpeniie Bay (Fedoseev 1971). More recently, numbers off eastern Sakhalin Island have exceeded 40,000 (Trukhin 1999). A 'most likely average value' of 30,000 to 40,000 has been used by the Russian Federation to calculate total admissible catch for eastern Sakhalin Island (V. Vladimirov pers. comm., 2007). A breeding site between Sakhalin and Hokkaido Islands has also been established with 13,600 seals being observed in March and 6,500 in April 2002 (Mizuno et al. 2002).

Largha seals are present along the entire eastern coast of Sakhalin Island, but during the winter months they are concentrated along the northern third of the Island in Terpeniie Bay. Largha seals show an annual migration in the autumn and winter to the edge of the pack ice. Pupping rookeries are generally located offshore on drift ice, especially on hummocked floes. Breeding takes place in late winter and spring and after breeding the seals stay on the ice to moult. Pups are born between February and March, and are weaned at one month. When the ice retreats, some seals migrate from the breeding region, whilst others remain in Sakhalin coastal waters forming many haul outs along the coast. Most of these haul outs are located at the mouths of salmon spawning rivers, especially at the inlet of Chaivo Bay, Cape Popova, Tyulenii Island and Aniva Bay (Blokhin et al. 2003a).

During the summer, largha seals gather at approximately 54 rookeries at the mouths of rivers and on coastal bars along the east and south coasts of Sakhalin Island, including Lunsky, Nabilskyi, Piltun and Aniva bays (Kosygin et al. 1986; Lagerev 1988; Perlov et al. 1996, Bradford and Weller 2005). In July 2000, three rookeries with a total estimated 600 to 800 individuals, and in August 2000, four rookeries with a total estimated 4,000 to 5,000 individuals were observed on a sand spit at the entrance to Chaivo Bay, waiting for the annual migration of Pacific salmon (Sobolevsky 2001). In 1998, 16 to 489 largha seals were counted during systematic shore-based counts in Piltun lagoon between 24 July and 31 August (Bradford and Weller 2005), and in August 2000, one rookery with more than 500 individuals was recorded at the mouth of Piltun Bay (Sobolevsky 2001). There was a noticeable peak in seal numbers in late August (1998 and 2000) that appeared to coincide with seasonal herring and salmon runs (Bradford et al. 1999; Bradford and Weller 2005). In July 2000, more than 50 individuals were recorded at the mouth of Nabilskyi Bay and 38 individuals were recorded at the mouth of Lunsky Bay. In August, numbers increased to more than 100 at the mouth of Lunsky Bay, and remained the same at Nabilskyi Bay, possibly because of the continuous presence of fishermen there (Sobolevsky 2001). Rookeries were not present at Lunsky and Nabilskyi bays in September, and almost no seals were found at the mouth of those bays in October (Sobolevsky 2001).

SakhNIRO has conducted baseline studies focused specifically on the Piltun, Lunsky and Aniva bay areas (SakhNIRO 1999a). In Piltun Bay, over 200 largha seals were observed. The majority of seals were encountered at the mouth to the bay, in the riptides and surf over the many sandbars. Beyond the bay mouth, the number of sightings diminished significantly, and about 2 km from the bay mouth no seals were observed. SakhNIRO noted, however, that the observed reduction in numbers beyond the bay may have been due to the presence of fishermen in the area who were fixing dog salmon nets at the time of the studies. On the shore itself, the studies recorded that the bay was isolated due to the dense covering of dwarf cedar trees, alder and bushes, and inaccessible due to the high-energy wave environment over the sandbars when approaching from the water. These access difficulties minimise human occupation and associated disturbance that may explain the relatively high numbers of seals observed in Piltun Bay.

In Lunsky Bay, SakhNIRO reported similar observations to those made for Piltun Bay. Largha seals dominated sightings, with over 150 individuals being recorded. Animals were mainly concentrated at the bay mouth, in the surf zone, over the sandbars and along the shore. Seals were generally not aggregating into groups but were encountered singly. As in Piltun Bay, the number of seals decreased with increasing distance from the bay mouth. It was noted that the animals exhibited cautious avoidance behaviour, diving 50 to 100 m away from the survey boats and leaving the open water area for the sandbars as soon as the vessels entered the bay. This behaviour may be a reaction to local hunting (SakhNIRO 1999a).

In Aniva Bay, observed seal numbers were generally low, with only five largha seals being recorded (SakhNIRO 1999a).

Adult seals feed on fish, cephalopods and crustaceans, whereas newly weaned pups apparently feed on euphausiids and small amphipods found around the ice floes (few data are available on ice biota from this region). When hauled out on ice or land, largha seals are very sensitive to approaches by aircraft, often moving into the water when the aircraft is still at a lateral distance of 1 km (Frost and Lowry 1990; Frost et al. 1993; Rugh et al. 1993).

5.9.2.3 Ribbon Seals (Histriophoca fasciata)

Ribbon seals are classified as Lower Risk/Least Concern on the IUCN of Threatened Species (IUCN 2007) and are not included in the Red Book of the Russian Federation (Krasnaya Kniga RFZ 2001). They are harvested from the Sea of Okhotsk. The average annual catch during the period of unregulated sealing (1955-68) was up to 13,000 ribbon seals (Fedoseev 2000), but since that time sealing has been restricted. Ribbon seals are found off the northeast coast of Sakhalin Island with a concentration from Lunsky Bay to Chaivo Bay during winter-spring (Fedoseev 1997) beginning in February (Kosygin et al. 1985).

Based on ten years of aerial surveys conducted between 1968 and 1990, estimated numbers in the Sea of Okhotsk ranged from 200,000 to 630,000, with an average of 350,000 to 450,000. The average in the waters of eastern Sakhalin Island was 110,000 (Fedoseev 2000). Two surveys along the eastern coast of Sakhalin Island in 1968 and 1969 showed that fluctuations in numbers might be significant for ribbon seals (Fedoseev 1971). In 1968 and 1969, respectively, the estimated ribbon seal populations were 47,000 and 27,000 on north-eastern Sakhalin Island, and 30,000 and 10,000 on south-eastern Sakhalin Island.

Between 1975 and 1990, there was a trend of rapid growth and earlier maturation (Fedoseev and Volokhov 1991), and numbers began to increase rapidly in the late 1970s. Average numbers for the 1988, 1989, and 1990 surveys were approximately 550,000 in the Sea of Okhotsk (Fedoseev 2000). More recently, a ‘most likely average value’ of 80,000-100,000 has been used by the Russian Federation to calculate total admissible catch for eastern Sakhalin Island (V. Vladimirov, pers. comm., 2007).

During the winter and spring, the majority of animals are concentrated offshore on hummocked flows with open water areas along the north-eastern coast between Lunsky Bay and Chaivo Bay. Rookeries may be established 200 to 240 km from the ice edge. In years where there is low ice cover or early ice retreat, the seals may move to coastal waters, where they establish moulting rookeries on drifting ice. Ribbon seals are not known to establish coastal rookeries. As the ice melts, the density of animals on the remaining ice cover increases. When the ice disappears altogether, the seals convert to a completely pelagic lifestyle, and are distributed across the entire Sea of Okhotsk. Ribbon seals are reportedly easy to approach and are not easily disturbed (Nowak 1999).

In the southern part of the Sea of Okhotsk, ribbon seals have a higher abundance than ringed seals but are less abundant than largha seals. No ribbon seals were observed during surveys conducted in Terpeniya Bay and Aniva Bay by SakhNIRO in September 1998 or by DVNIGMI in July 2001 (DVNIGMI 2002). Figure 5-17 illustrates sightings of ribbon seals in the Sakhalin Energy MMO database, 2003-2007 (SEIC 2007). Ribbon seals feed predominantly on pelagic fish such as walleye pollock, Pacific cod and capelin, cephalopods and crustaceans (LGL 2003).

5.9.2.4 Bearded Seals (Erignathus barbatus)

Bearded seals are classified as Lower Risk/Least Concern on the IUCN Red List of Threatened Species (IUCN 2007) and are not included in the Red Book of the Russian Federation (Krasnaya Kniga RFZ 2001). They are harvested from the Sea of Okhotsk and the average annual catch during the period of unregulated sealing (1955-68) was approximately 10,000 individuals (Fedoseev 2000), but since that time sealing has been restricted.

They are strongly associated with the ice and they tend to be concentrated to the north of the Sea of Okhotsk. Fedoseev (2000) estimated that there are 200,000 to 250,000 bearded seals in the Sea of Okhotsk, including 60,000 to 75,000 in the waters of eastern Sakhalin Island. More recent estimates report 350,000 seals in the Sea of Okhotsk and 35,000 to 40,000 seals in the eastern Sakhalin region (V. Vladimirov, pers. comm., 2007).

Bearded seals are usually found in shallow waters over the continental shelf, avoiding areas of continuous, thick, shore-fast, or drifting ice, but favouring moving ice with numerous open water gaps.

In winter-spring, beginning in February (Kosygin et al. 1985), they occur all along the northeast coast of Sakhalin Island (Fedoseev 1971). In summer, they are scattered along the northeast and west coasts in low numbers, occurring at some rookeries but not in large numbers; during summer 1999, bearded seals were present at some rookeries and scattered along the coast in the areas surveyed (from Niyskiy Bay to Piltun Bay), but were not common and were observed only as single individuals (Sobolevsky 2000, 2001). In 2000, the distribution was similar in the area surveyed (Lunsky Bay to Piltun Bay), but they occurred in groups of 5 to 10 animals, and more were seen in coastal rookeries than in 1999 (Sobolevsky 2001). The main reproductive groups are observed between Cape Elizabeth, at the north of the island, and 50°N (approximately halfway down the island). Figure 5-17 illustrates sightings of bearded seals in the Sakhalin Energy MMO database, 2003-2007 (SEIC 2007).

Bearded seals generally tend not to congregate on ice, but occur singly on the shear zone between shore-fast and drift ice (Nikolaev and Silishchev 1982 in LGL 2003). The only known large haul-out locations are gravel beaches on the north-western coast of Sakhalin Island, where they come on shore in large numbers (~2,000) during the summer to rest and moult (Kosygin et al. 1986). Bearded seals often stay close to the water when hauled out and will typically dive immediately if disturbed (Burns and Harbo 1972; Burns and Frost 1979; Alliston 1981; Nowak 1999).

Bearded seals are typically benthic feeders, feeding upon crustaceans, gastropods, bivalves, annelids and cephalopods. The seals also feed upon some fish species including walleye pollock, sand lance and plaice (Bukhtiyarov 1990 in LGL 2003). As benthic feeders, the distribution of bearded seals is restricted to depths of less than 200 m (LGL 2003).

5.9.2.5 Northern Fur Seals (Callorhinus ursinus)

Northern fur seals are listed as Vulnerable on the IUCN Red List of Threatened Species (IUCN 2007) but are not considered rare in the Sea of Okhotsk and are a harvested species in Russia.

In the Sea of Okhotsk, the total population may be as high as 200,000 individuals (V. Vladimirov, pers. comm., 2007). Approximately 95,000 to 100,000 individuals are found in a rookery on Robben (Tuyleni) Island, southeast of Cape Terpeniie, and in adjacent waters eastward of the Island (V. Vladimirov pers comm., 2007). Most northern fur seals occur along the south-eastern coast of Sakhalin Island. Small numbers are reported in Aniva Bay during the ice-free season. They feed on small schooling fish and cephalopods, especially squid (Sobolevsky 1984).

The northern fur seal is a highly pelagic species, with only young fur seals spending appreciable amounts of time on land. Fur seals concentrate in areas of upwelling over seamounts and along continental slopes, and are rarely encountered close to shore except in the vicinity of rookeries. Northern fur seals typically winter in the Sea of Japan, migrating north to the Sea of Okhotsk in the spring to return to established rookeries. Most pups are born from late June to late July and are weaned at three to four months. While breeding males may remain at the rookeries for the entire breeding season, females return to sea regularly.

Large numbers of fur seals were killed for their pelts in the 19th and early 20th centuries; there have also been a significant number of fur seals killed accidentally by entanglement in fishing nets (Lander and Kajimura 1982).

Northern fur seals enter Piltun Bay infrequently (Sobolevsky 2000). In summer 2000, they were observed at some rookeries during surveys from Lunsky Bay to Piltun Bay (Sobolevsky 2001). Small numbers of animals have been recorded within Aniva Bay during the spring and autumn migrations and some sightings have been made between Lunsky and Piltun Bays (DVNIGMI 2001). During surveys by SakhNIRO in September 1998 and by DVNIGMI in July 2001, animals were only observed in Terpeniya Bay (including the Poronaysk Port area and Cape Terpeniy) where they were abundant. Approximately 75,000 to 80,000 individuals were observed at the rookery on Tyuleni Island, some 20 km southeast of Cape Terpeniya, and in adjacent waters eastward of the Island (Vladimirov 2002 in LGL 2003). Figure 5-17 illustrates sightings of northern fur seals in the Sakhalin Energy MMO database, 2003-2007 (SEIC 2007).

5.9.2.6 Steller Sea Lions (Eumetopias jubatus)

Steller sea lions, also know as northern sea lions, are listed as Vulnerable in the Red Data Book of Russia (Krasnaya Kniga RFZ 2001) and as Endangered in the IUCN Red List of Threatened Species (IUCN 2007).

Steller sea lions are distributed around the North Pacific Ocean rim from northern Hokkaido, Japan through the Kuril Islands and Sea of Okhotsk, Aleutian Islands and central Bering Sea, southern coast of Alaska and south to the Channel Islands, California. The world population of Steller sea lions includes two stocks divided at 144°W longitude (Cape Suckling, just east of Prince William Sound, Alaska). The stock differentiation is based primarily on genetic differences, but also on differing population trends in the two regions. Steller sea lions have undergone dramatic declines in population across large portions of their range. This is thought to be due to a combination of habitat loss, habitat degradation, invasion by alien species, and the effects of hunting. The population has declined by approximately 10% annually since the early 1990s.

Approximately 9,500 to 10,000 Steller sea lions now inhabit the Sea of Okhotsk with approximately 1,100 individuals in the eastern Sakhalin region (Burkanov et al. 2006; V. Vladimirov pers. comm., 2007). In 2005, more than 1,500 adult and 407 newborn animals were recorded at the only known breeding rookery on Sakhalin, located on Tyuleni Island (Kuzin 2006). Two main bachelor haul outs have also been identified, on Kamen Opasnosti Rock in La Perouse Strait and Kuznetsova Cape on the south-western coast of Sakhalin Island. Kamen Opasnosti Rock is used throughout the year, with up to 700 animals congregating there and with more animals occurring in the late winter and spring. The haul out at Kuznetsova Cape is also used year-round with more animals occurring in the late winter and spring; approximately 350 to 500 animals have been observed at this location (LGL 2003; Cupakhina et al. 2004). During harsh winters when land ice or solid ice at the shore is formed, the sea lions leave the area (Cupakhina et al. 2004). A smaller haul out is also present on the harbour breakwater at Nevelsk (on the western coast, 50 km south of Kholmsk). Animals start hauling out in late January through February and abandon the location in late November (Cupakhina et al. 2004). During the summer, animals may be seen along the entire eastern side of Sakhalin Island and across the northern section of Sakhalin Island into Amurskiy Bay. In September 1982, more than 200 Steller sea lions were recorded along the western coast of Sakhalin Island in Tatar Strait (Berzin et al. 1984). Rookeries tend to be located on remote, rocky coasts and islands. The number of Steller sea lions at rookeries begins to increase in early May and reaches a maximum in July. Females give birth from mid-May to mid-July, with most births occurring in early June.

Fish, such as Atka mackerel, walleye pollock, salmon, sculpins and sandlance dominate the diet of Steller sea lions (Sobolevsky 1984; Waite and Burkanov 2004).

Steller sea lions may occur in small numbers near the PA license area. Their closest large rookery is more than 300 km to the south of Lunskoye. They enter Piltun Bay infrequently (Sobolevsky 2000), and were not observed in summer 2000 during surveys from Lunsky Bay to Piltun Bay (Sobolevsky 2001). In 2005, 138 observations of 151 individuals were recorded during Sakhalin Energy construction activities and it was considered a fairly common species for the project area. It was encountered in all operational areas and during transit, however most of these observations were recorded in the Lunskoye area (SEIC 2006). Figure 5-18 illustrates sightings of Steller sea lions in the Sakhalin Energy MMO database, 2003-2007 (SEIC 2007).

5.10 Marine and Coastal Birds

5.10.1 Introduction

The bays along the north-east coast and the near shore marine waters provide habitat for a large number and diversity of breeding and migratory birds (see Table 5-9). The Piltun, Chaivo, Lunsky and Nabilsky Bays are the most important areas along the north-eastern coastline for migrating waders and seabirds during the spring and autumn. Birds found in this region include rare species registered in the Red Data Book of the Russian Federation and the IUCN Red List of Threatened Species (2007). Species migrating through the region may be observed for a very short period of time, while others nest and feed and are present for longer periods.

In the spring, approximately 1 million waterfowl, 1 million albatrosses, petrels, gulls and auks and 1-1.5 million waders migrate through the area. In autumn, these populations increase by 20-30% (SEIC 2002a, TEO-C Volume 7 Book 1-EIA: Chapter 1).

Table 5-9. Common bird species of the north-east coast of Sakhalin Island.

English Name	Scientific Name	Pattern of Occurrence	RF Red Book Status	IUCN Status
Seabirds and Sea ducks				
Red-throated Diver	*Gavia stellata*	Br		
Black-throated Diver	*Gavia arctica*	Br	2	
Northern Fulmer	*Fulmarus glacialis*	Mg		
Sooty Shearwater	*Puffinus griseus*	Mg		
Short-tailed Shearwater	*Puffinus tenuirosiris*	Mg		
Fort-tailed Storm-petrel	*Oceanodroma furcata*	Mg		
Great Cormorant	*Phalacrocorax carbo*	Br		
Pelagic Cormorant	*Phalacrocorax pelagicus*	Br		
Red-faced Cormorant	*Phalacrocorax urile*	Mg		
Tufted Duck	*Aythya fuligula*	Br		
Greater Scaup	*Aythya marila*	Br		
Black Scoter	*Melanitta nigra*	Br		
White-winged Scoter	*Melanitta fusca*	Br		
Harlequin Duck	*Histrionicus histrionicus*	Br		
Long-tailed Duck	*Clangula hyemalis*	Mg		
Marbled Murrelet	*Brachyramphus marmoratus*	Br	3	VU
Common Goldeneye	*Bucephala clangula*	Br		
Red-breasted Merganser	*Mergus serrator*	Br		
Goosander	*Mergus merganser*	Br		
Red-necked Phalarope	*Phalaropus lobatus*	Br		
Common Gull	*Larus canus*	Br		
Slaty-backed Gull	*Larus schistisagus*	Br		
Black-headed Gull	*Larus ridibundus*	Mg		
Black-legged Kittiwake	*Rissa tridactyla*	Br		
Common Tern	*Sterna hirundo*	Br		
Aleutian Tern	*Sterna aleutica*	Br	3	
Common Guillemot	*Uria aalge*	Br		
Brunnich's Guillemot	*Uria lomvia*	Br		
Parakeet Auklet	*Cyclorrhynchus psittacula*	Mg		
Crested Auklet	*Acthia cristatella*	Br		
Least Auklet	*Acthia pusilla*	Mg		
Tufted Puffin	*Lunda cirrhata*	Mg		
Waterfowl				
Whooper Swan	*Cygnus cygnus*	Br		
Bewick's Swan	*Cygnus columbianus bewickii*	Mg	3	
White-fronted Goose	*Anser albrifrons*	Mg		
Bean Goose	*Anser fabalis*	Mg		
Brent Goose	*Branta bernicla*	Mg	3	

English Name	Scientific Name	Pattern of Occurrence	RF Red Book Status	IUCN Status
Eurasian Wigeon	*Anas penelope*	Br		
Falcated Duck	*Anas falcata*	Br		
Green-wing Teal	*Anas crecca*	Mg		
Mallard	*Anas platyrhynchos*	Br		
Northern Pintail	*Anas acuta*	Br		
Garganey	*Anas querquedula*	Br		
Northern Shoveler	*Anas clypeata*	Br		
Predatory Birds				
White-tailed Sea-eagle	*Haliaeetus albicilla*	Br	3	LR/NT
Steller's Sea-eagle	*Haliaeetus pelagicus*	Br	3	VU
Osprey	*Pandion haliaetus*	Br		
Peregrine Falcon	*Falco peregrinus*	Mg	2	
Waders				
Little Ringed Plover	*Charadrius dubius*	Br		
Lesser Sandplover	*Charadrius mongolus*	Mg		
Bar-tailed Godwit	*Limosa lapponica*	Mg		
Black-tailed Godwit	*Limosa limosa*	Mg		
Whimbrel	*Numenius phaeopus*	Mg		
Common Redshank	*Tringa totanus*	Br		
Common Greenshank	*Tringa nebularia*	Br		
Wood Sandpiper	*Tringa glareola*	Br		
Common Sandpiper	*Actitis hypoleucos*	Br		
Great Knot	*Calidris tenuirostris*	Mg		
Red Knot	*Calidris canutus*	Mg		
Red-necked Stint	*Calidris ruficollis*	Mg		
Long-toed Stint	*Calidris subminuta*	Br		
Curlew Sandpiper	*Calidris ferruginea*	Mg		
Dunlin	*Calidris alpina*	Br		

Key:
Red Book: **1** = endangered and under threat of extinction; **2** = vulnerable; **3** = rare
IUCN: **CR** = Critically Endangered; **EN** = Endangered; **VU** = Vulnerable; **LR** = Lower Risk; **NT** = Near Threatened; **Br** = Breeding; **Mg** = Migratory

5.10.2 Marine and Coastal Birds

The geographic range and abundance of certain seabirds depend on the ecological, physiographical and hydrological conditions of the region. According to their habitat requirements, seabirds can be subdivided into several groups.

The coastal, or neritic species tend to occupy a several km wide coastal zone, even during their migrations. This group includes several species of cormorants, Black-headed Gull (*Laris ridibundus*), Mew Gull (*L. canus*), divers, grebes, almost all waterfowl (especially diving ducks), and a few other species present in the coastal waters of Sakhalin Island. The shelf, or distant-neritic group is composed mainly of gulls and alcids (guillemots and auks). These species are most abundant on the shelf and continental slope, though they may also occur in deep-sea regions in peripheral and even central parts of the Sea of Okhotsk. Among the oceanic group, only Leach's Storm-petrel (*Oceanodroma leucorrhoa*) and three species of albatrosses (*Diomedea albatrus*, *D. immutabilis*, and *D. nigripes*) occur in the sea east of Sakhalin Island. The seabirds of this group are generally found in open oceanic waters far offshore. Using oceanic currents, they penetrate in small numbers into the Sea of Okhotsk where they remain mostly in the waters around the Kuril Islands and rarely occur off the coast of Sakhalin. The intrazonal neritic-oceanic group includes all shearwaters (*Puffinus* spp.), Northern Fulmar (*Fulmarus glacialis*), Tufted Puffin (*Lunda cirrata*), and Fork-tailed Storm-petrel (*Oceanodroma furcata*). Birds of this group are abundant both on the shelf and in the open ocean, and reach high numbers in the coastal waters of Sakhalin Island.

From the end of summer until the beginning of winter, all seabird species of the Sakhalin Island region and the seabirds nesting north of Sakhalin Island make a slow nomadic movement along Sakhalin Island to the south. Several waves of migrating seabirds pass along the coast during these months. The north-eastern coast of Sakhalin Island is a major migration route where birds from the lower part of the Amur River join those from both the north-western and northern parts of the Sea of Okhotsk. In total it is estimated that at least 10 million seabirds nest in the northern Sea of Okhotsk, among which auks, murrelets, and Tuffed Puffin predominate (Kondratiev 1991). Even if only one fifth of these birds migrate along the western coast of the Sea of Okhotsk, while the majority use the route along the eastern coast of the Sea of Okhotsk, then at least two million seabirds migrate along eastern Sakhalin Island in the autumn.

5.10.3 Breeding Birds

The breeding bird population of the north-east coast of Sakhalin Island is dominated by species characteristic of open water and associated wetland/coastal habitats. Wet sedge marsh/bogs and sparse larch/ledum forest around the lagoons support a number of coastal specialists. These include the Sakhalin subspecies of Dunlin (*Calidris alpina actities*), which breeds close to the shore in open areas of marsh with pools and the extremely rare Spotted Greenshank (*Tringa guttifer*), which inhabits sparse waterlogged larch forest close to the lagoons. The Aleutian Tern (*Sterna aleutica*) breeds in colonies, usually on small islands within the lagoons and around permanent pools close to the shore. Areas of open water provide breeding habitat for several species of duck including Common Teal (*Anas crecca*), Mallard (*Anas platyrhynchos*) and Tufted Duck (*Aythya fuligida*), grebes and divers. The population of breeding ducks in Piltun and Chaivo bays is probably in excess of several hundred pairs, with nesting normally beginning at the end of May and continuing through into August (Fauna Information and Research Centre 2001; FESU 2004).

Several species of birds of prey inhabit the coastline and bays of north-eastern Sakhalin, including Steller’s Sea-eagle (*Haliaeetus pelagicus*), White-tailed Sea-eagle (*H. albicilla*), Osprey (*Pandion haliaetus*) and Peregrine Falcon (*Falco peregrinus*), all of which are included in the Red Data Book of the Russian Federation. Available survey data (2010) indicates that there are in the region of ten pairs of Steller’s sea-eagles breeding in the Piltun Bay area and fifteen pairs in Chaivo Bay. Both species of sea-eagle are hunters and scavengers taking fish (primarily salmon) from the lagoons and river mouths. Breeding Steller’s Sea-eagles from Sakhalin typically overwinter on Hokkaido or in the southern Kuril Islands.

5.10.4 Migratory Birds

Surveys undertaken during the spring and autumn migratory periods indicate that the wetland habitats and near shore coastal waters of northeastern Sakhalin support significant populations of waterbirds.

The exact number of migrating waterbirds that use the waters of Sakhalin Island is unknown, but is notably higher than the number of local breeding species. The total number of migrating Anatidae, including geese, mergansers, and swans, is likely to reach at least 1 million individuals. Shorebirds migrating along eastern Sakhalin Island are even more numerous, perhaps reaching 1.5 million individuals. Migration routes that originate on the western and northern coasts of the Sea of Okhotsk also focus on the northern and eastern coasts of Sakhalin Island.

Sea ducks accumulate in large numbers in the coastal waters near the mouths of Chaivo, Piltun and Lunsky bays as well as within the bays themselves (SEIC 2002a, TEO-C Volume 2A Book 8-EPB: Chapter 8). Spring migration occurs from the end of April to the end of May/beginning of June. During this period, the numbers of diving ducks can comprise up to 50% of the total bird population of the area. Commonly observed species include the Common Goldeneye (*Bucephala clangula*), Tufted Duck (*Aythya fugligula*), Greater Scaup (*A. marila*) and Red-breasted Merganser (*Mergus serrator*). Autumn migration for ducks occurs from September to October, with the dominant species being White-winged Scoter (*Melanitta fusca*), Black Scoter (*M. nigra*) and Harlequin Duck (*Histrionicus histrionicus*). In November, numerous flocks of Long-tailed ducks also appear in the area, mainly in offshore waters. The numbers of sea ducks remains high until early November, when ice covers most of the area. Several sea duck species may also be present in large numbers in offshore waters during moulting (e.g. from the end of July to the middle of August, flocks of non-breeding White-winged Scoters numbering up to 40,000 individuals may occur close to Piltun Bay).

During the spring migration over 10,000 swans including Whooper Swans (*Cygnus cygnus*) and Bewick’s Swans (*C. columbianus bewickii*) use Piltun, Chaivo and Nabilsky bays as a staging area prior to moving further north to breeding grounds on the Siberian tundra. A number of species of geese occur in much smaller numbers, for example, Bean Goose (*Anser fabalis*) and White-fronted Goose (*A. albrifrons*), and generally migrate through the area in September-October without stopping to feed or moult.

Large numbers of gulls also occur during migration and over the whole summer period. Gulls congregate mostly in the mouths of the bays and on the shoreline, with the number increasing considerably during August and September, when young birds start to move away from the breeding grounds. In the autumn, gulls form large congregations (up to 1,000 birds) along the coastline’s main migration path. The migration of terns is less pronounced than that of gulls. Terns are most numerous during the nesting period when the birds concentrate around their colonies, located on the islands inside bays. In the Piltun, Chaivo, Lunsky and Nabilskyi bays, 10,000-23,000 pairs of Common Terns (*Sterna hirundo*) nest, and more than 500 pairs of Aleutian Terns (*S. aleutica*) have been recorded nesting on a small island (Wrangel Island Natural Monument) located near the north end of Piltun Bay. Approximately 20% of the world population of Aleutian Terns–about 5,000 individuals— nest on the north-eastern coast of Sakhalin Island.

Approximately 40 species of shorebirds migrate along the Sakhalin coast on their way to or from breeding grounds to the north or on the island. The main autumn migration generally occurs from the end of July to the beginning of October, the predominant species including Mongolian Plover (*Charadrius mongolus*), Dunlin, Black-tailed Godwit (*Limosa limosa*) and Red-necked Stint (*Calidris ruficollis*). During spring the migratory assemblage also includes species such as Great Knot (*Calidris tenuirostris*) and Whimbrel (*Numenius phaeopus*). In October, half of the bird population may comprise of auks, including murrelets and guillemots.

5.11 Protected Areas

5.11.1 Statutory Protected Sites

Natural Monuments are designated to protect interesting or unique natural or anthropogenic objects and are managed by the Department of Forestry and Protected Areas.

There are no protected areas designated under Russian Federation legislation within the immediate vicinity of the Piltun-Astokh field; the nearest site is the Natural Monument of Lunsky Zaliv, Lunsky Bay. Lunsky Zaliv is a 221 km^2 area of regional importance (i.e. designated at the Sakhalin Oblast level) covering protected bird and mammal species and the habitats that support them. The stated objectives of this Natural Monument designation are to protect migratory waterfowl and shore bird species, and to conserve the nesting sites of the Steller's sea-eagle.

5.11.2 Ramsar Candidate Sites

The wetlands and lagoon systems stretching from Lunsky Bay in the south to the north of Piltun Bay are recognised as being of international importance and are incorporated into the Russian Federation 'Shadow List' of potentially qualifying sites for future entry into the Ramsar Convention register of lands of international importance. These wetlands are recognised as important for the range of habitats that they represent (e.g. brackish-freshwater lagoons, sphagnum bogs, coastal dunes, rivers and freshwater lakes) and, in particular, the diversity of migratory and breeding waterbird populations, including a number of rare and protected species.

5.11.3 Important Bird Areas

In 1999/2000, an area on the north-eastern coast of Sakhalin bounded by coordinates 51°10'-53°20' N and 143°00'-143°20' E, was awarded the status of an Important Bird Area (IBA) of Russia. The site was classified in recognition of the significance of the area for the diversity of internationally rare bird species and waterbird populations that it supports, such as Swan Goose (*Anser cygnoides*), Baikal Teal (*Anas formosa*), Whooper Swan, Spotted Redshank (*Tringa erythropus*), Spotted Greenshank, Red-breasted Merganser (*Mergus serrator*), Tufted Duck, Mongolian Plover and Aleutian Tern (Birdlife International 2007). At present the use of natural resources in this area is not prohibited.

5.12 The Human Environment

5.12.1 Regional Demographics

Sakhalin Island and the Kuril Islands form the territory of the Sakhalin Oblast, which is divided into 17 districts, or raions. The Sakhalin Oblast currently has a human population of approximately 550,000, of which 530,000 live on Sakhalin Island (Census data from 2002). The major population centres are the southern Kholmsk region and the Oblast regional capital, Yuzhno-Sakhalinsk. Over 85% of the population live in the main towns of Okha, Yuzhno-Sakhalinsk, Kholmsk and Nevelsk. Okha is the northern centre of the oil and gas industry. In Nogliki district, the population is approximately 13,500 of which 11,700 live in the town of Nogliki (Census data from 2002).

Recent, large-scale foreign investment during the past decade has significantly increased the movement of people in and out of Sakhalin Island, and it is therefore difficult to gain an accurate picture of the actual demographics of the resident population. However, general indicators suggest that the population of the island is in decline, due to two reasons:

- Low birth rates are evident throughout the Oblast region, and there is a low proportion of children and teenagers within the population;

- There has been a significant migration of the population away from the area; the emigration of than 125,000 individuals from Sakhalin Island in the 1990s was largely attributable to the removal of monetary incentives by the Russian Federation. Emigration (particularly from rural areas) to mainland Russia may still be continuing due to the high increase in costs that have occurred on the Island associated with recent investment and economic development.

5.12.2 Development, Economics and Employment

As a result of the region's natural resource wealth and the resulting foreign investment, per capita Gross Regional Product ("GRP") of the Oblast has increased quickly and is substantially higher than the Russian national average; GRP was 129.5 per cent of the national average in 2000.

Table 5-10 compares HDI parameters of Sakhalin to the national average, national leader (Moscow), and neighbouring regions in the Far East. It is notable that Sakhalin achieves the seventh highest HDI rating, out of a total of 80 regions, in Russia, and only slightly behind that of Moscow. Sakhalin's neighbours, Magadan, Khabarovsk, Kamchatka, and Primorskiy, score far less well.

Table 5-10. HDI rating of selected regions in the Russian Federation

	GDP, USD of PPP	Income Index	Life Expectancy	Life Span index	Literacy, %	Students aged 7 - 24, %	Education Index	HDI	Rating
Russian Federation	16092	0.848	67.88	0.715	99.4	75.0	0.913	0.825	
Moscow	37987	0.991	72.84	0.797	99.8	100.0	0.999	0.929	1
Sakhalin Region	29244	0.948	64.39	0.657	99.4	66.4	0.884	0.829	7
Magadan Region	12131	0.801	63.70	0.645	99.6	85.4	0.949	0.798	32
Khabarovsk Territory	10049	0.769	65.27	0.671	99.5	75.1	0.914	0.785	48
Kamchatka territory	8890	0.749	66.36	0.689	99.7	67.9	0.891	0.776	58
Primorskiy Territory	8676	0.745	65.50	0.675	99.5	72.7	0.906	0.775	60

Data from "National Human Development Report in the Russian Federation2010", published under the UNDP Russia, available at http://www.undp.ru/

Within Sakhalin, the economies of the smaller communities are generally depressed. The economies of the bigger centres such as Nogliki, Yuzhno-Sakhalinsk, Korsakov are stable. The main employers in the smaller communities are the forestry, fishing, agricultural and service (schools, hospital and utilities) sectors. In Nogliki the leading employers are the oil and gas industry, forestry and fishing sectors.

The unemployment rate varies from place to place but is higher in the smaller communities where there are no businesses to stimulate development. Administrative centres have lower unemployment levels. Unofficially, the most common ways to earn money, especially in small communities, are the roadside sale of marine products, wild plants, homemade products, and temporary work during the fishing season.

Agriculture plays a significant role in local community economies. Most families in the smaller communities keeps a garden/subsidiary plot and in urban communities people have dachas located outside or on the outskirts of town. These play an important role in household subsistence strategies. Many people in rural communities consider their household plots to be an additional or major source of food. For some, gathering wild plants is also an additional source of food and income, and for many families living close to the coast fish is a substantial source of food and additional income.

5.12.3 Indigenous Peoples and Traditional Trades

Sakhalin's indigenous population comprises a number of ethnic groups, the main groups being the Nivkhi, Uilta, Evenki and Nanai. The total population of indigenous people on Sakhalin Island is approximately 3,500, with the Nivkh population making up approximately 75% of this total (SIMDP 2006).

According to the RF Government Decree of 1993, there are officially six districts (excluding Yuzhno-Sakhalinsk) on Sakhalin Island where Indigenous Minorities live. In all of these districts, the settlements are ethnically mixed and Russian-speaking. In general, Indigenous Minorities live clustered in large villages but are also scattered within towns, with the exception of Yuzhniy Island, Poronaisk. As of January 2000, 58% of indigenous residents (1976) lived in towns and 42% live in rural areas. Rural indigenous populations are declining throughout Sakhalin because of migration to district centres (SIMDP 2006).

Nogliki District has the highest percentage of indigenous people, with approximately 30% of the total indigenous population of the island; 7% of the total population of the Nogliki District are indigenous (SIMDP 2006). About two thirds of the indigenous people in the area belong to the Nivkhi, and one third to the Uilta and Evenki. Nogliki, the district centre, has the largest indigenous community on Sakhalin with a population of 831. The town includes a local museum, two Native dance troupes, and craft and souvenir making industries. The regional Association of Indigenous People is also based in Nogliki. Val has the second largest native community in the district and there is a smaller population in the village of Piltun. The main indigenous economic activity is seasonal fishing. Five to seven families (representing about 20 Uilta and Evenk herders) are involved in reindeer herding in Nogliki District. They live in the forest in winter and on the shores of the eastern bays in summer when the reindeer are moved to traditional pasturing areas (e.g. southern Piltun Bay).

Traditional food consumption patterns have changed over the past few decades among indigenous people. Food items (e.g. fish, meat, berries and other plants) obtained from wild resources now make up only 20-50% of food consumed in the majority of families. The native diet now includes vegetables that are grown in garden plots, exchanged for fish or bought in shops. Salmon, however, typically still makes up a significant and important part of the diet and many indigenous people are involved in salmon fishing.

Nogliki District has 15 native clan enterprises, most of which are involved in fishing (salmon and other marine and freshwater species). Several of these enterprises have been allocated fishing grounds on the bays for temporary or unlimited use with inheritance rights and are engaged in commercial fishing for non-salmon species using commercial quotas. However, most of the enterprises fish for salmon species using mainly personal quotas from family or from the local community.

5.12.4 Commercial Fishing

5.12.4.1 Fishing Industry

The Sea of Okhotsk is of national importance to Russia as a fishing ground, supporting a diversity of commercially important species. Sakhalin's fishing industry is predominantly concentrated towards the south of the Island, although fishing activities and settlements occur throughout the island's coastal areas. Fishing operations are conducted on all scales, from small coastal fishing to large ocean trawlers (BISNIS 2002). The majority of the fishing fleet has seen deterioration as a result of the economic reforms in the early 1990s. Overfishing and domestic and foreign poaching in the Sea of Okhotsk is considered to have affected the majority of the major fish stocks.

Fishing activity in the Piltun-Astokh area is considered to be minor, with small local vessels confined predominantly to near shore coastal waters. An investigation of commercial fishing activities, executed by the GU Regional Centre for Coastal Fishing and Fish Finding (2003) concluded that fishery intensity in both the Piltun and Lunskoye areas is low, reflecting low stock densities for commercial species (e.g. saffron cod) and the absence of any significant infrastructure (i.e. ports and harbours) to support commercial fishing. What fishing activity there is, consists of small-scale fisheries for:

- Great (starry) flounder, *Platichthys stellatus* (July to September) with a maximum permissible annual catch limited to 160 t for the north-eastern region as a whole;
- Coastal and lagoon fishing for salmon (August to September);
- Herring, *Clupea pallasi* (July);
- Navaga (saffron cod, *Eleginus gracilis*) in winter; and
- Pacific capelin, *Mallotus villosus* (July).

Of the above species, saffron cod is of most commercial interest in the area. This species spawns in the estuarine waters of the Piltun, Chaivo, Niskiy, Nabil, and Lunsky bays and in other areas of the Sea of Okhotsk. Spawning grounds are located close to the coast, at a depth of 2 to 8 m. Saffron cod tend to shoal in the coastal zone towards the end of November after the coastal ice appears. The commercial fishing season starts in December and finishes in March, with maximum catches registered in January to February. The fish are caught in the spawning grounds using fyke nets and are also caught by local people through the sea ice. Data (SakhNIRO 2004) indicate that the waters of Piltun Bay support the highest densities of this species, which is reflected by the fact that approximately 70% of the saffron cod catch is harvested from this area.

The saffron cod catch by the end of the 1980s was approximately 400 tonnes per annum (tpa) due to the commercialisation of fishing. Catches have fluctuated over time as a result of ice conditions, which influence the suitability of spawning grounds at the mouths of the lagoons and also determine the navigability of channels and level of fishing activity. Since 1986, the commercial catch of saffron cod has decreased falling from a maximum of 950 tonnes (in 1985) to 40 tonnes in 2004. In analysing the abundance of saffron cod generations from north-eastern Sakhalin, two distinct periods can be distinguished. The first is between 1976-1984, when the mean abundance (of all age classes) constituted 11 million individuals (varying between 8.0–15.9 million); the second, from 1985 through to the present time, involves a significant decline in abundance to approximately two million individuals (SEIC 2005).

The value of the commercial stock has fluctuated in line with changes in recorded biomass. The maximum commercial stock was in 1985 (1.8 thousand tonnes), while much lower stocks were recorded in 1993, 1994, 2000 and 2001 with values ranging from 0.3 to 0.47 thousand tonnes. The significant recorded decrease in commercial catch in this species has been attributed to overfishing during the 1970-1980s. It is also believed that the low levels of reported catch in the 1990s and up to the present day do not reflect the actual tonnage being landed. SakhNIRO (2004) considers that the present population of saffron cod in the Piltun area is stable, albeit at historically low levels when compared with the population levels of the pre-1990s.

Other commercial fisheries within the vicinity of the Piltun area are limited to the use of Danish seines (snurrevaads) for starry flounder and Pollock, using small seine-net fishing vessels. The fishery is small-scale and the fishery companies operating in the area include Vostok fish works, Vostok-Nogliki Company Ltd and Ostrov Company Ltd. Landing tonnages for the target fish species are unknown.

As part of the seismic permitting process, the acquisition contractor will engage with the local fisheries authorities as part of their permitting requirements. This engagement involved fish damage calculations, which is a standard regulatory requirement. The contractor will also seek approval for the timing and execution of the seismic survey from the Department of Federal Fishery Agency (FFA) for Sakhalin and Kurils. A similar approval will also be obtained from Rosrybolovstvo (Federal Authority controlling and permitting fishing activities).

5.12.4.2 Salmon

The Sakhalin salmon fishery is of particular economic importance, contributing approximately 40% of the total salmon catch of the Russian Far East. The most important species for commercial fishing are the pink (*Oncorhynchus gorbuscha*) and chum salmon (*O. keta*). The pink salmon is important due to its large yield, providing some 89% of the total salmon caught in 2000-2004, while the chum salmon provided 10.5%. The other salmon species may be caught as a supplement to the yield and are popular for sports fishing (SEIC 2002a, TEO-C Volume 7 Book 1-EIA: Chapter 1).

The pink salmon stock in the Sakhalin-Kuril Islands region is relatively high in comparison with many other areas in the north Pacific. In the 1990s the average annual catch of pink salmon was 72,500 tonnes, up from 13,000 tonnes in the 1950s when intensive drift fishing at sea led to large declines in Pacific salmon populations. The current high stock levels are largely due to the intensive cultivation of fish in hatcheries that has occurred since the 1970s, the natural recovery of stocks, increased fishing effort and potentially the influence of climate change. On Sakhalin, the 1980s saw considerable changes in the artificial cultivation of pink salmon with the optimisation of growing and release of fry. The renovation of hatcheries also contributed to very high levels of pink salmon stocks and catches during the 1990s. In recent years the salmon catch has been rising. The average catch for the period 2000-2004 was 84,000 tonnes and rose to 130,000 tonnes in 2005 and 140,000 tonnes in 2006 (Sinyakov 2006). The majority of the pink salmon fishery is concentrated in the south and south-east of Sakhalin Island. Data from SakhNiro (2000) indicates that the proportion of the pink salmon catch from the north-east varied between 0 and 13.5% of the total catch over the period 1980-1999, but was typically in the region of 2-5%.

The commercial importance of chum salmon centres on the autumn migration, when the bulk of fish are caught in coastal waters. The chum salmon stock in the Sakhalin-Kurils region has been low in recent years and the catch of this species over the period has been in the range of

2.2-5.8 thousand tonnes. North-east Sakhalin represents one of the main fishery areas for this species, typically contributing 10-20% of the total catch. However, the relative contribution of the area has fallen in more recent years due to the influence of fish released and caught from hatcheries in Terpenyia Bay and the southeast of the Island (SakhNiro 2000). Traps and coastal fishing gear are normally used but at sites where artificial cultivation (hatcheries) takes place, they are caught next to fish screens.

5.12.4.3 Marine Invertebrates

The shelf of north-eastern Sakhalin Island is populated by a high concentration of invertebrates including shrimps, crabs, bivalves, gastropods (common whelk), cephalopods (squid, octopus) as well as echinoderms (Cucumaria and sea urchin). Commercially valuable invertebrates within the Piltun area include nine species of crabs, 15 species of shrimps, six species of gastropods, one species of bivalve and two species of echinoderms (SEIC 2002a, TEO-C, Volume 7, Book 1, Section 1).

An extensive trawl sampling programme undertaken by SakhNIRO clearly demonstrates that a number of crab and shrimp species are present in commercial quantities off the north-east coast of Sakhalin, including blue king crab, opilio crab as well as pink, bear cub and sculptured shrimps. According to SakhNIRO (2001) several of these species, but notably spiny lebbeid and deep-water pandalopsis (*Pandalopsis ochotensis*), have become of interest to commercial fisherman and stocks are beginning to be exploited. However, no information on the scale of this fishery is presently available. The distribution and characteristics of stocks of a number of species are briefly highlighted below.

- Snow crab (*Chionoecetes opilio*): This species is widely distributed along the north-eastern Sakhalin coast, occupying all substrates between 90-500 m water depth. Commercial male specimens were recorded by SakhNIRO from 20% of survey trawl stations at depths of 200-500 m. Overall, the catch data indicated a relatively homogeneous distribution but with a few small areas of higher abundance.
- Blue king crab (*Paralithoides platypus*): Occurs in the southern part of the north-east shelf in the Terpeniya Gulf area at depths of 25-300 m, mainly on sand and pebble substrates (SakhNIRO 2001). Only one commercially viable aggregation of this species was observed.
- Sculptured shrimp (*Sclerocrangon boreas*): This species was recorded from 30% of all trawl survey stations by SakhNIRO indicating that it is widely distributed along the north-eastern coast. It favours water depths of between 20-200 m and commercially exploitable populations were observed in the northern part of the shelf, to the north of Lunsky Bay.
- Bear-cub shrimp (*Sclerocrangon salebrosa*): This species occupies relatively shallow water (30-100 m) generally on sandy substrates along the north-eastern coast. The greatest aggregations were observed to occur off Schmidt Peninsula and further to the south offshore of Nabilsky Lagoon.
- Spiny lebbeid (*Lebbeus groenlandicus*): Occurs at depths from 20-500 m mainly on sand and sandy-pebble substrates. During the trawl survey undertaken by SakhNIRO (2001), maximum catches were recorded at depths of 150 m with the main populations being centred in waters off Schmidt Peninsula and much further to the south off Terpeniya Point.

5.12.5 Hunting of Marine Mammals and Birds

5.12.5.1 Marine Mammals

Commercial, aboriginal and research groups hunt seals and other marine mammals in the Sea of Okhotsk. Traditionally, seal meat, fat (oil) and liver were used for food, while clothes and footwear were made out of sealskin. Today, many indigenous people still consume seal oil and meat, and they use seal fur in souvenir making. The main marine mammal hunting grounds are Chaivo, Nysky, Nabil and Lunsky bays, where largha, ringed and ribbon seals are hunted during the winter months. Hunting of seals in the Piltun area is mainly confined to shoreline areas and occurs through sea ice during the winter. Available evidence indicates that that seal populations have remained constant in recent decades indicating a sustainable level of hunting is being achieved. Commercial whaling is not permitted and does not occur in coastal areas..

5.12.5.2 Birds

The hunting of ducks is officially prohibited in the Piltun area, however, illegal hunting practices have been observed in the bay during the autumn migrations when the largest numbers of birds are present. During this period, it has been reported that numerous shots have been heard, and that the birds in the area display random flight behaviour in response to this threat (Fauna Information and Research Centre 2001). Some gull and duck egg collecting is undertaken by indigenous people, but there is no information available on the scale of this activity or of its likely impact on local breeding bird populations.

5.12.6 Algal Collection and Cultivation

In the Sea of Okhotsk, algal species with commercial value include:

- Kelp (*Laminaria japonica*) which is found predominantly in the northern areas of the sea, and is often cultivated using rock planting, long-line and rope-curtain techniques;
- Brown algae (*Undaria pinnatifida*); and
- Red algae (*Porphyra* sp.).

In the coastal areas close to the Piltun-Astokh field the environmental conditions are such that the target algal species are either absent or only present in limited abundance. As such, there is no evidence of any algae collection or cultivation activities and if it does occur it will be on a small scale in populated coastal areas (US-Japan Cooperative Program in Natural Resources 2002).

5.12.7 Tourism, Recreation & Amenity

Sakhalin's fledgling tourist industry currently consists of approximately 50 local companies offering tourism services including canoeing, yachting, diving, ship tours, fishing and ice fishing. The coastline onshore from the Piltun-Astokh area comprises coastal wetlands with limited accessibility and no tourism.

5.12.8 Ports & Vessel Navigation

Shipping is the primary method for import and export of goods to and from Sakhalin Island. There are 11 ports on the island, the two main ones being Korsakov and Kholmsk in the south, where ice-free conditions prevail for most or all of the year. Major merchant shipping routes do not extend northwards from these southern ports. During the winter only icebreakers and specially strengthened (ice class) vessels can operate in the northern seas of Sakhalin Island due to the volume and thickness of sea ice that restricts the importing and exporting capabilities of these areas (SEIC 2002a, TEO-C Volume 7 Book 1-EIA: Chapter 1). Existing, non-industrial vessel activity within the Piltun-Astokh area is therefore low and is likely to include only small numbers of commercial fishing ships during the summer-autumn months as well as vessels servicing the oil and gas platforms of PA-A (Molikpaq) and the recently installed PA-B.

5.12.9 Land-based Infrastructure

Sakhalin Island has relatively limited existing infrastructure, especially in northern Sakhalin where there are few adequate roads linking the main communities. Coastal infrastructure opposite the Piltun-Astokh area is limited to the coastal road and railway that runs north-south approximately 15-20 km inland from the shoreline. There are also a number of small tracks leading to the coast from the settlements of Piltun and Garomay that are used by seasonal hunters and fisherman (SEIC 2002a, TEO-C Volume 7 Book 1-EIA: Chapter 1).

5.12.10 Oil & Gas Infrastructure

There are currently two oil and gas platforms located within the PA field. PA-A (or Molikpaq) is located at the southern end of the field approximately 15 km offshore and has been producing oil since July 1999. The PA-B platform was installed in July 2007 and is located approximately 23.5 km to the north of Molikpaq at the northern end of the Piltun-Astokh area. Hydrocarbons from PA-B are transported by the offshore pipeline system via PA-A making landfall at the northern end of Chaivo Spit where the four export pipelines will be tied into two 51 cm diameter pipelines at the onshore manifold. The gas and oil produced from both PA-A and PA-B platforms will be processed on each platform and exported as dry gas and dewatered oil.

5.12.11 Other Submarine Infrastructure

There are no existing, non-industrial submarine cables or other submarine infrastructure in the vicinity of the Piltun-Astokh area.

5.12.12 Maritime Archaeology & Cultural Heritage

Sea level at the end of the last glaciation, some 12,000 years ago (Early Holocene) was approximately 120 m lower than today and the present seabed in the Piltun-Astokh area was an exposed land area. As sea level rose following the melting of the large continental ice sheets, land areas became inundated. This former land surface, now covered by marine sediments, may contain fossilised organic remains and, potentially, evidence of past human presence. The Laboratory of Archaeological Research at the Yuzhno-Sakhalinsk State Pedagogical Institute considers the potential for finds-of archaeological interest to be high in marine areas up to sea depths of 100-120 m, with the highest concentrations likely to occur in water depths of 10-20 m (Yuzhno-Sakhalinsk State Pedagogical Institute 1998). There are no known wrecks of maritime archaeological interest in the Piltun area.

5.12.13 Military Interests

There are no known military interests (military bases, ports, establishments or unexploded ordinance) in the Piltun-Astokh area or surrounding areas.

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6 ENVIRONMENTAL IMPACT ASSESSMENT

6.1 Introduction

This chapter presents the environmental impact assessment of the proposed site survey. The assessment evaluates the significance of the potential impacts of the survey on the physical, biological, and human environment, in the absence of mitigation measures. A comparison between unmitigated and residual impacts (i.e. those impacts remaining after mitigation) is provided under Chapter 8.

6.2 EIA Methodology

This impact assessment was conducted on the basis of a project description and the likely interactions between the survey elements and the valued ecosystem components identified during issues scoping. Impact significance was assessed based on a review of available literature, monitoring data, specialist investigations, conclusions of communications with identified stakeholders, consultation with experts, and professional judgment. In evaluating impacts (adverse and beneficial, direct and indirect), consideration was given to criteria, where appropriate, including magnitude, duration and geographical extent of expected interactions within spatial and temporal boundaries. In some instances, impact predictions proved difficult where data were limited. Consideration of cumulative impacts was included; baseline conditions are to some extent indicative of the cumulative effects of various historical anthropogenic activities such as hunting, industrial activities, and military operations. Mitigation measures were developed, based on the impact assessment, to reduce potential effects of the survey. A monitoring programme, integral to the mitigation strategy, will allow residual effects to be evaluated.

6.2.1 Spatial and Temporal Boundaries

Assessment boundaries help define the scope of work required to evaluate potential effects resulting from a proposed activity. In establishing temporal boundaries, consideration was given to the various stages of the survey (e.g. vessel mobilisation, data acquisition, and vessel demobilisation), periods of ecological component-project interaction, as well as characteristics of the potentially affected components (e.g. the time required for an effect to become apparent, or the time required for the component to return to its original condition). The temporal aspect was also considered when evaluating potential effects (e.g. whether changes in a population are a consequence of survey activities or whether they are a consequence of the natural population cycle).

Spatial boundaries were determined by considering zones of interaction between an ecological component and the 'footprint' of survey activities (e.g. seismic acquisition area, seismic vessel plus array, supporting vessels, navigation corridors etc.). These zones could be influenced by, for example, species distribution and behaviour (migration and feeding), and, in some instances, extend beyond the physical boundaries of the activity.

6.2.2 Issues Scoping

Scoping is a process where the scope and terms of reference of the impact assessment are defined. It outlines those issues that are to be addressed during the impact assessment, and identifies valued ecosystem components (VECs); VECs are those elements of a project or activity's surroundings that are of importance, for example, a protected species (Gray Whale), or a resource (local fisheries), central to a government agency and other stakeholders. Identification of VECs helps to rationalise the scope of the assessment and to focus the impact evaluation process on the most important environmental receptors. Specifically, the source-pathway-receptor concept was considered in determining the reasonable likelihood of significant interaction ('pathways') of ecosystem components ('receptors') with survey activities ('sources').

In scoping this assessment, previous environmental assessments for Sakhalin Island and elsewhere were reviewed (e.g. Clarke et al. 2001; SEIC 2003, 2005,2010; U.S. Navy 2005; L-DEO and NSF 2006; MMS 2006; MMS 2007) together with reports that focus on the Gray Whale. The key environmental issues for this assessment have been identified as:

- Disturbance and injury to marine mammals;
- Disturbance to marine invertebrates, fish and birds;
- Effluent discharge, emissions, and waste disposal;
- Accidental spills, leaks and dropped objects; and
- Interaction with other users of the area.

Based on these issues, source-pathway-receptor relationships were identified; Table 6-1 cross-references the sections of this report where these issues are discussed.

6.2.3 Specialist Investigations

Of all components of the site survey, the 2D seismic survey is expected to produce the most noise – although at levels very much lower than typical 3D seismic surveys. JASCO Applied Sciences conducted acoustic modelling to predict sound level footprints around the 2D seismic source – an array of four airguns of 40 in^3 each. The sound footprints were overlaid on a map of the NE Sakhalin coast to determine if ensonification of the Piltun feeding area by threshold levels was likely to occur. Sakhalin Energy discussed this information with the WGWAP and with the Seismic Survey Task Force (SSTF) at several meetings (see §4.3), where it was considered during the development of agreed mitigation measures for the proposed survey.

6.2.4 Stakeholder Consultation

Involving stakeholders at an early stage, identifying their concerns and addressing them in the impact assessment, increases the credibility of the EIA process. As already mentioned, details on stakeholder consultation for the proposed survey are described in Chapter 4.

Table 6-1. Impact sources, pathways, and receptors for the proposed 2D seismic survey

SOURCE	Active Airgun Array	Vessel Operations				
PATHWAY	Ensonification of marine environment	Ensonification of marine environment	Streamer Entanglement	Collision	Emissions, effluent discharge, waste disposal	Accidental spills, leaks, dropped objects
RECEPTOR						
Baleen whales (mysticetes)	6.4.2	6.4.2	6.4.5.1	6.4.5.3	6.8	6.9
Toothed whales (odontocetes)	6.4.3	6.4.3	6.4.5.1	6.4.5.3	6.8	6.9
Seals (pinnipeds)	6.4.4	6.4.4	6.4.5.1	6.4.5.3	6.8	6.9
Marine invertebrates and fish	6.5.1/6.5.2	6.5.1/6.5.2	N/A	6.5.2.2	6.8	6.9
Seabirds	6.6.3	6.6.3	6.6.3.3	6.6.3.3	6.8	6.9
Social and economical activities	N/A	N/A	N/A	N/A	N/A	N/A
Commercial fisheries	6.5.2/6.7.1	6.5.2/6.7.1	6.7.1	6.7.1	6.7.1	6.7.1
Subsistence hunting and fishing	N/A	6.7.2	N/A	N/A	6.8	6.9
Marine traffic	N/A	N/A	N/A	6.7.4	N/A	6.7.4
Offshore structures	N/A	N/A	N/A	6.7.5	N/A	6.7.5
Archaeology and cultural heritage	N/A	N/A	N/A	6.7.6	N/A	6.7.6
Military activities	N/A	N/A	N/A	N/A	N/A	N/A

6.2.5 Analysis of Alternatives

World Bank impact assessment guidance requires project justification and an analysis of alternatives; the latter should include evaluation of the “no-go option” – i.e. the consequences of the project not being carried out. The purpose of assessing alternatives is to establish the preferred or most environmentally sound and benign option for achieving the project objectives. Alternatives to the proposed survey are discussed in Chapter 7.

6.2.6 Impact Significance

Impacts may be direct or indirect, permanent, long-term, short-term, or temporary. Quantitative predictions of environmental impacts are generally acknowledged as problematic; there are a number of different methods used to define impact and significance levels.

According to Sakhalin Energy’s HSE management system, the magnitude, scale and duration of impacts must be taken into consideration during significance evaluation; elements include:

transmissibility to receptor, cumulative effects, size/proportion of the affected population/area, status (i.e. vulnerability, sensitivity, value) of receptor, and stakeholder perceptions.

The impact significance criteria presented in the executive summary and section 6.2.2 of the this EIA cover the ecological impacts and do not cover impacts to humans or environmental quality. Obviously, ecological impacts are those of primary concern here, but impacts are also assessed in the EIA on, for example, commercial fisheries etc. Section 6.2.2 make reference to alignment of the impact significance criteria with the Sakhalin Energy HEMP procedure[61]. However, for completeness both the environmental and societal impacts significance are given below, as is the Risk Classification Matrix

Risk Classification Matrix

The consequences of an incident or breach shall be separately identified in relation to each of the five categories – harm to people (P), **social (S)**, assets (A), **environment (E),** and reputation (R) – using the following Risk Assessment Matrix.

	CONSEQUENCES					INCREASING LIKELIHOOD				
						A	B	C	D	E
Severity	People	Social	Assets	Environment	Reputation	Never heard of in the industry	Heard of in the industry	Has happened in the Company or more than once per year in the industry	Has happened at the Location or more than once per year in Company	Has happened more than once per year at the Location
0	No injury or health effect	No impact	No damage	No effect	No impact					
1	Slight injury or health effect	Slight impact	Slight damage	Slight effect	Slight impact		Blue			
2	Minor injury or health effect	Minor impact	Minor damage	Minor effect	Minor impact					
3	Major injury or health effect	Moderate impact	Moderate damage	Moderate effect	Moderate impact			Low	Amber	
4	PTD or up to 3 fatalities	Major impact	Major damage	Major effect	Major impact		High	Amber		
5	More than 3 fatalities	Massive impact	Massive damage	Massive effect	Massive impact					Red

For an incident or breach involving **actual damage**:

- the actual Severity rating of “0” to “5” (vertical axis) shall be determined for each individual category P, S, A, E and R,
- the **overall Severity rating** for the incident or breach is the highest of the individual category ratings.

To assess **potential damage**:

- the potential Severity rating of “0” to “5” shall be selected for each individual category P, S, A, E and R, to reflect the consequences of credible scenarios that may potentially develop from the release of a hazard (incident/breach);
- the Increasing Likelihood rating of “A” to “E” (horizontal axis) shall then be determined for each individual category P, S, A, E and R, based on historical evidence and experience that the selected Severity ratings have materialised within the Industry, Company or Location. The consequence estimates are based on envisaged scenarios of what might happen, and likelihood estimates are based on historical information that such a scenario has happened under similar conditions. This should not be confused with the likelihood that the hazard is released, rather it is the likelihood of the selected potential Severity rating occurring;

[61] Sakhalin Energy’s Hazard and Effects Management Process prescribes six levels of impact severity, designed to integrate with Shell’s Risk Assessment Matrix: (0) no effect; (1) slight effect; (2) minor effect; (3) moderate effect; (4) major effect; and (5) massive effect. According to HEMP procedure, unmitigated significance is assessed in order to determine those aspects that must be managed – in line with ISO14001:2004; aspects that cause minor effects (or greater) are required to be managed. For the purpose of this EIA – and in conformance with previous company EIA methodology – six levels of impact severity have been simplified to four, by combining HEMP levels 0 and 1, and HEMP levels 4 and 5.

- the risk classification for each individual category P, S, A, E and R shall be determined by the intersection of the chosen column with the chosen row;
- the **overall risk classification** for the incident or breach is the highest of the individual category ratings.

To be clear, where any incident or breach has multiple applicable actual and/or potential Severity ratings, each of which could have a different risk classification, that incident or breach will be ranked at the highest risk classification for any of the applicable actual or potential consequences

Ecological/Environmental Impact Assessment Four levels of ecological/environmental impact significance are applied (SEIC 2003):

- **Major Effect**: affects an entire population or species in sufficient magnitude to cause a decline in abundance and/or change in distribution beyond which natural recruitment (reproduction, immigration from unaffected areas) would not return that population or species, or any population or species dependent upon it, to its former level within several generations of the species being affected;
- **Moderate Effect**: affects a portion of a population and may bring about a change in abundance and/or distribution over one or more generation(s) of the species affected, but does not threaten the integrity of that population or any population dependent on it. Moderate Impact to the same resource multiplied over a wide area would be regarded as a Major Impact;
- **Minor Effect**: affects a specific group of localised individuals within a population over a short time period (one generation of the species affected or less), but does not affect other trophic levels or the population itself;
- **Negligible or No Effect**: where no significant impact is predicted to occur; the impact is of such small magnitude that it does not require further consideration in the assessment.

Social Impact Assessment Six level impact significance are applied

Severity	Description
0	**No measurable adverse impact.**
1	**Slight impact** • Slight adverse impact to one or more people or their assets which results in no measurable adverse impact on their living standards or livelihood.
2	**Minor impact** • Minor adverse impact on one or more people or on their assets which can be readily identified, is contained within a limited geographical area, and results in a reduction in the living standards or livelihoods of those affected[62] • Loss of opportunity for affected persons to derive legitimate material benefits from the Project or to participate in Project public consultation or grievance process. • Damage that is able to be remedied to amenities or objects of cultural importance to the extent this has not been the subject of prior adequate compensation.
3	**Moderate impact** • Considerable adverse impact on one or more people or on their assets which can be readily identified is contained within a limited geographical area, and results in varied

[62] In each case to the extent such damage has not been the subject of prior compensation or supplementary assistance benefiting the people impacted and excluding the impacts from general inflationary changes.

Severity	Description
	primary and secondary impacts on the living standards or livelihoods of those affected[63]. The determination of an appropriate response, such as compensation, will require focused studies. • Destruction of a site or major object or amenity of local or regional cultural importance, or national objects that are not under legislative protection, to the extent this has not already been the subject of prior adequate compensation. • Considerable discontent in groups within the labour force and/or community in relation to practices attributable to the construction and/or operation of the Project. Acts of petty violence or other criminal acts by or against Project workers capable of resulting in serious injury or localised civil unrest.
4	**Major impact** • Major adverse impact on many people or their assets which cannot be readily identified and/or is over a widespread area, and results in long-term varied impacts including secondary impacts on their living standards or livelihoods. Extensive studies required to identify potential compensation measures; full compensation unlikely to be possible. • Destruction of a site or major object or amenity of national cultural importance which is under legislative protection. • Serious social conflict involving a significant number of members of the community or labour force in relation to practices attributable to the construction and/or operation of the Project. Acts of organised crime (including violence) or other serious crimes by or against Project workers capable of resulting in severe injuries to people or civil unrest at multiple locations.
5	**Massive impact** • Massive adverse impact on extensive populations or on their assets, resulting in varied and probably irreversible impacts on their living standards or livelihoods[64]. • Destruction of a site or major amenity of international cultural importance which is under legislative protection. • Massive social conflict resulting in widespread rioting, widespread life threatening violence against Project entities or Project workers, or by or against communities affected by the Project in relation to practices attributable to the construction and/or operation of the Project.

Severity and other Consequential Business Losses (100% costs, USD)

Severity	Description
0	Zero damage
1	Slight damage - no disruption to operation (costs less than 10,000)
2	Minor damage - brief disruption (costs less than 100,000)
3	Local damage - partial shutdown (can be restarted but costs up to 1,000,000)
4	Major damage - partial shutdown (2 weeks shutdown costs up to 10,000,000)
5	Extensive damage - Substantial or total loss of operation (costs >10,000,000)

Impact predictions have been made using available data, but where uncertainty remains, this is acknowledged and an indication of its scale is provided. Where the sensitivity of a receptor to a particular activity is unknown and the level of impact cannot be predicted, the EIA team has used professional judgement as to whether a significant impact is likely to occur.

63 In each case to the extent such damage has not been the subject of prior compensation or supplementary assistance benefiting the people impacted and excluding the impacts from general inflationary changes.

64 In each case to the extent such damage has not been the subject of prior compensation or supplementary assistance benefiting the people impacted and excluding the impacts from general inflationary changes.

6.2.7 Mitigation

Mitigation measures are adopted to avoid or to reduce potential adverse impacts of a project on the receiving environment. For areas where there is uncertainty relating to the magnitude of predicted impacts, monitoring programmes may form part of the mitigation strategy. In some instances, near real-time monitoring may allow adjustments to existing mitigation measures to be made. Based on the impact assessment, monitoring and mitigation will be implemented during the seismic survey to reduce moderate and major impacts on the marine environment to as low as reasonably practicable (ALARP). For minor and negligible impacts specific mitigation is not required, although activities will be managed according to best-practice where relevant. Measures identified for the proposed seismic survey are presented in Chapter 8.

6.3 Seismic Sound and Zones of Influence[65]

6.3.1 Airgun Array Modelling Prepared by JASCO

An airgun is a device that generates an acoustic pulse by the rapid release of highly compressed air. The seismic signature of an array of airguns is far superior to that of any individual airgun. Airgun arrays, composed of closely spaced airguns in a fixed geometrical arrangement, are the most commonly-used acoustic source for marine-based deep-seismic surveying, because they are able to produce repeatable, high-amplitude, sharply peaked acoustic signals with relatively weak secondary (bubble) pulses.

The acoustic source planned for this seismic survey is an array of four airguns (Figure 6-1), each 40 in^3 in volume, operated at a nominal pressure of 2,000 psi and a depth of 2.5m.

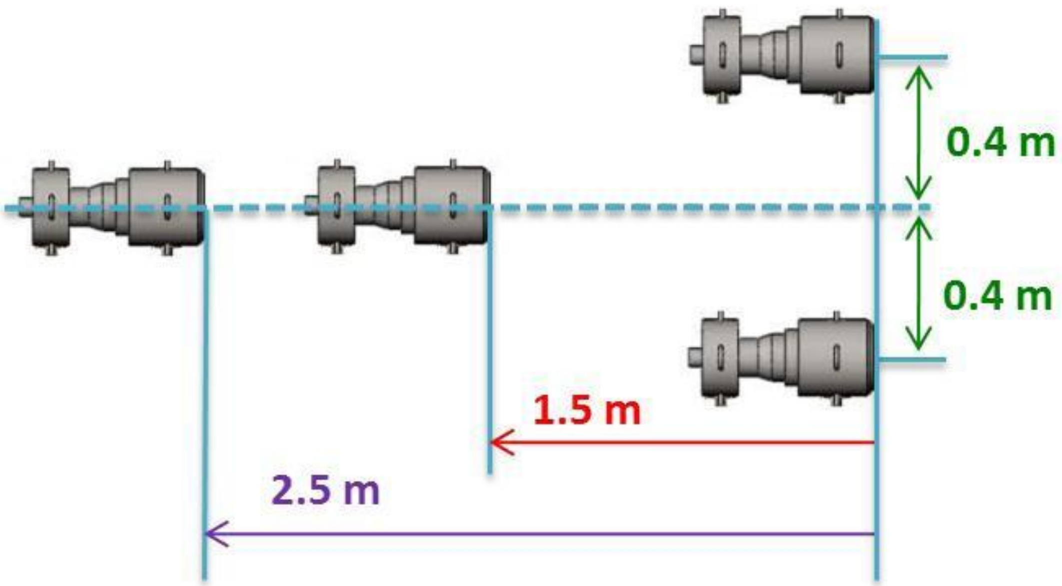

Figure 6-1. Planar view of airgun array for South Piltun 2D seismic survey.

[65] Information in this section was provided entirely by JASCO Applied Sciences, reproduced with kind permission from their report titled "Model-based sound footprint estimation for a 4 x 40in3 airgun array in South Piltun: Sakhalin Energy South Piltun Geotechnical Survey, summer 2012 (planned)" by Racca and Li (dated August 2011).

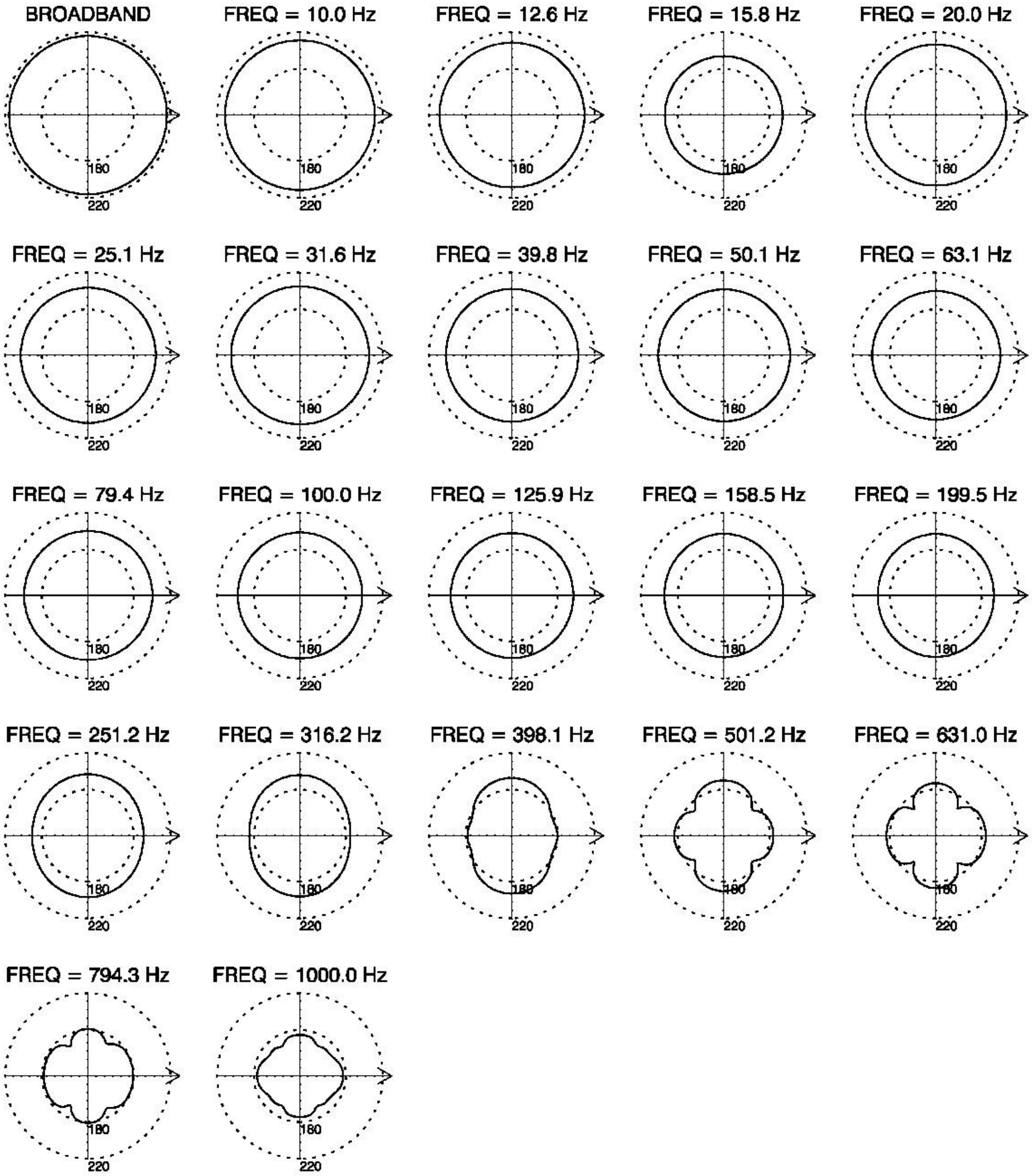

Figure 6-2. Azimuth directivity pattern of source level (per-pulse SEL in dB re 1μPa^2-s) for 4 x 40 in^3 airgun array broadband and in one-third-octave bands with centre frequencies from 10Hz to 1kHz. The right-pointing arrow denotes the array tow axis direction

The sound radiation directivity pattern of the source was estimated using JASCO's Airgun Array Source Model, AASM (MacGillivray, 2006). This full-waveform airgun array signature model is based on the physics of the oscillation and acoustic radiation of airgun bubbles. It solves a set of parallel differential equations that govern the airgun bubble oscillations and accounts for additional physical effects, including pressure interactions between airguns, port throttling, and bubble damping. The output of the model is a set of notional source signatures, corresponding to the individual airgun signals. These are then used to compute the directional levels of the array in the frequency domain by applying the appropriate phase delay to each notional source and summing the far-field contributions. For the purpose of subsequent propagation modelling the directional levels are computed in one-third octave bands.

Figure 6-2 shows the resulting azimuth directivity patterns of the per-pulse sound exposure level (SEL) in the bands from 10 Hz to 1 kHz. The array begins to show pronounced directionality at frequencies above 200 Hz, with prominent lobes perpendicular to the tow axis (broadside) gradually yielding intensity to fore-aft (endfire) lobes at frequencies above 500 Hz. Although the broadband source level pattern shows no directivity because of the dominant contribution from the omni-directional lower-frequency patterns, this does not imply that the propagated broadband footprint should also have no directionality. Indeed the source-related directivity of the received levels depends on the spectral content of the array pulse signals at range, which in shallow water is usually characterized by a rapid loss of low-frequency energy and thus relative enhancement of the more directional higher-frequency components.

6.3.2 Sound propagation modelling

In order to characterize the survey's acoustic footprint extending into the near shore Gray Whale feeding area, the propagation of acoustic pulse energy from the airgun array at individual seismic shot locations was modelled for the acoustic environment in the South Piltun region using JASCO's software package MONM (Marine Operation Noise Model). This software is an enhanced implementation of the widely used Parabolic Equation code RAM (Collins, 1993) modified to account for shear-wave losses at the seabed – an important consideration in the shallow water, absorptive bottom environment on the Sakhalin shelf. This model uses a complex density method to implement the shear-wave energy conversion in a significantly faster computational manner than other approaches.

The model was already verified dynamically in the field against telemetric data and found to meet the 3dB tolerance required by the MMP throughout the extent of each survey line, once the appropriate modelling case was matched based on the received pulse levels at the PML during the first minute of the line run. MONM was previously applied to successful estimation of industrial noise associated with construction of Sakhalin 2 offshore infrastructure over a number of seasons. MONM was also used in the modelling of baseline seismic noise footprints in the environmental impact assessment study for the 2010 Astokh 4D seismic survey, as well as the behavioural effects mitigation boundaries utilized by the monitoring teams during the execution of that survey.

The sound propagation properties assumed for the present study are the same as for the baseline modelling of the 4D survey. The geo-acoustic parameters are listed for reference in Table 6-2 and the water sound velocity profile, obtained from typical CTD casts for the early part of the summer season, in Table 6-3. A standard bathymetry dataset for the region, used in all prior modelling studies for the Sakhalin 2 activities, provided the depth profiles.

Table 6-2. Geo-acoustic parameters used in modelling.

Depth (mbsf)	Density (kg/m3)	P-wave speed (m/s)	P-wave attenuation (dB/λ)	S-wave speed (m/s)	S-wave attenuation (dB/λ)
0	1772	1652	0.14	150	13.6
500	1772	2152	0.14		
>500	1772	2152	0.14		

Table 6-3. Water sound velocity profile used in modelling.

Depth (m)	Sound Speed in water (m/s)
0.9	1469
2.5	1467
3.1	1466
5.1	1461
6.8	1456
8.0	1452
9.0	1448
10.2	1446
11.5	1444
32.0+	1444

At each modelled source location MONM estimated the frequency dependent sound transmission loss (TL) along a fan of radials at an angular increment of 2.5 degrees; along each radial the range step was 15 metres. The TL was computed at the centre frequencies of 24 one-third octave bands from 5 Hz to 1 kHz; it was then applied to the corresponding source level estimates from AASM (aligning the array tow direction with the major axis of the survey area, at a heading of 170º True) to produce estimates of received per-pulse SEL on a radial grid of planar locations. Summing the acoustic energy contributions in all frequency bands yielded broadband SEL. The received level was sampled at multiple depths in 2m increments from the surface to the seafloor; the maximum over depth was used to give the most conservative estimate of the footprint.

6.3.2.1 South Piltun

Sound level footprints were modelled for four shot points at the corners of the notional 2D geotechnical survey area shown in Figure 6-3to define the extreme reaches of the sound emission over the pattern of line acquisitions, assumed to be run in a direction parallel to the coastline. In addition, the full-line boundary of sound level contours for the survey line closest to shore was obtained by modelling the sound footprint at 30 evenly spaced intermediate locations between the NW and SW corners, and further increasing the sampling density by interpolating the footprints at 9 points between each of the modelled locations. This yielded a total of 311 footprint estimation points along the line, thus describing a detailed contour envelope boundary that would reveal any potential shoreward propagation anomalies caused by local bathymetry features.

Figure 6-3 shows the sound level contours at the four corner points (solid colour fills) and the contours envelope of the full near-shore survey line (shaded colour fills) for per-pulse SEL values from 170 down to 155 dB re 1μPa^2-s. The essentially uniform shape of the full-line envelope indicates that the sound propagation from all shot points along the line is well behaved, without anomalies which might suggest the possibility of stronger localized shoreward noise. It is noted for reference that a per-pulse SEL of 156 dB re 1μPa^2-s was taken as threshold of potential behaviour disturbance for the grey whales in the mitigation plan for the 2010 Astokh 4D survey.

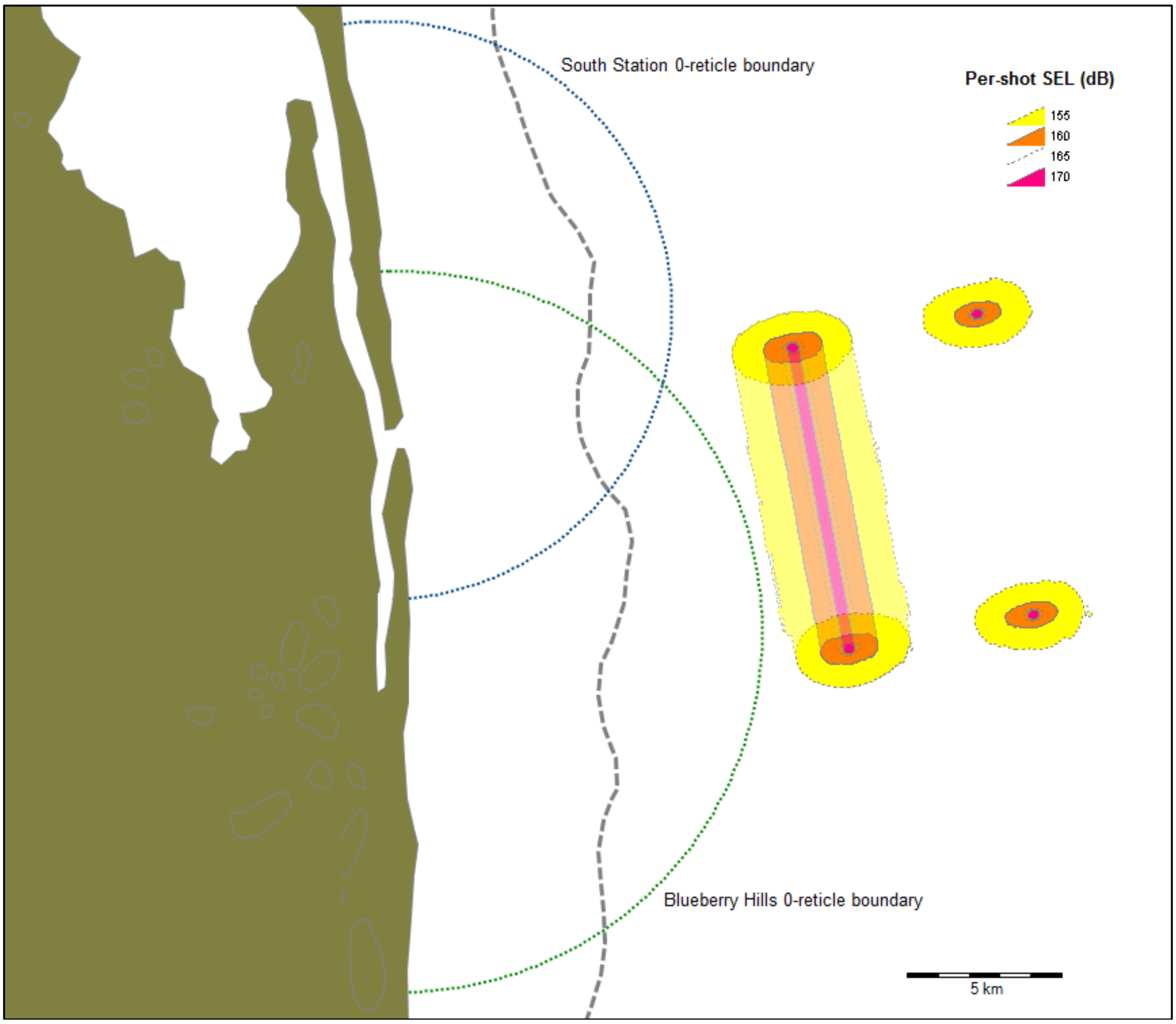

Figure 6-3. Modelled acoustic footprint of the source array over the westernmost sail line and two easternmost corners of the high-resolution 2D survey area (sound levels are per-pulse SEL in dB re 1μPa^2-s). Also shown are the 95-percentile boundary of the whale distribution density (dashed grey) and the visibility limits of shore-based monitoring from the observation towers used in the 2010 Astokh 4D survey (blue and green dotted lines).

For the shot point closest to shore (i.e. NW corner of the notional survey area), the modelled sound level contours were extended in the shoreward direction to a per-pulse SEL of 120 dB re 1μPa^2-s to estimate the maximum levels of ensonification within the feeding area of the whales.

The results are shown in Figure 6-4. It can be observed that the per-pulse sound level is down to approximately 140 dB re 1μPa^2-s at the 95-percentile boundary of the grey whale distribution, while the 120 dB re 1μPa^2-s contour extends essentially to the coastline.

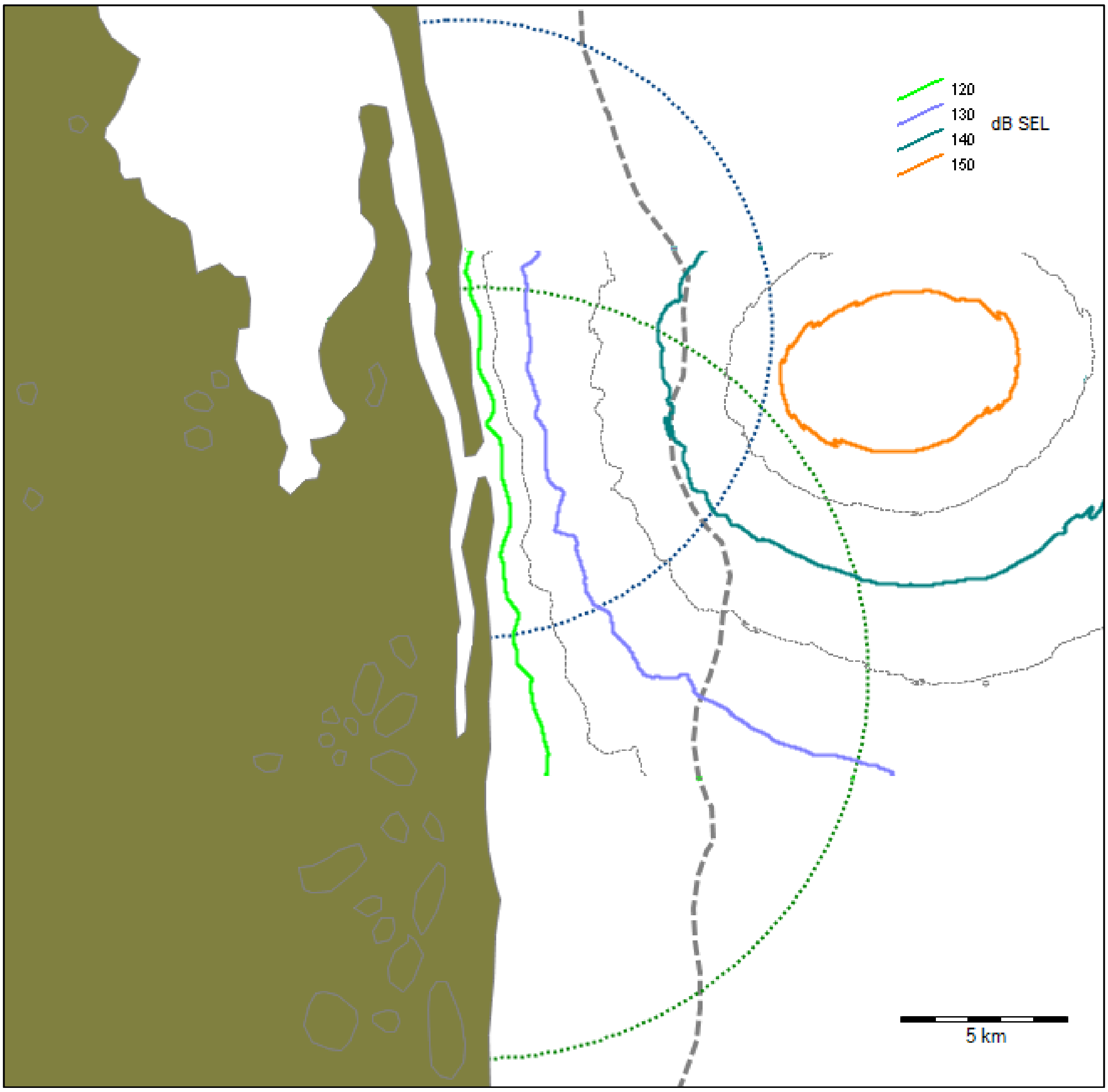

Figure 6-4. Modelled shoreward propagation of the acoustic signal from the NW corner of the of the high-resolution 2D survey area (sound levels are per-pulse SEL in dB re 1μPa^2-s). Also shown are the 95-percentile boundary of the whale distribution density (dashed grey) and the visibility limits of shore-based monitoring from the observation towers used in the 2010 Astokh 4D survey (blue and green dotted lines).

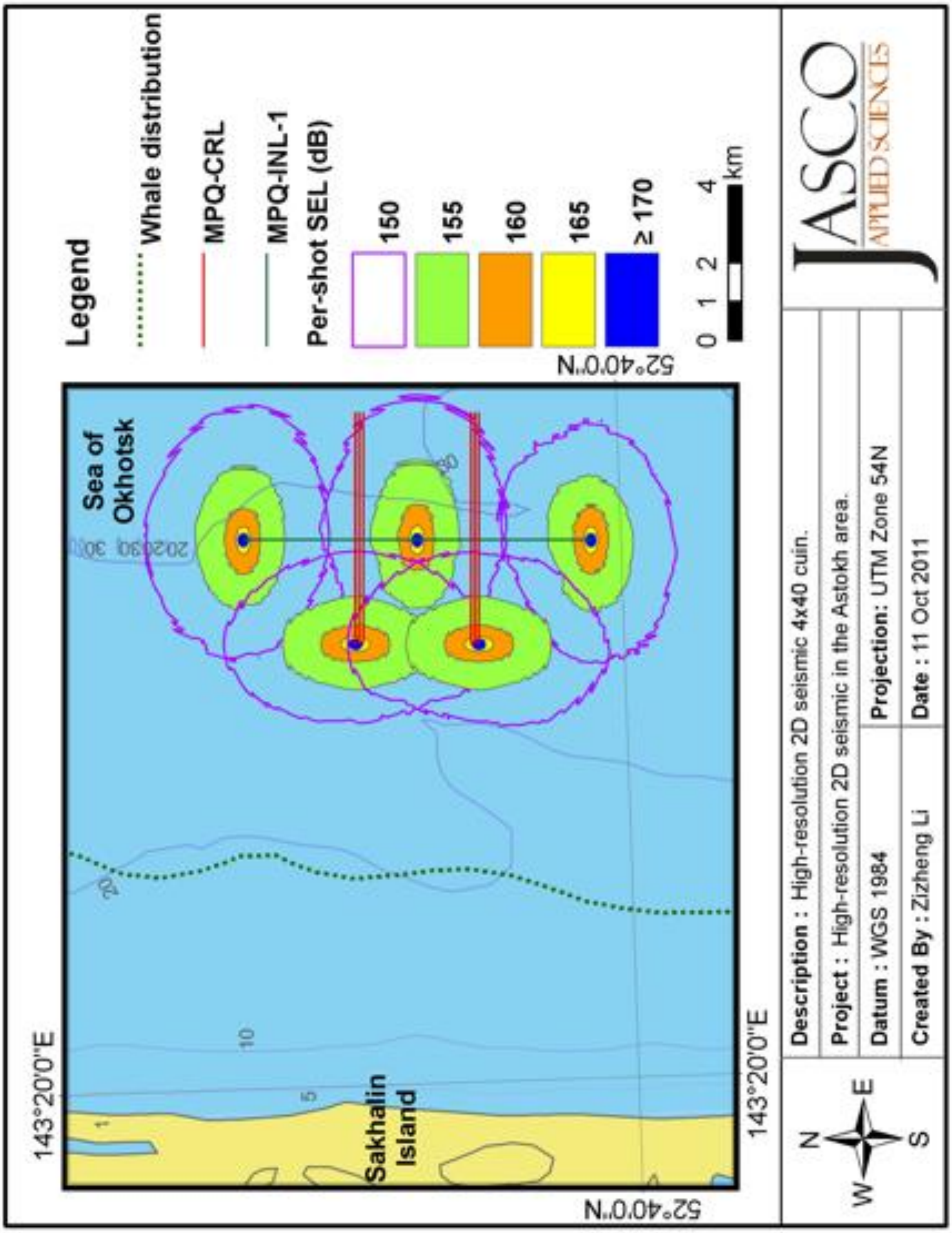

Figure 6-5. Modelled acoustic footprint of the source array for the PA-A relief wells survey for five points: two at the nearshore endpoints of the E-W survey lines and three along the length of the west-most line in the N-S group; sound levels are per-pulse SEL in dB re 1µPa^2-s. Also shown are the coastline and the 95-percentile boundary of the whale distribution density (dotted green).

6.3.2.2 PA-A Relief Wells

Figure 3-9 shows the line pattern for the proposed high-resolution 2D seismic survey for Astokh relief wells near PA-A. Sound propagation modelling was applied to five points to predict sound level footprints: two at the nearshore endpoints of the E-W survey lines (using the central line of each cluster) and three along the length of the west-most line in the N-S group at the start, mid-point and end. This accounts for the different projected noise in the broadside and endfire directions of the 4 x 40 in^3 airgun array[66]. The sound propagation modelling results are rendered in Figure 6-5.

6.3.3 Modelling Results Relative to Noise Criteria and Important Areas

6.3.3.1 Noise Criteria

The noise impact assessment and mitigation strategy for Sakhalin Energy's 2010 Astokh 4D seismic survey hinged on two sound level thresholds: 180 and 163 dB re µPa RMS over the duration of a pulse[67]. The higher of these criteria – which is commonly adopted by environmental regulators – establishes a safety radius or exclusion zone around the seismic source that must remain free of whales in order for the survey to proceed; this is a critical radius because observation of a whale within it triggers specific mitigation measures (see Chapter 8). Clearly for a directional source like an airgun array there is not, strictly speaking, a single safety radius since the footprint is not circular. Various approaches could be adopted to compensate for the fact that the broadside maxima would push the boundary farther out from the vessel (although the actual ensonified area in the extreme lobes is small); generally some form of percentile is used rather than taking the full broadside range as safety radius. However, given the critically endangered status of the Gray Whale that occur in the area, the precautionary approach is to adopt the full broadside range instead. For the 2010 Astokh 4D seismic survey, the *ab initio* safety radius was therefore established as the maximum extent of the modelled full-line envelope contour to 170 dB re μPa^2-s per-pulse SEL, using a conservative exchange factor of 10 dB between the SEL and RMS metrics[68].

The second of the two sound thresholds, 163 dB re µPa RMS, is commonly associated with onset of behavioural disturbance in a proportion of the population (discussed in §6.4.6). The estimated envelope footprint to 156 dB re μPa^2-s per-pulse SEL – a conservative modelling proxy for the 163 dB re µPa RMS footprint – is overlaid on whale density maps and impact metrics to compute the expected number of individuals potentially exposed to sound levels that may elicit behavioural changes. It is of interest to determine if the 156 dB per pulse SEL ensonifies any part of the feeding area, where feeding or weaning whales might be impacted.

To date, preliminary analysis regarding to noise levels to which Gray Whale respond, and in particulartheir response to noise levels lower than the assumed level of 163 dB (ms)/156 dB(SEL) has shown no correlation between seismic activity and animal behaviour. Preparations for additional research are currently on going.

[66] SIEC is currently investigating the possibility of using 3 X 60 in^3 gun array and will advise following modelling work should this be a more optimum configuration

[67] The issue of whether the cumulative SEL metric should be used as a basis for impact assessment and mitigation criteria was the subject of extensive discussion by the IUCN-convened Seismic Survey Task Force at its second meeting in Lausanne, 13-16 March 2008. The conclusion reached by the SSTF was that adhering to widely adopted and better understood criteria based on single-pulse levels such as the 180 dB re µPa RMS used by various authorities to define a safety exclusion zone around the seismic source (Weir and Dolman 2007) would be the more precautionary course of action in the face of insufficient scientific data to support a different and novel approach based on cumulative SEL.

[68] Chapter 8 describes the monitoring and mitigation measures relevant to this threshold.

Important Areas

The western gray whale Piltun feeding area on the NE Sakhalin coast is a focus of ongoing conservation efforts (see §5.9.1.1). Annex F to the report[69] of the fourth meeting of the WGWAP SSTF in December 2009 describes the hybrid approach for estimation of the 95-percentileboundary of the Piltun feeding area; this is discussed in further detail in §6.4.6.1 below. This boundary[70] was recognised by the SSTF and the WGWAP, and was applied in the determination of A-lines for the 2010 Astokh 4D survey. It has also been adopted by JASCO, Sakhalin Energy and the SSTF during assessment and planning of the proposed 2012 2D site survey (e.g. see WGWAP SSTF-6 Report[71]). Relevant sections of the 95-percentile boundary line are depicted in Figure 6-3, Figure 6-4, and Figure 6-5 above.

6.3.4 Conclusion of JASCO's Acoustic Propagation Modelling Results

The sound source level and propagation modelling for the 4 x 40 in^3 airgun array[72] to be used in the planned South Piltun high-resolution 2D geotechnical survey has shown that the expected range of potential influence of pulsed noise from this operation is relatively small. From an injury prevention standpoint, the radius to the 180 dB re 1μPa rms sound pressure limit for temporary auditory threshold shift (TTS) – translated with a precautionary margin to 170 dB re 1μPa^2-s per-pulse SEL – extends less than 200m from the shot point at any of the modelled locations including the ones in deeper water at the eastern edge of the survey area. In terms of behavioural influence, using the same onset criterion of 156 dB re 1μPa^2-s per-pulse SEL adopted for the 2010 Astokh 4D survey, the results show that the South Piltun operation should not expose any whales within the 95-percentile distribution boundary by a margin of at least 4 kilometres.

6.4 Effects of Noise and Disturbance on Marine Mammals

6.4.1 Hearing Abilities of Marine Mammals

Seismic surveys generate underwater noise. Exposure to elevated noise levels may induce temporary or permanent hearing impairment and/or behavioural changes in marine mammals. These effects are highly variable, and can be broadly categorized as follows (based on Richardson et al. 1995):

- The noise may be too weak to be heard at the location of the animal (i.e. noise levels that are lower than ambient noise, or lower than the hearing threshold of the animal at relevant frequencies, or both);
- The noise may be audible, but not strong enough to elicit any overt behavioural response (i.e. the animals may tolerate it);
- The noise may be strong enough to elicit behavioural reactions of variable extent, and of variable relevance to the well being of the animal. These can range from subtle effects (detectable only by statistical analysis) on respiration or other behaviours, to active avoidance reactions;
- With repeated exposure to noise, animals may exhibit either diminishing responsiveness (habituation), or the disturbance effects may persist; the latter case is most likely to occur

[69] http://cmsdata.iucn.org/downloads/wgwap_seismic_survey_tf_report_4.pdf
[70] Since calculation of the 95-percentile boundary (or PML) was based on systematic and opportunistic distribution data, the location of the PML during June-July, when whales begin arriving and their numbers start to increase, would not be exactly the same as during peak densities in August-September. This element of the impact assessment is based on Sakhalin Energy's planned June-July timeline for 2D as presented in §3.5.7, in line with WGWAP recommendation to complete the 2D survey as early in the season as possible.
[71] http://cmsdata.iucn.org/downloads/sstf_6_report_final.pdf
[72] SIEC is currently investigating the possibility of using 3 X 60 in^3 gun array and will advise following modelling work should this be a more optimum configuration

when the sound has highly variable characteristics, is unpredictable in occurrence, and associated with situations that the animal perceives as a threat;

- Anthropogenic noise that is heard by marine mammals may reduce (mask) their ability to hear natural sounds at similar frequencies, e.g. calls from conspecifics, echolocation sounds of odontocetes, and environmental sounds such as surf noise or ice noise. Intermittent airgun or sonar pulses could mask natural sounds, but for only a small period, given the short duration of these pulses relative to the inter-pulse intervals; and
- Very strong sounds have the potential to cause temporary or permanent reduction in hearing sensitivity, or other physiological effects.

Marine mammals use underwater sound to communicate and to gain information about their surroundings. The hearing abilities of marine mammals depend on the following (Richardson et al. 1995; Au et al. 2000):

- Absolute hearing threshold (the level of sound barely audible in the presence of significant ambient noise) at the frequency in question. The “best frequency” is the frequency with the lowest absolute threshold;
- Critical ratio (the signal-to-noise ratio required to detect a sound at a specific frequency in the presence of background noise around that frequency);
- The ability to localize sound direction at the frequencies under consideration; and
- The ability to discriminate among sounds of different frequencies and intensities.

6.4.1.1 Mysticetes (Baleen Whales)

The hearing abilities of mysticetes have not been studied directly. However, the anatomy of the baleen whale inner ear seems to be well adapted for detection of low-frequency sounds (Ketten 1991, 1992, 1994, 2000). Behavioural evidence also indicates that they hear well at frequencies <1 kHz (see Richardson et al. 1995). The anthropogenic sound levels that they are able to detect below 1 kHz are probably limited by natural ambient noise, the levels of which tend to increase as frequencies decrease below 1 kHz.

The hearing systems of mysticetes are thought to be more sensitive to low-frequency sounds than those of small odontocetes, which have been studied directly. However, some studies do suggest that mysticetes may also be able to hear, and respond to, much higher frequency sounds. Mysticetes produce sounds at frequencies up to 8 kHz and, for humpback whales, to >15 kHz (Au et al. 2001). Watkins (1986) noted that some mysticetes reacted to pinger sounds up to 28 kHz, but not to pingers or sonars emitting sounds at >36 kHz. Todd et al. (1992) reported that mysticetes reacted to sonar sounds at 3.5 kHz when received levels were 80–90 dB re 1 μPa. Mysticetes are also known to react to other sources centred at 4 kHz (see Richardson et al. 1995 for review). Migrating gray whales reacted to a 21–25 kHz whale-finding sonar with a source level of 215 dB re 1 μPa-m (Frankel 2005). While mysticetes may be more sensitive to low frequencies, at least some species are able to hear sounds produced by mid- and high-frequency sonars. A summary of underwater and sound production characteristics of mysticetes is provided in Table 6-4.

Table 6-4. Summary of Underwater Hearing and Sound Production Characteristics of Mysticetes.

Species	Sound Production			Hearing Range (Hz)(a)
	Frequency Range (Hz)	*Dominant Frequencies (Hz)*	*Source Level (dB re 1 µPa-m)*	
North Pacific right whale	<400	90–150	-	-
Bowhead whale	20–3,500	Tonal moans: 100–400 Song: <4000	128–189	-
Gray whale	20–20,000	Knocks/pulses: 327–825 Tonal moans: 100–200 & 700–1,200 Calf clicks: 3400–4000	167–188	800–1,500 up to 25,000 Hz (b)
Humpback whale	10(b)–>15,000	Male Song: 120–4,000 Social sounds: <3,000 Feeding calls: 500 Calf sounds: 10–300(c)	Male song: 144–174 (mean 165) Social sounds: 190	700–10,000, Max. sensitivity 2,000–6,000(d)
Minke whale	60–20,000	Downsweeps: 50–250 Thumptrains: 100–200 Pulses: 50–9400 Moans: 60–140 Rachet: 850 Pings/clicks: <12,000	151–175	-
Fin whale	10–750	Pulses: 18–35 FM calls: 20–70 Moans: 20	155–190	-
Blue whale	10–390	Songs: 30–100 FM calls/moans: 15–25	180–190	-

Sources: Richardson et al. 1995a; U.S. Navy 2005; see also notes below.

Notes: (a) For some species, the frequency range of hearing has been suggested (e.g., notes b, d) based on indirect evidence, but there are no specific data for any mysticete. Some mysticetes are believed to have at least limited hearing capabilities at frequencies as low as 7 Hz or as high as 22 kHz (Miller et al. 2005a), given their auditory anatomy, the frequencies of their calls, and their responsiveness (or lack thereof) to sounds at particular frequencies.
(b) As suggested by Dahlheim and Ljungblad (1990) in U.S. Navy (2005). Frankel (2005) reported responses to a 21-25 kHz whale-finding sonar.
(c) Zoidis et al. 2005, 2006.
(d) Estimated using mathematical function developed by Houser et al. (2001) in U.S. Navy (2005).

6.4.1.2 Odontocetes (Toothed Whales)

Hearing abilities of some odontocetes have been studied in detail (reviewed by Richardson et al. 1995 and Au et al. 2000). Hearing sensitivities as a function of frequency have been determined for several species. The small- to medium-sized odontocetes that have been studied had relatively poor hearing sensitivity at frequencies below 1 kHz, but extremely good sensitivity at and above several kHz. There are very few data on the absolute hearing thresholds of most of the larger, deep-diving odontocetes, such as the sperm and beaked whales. However, Mann et al. (2005) and Cook et al. (2006) both report that a Gervais' beaked whale showed evoked potentials from 5–80 kHz, with the best sensitivity at 40–80 kHz. A summary of underwater and sound production characteristics of odontocetes is provided in Table 6-5.

Table 6-5. **Summary of Underwater Hearing and Sound Production Characteristics of Odontocetes.**

Species or Group	Sound Production[(a)]			Hearing	
	Frequency Range (kHz)	*Dominant Frequencies (kHz)*	*Source Level (dB re 1 μPa-m)*	*Frequency Range (kHz)*	*Threshold at Best Sensitivity (dB re 1 μPa)*
Sperm whale	<0.1–30	2–4, 10–16	202 & 236	2.5–60	-
Cuvier's beaked whale	13–17	-	-	-	-
Baird's beaked whale	12–134	23–24.6, 35–45	-	-	-
Beaked whales (*Mesoplodon* spp.)	0.3–80	0.3 – 2	200 – 220	-	-
Beluga	0.1–150	0.1–16, 40–60, 100–120	206 – 225	0.04–150	42 at 11–100 kHz[(b)]
Dolphins (*Cephalorhynchus* spp.)	0.32–150	0.8–2, 4–4.5, 116–134	160 – 163	-	-
Bottlenose dolphins (*Tursiops* spp.)	0.05–150	0.3–14.5, 25–30, 95–130	125–173 228	0.15–135	42–52 at 15 kHz[(b)]
Common dolphins (*Delphinus* spp.)	0.2–150	0.5 – 18 30 – 60	143–180	<5–150	53 at 65 kHz[(c)]
Dolphins (*Lagenorhynchus* spp.)	0.06–325	0.3–5, 4–15, 6.9–19.2, 60–80	80–219	0.5–135	-
Right whale dolphins (*Lissodelphis* spp.)	1–<40	1.8–3	170	-	-
Orca/Killer whale	0.08–85	1-20	105–160	< 0.5–120	35 at 15–42 kHz[(b)]
Pilot whales (*Globicephala* spp.)	0.28–100	2–14, 30–60	180	-	-
Porpoises (*Phocoena* spp.)	0.04–150	0.04-0.6, 1.4–2.5, 110 – 150	177	0.1–140	55 at ~ 30 kHz[(b)]
Dall's porpoise	0.04–160	0.04–12 120–130	175	-	-

Sources: Richardson et al. 1995; Sauerland and Dehnhardt 1998; Kastelein et al. 2003; Johnson et al. 2004; U.S. Navy 2005; Zimmer et al. 2005; Cook et al. 2006.

Notes:
(a) Sauerland and Dehnhardt 1998; hearing threshold directly measured.
(b) Richardson et al. 1995; hearing thresholds directly measured for beluga, killer whale, harbour porpoise, and bottlenose dolphin.
(c) U.S. Navy 2005; hearing threshold directly measured.

6.4.1.3 Pinnipeds (Seals and Sea Lions)

Underwater audiograms have been determined using behavioural methods for five species of earless seals (phocids), two species of eared seals (otariids), and the walrus (reviewed in Richardson et al. 1995; Kastak and Schusterman 1998, 1999; Kastelein et al. 2002). In comparison with odontocetes, pinnipeds tend to have lower frequencies, lower high-frequency cutoffs, better auditory sensitivity at low frequencies, and poorer sensitivity at the frequency. In particular, phocid seals have better sensitivity at low frequencies (1 kHz) than do odontocetes. These data suggest that mid- to high-frequency sonar systems (as well as some low-frequency systems) are likely audible to pinnipeds.

Below 30–50 kHz, the hearing thresholds of most tested pinniped species are essentially flat at about 1 kHz, and range 60–85 dB re 1 μPa. Measurements for a harbour seal indicate that, below 1 kHz, its thresholds deteriorate (increase) gradually to ~97 dB re 1 μPa at 100 Hz (Kastak and Schusterman 1998). The northern elephant seal appears to have better underwater sensitivity than does the harbour seal, at least at low frequencies (Kastak and Schusterman 1998, 1999). For the otariids, the high frequency cutoff is lower, and the sensitivity at low frequencies (e.g. 100 Hz) is poorer than for phocids, at least for harbour and elephant seals. A summary of underwater and sound production characteristics of pinnipeds is provided in Table 6-6.

Table 6-6. Summary of Underwater Hearing and Sound Production Characteristics of Pinnipeds

Species	Sound Production*			Hearing**	
	Frequency Range (kHz)	*Dominant Frequencies (kHz)*	*Source Level (dB re 1 μPa-m)*	*Range (kHz)*	*Threshold at Frequency of Sensitivity (dB re 1 μPa)*
Bearded seal	0.02-6	1-2	178	-	-
Spotted seal	0.5-3.5	-	-	-	-
Ringed seal	0.4-16	<5	95-130	1-100	60-81
Ribbon seal	0.1-7.1	-	160	-	-
Northern fur seal	-	-	-	0.5-40	60 (at 4-28 kHz)
Steller sea lion	Female: 0.03-3	Female: 0.15-1	-	Male: 1-16 Female: 16-25	Male: 77 (at 1 kHz) Female: 73 (at 16 kHz)

Sources: * Richardson et al. 1995; Wartzok and Ketten 1999; Sanvito and Galimberti 2000a, b; Campbell et al. 2002; Charrier et al. 2002, 2003; U.S. Navy 2005.
** Richardson et al. 1995; Kastak and Schusterman 1999; Kastelein et al. 2002, 2005; U.S. Navy 2005.

Notes: - = Not available/unknown.

6.4.2 Known and Potential Acoustic Effects on Mysticetes

This section provides a synopsis of the potential acoustic effects (e.g. masking, disturbance, temporary / permanent hearing impairment, and other physiological effects) of seismic surveys on mysticetes (see Table 6-7 for summary). Subsequent sections provide similar information for odontocetes (§6.4.3) and for pinnipeds (§6.4.4).

It is possible that an animal sufficiently close to a high-energy sound source and for sufficient duration could be harmed by the energy of the sound, even if the frequencies of the sound lie outside the hearing range of the animal. However, of concern here are seismic survey-generated sounds that overlap the hearing range of mysticetes in general, and of Gray Whales in particular.

Since mysticete hearing sensitivity is poorly understood[73], this impact assessment assumes that mysticetes whose sound production characteristics overlap those of seismic survey-related sounds, can also hear those sounds. Typical sound characteristics of airguns, echosounders, and vessels produced by seismic activities are compared to known sound production characteristics of mysticetes below; also see Table 6-4.

Sounds produced by mysticetes range in frequency approximately 7 Hz to 22 kHz (Table 6-4; Richardson et al. 1995; Miller et al. 2005a). Mysticetes are therefore considered most sensitive to low-frequency sounds.

Airguns used in seismic surveys typically have dominant frequency components <200 Hz and zero-to-peak nominal source outputs ranging from 240-265 dB re 1 uPa-1.m (rms). This frequency range overlaps the lower range of sound produced by most mysticetes (see Table 6-4); mysticetes expected to be most sensitive to sound produced by airguns are those that rely primarily on these frequencies, including the blue and fin whale. Airguns also produce a small proportion of mid- and high-frequency sounds, although at lower energy levels, and the nominal source outputs of airguns are well within the detection thresholds of mysticetes (Table 6-4). Pulsed sounds associated with airguns also have higher peak levels than most other anthropogenic sounds to which marine animals are routinely exposed.

Echosounders typically operate at frequencies of approximately 11-12 kHz with a maximum source level near 240 dB re 1 μPa-m (rms). This frequency range overlaps the frequency range of sounds produced by three species of mysticete that occur in the Sea of Okhotsk, viz. the Gray Whale, humpback, and minke whale (Table 6-4).

The frequencies and amplitudes of sounds emitted by ship engines and by vessel hulls (reviewed in Richardson et al. 1995 and NRC 2003) also overlap the frequencies and thresholds of mysticete hearing, although the intensity of vessel sounds would be considerably less than sounds emitted by airguns and sonar (Richardson et al. 1995). Limited studies indicate that vessel sounds may cause behavioural responses in mysticetes, depending mainly on species, location, behaviour, novelty, vessel activities, and habitat (reviewed in Richardson et al. 1995). However, vessel sound intensities would not be expected to cause anything more than localized behavioural changes, considering that large vessel traffic is prevalent worldwide and is considered a usual source of ambient sound (McDonald et al. 2006). Based on the above, potential effects of vessel noise on mysticetes are likely to be short-term in nature and are not further discussed in detail in this document.

Thus, airgun and echosounder noise may cause physiological and behavioural effects in mysticetes. The likelihood of these effects occurring depends on the sound intensity received by the individual, as well as the sensitivity of the individual to sound and disturbance (e.g. prior

[73] Hearing sensitivity has only been measured for a captive eastern gray whale, Table 6-7.

habituation, activity, behaviour, age, sex, etc.). The magnitude and type of effect would generally depend on proximity to the source, but may also be influenced by other factors (e.g., water depth, water temperature, airgun array size and volume etc.). Physiological effects might occur in those individuals sufficiently close to an active source operating at high levels for sufficient duration of time. While short-term behavioural effects are more likely to occur, adverse effects on the viability of mysticete populations would not be expected in most cases.

Although energies of seismic airgun sounds are generally greatest at frequencies from 10 to 200 Hz (Goold and Fish 1998; Sodal 1999), significant energy above 500 Hz has also been recorded (DeRuiter et al. 2005; Potter et al. 2006; Tyack et al. 2006; Goold and Coates 2006). DeRuiter et al. (2005) and Tyack et al. (2006) also noted that on-axis source levels and spherical spreading assumptions alone are inadequate to describe airgun pulse propagation, and that source and environmental characteristics also influence the level and frequency output of seismic airguns. Goold and Coates (2006) concluded that the output of airguns covers the entire known frequency range used by marine mammals, and that this output includes substantial energy levels clearly audible to most, if not all, cetacean species.

Additional research shows that low-frequency airgun signals can be detected thousands of kilometres from their source. For example, sound from seismic surveys conducted offshore Nova Scotia, the coast of western Africa, and northeast of Brazil were reported to be a dominant feature of the underwater sound field recorded along the mid-Atlantic ridge thousands of kilometres distant from any one of these sources (Nieukirk et al. 2004).

6.4.2.1 Masking

Anthropogenic noise may reduce the ability of marine mammals to communicate if the frequency of the noise is similar to that of the sounds used by marine mammals; this interference (masking) is more likely to occur with continuous noise than with pulsed sounds.

In general, most of the sound energy emitted by airguns is at low frequencies. Since baleen whales use low-frequency sound and communicate over great distances, they are considered particularly vulnerable to masking by these industrial sounds (Simmonds et al. 2006).

Even though relevant data are limited, masking by pulsed sounds (even from large arrays of airguns) of marine mammal communication and other natural sounds is expected to be limited (e.g. Richardson et al. 1986; McDonald et al. 1995; Greene et al. 1999; Nieukirk et al. 2004; Smultea et al. 2004). Some whales have been known to continue calling in the presence of seismic pulses (e.g., Richardson et al. 1986; McDonald et al. 1995; Greene et al. 1999; Nieukirk et al. 2004; Smultea et al. 2004; Holst et al. 2005a, 2005b, 2006).

Communications between marine mammals should not be appreciably masked by sonar sound given the low duty cycle of the sonar and the brief period when an individual would potentially be within its beam. Furthermore, echosounder sonar signals (approximately 11-12 kHz) do not overlap with the predominant frequencies of mysticete calls.

Table 6-7. Summary of Known and Anticipated Effects of Seismic Survey Sounds on Mysticetes.

Species or Groups*	Masking	Disturbance	TTS	Injury or PTS	Other Physiological Effects	Comments
Balaenidae and Neobalaenidae spp. – Right whale (North Atlantic, North Pacific), Pygmy right whale, Bowhead whale	N Atlantic right whales shift call frequencies in response to strong vessel sounds (Parks et al. 2005); Bowheads heard calling between seismic pulses (Richardson et al. 1986; Greene et al. 1999).	Temporary behavioural changes, avoidance or displacement likely from seismic source at levels <160–170 dB re 1 µPa (rms)(see text); some balaenopterids show little or no displacement during seismic operations (Moulton and Miller 2005); Bowheads show strong avoidance at received levels of 152–178 dB during migration (Richardson et al. 1986, 1995; Ljungblad et al. 1988); Bowheads more tolerant of seismic sound during feeding than migration (Miller et al. 1999, 2005b; Richardson et al. 1999); no data on wintering bowheads.	Not likely—Balaenidae and other mysticetes typically avoid seismic vessels (Richardson et al. 1995); no specific data on TTS thresholds in mysticetes; auditory thresholds of mysticetes within their frequency band of best hearing believed to be higher (less sensitive) than odontocetes at their best frequencies (Clark and Ellison 2004)	Not likely—Balaenidae and other mysticetes typically avoid seismic vessels (Richardson et al. 1995); no specific data on PTS thresholds in mysticetes	Auditory impairment or other non-auditory physical effects limited to short distances and unlikely—mysticetes typically avoid seismic vessels (Richardson et al. 1995); Right whales possibly risk oil ingestion if spill, due to restricted feeding areas (e.g. bays); risk of ship strikes for slow-moving species unlikely due to slow speed of seismic vessels and monitoring efforts	Behavioural changes likely; injury not expected due to behavioural avoidance. Prolonged or population-level effects not likely
North Pacific Gray whale	Increase in call rates and change in call structure noted in response to small boat engine noise (Dahlheim 1987).	Seismic: temporary avoidance, displacement and cessation of feeding shown at 4 km from source, at 170 dB re 1 µPa (rms) (Malme and Miles 1985; Malme et al. 1986, 1988); no data on wintering gray whales. Sonar: limited avoidance exhibited to whale finding sonar (Frankel 2005). Minor short-term course changes during migration in response to SURTASS LFA sonar playback signals with source levels of 170–178 dB re 1 µPa (rms) (Clark et al. 2001)	See Balaenidae above	See Balaenidae above	Auditory impairment or other non-auditory physical effects limited to short distances and unlikely-- mysticetes typically avoid seismic vessels (Richardson et al. 1995)	See Balaenidae above

Species or Groups*	Masking	Disturbance	TTS	Injury or PTS	Other Physiological Effects	Comments
North Pacific Gray whale		Changes in 5 of 11 Gray Whale behavioural characteristics attributable to seismic survey variables, but no changes in 6 of 11 behavioural characteristics (Gailey et al. 2007). Change in distribution of some Gray Whale (Weller et al. 2002, Yazvenko et al. 2002, 2007a) near 3D seismic survey; no detectable change in feeding behaviour of western whales remaining near seismic survey (Yazvenko et al. 2002, 2007b)	See Balaenidae above	See Balaenidae above	Auditory impairment or other non-auditory physical effects limited to short distances and unlikely-- mysticetes typically avoid seismic vessels (Richardson et al. 1995)	See Balaenidae above
Humpback whale	Sonar: Songs lengthened during 42-s LFA sonar transmissions (received levels up to 150 dB re 1 μPa) likely to compensate for acoustic interference (Miller et al. 2000). Mysticetes showed no significant responses when 38-kHz echosounder and 150-kHz ADCP transmitting (Gerrodette and Pettis 2005).	Seismic: Temporary avoidance by pods with females at mean received levels of 140 dB re 1 μPa (rms), but some males approached within 179 dB (McCauley et al. 1998); avoidance reaction greater for cow-calf pairs than travelling pods (McCauley et al. 1998, 2000a). No avoidance in some surveys (Malme et al. 1985; Mobley 2005). Sonar: Humpbacks moved away from MF 3.3-kHz sonar pulses, and increased swimming speeds and track linearity in response to 3.1–3.6-kHz sonar sweeps (Maybaum 1990, 1993).	See Balaenidae above	See Balaenidae above	See E Pacific gray whale above	See Balaenidae above s
Minke whale	Limited possible effects based on other mysticete species (see above).	Off U.K., all baleen whales (including minkes) remained significantly further from active airguns vs. quiet periods (Stone and Tasker 2006). Some individuals showed little or no avoidance during seismic operations (Stone 2003; Moulton and Miller 2005); individual minkes	See Balaenidae above.	See Balaenidae above.	See E Pacific gray whale above.	See Balaenidae above.

Species or Groups*	Masking	Disturbance	TTS	Injury or PTS	Other Physiological Effects	Comments
		occasionally approached airgun array to near 170-180 dB re 1 μPa (rms) (MacLean and Haley 2004).				
Bryde's whale, Sei whale	Limited possible effects based on other mysticete species (see above).	Temporary avoidance or displacement based on results of other mysticetes (e.g., see minke and humpback); no data available on reactions of Bryde's whales; sei whales less likely to remain submerged during periods of seismic shooting (Stone 2003). Off U.K., all baleen whales (including seis) remained significantly further from active airguns vs. quiet periods (Stone and Tasker 2006).	See Balaenidae above.	See Balaenidae above.	See E Pacific gray whale above.	See Balaenidae above.
Fin whale	Heard calling between seismic pulses (McDonald et al. 1995). Ceased calling during pulsed pile-driving noise (Borsani et al. 2005). Limited possible effects based on other mysticete species (see above).	Fin whales less likely to remain submerged during periods of seismic shooting (Stone 2003); Off U.K., all baleen whales (including fins) remained significantly further from active airguns vs. quiet periods (Stone and Tasker 2006).	See Balaenidae above.	See Balaenidae above.	See E Pacific gray whale above.	See Balaenidae above.
Blue whale	Heard calling between seismic pulses (McDonald et al. 1995). Limited possible effects based on other mysticete species (see above).	See minke whale above. Off U.K., all baleen whales (including blues) remained significantly further from active airguns vs. quiet periods (Stone and Tasker 2006).	See Balaenidae above.	See Balaenidae above.	See E Pacific gray whale above.	See Balaenidae above.

6.4.2.2 Disturbance

Disturbance includes a range of effects, including subtle changes in behaviour, more conspicuous changes in activities, and displacement. Reactions to sound depend on species, state of maturity, experience, current activity, reproductive state, time of day, and other factors (Richardson et al. 1995). If a marine mammal reacts briefly to an underwater sound by, for example by changing its behaviour or moving a small distance, the impacts of the change are unlikely to be significant to the individual, let alone the population. However, if industrial sound causes marine mammals to displace from an important feeding or breeding area for a prolonged period, impacts on the animals could be significant.

Criteria that may be used to assess potential disturbance of mysticetes by seismic survey noise are derived from behavioural observations during studies of several species (e.g. Southall et al. 2007 and references contained therein). Detailed studies have been conducted on humpback, gray, and bowhead whales; less detailed data are available for other species of baleen whales.

Baleen whales generally tend to avoid areas where airguns are operating, but avoidance radii are variable. While some whales were reported to show no overt reactions to pulses from large arrays of airguns at distances beyond a few kilometres – even though the airgun pulses remained well above ambient sound levels to much further distances – other whales deviated from their normal migration route and/or interrupted their feeding and moved away when exposed to strong sound pulses from airguns. In the case of migrating eastern gray and bowhead whales, observed changes in behaviour appeared to be of little or no biological consequence to the animals. They simply avoided the sound source by displacing their migration route to varying degrees, but within the natural boundaries of their migration corridors.

Studies of gray, bowhead, and humpback whales that received pulsed sound of 160–170 dB re 1 µPa (rms) demonstrated obvious avoidance behaviour by a substantial portion of the exposed animals; these levels (160–170 dB) were recorded at distances of 4.5 to 14.5 km from large airgun sources. Subtle behavioural changes were occasionally evident at lower levels, although it should also be noted that studies of bowhead and humpback whales sometimes found strong avoidance reactions at received levels lower than 160–170 dB re 1 µPa (rms).

Humpbacks

Responses of humpback whales to seismic surveys have been studied during their migration and in their summer feeding grounds; there has also been discussion of effects while in their Brazilian wintering grounds. McCauley et al. (1998, 2000a) reported that the overall distribution of humpbacks migrating near Western Australia was unaffected by a full-scale seismic programme, although localized avoidance of airguns occurred; that survey included a 16-airgun 2,678-in^3 array and a single 20-in^3 airgun with source level 227 dB re 1 µPa-1·m (peak-peak). Avoidance reactions began at 4-5 km from the full-scale seismic array for travelling pods, with more sensitive resting pods (cow-calf) avoiding this source by 7-12 km (McCauley et al. 1998, 2000a). Most pods avoided an operating seismic boat by 3-4 km at an estimated received level of 157-164 dB re 1 µPa (rms) (McCauley et al. 2000a, 2000b). Mean avoidance distance where humpbacks began showing avoidance reactions to an approaching airgun corresponded to a received sound level of 140 dB re 1 µPa (rms). Humpback pods with females consistently avoided an approaching single airgun (Bolt 600B, 20-in^3 chamber). However, some individual humpback whales, especially males, approached to within distances of 100-400 m (328-1,312 ft), where the maximum received level was 179 dB re 1 µPa (rms).

Humpback whales in their summer feeding grounds in southeast Alaska did not exhibit persistent avoidance when exposed to seismic pulses from a 100-in^3 airgun (Malme et al.

1985). Some humpbacks seemed “startled” at received levels of 150–169 dB re 1 μPa (rms). Malme et al. (1985) concluded that there was no clear evidence of avoidance, despite the possibility of subtle effects, at received levels up to 172 dB re 1 μPa (rms).

Engel et al. (2004) suggested that South Atlantic humpback whales wintering off Brazil may be displaced or even strand upon exposure to seismic surveys. However, the evidence for this was circumstantial, subject to alternative explanations (International Association of Geophysical Contractors 2004), and inconsistent with results from direct studies of humpbacks exposed to seismic surveys in other areas and seasons. After allowance for data from subsequent years, there was “no observable direct correlation” between strandings and seismic surveys (IWC 2007).

Weir (2008) found that the encounter rate of humpback whales during a seismic survey off Angola (using a 5,085 in^3 or 3,147 in^3 array) did not differ significantly when airguns were operating or silent, although the mean distance of sightings was greater when the airguns were firing.

Bowheads

Responsiveness of bowhead whales to seismic surveys can be quite variable depending on their activity (migrating vs. feeding). Bowhead whales migrating west across the Alaskan Beaufort Sea in autumn, are unusually responsive, with substantial avoidance occurring out to distances of 20–30 km from a medium-sized airgun source at received sound levels of around 130 dB re 1 μPa (rms) (Miller et al. 1999; Richardson et al. 1999). However, bowheads are not as sensitive to seismic sources during the summer feeding season and they typically begin to show avoidance reactions at a received level of about 160–170 dB re 1 μPa (rms) (Richardson et al. 1986; Ljungblad et al. 1988; Miller et al. 1999, 2005b). Nonetheless, statistical analysis showed evidence of subtle changes in surfacing, respiration and diving cycles when feeding bowheads were exposed to lower-level pulses from distant seismic operations (see Richardson et al. 1986). The feeding whales may exhibit subtle changes in behaviour in response to the sounds, but the need to feed apparently reduces the tendency to move away. There are no data on reactions of wintering bowhead whales to seismic surveys.

Gray Whales (Eastern Observations)

Reactions of migrating and feeding (but not wintering) gray whales to seismic surveys have been studied. Malme et al. (1986, 1988) estimated – based on small sample sizes – that 50% of eastern gray whales stopped feeding in response to pulses from a single 100-in^3 airgun in the northern Bering Sea at an average received level of 173 dB re 1 μPa (rms). About 10% interrupted feeding at received levels of 163 dB re 1 μPa (rms). Malme at al. (1986) estimated that an average pressure level of 173 dB re 1 μPa occurred at a range of 2.6–2.8 km from an airgun array with a source level of 250 dB (0-peak) during his studies in the northern Bering Sea. These findings were generally consistent with studies on larger numbers of gray whales migrating off California and on western gray whales feeding off Sakhalin Island, Russia (Johnson 2002; Johnson et al. 2007; Gailey et al. 2007; Yazvenko et al. 2007a, 2007b).

Malme and Miles (1985) concluded that, during migration, changes in swimming pattern occurred for received levels of about 160 dB re 1 μPa (rms) and higher. The 50% probability of avoidance was estimated to occur at a closest possible approach (CPA) distance of 2.5 km from a 4,000-in^3 array operating off central California. This would occur at an average received level of about 170 dB re 1 μPa (rms). Some slight behavioural changes were noted at received levels of 140–160 dB re 1 μPa (rms).

Gray whales in British Columbia exposed to seismic survey sound levels up to about 170 dB re 1 μPa did not appear to be disturbed (Bain and Williams 2006). In this case, moving away from the airguns would have involved moving to higher exposure levels (moving into deeper water where sound propagated more efficiently). In general, the gray whales in this study seemed more tolerant of airgun noise than harbour porpoises and Steller sea lions; thus, it is unclear whether their movements reflected a response to sounds associated with seismic surveys (Bain and Williams 2006).

Gray whales (Western Observations)

There was no indication that Gray Whale potentially exposed to seismic survey sounds were displaced from their overall feeding grounds near Sakhalin Island during seismic programmes in 1997 (Würsig et al. 1999) and in 2001 (Weller et al. 2002). However, in 2001 there were indications of subtle behavioural effects (Gailey et al. 2007) and localized avoidance by some individuals (Weller et al. 2002, 2006a, 2006b; Yazvenko et al. 2007a).

Odoptu 3D seismic survey, 2001

During August – September 2001, a 3D seismic survey was carried out near Odoptu[74], adjacent to the Gray Whales Piltun feeding area on the northeast coast of Sakhalin; the seismic array had a total volume of 1,640 in^3. An intensive monitoring programme involving vessel- and shore-based observations, aerial surveys, and acoustic measurements was implemented to provide information on gray whale reactions to seismic noise (Johnson 2002; Johnson et al. 2007).

Aerial surveys, combined with shore- and vessel-based observations, showed that gray whales remained in the general region where the seismic survey was conducted, but some individual whales were displaced locally (Johnson et al. 2007). Corresponding multivariate statistical analyses did not indicate that the frequency of gray whale feeding behaviour in the overall region was influenced by seismic activity even though the seismic surveys apparently caused some local avoidance (Johnson et al. 2007). Observations from shore adjacent to the area where whales fed and where the seismic programme occurred showed no direct connection between local gray whale abundance and seismic surveys. Some behavioural parameters were correlated with seismic survey variables, but the behavioural effects were short-term and within the natural range of variation (Gailey et al. 2007; Johnson et al. 2002; Johnson et al. 2007). Gailey et al. (2007) reported that while univariate analyses indicated no significant statistical correlation between seismic survey variables and Gray Whale movement and behaviour variables, multiple regression analysis did indicate that at higher received sound levels, whales travelled faster, changed directions of movement less, were recorded further from shore, and breathed less often and stayed under water longer between respirations.

Acoustic monitoring revealed that gray whales located in primary feeding habitat were not exposed to received levels of seismic sound exceeding 163 dB re 1 μPa (rms) (Rutenko et al. 2007). Gray whales continued to feed in the same general area in 2001 as they did in 1999 and 2000 – when there were no seismic surveys in the Odoptu area –although the seismic survey apparently did cause local displacement of some individual gray whales and changes in some behavioural parameters (Johnson 2002, 2007; Yazvenko et al. 2007a; Gailey et al. 2007). Based on multiple regression analysis, Yazvenko et al. (2007b) concluded that Gray Whale bottom feeding activity was not affected by the Odoptu 2001 seismic activity.

Astokh 4D seismic survey, 2010

During 18 June – 2 July 2010, Sakhalin Energy conducted a 4D seismic survey in the Astokh part of the Piltun-Astokh field. The array consisted of 31 individual airguns with a total volume of 2,620 in^3, a firing pressure of 2,000 psi, and a shot interval of approximately 7.2 seconds between pulses during normal survey conditions at five knots.

[74] Odoptu is part of the Sakhalin-1 concession located north of Sakhalin-2's Piltun-Astokh field on the northeast coast of Sakhalin Island.

The western boundary of the seismic survey area was located approximately 4 km from the eastern ‘boundary’[75] of the Gray Whale Piltun feeding area. Acoustic modelling by JASCO predicted that, when the vessel would be acquiring seismic data on the western side of the survey area, sound levels in excess of $163dB_{RMS}$ would enter the feeding area.

Given company policy to minimise disturbance of Gray Whale in their feeding area – in line with RF law on the protection of the habitats of RDB species – Sakhalin Energy sought advice on impact mitigation and monitoring from the WGWAP and their SSTF during 13 meetings. Extensive discussion and analysis yielded a mitigation and monitoring programme, described by the WGWAP to be “one of the most complete whale-focussed MMPs developed for a seismic survey anywhere in the world[76]”. In essence, the programme required the survey to be completed as early as possible in the ice-free season – before peak whale densities – and linked mitigation measures to monitoring, including:

- Real-time acoustic monitoring - radio telemetry stations positioned at 2,500 m intervals along the edge of the feeding area (perimeter monitoring line)
- Archival acoustic monitoring - receivers placed near the 10 m isobath within the feeding area.
- Visual monitoring from all vessels - Minimum of two active MMOs on the seismic vessel at any given time during ramp-up, shooting, and for 20 minutes before start of ramp-up.
- Shore-based visual monitoring of feeding area - Two behaviour-monitoring teams not linked to operational criteria.
- Vessel-based visual monitoring of feeding area - Behaviour and distribution monitoring team on acoustic tender vessel.

A considerable amount of monitoring data was collected, and although it remains to be fully analysed, initial indications do not indicate an impact occurred on whale densities (see WGWAP SSTF-6 Report[77]); counts of gray whales increased from 3–18 whales/day during the pre-seismic period to an average of 44 whales/day during the last few days of the seismic activity (27 June–1 July), consistent with the arrival of Gray Whale in the feeding area. Sakhalin Energy reported that shut-down was initiated in accordance with approved mitigation measures on four occasions; twice when whales were observed in the A-zone, and twice when ‘aberrant’ behaviour (multiple breaching) was observed; full analysis of the data is awaited by Sakhalin Energy and WGWAP.

Lebedenskoye 3D seismic survey, 2010

According to available information (WGWAP9/19[78], Table 6-16), Rosneft-Shelf-FarEast (RNSFE) conducted a 3D seismic survey in the Lebedinskoye license area during August-November 2010; the marine part of the survey was located inside the northern reaches of the Piltun feeding area (Figure 6-8).No data from RNSFE for the Lebedinskoye survey are yet in the public domain. According to the preliminary NGO Report (*WGWAP9/19* submitted at the Ninth Meeting of the WGWAP by WWF, IFAW Russia, Pacific Environment, and Sakhalin Environment Watch), fewer whales were sighted by NGO observers during the Lebedinskoye survey than immediately before it; further details are provided in their report. The NGO report acknowledges, “In the absence of acoustic data and detailed information on the activities undertaken by vessels in the area, it is not possible to conclude that the observed changes in whale abundance were caused by the increased anthropogenic disturbance in the area”.

[75] For the purpose of the Mitigation and Monitoring Programme, the boundary of the feeding area was calculated to be the 95-percentile contour line based on density analysis of WGW distribution data, June-July 2005-2007.
[76] http://www.iucn.org/wgwap/wgwap/seismic_survey_monitoring_and_mitigation_plan/, 20 May 2011.
[77] http://www.iucn.org/wgwap/wgwap/task_forces/seismic_survey_task_force/
[78] http://www.iucn.org/wgwap/wgwap/meetings/wgwap_9/

Other baleen whales

Blue, sei, fin, and minke whales have sometimes been reported in areas ensonified by airgun pulses (Stone 2003; MacLean and Haley 2004). Stone (2003) reported that when good observations could be made numbers of rorquals seen off the U.K. were similar during periods when seismic airguns were operating or silent.

When all data for different baleen whale species were combined and analysed, results indicated their localized avoidance, remaining significantly further from the airguns during seismic operations offshore the U.K. compared with non-seismic periods (Stone and Tasker 2006). However, this effect was not evident in separate datasets for individual species (Stone 2003; Stone and Tasker 2006).

Off Nova Scotia, Moulton and Miller (2005) found little or no difference in sighting rates and initial sighting distances of balaenopterid whales when airguns were operating versus silent. However, there were indications that these whales were more likely to be moving away when seen during airgun operations. Minke whales have occasionally been observed to approach active airgun arrays where received sound levels were estimated to be near 170-180 dB re 1 µPa (MacLean and Haley 2004).

Data on short-term behavioural reactions (or lack of reaction) of cetaceans to impulsive sounds are not necessarily indicative of long-term effects. It is unknown whether impulsive sounds affect reproductive rate or distribution and habitat use in subsequent days or years. However, eastern gray whales have continued to migrate annually along the west coast of North America with substantial increases in the population over recent years (Angliss and Outlaw 2005), despite intermittent seismic exploration and much ship traffic in that area for decades. Similarly, bowhead whales have continued to travel to the eastern Beaufort Sea each summer, and their numbers have also increased notably despite seismic exploration in their summer and autumn range for many years (Richardson et al. 1987; Angliss and Outlaw 2005). In any event, the brief exposures to sound pulses from the proposed airgun sources are highly unlikely to result in prolonged effects.

Effects of sonar

Behavioural reactions of free-ranging marine mammals to military and other sonar, such as echo-sounders, appear to vary by species and circumstance. Fewer studies have been conducted on the response of baleen whales to sonar sounds than to seismic survey sounds. During exposure to a 21–25 kHz whale-finding sonar with a source level of 215 dB re 1 µPa-m, Gray Whales showed slight (approx. 200 m) avoidance behaviour (Frankel 2005). In a 1998 playback experiment of LFA SURTASS sonar, migrating gray whales made minor course changes within their migration corridor in response to LFA signals with source levels of 170-178 dB re 1 µPa-m that originated from a sound source located directly in the middle of the whale’s migration path. The whales resumed their course after tens of minutes once the signal ceased (Clark et al. 2001). When the LFA SURTASS source was moved to a location 3.2 km offshore of the whales’ migration path, there was no evidence of deflection. Among humpback whales off Kaua’i, no distribution or population changes were found during 2 years of transmissions by the North Pacific Acoustics Laboratory (Mobley 2005).However, all of those observations are of limited relevance to the proposed seismic survey by Sakhalin Energy. Pulse durations from those sonars were much longer than those of the echo-sounder proposed for use during this survey. During the proposed survey, the individual echo-sounder pulses would be very short, and a given mammal would not receive many of the downward-directed pulses as the vessel passes by. Behavioural responses are not expected unless marine mammals are very close to the source.

6.4.2.3 Temporary Hearing Impairment

Temporary hearing impairment, or TTS, is the mildest form of hearing impairment that can occur during exposure to a strong sound (Kryter 1985). While experiencing TTS, the hearing threshold rises and a sound must be stronger in order to be heard. At least in terrestrial mammals, TTS can last from minutes or hours to (in cases of strong TTS) days. For sound exposures at or somewhat above the TTS threshold, hearing sensitivity of both terrestrial and marine mammals recovers rapidly after exposure to the sound ends. TTS is not considered an injury (Southall et al. 2007). Few data on sound levels and durations necessary to elicit mild TTS have been obtained for marine mammals, and none of the published data concern TTS elicited by exposure to multiple pulses of sound. Available data on TTS in marine mammals are reviewed in some detail by Southall et al. (2007).

Temporary or even permanent hearing impairment is possible when marine mammals are exposed to very strong sounds (Goold and Coates 2006), and temporary threshold shift (TTS) has been demonstrated and studied in certain captive odontocetes and pinnipeds exposed to strong sounds (reviewed in Southall et al. 2007). However, there has been no specific documentation of either TTS or PTS for marine mammals exposed to sequences of airgun pulses under realistic field conditions. For the past several years, NMFS policy regarding exposure of marine mammals to high-level sounds is that cetaceans and pinnipeds should not be exposed to impulsive sounds ≥180 and 190 dB re 1 μPa (rms), respectively (NMFS 2000). Those criteria have been used in defining the safety (shut-down) radii for previous seismic surveys. However, those criteria were established before there were any data on the minimum received levels of sounds necessary to cause temporary auditory impairment in marine mammals:

- The 180-dB criterion for cetaceans is probably quite precautionary (i.e. lower than necessary to avoid TTS, let alone permanent auditory injury), at least for delphinids and similar species for which TTS measurements are available;
- The 190-dB criterion for pinnipeds may not be as precautionary, at least for harbour seals; there are indications that the TTS threshold in the harbour seal is lower than in odontocetes (Southall et al. 2007);
- The level associated with the onset of TTS is often considered to be a level below which there is no danger of permanent damage; TTS is a normal and temporary phenomenon occurring when animals (and humans) are exposed to strong sounds, and it does not constitute injury (e.g. Kryter 1985; Southall et al. 2007).
- The minimum sound level necessary to cause permanent threshold shift (PTS) is higher, by a variable and generally unknown amount, than the level that induces barely-detectable TTS; the actual PTS threshold is likely to be well above the level causing onset of TTS (Southall et al. 2007).

Southall et al. (2007) suggest that thresholds for injury (and behavioural responses) should be examined separately for five functional hearing groups: low-frequency cetaceans (mysticetes, for which the functional hearing range is concluded to be 7 Hz to 22 kHz); mid-frequency cetaceans (the majority of odontocetes, 150 Hz to 160 kHz); high-frequency cetaceans (remaining odontocetes, 200 Hz to 180 kHz); pinnipeds in water (75 Hz to 75 kHz), and pinnipeds in air (75 Hz to 30 kHz). This review discusses low-frequency cetaceans (mysticetes), mid- and high-frequency cetaceans collectively, under “odontocetes”, and pinnipeds in water. Seismic surveys are assumed to be of little relevance to “pinnipeds in air”.

For mysticetes, there are no data on levels or properties of sound that are required to induce TTS. The frequencies to which baleen whales are most sensitive are lower than those to which odontocetes are most sensitive, and natural background noise levels at those low frequencies tend to be higher. As a result, auditory thresholds of baleen whales within their frequency band of best hearing are believed to be higher (less sensitive) than are those of odontocetes at their best frequencies (Clark and Ellison 2004). From this, it is suspected that received levels causing TTS onset may also be higher in mysticetes. Southall et al. (2007) conclude that it would be precautionary to assume that TTS would not occur in mysticetes at received levels any lower than those causing TTS in odontocetes.

Given recent stranding events associated with naval sonar operations, there is concern that mid-frequency (MF) sonar sounds can cause serious impacts to marine mammals (see above). However, the echo-sounder sonars that would be used in the proposed site survey are quite different than the sonars used in Navy operations. Pulse duration of the echo-sounder is very short relative to the naval sonars. And, at any given location, an individual marine mammal would be in the beam of the sonar for much less time given the generally downward orientation of the beam and its narrow fore-aft beamwidth. (Navy sonars often use near-horizontally-directed sound.) Those factors would all reduce the sound energy received from the echo-sounder rather drastically relative to that from the sonars used by the Navy.

Given an estimated maximum source level of 242 dB re 1 µPa (rms) for a typical echo-sounder, the received level for an animal within the sonar beam 100 m below the ship would be about 202 dB re 1 µPa (rms), assuming 40 dB of spreading loss. Given the narrow beam, only one pulse is likely to be received by a given animal. The received energy level from a single pulse of duration 15 ms would be about 184 dB re 1 $\mu Pa^2 \cdot s$ (i.e., 202 dB + 10 log (0.015 s). This is below the TTS threshold for an odontocete exposed to a single non-impulsive sonar transmission (Schlundt et al. 2000; Finneran et al. 2005) and even further below the anticipated PTS threshold (see below). Auditory thresholds of baleen whales within their frequency band of best hearing are believed to be higher (less sensitive) than are those of odontocetes at their best frequencies (Clark and Ellison 2004).

In any event, no cases of TTS are expected in mysticetes given three considerations: (1) the low abundance of baleen whales in most parts of the project area (seaward of the nearshore feeding area); (2) the strong likelihood that baleen whales would avoid the approaching airguns (or vessel) before being exposed to levels high enough for there to be any possibility of TTS (Wilson et al. 2006); and (3) the mitigation measures that will be adopted (see Chapter 8). Seismic pulses with received energy levels ≥170 dB SEL (180 dB rms) are expected to be restricted to radii no more than 200 m around the airguns (see §6.3.4).

6.4.2.4 Permanent Threshold Shift

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 has an impaired ability to hear sounds in specific frequency ranges. There is no specific evidence that exposure to airgun pulses can cause PTS in any marine mammal, even with large airguns arrays. However, given the likelihood that some marine mammals close to an airgun array might incur at least mild TTS (see Finneran et al. 2002), there has been speculation about the possibility that some individuals occurring very close to airguns might incur PTS (Richardson et al. 1995).

In terrestrial mammals, single or occasional occurrences of mild TTS are not indicative of permanent auditory damage. PTS might occur at a received sound level at least several decibels above that inducing mild TTS if the animal were exposed to strong sound pulses with rapid rise time. The specific difference between the PTS and TTS thresholds has not been measured for marine mammals exposed to any sound type. When exposure is measured in SEL units the offset between PTS-onset and TTS-onset for marine mammals exposed to impulse sound is at least 15 dB (Southall et al. 2007). Thus, for cetaceans Southall et al. estimate that the PTS threshold might be a cumulative SEL (for the sequence of received pulses) of ~198 dB re 1 $\mu Pa^2 \cdot s$. Given the higher level of sound necessary to cause PTS (versus TTS), it is even less likely that PTS could occur. In fact, even the levels immediately adjacent to the airguns may not be sufficient to induce PTS, especially because a mammal would not be exposed to more than one strong pulse unless it swam immediately alongside the airgun for a period longer than the inter-pulse interval. The low-to-moderate levels of TTS that have been induced in captive odontocetes and pinnipeds during controlled studies have shown no measurable residual PTS (Kastak et al. 1999; Schlundt et al. 2000; Finneran et al. 2002; Nachtigall et al. 2003, 2004).

Southall et al. (2007) also note that, regardless of the cumulative received energy (SEL), there is concern about the possibility of PTS if a cetacean (or pinniped) received one or more pulses with a very high peak pressure. Based on data from terrestrial mammals, a precautionary assumption is that impulse sounds might cause immediate PTS if the received peak pressure were 6 dB (or more) above than the TTS threshold as measured on a peak-pressure basis (Southall et al. 2007). They conclude that PTS might occur in cetaceans (as exemplified by belugas and bottlenose dolphins, but with no examples among mysticetes). A peak pressure of 230 dB re 1 μPa (3.2 bar · m, 0-pk) would only be found within a few meters of the largest airguns used in most airgun arrays (Caldwell and Dragoset 2000). A peak pressure of 218 dB re 1 μPa could be received somewhat farther away; to estimate that specific distance, one would need to apply a model that accurately calculates peak pressures in the near-field around an array of airguns.

As discussed previously, mysticetes generally avoid the immediate area around operating seismic vessels. Implementation of monitoring and mitigation measures, including visual monitoring, power downs, and shut downs of the airguns when marine mammals are seen within the safety radii (Johnson et al. 2007; Nowacek et al. 2007; Weir and Dolman 2007), minimize the already low probability of exposure of marine mammals to sounds strong enough to induce PTS.

6.4.2.5 Strandings and Mortality

Marine mammals close to underwater detonations of high explosives can be killed or severely injured, and auditory organs are especially susceptible to bursts of energy (Ketten et al. 1993; Ketten 1995). Airgun pulses are less energetic and have slower rise times, and there is no evidence that they can cause serious injury, death, or stranding even in the case of large airgun arrays. However, the association of mass strandings of beaked whales with naval exercises and, in one case, a seismic survey, has raised the possibility that beaked whales (an odontocete) exposed to strong pulsed sounds may be especially susceptible to injury and/or behavioural reactions that can lead to stranding (see §6.4.3.5 for further discussion of odontocetes).

Strandings and mortality may be due to various noise-related causes, including (1) swimming in avoidance of a sound into shallow water; (2) a change in behaviour (such as a change in dive profile, staying at depth longer than normal, or remaining at the surface longer than normal) that might contribute to tissue damage, gas bubble formation, hypoxia, cardiac arrhythmia, hypertensive haemorrhage or other forms of trauma; (3) a physiological change such as a vestibular response leading to a behavioural change or stress-induced haemorrhagic diathesis, leading in turn to tissue damage; and (4) tissue damage directly from sound exposure, such as through acoustically mediated bubble formation and growth or acoustic resonance of tissues. There are increasing indications that gas-bubble disease, induced in supersaturated tissue by a behavioural response to acoustic exposure, could be a pathologic mechanism for the strandings and mortality of some deep-diving cetaceans exposed to sonar, although the evidence of a causal connection remains circumstantial (Cox et al. 2006; Southall et al. 2007). These issues appear particularly relevant to odontocetes (mainly beaked whales and are dealt with in the following section).

Seismic pulses and MF sonar pulses are quite different. Sounds produced by airgun arrays are broadband with most of the energy below 1 kHz. Typical military MF sonars operate at frequencies of 2–10 kHz, generally with a relatively narrow bandwidth at any one time. Thus, it is not appropriate to assume that the effects of military sonar on marine mammals are similar to the potential effects of airguns on marine mammals. However, evidence that sonar pulses can, in special circumstances, lead to physical damage and mortality (Balcomb and Claridge 2001; NOAA and U.S. Navy 2001; Jepson et al. 2003; Fernández et al. 2004, 2005a,b; Cox et al. 2006), even if indirectly, suggests that caution is warranted when dealing with exposure of marine mammals to any high-intensity pulsed sound.

There is no conclusive evidence that cetacean strandings have resulted due to exposure to seismic surveys. Speculation concerning a possible link between seismic surveys and strandings of humpback whales in Brazil (Engel et al. 2004) was not well founded (IAGC 2004; IWC 2007). No injuries of baleen whales are anticipated during the proposed survey with implementation of the proposed monitoring and mitigation measures (see Chapter 8).

6.4.2.6 Other Physiological Effects

Other physiological effects that could occur in marine mammals close to strong underwater acoustic sources include: stress, neurological effects, bubble formation, and other types of organ or tissue damage.

It has generally been assumed that diving marine mammals are not subject to air embolism. However, recent studies have found associations between MF sonar activity and beaked whale strandings with acute and chronic tissue damage resulting from formation of in vivo gas bubbles. Examinations of several other stranded species have also revealed evidence of gas and fat embolisms (Arbelo et al. 2005; Jepson et al. 2005a; Méndez et al. 2005). Most of the afflicted species were deep divers. There is speculation that gas and fat embolisms may occur if cetaceans ascend unusually quickly when exposed to aversive sounds, or if sound in the environment causes the destabilization of existing bubble nuclei within body tissues (Potter 2004; Arbelo et al. 2005; Fernández et al. 2005a, 2005b; Jepson et al. 2005b; Cox et al. 2006). Even if gas and fat embolisms can occur during exposure to MF sonar, there is no evidence that that type of effect occurs in response to airgun sounds.

In general, little is known about the potential for seismic survey sounds to cause auditory impairment or other physical effects in marine mammals. Available data suggest that such effects, if they occur at all, would be limited to short distances and probably to projects involving large airgun arrays. However, the available data do not allow for meaningful quantitative predictions of the numbers of marine mammals that could potentially be affected. Most mysticetes show behavioural avoidance of seismic vessels and are considered especially unlikely to incur auditory impairment or other physical effects from acoustic sources associated with seismic surveys. In addition, mitigation measures including shut downs of the airguns if a marine mammal occurred within a given distance from the vessel, would reduce or eliminate any potential impacts.

6.4.3 Known and Potential Acoustic Effects on Odontocetes

A number of direct measurement studies have been conducted on the hearing capabilities of odontocetes (see Table 6-5). The small- to moderate-sized odontocetes that have been the subject of audiology have relatively poor hearing sensitivity at frequencies below 1 kHz, but extremely good sensitivity at and above several kHz (Richardson et al. 1995; Miller et al. 2005b). Sensitivity to the low frequencies most prominent in the broadband sounds produced by seismic operations and vessels is considered rather poor for most odontocete species. However, they presumably can hear the less prominent mid-to-high frequencies produced during these activities. Of the odontocetes, sperm whales are probably more sensitive to low frequencies based on what is known about their sound production (Table 6-5). Some odontocetes exhibit avoidance behaviour to seismic operations; this is discussed below.

Odontocetes are presumably more sensitive to the mid- to high frequencies produced by the echo-sounder / sonar than the generally low frequencies produced by the airguns and vessel (Table 6-5). The emitted beam of the echo-sounder / sonar is usually narrow (approx. 2°) in the fore-aft extent and wide (approx. 130º) in the cross-track extent. Therefore, an animal at depth near the track line would be in the main beam for only a fraction of a second, and is unlikely to be subjected to repeated pulses. Kremser et al. (2005) noted that the probability of a cetacean swimming through the area of exposure when such a sonar system emits a pulse is small; the animal would have to pass the transducer at close range and be swimming at a similar speed and direction to that of the vessel in order to be subjected to sound levels that could potentially result in significant damage. Thus, it is unlikely that echo-sounders produce pulse levels strong enough to cause hearing impairment or other physical injuries even in an animal that is (briefly) in a position near the source (UTA and NSF 2006).

There is potential for airgun noise to cause adverse physiological and behavioural effects in odontocetes, although such effects have not been clearly demonstrated. The likelihood of these effects would depend on the sound level received by the individual as well as any variability in sensitivity of the individual (i.e., prior habituation, activity, behaviour, age, sex, etc.). The level and type of effect would generally be related to proximity to the source, but may be influenced by other factors as well (e.g., water depth, water temperature, airgun array size, etc.).

Possible effects of vessel noise on odontocetes are variable. Studies indicate that vessel noise may cause behavioural disturbance or avoidance in some individuals and species, particularly beaked whales; among other species, there is no apparent response, while habituation, or even attraction and bowriding have been recorded in others (Richardson et al. 1995; Wűrsig et al. 1998). Apparent variability is related to species, location, behaviour, novelty of the sound, vessel activity, and habitat (Richardson et al. 1995). Based on the above, potential effects of vessel sound on odontocetes are considered to be short-term behavioural in nature and are not further discussed in detail in this document.

The potential effects of seismic survey activities on odontocetes are described in detail below and are summarized in Table 6-8.

Table 6-8. Summary of Known and Anticipated General Effects of Seismic Survey Sounds on Odontocetes.

Species or Groups	Masking	Disturbance	TTS	Injury or PTS	Other Physiological Effects	Comments
Sperm whale*	Heard calling between seismic pulses (Madsen et al. 2002; Tyack et al. 2003; Smultea et al. 2004).	Seismic: Variable behavioural reactions to seismic, but mostly tolerant and possible disruption of foraging (Mate et al. 1994; Madsen et al. 2002; Stone 2003; Stone and Tasker 2006; Jochens et al. 2006). Sonar: Unknown.	Seismic: Unknown; brief, mild TTS is estimated to occur at a received level of a single seismic pulse (with no frequency weighting) of ~186 dB re 1 μPa2 · s (Finneran et al. 2002) Sonar: TTS due to exposure from MBB or SBP unlikely (Kremser et al. 2005).	Unknown; PTS is estimated to occur 6 dB above the TTS threshold (Ketten and Finneran 2004).	Unknown	Studies show variability in reactions to seismic vessels; Behavioural exposures likely; potential injury not expected due to behavioural avoidance. Long-term or population-level effects not expected.
***Kogia* spp.– pygmy sperm & dwarf sperm whale**	Unknown.	Seismic: Unknown, but tend to avoid vessels (Richardson et al. 1995; Würsig et al. 1998). Sonar: Unknown.	Unknown.	Unknown.	Unknown.	Significant impacts unlikely due to general avoidance of vessels.
Beaked whales – *Berardius* spp., *Hyperoodon* spp., *Mesoplodon* spp., *Ziphius* spp., Shepherd's beaked whale, Longman's beaked whale	Vessel sound may reduce maximum sonar detection and communication range in Cuvier's beaked whales (Aguilar de Soto et al. 2005).	Seismic: Reactions undocumented, likely to show strong avoidance based on documented vessel avoidance and associated increase in dive depth (Kasuya 1986; Würsig et al. 1998), except for N bottlenose whale (Reeves et al. 1993; Hooker et al. 2001).	Unknown.	Unknown.	Seismic: One Cuvier's stranding event coincident with R/V Ewing seismic in Gulf of California but no evidence of cause/effect (Hogarth 2002; Yoder 2002). Sonar: Possibly susceptible to injury and/or strandings due to behavioural reactions when	Strandings and mortality attributed to effects of sonar. Effects of seismic, MBB sonar, and SBP are uncertain and unproven. Beaked whales are more difficult to monitor and mitigate for due to their deep-diving, vessel-avoidance behaviours; Behavioural exposures likely; potential injury

Species or Groups	Masking	Disturbance	TTS	Injury or PTS	Other Physiological Effects	Comments
		Sonar: Strandings coincident with MF sonar (2-10 kHz) (Barlow and Gisiner 2006).			exposed to strong sonar sound; fatal gas and fat embolisms attributed to exposure to sonar (Jepson et al. 2003; Fernández et al. 2005a, b).	not expected due to behavioural avoidance and no documented injuries due to seismic. Long-term or population-level effects not expected.
Beluga	Change in calls in response to strong sounds (Lesage et al. 1999).	Seismic: Temporary avoidance or displacement can occur at 20 km (Miller et al. 2005b). Sonar: Unknown.	Unlikely due to avoidance of seismic vessels; captive belugas tolerated levels of 192 to 221 dB re 1 µPa (rms) with no TTS (Schlundt et al. 2000; Finneran et al. 2000); TTS onset estimated at 195 dB re 1 µPa2 · s (Finneran et al. 2005).	Unlikely due to avoidance of seismic vessels.	Neural-immune changes in captive belugas in response to sound exposure of up to 228 dB re 1 µPa (rms) were minimal and returned to normal within 24 hr (Romano et al. 2004).	Behavioural exposures likely; potential injury not expected due to behavioural avoidance. Long-term or population-level effects not expected.
Orca - Killer whale	Noted change in calls in response to vessel sounds (Foote et al. 2004; Ashe and Williams 2006 in Dolman and Simmonds 2006).	Seismic: Temporary avoidance or displacement likely; appear more tolerant of seismic in deeper water (Stone 2003; Gordon et al. 2004).	Unlikely due to avoidance of seismic vessels.	Unlikely due to avoidance of seismic vessels.	Unlikely due to avoidance of seismic vessels.	Behavioural exposures likely; potential injury not expected due to behavioural avoidance. Long-term or population-level effects not expected.
Blackfish – false killer whale, pygmy killer whale, melon-headed whale, *Globicephala* spp.	Unlikely	Seismic: Temporary avoidance or displacement likely; short-finned pilot whales showed little reaction to seismic activity (Stone 2003; Gordon et al. 2004); false killer whales approached active	Auditory impairment unlikely due to avoidance of seismic vessels; possible exposure in short-finned pilot whales if remain close to seismic vessel during airgun operation.	PTS unlikely to occur unless exposed to airgun pulses >240 dB re 1 µPa (rms) in immediate vicinity of largest airguns (Richardson et al. 1995; Caldwell and Dragoset 2000).	Unlikely due to avoidance of seismic vessels; non-auditory physical effects would be limited to short distances.	Behavioural exposures likely; potential injury not expected due to behavioural avoidance. Long-term or population-level effects not expected.

Species or Groups	Masking	Disturbance	TTS	Injury or PTS	Other Physiological Effects	Comments
		seismic vessel within <250 m (Holst et al. 2005b); captive false killer whales showed no obvious reaction to single noise pulses with a received level of ~185 dB re 1 μPa (rms) (Akamatsu et al. 1993).				
Risso's dolphin	Unidentified small delphinids heard calling between seismic pulses (Holst et al. 2005b), including possible Risso's dolphins (Smultea et al. 2004).	Seismic: Small odontocetes show limited avoidance of <1 km (Goold 1996a; Stone 2003; Gordon et al. 2004); delphinid densities during seismic vs. non-seismic range from no change to 8x less common during seismic operations (Holst et al. 2006; Moulton and Miller 2005).	TTS unlikely to occur unless dolphins are exposed to repeated airgun pulses of 200 - 210 dB re 1 μPa (rms) within ~100 m radius of airguns; possible exposure when bow- or wake- riding although sounds considerably reduced at/near water surface.	See blackfish, above.	Auditory impairment or other non-auditory physical effects unlikely and limited to short distances from acoustic source.	Reactions to large airgun arrays seem to be confined to smaller radius than has been observed for mysticetes; a more appropriate threshold for onset of disturbance for delphinids and Dall's porpoise is considered to be 170 dB re 1 μPa (rms); also see beluga above.
Common dolphins- *Delphinus* spp.	Heard calling between seismic pulses (Smultea et al. 2004); increase in mean frequency during seismic operations (Wakefield 2001).	See Risso's dolphin above.	See Risso's dolphin above.	See blackfish above.	See Risso's dolphin above.	See Risso's dolphin above.
Fraser's dolphin	Unidentified small delphinids heard calling between seismic pulses	See Risso's dolphin above.	See Risso's dolphin above.	See blackfish above.	See Risso's dolphin above.	See Risso's dolphin above.

Species or Groups	Masking	Disturbance	TTS	Injury or PTS	Other Physiological Effects	Comments
	(Smultea et al. 2004; Holst et al. 2005b).					
Bottlenose dolphin - Tursiops spp.	Unidentified small delphinids heard calling between seismic pulses (Holst et al. 2005b), including possible bottlenose dolphins (Smultea et al. 2004)	See Risso's dolphin above; multiple individuals approached active seismic vessels to <15 m (Smultea et al. 2004; Holst et al. 2005b).	See Risso's dolphin above; captive bottlenose dolphin tolerated levels of 192 to 221 dB re 1 μPa (rms) with no TTS (Schlundt et al. 2000; Finneran et al. 2000); TTS onset estimated at 195 dB re 1 μPa2 ·s (Finneran et al. 2005).	See blackfish above.	Auditory impairment or other non-auditory physical effects would be limited to short distances; neural-immune changes in captive bottlenose in response to noise exposure of up to 228 dB re 1 μPa (rms) were minimal and returned to normal within 24 hr (Romano et al. 2004).	See Risso's dolphin above.
Stenella spp.	Heard calling between seismic pulses (Smultea et al. 2004).	See Risso's dolphin above; multiple individuals approached active seismic vessels to <5 m and some bow-rode (Haley and Koski 2004; Holst et al. 2005b; Smultea et al. 2004).	See Risso's dolphin above.	See blackfish above.	See Risso's dolphin above.	See Risso's dolphin above.
Lagenorynchus spp.	Unlikely	See Risso's dolphin above.	See Risso's dolphin above.	See Blackfish above.	See Risso's dolphin above.	See Risso's dolphin above.
Steno - Rough-toothed dolphin	See Fraser's dolphin above.	See Risso's dolphin above.	See Risso's dolphin above.	See blackfish above.	See Risso's dolphin above.	See Risso's dolphin above.
***Lissodelphis* spp.**	Unlikely	Unknown	Unknown.	Unknown.	Unknown	See beluga above.
Porpoises - Phocoena spp.	Harbour porpoises were silent or left area during pulsed pile-driving sound (Tougaard et al.	Seismic: Avoidance reported at <145 dB re 1 μPa (rms) at > 70 km (Bain and Williams 2006).	Unlikely due to avoidance of seismic vessels	Unlikely due to avoidance of seismic vessels	Unlikely due to avoidance of seismic vessels.	See beluga above.

Species or Groups	Masking	Disturbance	TTS	Injury or PTS	Other Physiological Effects	Comments
	2005).					
Dall's porpoise	Unlikely.	Seismic: Limited avoidance (Calambokidis and Osmek 1998); individuals approached active seismic vessels to <15 m and bow-rode (MacLean and Koski 2005); more tolerant of seismic activity and vessel traffic than harbour porpoise (MacLean and Koski 2005; Bain and Williams 2006).	See Risso's dolphin above.	See Blackfish above.	See Risso's dolphin above.	A more appropriate threshold for onset of disturbance for delphinids and Dall's porpoise is considered to be 170 dB re 1 μPa (rms) (L-DEO and NSF 2006a); also see beluga above.

6.4.3.1 Masking

Studies of reactions of odontocetes to sonar are very limited. Gerrodette and Pettis (2005) assessed odontocete reactions to an echo-sounder and an acoustic Doppler current profiler (ADCP) operated from oceanographic vessels in the ETP during 1998-2000. Results indicated that when the echo-sounder and ADCP were on, spotted and spinner dolphins were slightly more, and beaked whales less likely, to be detected during visual surveys (Gerrodette and Pettis 2005). Adverse reactions from odontocetes to the echo-sounder to be used in the proposed seismic survey are possible, but are not expected to occur.

Compared to mysticetes, odontocetes are considered less susceptible to masking of natural sound, because the low frequencies typically produced by industrial activities generally do not fall within the best hearing sensitivity of odontocetes (Table 6-5). Furthermore, airgun sounds are pulsed, with quiet periods between pulses, so that cetacean calls can often be heard between the seismic pulses (Smultea et al. 2004; Holst et al. 2005a, 2005b, 2006). Although there has been one report that sperm whales ceased calling when exposed to pulses from a very distant seismic ship (Bowles et al. 1994), more recent studies report that sperm whales continue to call in the presence of seismic pulses (Madsen et al. 2002; Tyack et al. 2003; Smultea et al. 2004). Some of these differences may be related to the degree of habituation of the animals to seismic sounds. Dolphins and porpoises are also commonly heard calling while airguns are operating (Gordon et al. 2004; Smultea et al. 2004; Holst et al. 2005a, 2005b). Available information indicates that the potential for masking of most odontocete calls by airguns is negligible.

Furthermore, echo-sounder signals also do not overlap the predominant frequencies of most odontocete calls (Table 6-5). In addition, the low duty cycle of echo-sounders and the brief period when an individual mammal is likely to be within its beam, reduce the possibility of significant masking of odontocete communications.

Broadband ship noise overlaps known hearing and sound production ranges of odontocetes (Richardson et al. 1995). The intensity and frequencies of underwater vessel sounds generally depend on vessel size and speed; larger vessels emit more sound than smaller vessels, and those underway with a full load, or those pushing or towing a load, are noisier than unladen vessels. Intense ship noise has been shown or hypothesized to adversely affect communication in some odontocetes. Lee et al. (2005) observed negative responses by rough-toothed dolphins to engine noise from large boats. Research on Cuvier's beaked whales showed that ship noise may reduce maximum sonar detection and maximum communication ranges by 43% and 18%, respectively, effectively reducing their ability to forage by up to 50% (Aguilar et al. 2005). Van Parijs and Corkeron (2001 in MMS 2006) found that vessel presence could affect acoustic behaviour of dolphins, particularly mother/calf pairs showing an increased rate of vocalization (perhaps in an attempt to maintain group cohesion) when vessels were present. Foote et al. (2004) noted that in the presence of whale watch boat traffic, killer whales extended the duration of their calls to counteract increasing anthropogenic sound once it reached a critical level.

6.4.3.2 Disturbance

Disturbance can include a variety of effects, including subtle changes in behaviour, more conspicuous changes in activities, and displacement. Little systematic information is available about reactions of odontocetes to pulsed sound; few studies similar to the more extensive mysticete/seismic pulse work summarized above have been reported for odontocetes. However, a systematic study on sperm whales has been reported (Jochens and Biggs 2003; Jochens et al. 2006; Tyack et al. 2003; Miller et al. 2006), and there is an increasing amount of information about responses of various odontocetes to seismic surveys based on monitoring data (Stone 2003; Smultea et al. 2004; Bain and Williams 2006; Holst et al. 2006; Stone and Tasker 2006; Moulton and Miller 2005).

In general, there seems to be a tendency for most delphinids to show some avoidance of seismic vessels operating large airgun arrays. Small odontocetes sometimes move away or maintain a greater distance from the vessel, when large airgun arrays are operating than when they are silent (Goold 1996a, 1996b, 1996c; Calambokidis and Osmek 1998; Stone 2003; Stone and Tasker 2006). In most cases, the avoidance radii for delphinids appear to be small, in the order of 1 km or less (Moulton and Miller 2005; Holst et al. 2006). Beluga may, at least occasionally, avoid seismic vessels by longer distances; aerial surveys during seismic operations in the south-eastern Beaufort Sea recorded much lower sighting rates of beluga whales within 10-20 km of an active seismic vessel. These findings were consistent with the low number of beluga sightings reported by observers aboard the seismic vessel (Miller et al. 2005a). Similarly, very few belugas were observed during a recent seismic monitoring programme in the southeastern Beaufort Sea (Harris et al. 2007). Nonetheless, seismic operators and marine mammal observers have recorded dolphins and other small toothed whales near operating airguns; some dolphins (and Dall's porpoise) appeared to be attracted to the seismic vessel and floats, and rode the bow wave of the vessel even when large arrays of airguns were firing (e.g., MacLean and Koski 2005; Moulton and Miller 2005).

Captive bottlenose dolphins and beluga whales exhibited changes in behaviour when exposed to strong pulsed sounds similar in duration to those typically used in seismic surveys (Finneran et al. 2000, 2002, 2005; Finneran and Schlundt 2004). However, the animals tolerated high-received levels of sound (peak–peak level >200 dB re 1 µPa) before exhibiting adverse behaviours. For pooled data at 3, 10, and 20 kHz, sound exposure levels during sessions with 25%, 50%, and 75% altered behaviour were 180, 190, and 199 dB re 1 µPa2 · s, respectively (Finneran and Schlundt 2004).

Results for porpoises depend on species. Dall's porpoises seem relatively tolerant of airgun operations (MacLean and Koski 2005; Bain and Williams 2006), whereas the limited available data suggest that harbour porpoises show stronger avoidance (Stone 2003; Bain and Williams 2006) at the lowest received level of sound (<145 dB re 1 µParms at a distance > 70 km). This apparent difference in responsiveness of these two porpoise species is consistent with their relative responsiveness to boat traffic in general (Richardson et al. 1995; Southall et al. 2007).

Most studies of sperm whales exposed to airgun sounds indicate that this species shows considerable tolerance of airgun pulses. In most cases, the whales do not show strong avoidance and they continue to call. However, controlled exposure experiments in the Gulf of Mexico indicated that foraging effort decreased when airgun pulses were fired by a seismic vessel operating in the area (Jochens et al. 2006); foraging behaviour was apparently disrupted by airguns at exposure levels ranging from <130 to 162 dB re 1 µPa (peak-peak) at distances of roughly 1–12 km from the source.

Weir (2008) found that the encounter rate of sperm whales during a seismic survey (using 5,085 in^{3}and 3,147 in^3 arrays) offshore Angola did not differ significantly when airguns were operating or silent, although the mean distance of sightings was greater when the airguns were operating. Atlantic spotted dolphin encounters, however, were significantly correlated to airgun operations, with encounters occurring at a significantly greater distance during full-array operations and approaches only occurring during guns-off periods (Weir 2008).

It is likely that beaked whales should normally show strong avoidance of an approaching seismic vessel, but this has not been documented explicitly. Most beaked whales tend to avoid approaching vessels of other types (Würsig et al. 1998),or may dive for extended periods when approached by a vessel (Kasuya 1986).

Northern bottlenose whales are sometimes quite tolerant of slow-moving vessels (Reeves et al. 1993; Hooker et al. 2001), although those vessels were not emitting airgun pulses; northern bottlenose whales have been observed from seismic vessels during periods of airgun operations (Moulton et al. 2006a, 2006b).

Odontocete reactions to large airgun arrays are variable and, at least for delphinids and some porpoises, seem to be confined to a smaller radius than has been observed for mysticetes. A ≥170 dB disturbance criterion (rather than ≥160 dB) is considered appropriate for delphinids that tend to be less responsive than other cetaceans. For example, Schlundt et al. (2000) reported that captive bottlenose dolphins and a beluga began to exhibit behavioural changes to 1-s tone bursts at received levels of 178-193 dB re 1 µPa (rms). However, other data suggest that some species that have poor low-frequency hearing may be more sensitive than previously thought. This may be the case under certain environmental conditions, when the output from seismic airguns includes energy at higher frequencies (DeRuiter et al. 2005; Goold and Coates 2006; Potter et al. 2006; Tyack et al. 2006). For example, several studies with limited observations suggested that sperm whales in the Southern Ocean and Gulf of Mexico might be fairly sensitive to airgun sounds from distant seismic surveys (Bowles et al. 1994; Mate et al. 1994; Jochens and Biggs 2003). Similarly, studies in the waters of British Columbia and Washington using large airgun arrays showed behavioural responses varied by species; the harbour porpoise, a high-frequency specialist, appeared to be the species affected by the lowest level of sound (Bain and Williams 2006).

During two National Science Foundation (NSF)-funded L-DEO seismic surveys, in which a large 20-airgun array (~7,000 in^3) was used, sighting rates of delphinids were lower, and initial sighting distances were farther away from the vessel during seismic than non-seismic periods (Smultea et al. 2004; Holst et al. 2005a, 2006). The mean CPA (closest possible approach) for delphinids for both cruises was significantly farther during seismic (1,043 m) than during non-seismic (151 m) periods. Surprisingly, during one of these cruises in the southeastern Caribbean, nearly all acoustic detections of odontocetes (including delphinids and sperm whales) were made during airgun operations (Smultea et al. 2004). In contrast, during the second survey (off the Yucatán Peninsula, Mexico), acoustic detection rates of odontocetes were nearly five times higher during non-seismic versus seismic periods (Holst et al. 2005a).

An analysis of observations taken during 201 seismic surveys in and near U.K. waters revealed that small odontocetes exhibited a wider range of responses to seismic surveys than did mysticetes or larger odontocetes, including significant declines in sighting rates during periods of seismic surveys (Stone and Tasker 2006). On the other hand, larger odontocetes (long-finned pilot whales, killer whales and sperm whales) showed little response to airgun activities, and no reduction in sighting rates was detectable during periods of seismic surveys. Stone and Tasker (2006) suggested that avoidance behaviours exhibited by small odontocetes, and to a lesser extent by other cetaceans, appeared to be temporary.

Two seismic surveys were completed in the Orphan Basin, off Newfoundland and Labrador, in 2004 and 2005 (Moulton et al. 2005, 2006a). During both surveys, dolphin-sighting rates[79] were higher during non-seismic periods than during seismic periods, although this difference was only statistically significant for the survey that took place in 2004. On the other hand, the mean CPA was significantly closer during non-seismic periods (652 m) compared to seismic periods (807 m) in 2005, but was not statistically significant in 2004 (705 m vs. 665 m, respectively). The sighting rates of large odontocetes – primarily sperm whales – and their CPAs did not differ statistically between seismic and non-seismic periods during both surveys. Similar results for odontocetes were observed during a marine mammal monitoring programme in the Laurentian Sub-basin (Moulton et al. 2006b).

[79] Taking temporal variation into consideration

In cases where odontocetes occur in channels and inlets that are sufficiently narrow to be ensonified across their width, received sound levels may quickly exceed the threshold for the onset of disturbance; if animals are unable to swim far enough to the side of the track line, disturbance could be more severe, and they might be driven ahead of the ship, increasing the scale of geographic displacement (Bain and Williams 2006).

Odontocetes may respond behaviourally to the presence of vessels, although responses are variable. Some species, especially delphinids, commonly approach vessels while others, mostly beaked whales, tend to avoid approaching vessels (Würsig et al. 1998). All three species of sperm whales have been reported to show avoidance reactions to standard vessels not emitting airgun sounds (Richardson et al. 1995; Würsig et al. 1998), and it is to be expected that they would tend to avoid an operating seismic survey vessel. None of these effects are expected to result in significant adverse effects on individuals or at the population level (see review in Richardson et al. 1995).

Reactions of free-ranging odontocetes to sonar appear to vary by species and circumstance. Observed reactions have included: silencing and dispersal in sperm whales (Watkins et al. 1985), increased vocalization and no dispersal in pilot whales (Rendell and Gordon 1999), and beachings in beaked whales. Various dolphin and porpoise species have been seen bowriding while multi-beam bathymetric (MBB) sonar, sub-bottom profilers (SBP), and airguns were operating during NSF-sponsored seismic surveys (Smultea et al. 2004; Holst et al. 2005a, 2005b; MacLean and Koski 2005).

Captive bottlenose dolphins and a white whale exhibited changes in behaviour when exposed to 1 s pulsed sounds at frequencies similar to those emitted by MBB sonar (but different in duration and bandwidth). Behavioural changes involved apparent deliberate attempts to avoid the sound energy (Schlundt et al. 2000; Finneran et al. 2002; Finneran and Schlundt 2004). The relevance of those data to free-ranging odontocetes is uncertain. The pulsed signals from typical seismic echo-sounders are weaker than those from MBB sonar. Therefore, behavioural responses are not expected unless marine mammals are very close to the source.

In summary, behavioural disturbance of some odontocetes is possible during the proposed seismic survey, due mainly to airgun operations. However, given the intermittent nature of pulsed seismic sounds, the relatively low noise levels of the proposed 160 in^3 2D survey (compared to large-scale 3D surveys), plus the relatively low-sensitivity of most odontocetes to low frequencies, impacts would likely be short-term and insignificant at the population level. Disturbance of odontocetes by the echo-sounder is also possible, but potential exposure of individual odontocetes would be brief and few in number.

6.4.3.3 Temporary Hearing Impairment

The majority of empirical data on sound exposure and onset of TTS in captive bottlenose dolphins and belugas relate to studies with non-impulse sound; there are limited data on TTS in response to a single pulse of sound from a watergun (Finneran et al. 2002). A detailed review of these data can be found in Southall et al. (2007).

In toothed whales, TTS threshold appears to firstly be a function of the total energy of the pulsed sound (Finneran et al. 2002, 2005). Finneran et al. (2005) also examined the effects of tone duration on TTS in bottlenose dolphins, exposed to 3 kHz tones for periods of 1, 2, 4 or 8 s, and hearing tested at 4.5 kHz. For one second exposures, TTS occurred at SELs[80] of 197 dB, while for exposures >1 s, SEL >195 dB resulted in TTS. At an SEL of 195 dB, the mean TTS (4 min after exposure) was 2.8 dB. Finneran et al. (2005) suggested that an SEL of 195 dB is the likely threshold for the onset of TTS in dolphins and beluga exposed to mid-frequency

[80] SEL is equivalent to energy flux, in dB re 1 μPa2 · s

tones of durations 1-8 seconds; i.e., TTS onset occurs at a near-constant SEL, independent of exposure duration. Their work implies that a doubling of exposure time results in a 3 dB lower TTS threshold.

Mooney et al. (2005) exposed a bottlenose dolphin to octave-band noise ranging from 4 to 8 kHz at SPLs of 160 to 172 dB re 1 µPa for periods of 1.8 to 30 min. Recovery time depended on the shift and frequency, but full recovery always occurred within 40 min. Consistent with the results of Finneran et al. (2005), who used shorter exposures, Mooney et al. also reported an inverse relationship of exposure time and SPL; as exposure time was halved, an increase in noise SPL of 3 dB was required to induce the same amount of TTS.

Based on available data[81], the received energy of a single seismic pulse (with no frequency weighting) would need to be ~ 186 dB re 1 µPa^2 · s (i.e., 186 dB SEL or 221–226 dB peak–peak) in order to produce brief TTS. Assuming that TTS threshold is a function of total received pulse energy (as discussed above), exposure to several strong seismic pulses that each have received levels near 175–180 dB SEL might result in TTS in a small odontocete. Seismic pulses with received energy levels ≥170 dB SEL (180 dB rms) are expected to be restricted to radii no more than 500 m around the airguns (see Figure 6-3). For an odontocete closer to the surface, the maximum radius with ≥175–180 dB SEL or ≥190 dB rms would be smaller. Based on available behavioural studies, many of the toothed whales that might occur within this distance of the track line will move away as the seismic vessel approaches (see above).

These data reflect an earlier conclusion of a panel of bioacoustics specialists – convened by the NMFS before TTS measurements for marine mammals became available – that cetaceans should not be exposed to pulsed underwater sound at received levels exceeding 180 dB re 1 µPa (rms): the level above which, in the view of the panel, one could not be certain that there would be no injurious effects, auditory or otherwise, to cetaceans (NMFS, 1995, 2000).

As far as we are aware, there are no published data confirming that the auditory effect of a sequence of airgun pulses received by an odontocete is a function of their cumulative energy, although – as stated above – this would seem likely. According to Southall et al. (2007), one would expect that a given energy exposure would have somewhat less effect if separated into discrete pulses, with potential opportunity for partial auditory recovery between pulses. However, as yet there has been little study of the rate of recovery from TTS in marine mammals, and in humans and other terrestrial mammals the available data on recovery are quite variable. Southall et al. (2007) conclude that, until relevant data on recovery are available for marine mammals, it would be appropriate not to assume that there is recovery during the intervals between pulses within a pulse sequence.

With the implementation of monitoring and mitigation measures such as those described in Chapter 8, there is less potential for seismic surveys to cause physical effects on odontocetes. If some odontocetes did experience hearing impairment, the effects would likely be TTS rather than PTS. Furthermore, any odontocetes potentially occurring near the track line would likely move away from the approaching seismic vessel before it was close enough to cause TTS.

6.4.3.4 Permanent Threshold Shift

Southall et al. (2007) estimated that received levels would need to exceed the TTS threshold by at least 15 dB for a risk of PTS. Thus, they estimate that the PTS threshold for cetaceans might be a cumulative SEL (for the sequence of received pulses) of ~198 dB re 1 µPa^2 · s. Southall et al. (2007) also noted that, regardless of the cumulative received energy (SEL), there

[81] The above information on TTS in odontocetes was derived from studies of bottlenose dolphin and beluga; there is currently no published TTS information for other types of cetaceans. However, preliminary evidence from a harbour porpoise exposed to airgun sound suggests that its TTS threshold may have been lower (Lucke et al. 2007).

is concern about the possibility of PTS if a cetacean received one or more pulses with a very high peak pressure.

Based on data from terrestrial mammals, Southall et al. (2007) suggested a precautionary assumption that impulse sounds with received peak pressure ≥6 dB above the TTS threshold might cause immediate PTS. A peak pressure of 230 dB re 1 μPa (3.2 bar · m, 0-pk) would only be found within a few meters of the largest airguns used in most airgun arrays (Caldwell and Dragoset 2000). Figure 6-3 and Figure 6-4 depict the modelled sound levels of the proposed high resolution 2D seismic survey.

6.4.3.5 Strandings and Mortality

The occurrence of mass strandings of beaked whales in the vicinity of naval exercises – and in one case in the vicinity of a seismic survey – suggests that beaked whales exposed to strong-pulsed sounds may be particularly susceptible to injury and/or behavioural reactions that lead to stranding.

Evidence that MF sonar pulses can lead to physical damage and mortality includes work by Balcomb and Claridge (2001), NOAA and the U.S. Navy (2001), Jepson et al. (2003), Fernández et al. (2004, 2005a), and Cox et al. (2006).

In September 2002, two Cuvier's beaked whales stranded in the Gulf of California, Mexico, when the R/V Ewing was operating an 8,490-in^3 airgun array nearby; although the link between the stranding and the seismic surveys was inconclusive (Hogarth 2002; Yoder 2002). Nonetheless, that incident and other incidents involving beaked whale strandings near naval exercises using loud sonars, suggests a need for caution in conducting seismic surveys in areas where beaked whales occur.

In September 2006, one carcass of Baird's beaked whale was found by Sakhalin Energy's carcass survey team stranded and in a state of advanced decomposition on a beach between Piltun and Chaivo Lagoons; in September 2007, a carcass of Cuvier's beaked whale was found decomposing in the water near PA-B. In both cases, according to the reports submitted to the WGWAP, cause of death was unclear and no link to any industrial activity was evident.

No injuries of beaked whales are anticipated during the proposed study due to the project location and the proposed monitoring and mitigation measures.

6.4.3.6 Other Physiological Effects

As mentioned in previous sections of this report, non-auditory physiological effects or injuries that might occur in marine mammals exposed to strong underwater sound include neurological effects, bubble formation, and other types of organ or tissue damage. Sound has also been accepted as a potential source of stress that may seriously disrupt communication, navigational ability and social patterns; however, little information is available on the effects of sound on the long-term wellbeing or reproductive success of marine mammals (Fair and Becker 2000).

Until recently, it was assumed that diving marine mammals are not subject to risk of air embolism. This possibility was first explored at a workshop held to discuss whether the stranding of beaked whales in the Bahamas in 2000 might have been related to bubble formation in tissues caused by exposure to sound from naval sonar (Balcomb and Claridge 2001; NOAA and U.S. Navy 2001; Gentry 2002). However, opinions at the workshop were inconclusive. Jepson et al. (2003) first suggested a possible link between MF sonar activity and acute and chronic tissue damage resulting from the formation of gas bubbles in vivo, based on the beaked whale stranding in the Canary Islands in 2002 during naval exercises. Fernández et al. (2005a) showed that those beaked whales did indeed have gas bubble-associated lesions as well as fat embolisms. Fernández et al. (2005b) also found evidence of fat embolism in three beaked whales that stranded 100 km north of the Canary Islands in 2004 during naval exercises. Examinations of several other stranded species have also revealed evidence of gas and fat embolisms (Arbelo et al. 2005; Jepson et al. 2005a; Méndez et al. 2005).

Cuvier's beaked whales comprise 81% of all stranded animals associated with sound events, while other beaked whales, including Gervais' beaked whale, Blainville's beaked whale and North Atlantic bottlenose whale account for 14%, and other cetaceans, including striped dolphin, pygmy sperm whale, and *Balaenoptera* spp., make up the rest (Hildebrand 2005). There is speculation that gas and fat embolisms may occur if cetaceans ascend unusually quickly when exposed to aversive sounds, or if sound in the environment causes the destabilization of existing bubble nuclei (Potter 2004; Arbelo et al. 2005; Fernández et al. 2005a; Jepson et al. 2005b; Cox et al. 2006). Even if gas and fat embolisms can occur during exposure to MF sonar, there is no evidence that that type of effect occurs in response to airgun sounds.

Some odontocetes, like beaked whales, show behavioural avoidance of seismic vessels and are therefore unlikely to incur auditory impairment or other physical effects. Monitoring and mitigation measures, including shut downs, further reduce the risk that such effects might occur.

6.4.4 Known and Potential Acoustic Effects on Pinnipeds

This section discusses acoustic effects (masking, disturbance, temporary and permanent hearing impairment), and other physiological effects of noise and disturbance on pinnipeds. Few studies on the reactions of pinnipeds to airguns and sonar have been published, and the biological significance of any effects and potential effects at the population scale are largely unknown.

As with odontocetes, pinnipeds typically hear and produce sounds at higher frequencies than those produced by airguns, and are therefore expected to be less affected by airgun operations than mysticetes. Echo-sounder frequencies occur in hearing range of pinnipeds; however, the pulses are short, and the beams narrow, and therefore pinnipeds at depth near the track line would only be subjected to brief exposure of this noise. Effects of these sonar on pinnipeds have not been reported.

Although the frequencies of sounds emitted by ship engines and hulls overlap with frequencies associated with pinniped hearing, the effects of vessel noise on pinnipeds have been variable (Table 6-6; reviewed in Richardson et al. 1995 and NRC 2003). Studies indicate that vessel noise may cause behavioural changes in some individuals and species, while in others there was no apparent response, or habituation and even attraction occurred (Richardson et al. 1995).

While various pinnipeds have been shown to react behaviourally to airgun pulses under some conditions, at other times they have shown no overt reactions (Richardson et al. 1995). In general, pinnipeds seem to be more tolerant of exposure to airgun pulses than mysticetes.

6.4.4.1 Masking

Like mysticetes and odontocetes, the masking effects of pulsed sound on pinniped calls are expected to be limited, given the intermittent nature of the noise, and that pinnipeds communicate at much higher frequencies than airgun sounds. Although some pinnipeds have good hearing ability, this does not necessarily mean that loud noise will not have masking effects (Southall et al. 2000). In fact, several species of pinnipeds, including harp and bearded seals, have been shown to produce distinct calls to avoid masking each other (e.g., Watkins and Schevill 1979; Terhune 1994, 1999; Serrano and Terhune 2001, 2002). Masking effects due to the echo-sounder are expected to be minimal or non-existent due to their directionality and the brief period when an individual pinniped is likely to be within the sonar beam.

Table 6-9. Summary of Known and Anticipated General Effects of Seismic Sounds from Airguns on Pinnipeds.

Species or Group	Masking	Disturbance	Temporary Hearing Impairment or TTS	Injury or PTS	Other Physiological Effects	Comments
Russian red book-Listed : Steller sea lion (VU)	No data – non-existent or negligible short-term effects expected.	No data – some short-term changes in behaviour and/or localized avoidance possible based on other pinniped species (see Non-Red Book Listed below).	No data – unlikely to occur, expected to avoid sounds before TTS occurs.	No data – highly unlikely to occur, expected to avoid sounds before PTS occurs.	No data – no effects expected.	Disturbance impacts expected to be similar to those for non-listed species.
Non-Red book Listed	Few data – expected to hear sounds well in noisy environments.(1) Non-existent or negligible short-term effects expected.	Usually tolerant; some show changes in behaviour and/or short-term, localized avoidance.(2-6)	Has not been demonstrated for brief pulses as produced by airguns or sonars.(7) See above.	Has not been demonstrated. See above.	No data – no effects expected.	Some short-term behavioural changes and/or localized avoidance.

Notes: VU = Vulnerable.
Sources: [1] Southall et al. 2000; [2]Arnold 1996; [3]Calambokidis and Osmek 1998; [4]Harris et al. 2001; [5]Moulton and Lawson 2002; [6]Miller et al. 2005b; [7]Finneran et al. 2003.

6.4.4.2 Disturbance

Few studies have been published on the reactions of pinnipeds to sounds from open-water seismic exploration (Richardson et al. 1995). However, pinnipeds have been observed during a number of seismic monitoring studies (Table 6-9). Visual monitoring from seismic vessels has shown only slight (if any) avoidance of airguns by pinnipeds, and only slight (if any) changes in behaviour. Ringed seals frequently do not avoid the area within a few hundred meters of operating airgun arrays (Harris et al. 2001; Moulton and Lawson 2002; Miller et al. 2005b). However, telemetry work suggests that avoidance and other behavioural reactions by two other species of seals to small airgun sources may be stronger than evident from visual studies (Thompson et al. 1998).

There are currently no data on the potential disturbance effects of sonar on pinnipeds. Based on observed pinniped responses to other types of pulsed sounds, pinniped reactions to echo-sounders are expected to be limited, without lasting consequence to the animals. Behavioural responses are not expected unless marine mammals are very close to the source.

6.4.4.3 Temporary Hearing Impairment

TTS thresholds associated with exposure to brief pulses of underwater sound have not been measured in pinnipeds. Evidence from prolonged exposures suggests that some pinnipeds may incur TTS at lower received levels than for small odontocetes exposed for similar durations (Kastak et al. 1999, 2005; Ketten et al. 2001). Studies of TTS in pinnipeds showed varying results dependent on duration and received levels of sound (Kastak et al. 1999; Schusterman et al. 2000; Finneran et al. 2003). Kastak et al. (1999) documented that mild TTS occurred at received levels of about 135–150 dB re 1 μPa (rms) and that pinnipeds recovered to baseline hearing sensitivity within 24 hours of exposure. Longer exposure (i.e., 40 min vs. 20 min) lowered the TTS threshold, confirming that there is a duration effect in pinnipeds (Schusterman et al. 2000). Kastak et al. (2005) reported that the amount of threshold shift increased with increasing SEL in a California sea lion and harbour seal. They noted that, for non-impulse sound, doubling the exposure duration from 25 to 50 min (i.e., a +3 dB change in SEL) had a greater effect on TTS than an increase of 15 dB (95 vs. 80 dB) in exposure level. Mean threshold shifts ranged from 2.9–12.2 dB, with full recovery within 24 hr (Kastak et al. 2005). Kastak et al. (2005) suggested that, for non-impulse sound, SELs resulting in TTS onset in pinnipeds may range from 183 to 206 dB re 1 $\mu Pa^2 \cdot s$, depending on the absolute hearing sensitivity.

Onset of TTS in pinnipeds would occur at a lower cumulative SEL, assuming a greater auditory effect of broadband impulses with rapid rise times. The threshold for onset of mild TTS upon exposure of a harbour seal to impulse sounds has been indirectly estimated as being an SEL of ~171 dB re 1 $\mu Pa^2 \cdot s$ (Southall et al. 2007). That would be equivalent to a single pulse with received level ~181–186 dB re 1 μParms, or a series of pulses for which the highest rms values are a few dB lower.

At least for continuous noise, TTS onset occurs at appreciably higher received levels in Californian sea lions and northern elephant seals, than in harbour seals (Kastak et al. 2005). Thus, the former two species would likely need to be closer to airgun array before TTS would occur.

As far as we are aware, there are no specific data on the effects of echo-sounders on pinnipeds.

6.4.4.4 Permanent Threshold Shift

NMFS policy in the United States recommended that marine mammals, including pinnipeds, should not be exposed to impulsive sound ≥ 190 dB re 1 μPa (rms) (NMFS 2000); in the view of their panel of bioacoustics specialists, this was the level above which one could not be certain that there would be no injurious effects, auditory or otherwise.

Southall et al. (2007) estimate that the PTS threshold for harbour seals could be a cumulative SEL of ~186 dB re 1 $\mu Pa^2 \cdot s$; for the California sea lion and northern elephant seal the PTS threshold would likely be higher. Southall et al. conclude that PTS might occur if pinnipeds were exposed to peak pressures exceeding 230 or 218 dB re 1 μPa (peak). It is highly unlikely that a pinniped would remain within a few meters of an airgun or other acoustic source for sufficiently long to incur PTS.

6.4.4.5 Strandings and Mortality

No mortalities or strandings of pinnipeds have been linked to acoustic sources that would be used during the proposed seismic survey.

6.4.4.6 Other Physiological Effects

To date, potential physiological effects (such as stress, neurological effects, bubble formation, and other types of organ or tissue damage) of sonar or airgun noise on pinnipeds have not been examined. Marine mammals that show behavioural avoidance of seismic vessels, including some pinnipeds, are unlikely to incur such physiological damage.

6.4.5 Other Potential Impacts of Seismic Surveys on Marine Mammals

6.4.5.1 Entanglement

Entanglements occur when marine mammals become caught in cables, lines, nets, or other objects suspended in the water column. During seismic operations, numerous cables, lines, and other objects primarily associated with the airgun array and hydrophone streamers will be towed behind the survey ship near the water's surface. Incidents of entanglement by mysticetes in fishing gear are well known. Heyning and Lewis (1990) noted that eastern gray whales were the most frequently entangled species (94% of records) in Southern California. Most of the entangled gray whales were 3 years of age or younger (<10 m in length), and many of the live entanglements were released alive; it is unknown whether entanglement has any long-term effects on live-released whales (Moore and Clarke 2002). Visual observations during the proposed survey will monitor the towed array and other equipment. Cetaceans would be expected to avoid the seismic vessel, further lessening the likelihood of any impacts related to entanglements.

Incidents of entanglement of pinnipeds in fishing gear and other marine debris are also well known (Arnould and Croxall 1995; Hanni and Pyle 2002; Page et al. 2004). Northern fur seals have been particularly susceptible to entanglement. In some years over 50,000 fur seals in Alaskan waters were dying from entanglement in fishing nets and strapping bands (NRC 1995). So great was the mortality of northern fur seals, that their population was deemed directly threatened by entanglement. Visual observation of the area surrounding the seismic vessel during the survey will ensure that any close approaches to the equipment by pinnipeds are monitored and the appropriate action taken to ensure that entanglements do not occur.

6.4.5.2 Ingestion

In the highly unlikely event of an oil or fuel spill, marine mammals could ingest oil with water, contaminated food, or oil could be absorbed through the respiratory tract. Mysticete species like the humpback and right whales that feed in constricted areas (e.g., bays) may be at greater risk of ingesting oil (Würsig 1990). Some of the ingested oil is voided in vomit or faeces but some is absorbed and could cause toxic effects (Geraci 1990). When returned to clean water, contaminated animals can expel this internal oil through urine or faeces (Engelhardt 1978, 1982). Marine mammals exposed to an oil spill are unlikely to ingest enough oil to cause serious internal damage (Geraci and St. Aubin 1980; 1982), and any effects are probably reversible (Spraker et al. 1994).

Cetaceans may also inhale vapours from volatile fractions of oil from a spill. The most likely effects of inhalation of these vapours would be irritation of respiratory membranes and absorption of hydrocarbons into the bloodstream (Geraci 1990). Stressed individuals that could not escape a contaminated area would be most at risk. Seals are also at risk from hydrocarbons and other chemicals that evaporate from spills. Seals generally keep their nostrils close to the water surface when breathing, so they are likely to inhale vapours if they surface in a contaminated area. Grey seals that presumably inhaled volatile hydrocarbons from the Braer oil spill exhibited a discharge of nasal mucous, but no causal relationship with the oil was determined (Hall et al. 1996). Laboratory studies of ringed seals indicate that the inhalation of hydrocarbons may cause more serious effects like kidney and liver damage (St. Aubin 1990). However, exposure conditions were much higher than would be expected in a natural setting.

In mysticetes, crude oil could coat the baleen and reduce filtration efficiency. However, effects would be minimal and reversible. The filtration efficiency of baleen did not change when experimentally fouled with oil (St. Aubin et al. 1984), and most adherent oil was removed within 30 min after fouling (Geraci and St. Aubin 1985). The effects of oiling of baleen on feeding efficiency appear to be only minor (Geraci 1990).

The proposed survey will have an approved oil spill response plan in place to ensure a prompt response to any incident.

6.4.5.3 Ship Strikes

Studies indicate that vessel traffic may have negative impacts on marine mammals, particularly baleen whales, through collisions (e.g., Moore and Clarke 2002; Jensen and Silber 2003). Efforts are usually made by vessel operators to avoid marine mammals; in addition to injury or death of the animal, such collisions can result in damage to the vessel. Many species of baleen whales tend to show avoidance in response to vessels (reviewed in Richardson et al. 1995; Macleod et al. 2006). However, avoidance does not always prevent collisions, injury, and mortality of whales, especially for the slower-swimming species such as right whales (reviewed in Richardson et al. 1995; Jensen and Silber 2003).

Collisions between ships and marine mammals occur in many parts of the world and has been summarized by Laist et al. (2001) and Jensen and Silber (2003). These datasets indicate that migrating gray whales appear more susceptible to collisions compared to other whale species (Laist et al. 2001). In the North Atlantic, endangered right whales are also known to be highly susceptible to vessel collisions, experiencing significant mortality and damage from collisions (Richardson et al. 1995; Laist et al. 2001; Jensen and Silber 2003). Shipping has been restricted in some areas of the Northwest Atlantic, such as the Bay of Fundy, during times when right whales congregate there. Off the east coast of the U.S., NMFS has recommended vessel routes and vessel speed reductions to reduce the number of collisions. Collisions have also been reported for other species of mysticetes, including humpback, fin, and minke whales (Barlow et al. 1994; Richardson et al. 1995; Laist et al. 2001; Jensen and Silber 2003).

Although most whales try to avoid ships, collisions do occur when a whale attempts to flee ahead of the vessel (Richardson et al. 1995). Whales to the side or beneath the vessel can also be dragged into the vessel’s propeller by the low pressure wave around the vessel (Knowlton et al 1998). The likelihood of collisions increases during darkness and poor weather conditions, particularly fog, thunderstorms, and high seas. Particular care is needed to minimize the chance of collisions during poor visibility. It is unknown whether whales are always killed by such impacts. It also appears likely that most impacts are not reported. For example, large vessels may be unaware that an impact has occurred. Often, impacts are only realized after-the-fact if the whale remains caught on the front of the ship when the vessel enters port. Pinnipeds can probably move quickly enough to avoid collisions with ships. However, when feeding, pinnipeds may be inattentive to vessels. Fur seals are attracted to fishing vessels to feed and some are killed by the propellers (Richardson et al. 1995). Sea lions and seals have been seen with wounds and disfigurements caused by the propellers of powerboats. Between 1996 and 2000, two northern elephant seals were struck and killed due to ship strikes off California (Monterey Bay National Marine Sanctuary 2006).

Evidence suggests that a greater rate of mortality and serious injury correlates with a greater vessel speed at the time of a ship strike (Laist et al. 2001; Vanderlaan and Taggart 2007). Most lethal and severe injuries to large whales resulting from documented ship strikes have occurred when vessels were travelling at 14 knots or greater (Laist et al. 2001). Vanderlaan and Taggart (2007), using a logistic regression modelling approach based upon vessel strike records, found that for vessel speeds greater than 15 knots, the probability that a collision will result in a lethal injury (mortality or severely injured) approaches 1. The probability that a collision will result in lethal injury declined to approximately 20 % at speeds of 8.6 knots and to less than 5 % at of 4 knots (Vanderlaan and Taggart 2007). Considering the reduced speed at which seismic survey vessels travel during periods of active seismic surveying (typically 4.5 to 5 knots), plus the extra noise that they emit relative to routine vessel traffic, the risk of lethal injury from a vessel strike, would be limited.

A modelling exercise undertaken to assess the monthly risk of collisions along typical Sakhalin Energy vessel routes (e.g., Korsakov to PA-A, Kaigon to PA-A, PA-A to PA-B) suggested a low number of expected monthly ship/whale encounters with Sakhalin Energy vessels in Sakhalin Island waters per route, with a range of 0.00 to 0.10 expected encounters during the June-July time period and a range of 0.00 to 0.20 expected encounters during the August-September time period (Muir et al. 2006). To translate expected encounters into expected ship strikes, it is necessary to adjust for evasive action taken by whales and/or vessels prior to a possible encounter. While the model allowed the avoidance and observer variables to be adjusted, these could only be tested as a sensitivity analysis because data were not available to estimate these parameters. There have been no ship strikes associated with industrial activity in north-east Sakhalin Island. Mitigation measures implemented by Sakhalin Energy (SEIC 2007) and detailed in Sakhalin Energy's Marine Mammal Protection Planappear to have been effective at minimizing the risk. SEIC reports annually on this to WGWAP, Lenders, environmental consultants and Russian Federation authorities, The model does suggest that the risk of ship strikes could increase during periods of low visibility or high sea state and thus additional, enhanced, mitigation measures may be warranted during certain conditions (see Chapter 8 for more information on mitigation measures for the proposed survey).

The risk of collision with marine mammals exists but is extremely unlikely due to the slow operating speed of the seismic and other site survey vessels. The presence of on-board observers substantially minimizes the risk of ship strikes.

6.4.6 Impact Assessment of the Proposed Survey on Marine Mammals

Given concerns about the impacts of seismic surveys on marine mammals in general, and the potential impacts on endangered species in particular, significance criteria summarized in §6.2.6 have been further defined: impact significance can be related to the numbers of individuals affected or the degree of the impact on the individuals (e.g. mortality, sub-lethal effects, or exclusion attributable to disturbance). For example, for critically endangered species, the death of one individual, or the exclusion of a group of individuals from their feeding areas for more than one month, would be defined as a major impact (SEIC 2003).

6.4.6.1 Mysticetes

Unmitigated impact on mysticetes (excluding Gray Whale) by the proposed survey is likely to be of low magnitude, local or district-wide in scale, and of short duration. The impact significance is considered *moderate* due to the possibility of PTS, TTS, collisions, and localized disturbance.

Impacts on Gray whales

Systematic aerial, vessel, and two (behaviour and vehicle) shore-based scan surveys to monitor the seasonal distribution and number of Gray Whale along the NE Sakhalin coast have been conducted on an annual basis since 2002 (Würsig et al. 2003; Blokhin et al. 2003a, 2003b; Maminov 2004; Gailey et al. 2005, 2006, 2007, 2008, 2009, 2010; Vladimirov et al. 2005, 2006, 2007, 2008, 2009, 2010; Meier et al. 2007; Yazvenko et al. 2007a, 2007b).

These surveys have been designed to provide quantitative information on:

- The distribution and number of Gray Whale (all surveys) and Gray Whale feeding plumes in the Piltun feeding area (aerial surveys); and
- The distribution and number of Gray Whale in the Offshore feeding area and over a broader area of the NE Sakhalin shelf (aerial and vessel surveys).

The Gray Whale distribution data from these systematic surveys were analyzed to produce estimates of whale densities at 1 km^2 resolution. The analysis involved a method developed by LGL Limited, West Inc., and with the University of St. Andrews; the latter are developers of the Distance Sampling software (Thomas et al. 2006) used in those analyses.

The Piltun feeding area was divided into a grid of 1.0 x 1.0 km cells, and a Gray Whale density estimated for each cell that has been sampled by each systematic survey. Distribution data from the period 26 September to 19 October 2004, when non-Sakhalin Energy geophysical seismic surveys were underway were excluded from the Gray Whale density analysis because of the possibility that gray whale distribution was affected by those surveys.

Sensitivity tests were conducted to investigate the potential effects of parameter values (grid cell size, grid cell shape, and length of the time period used to sample the survey data) on density estimates and consequently on the number of Gray Whale estimated to be within a study area. These tests showed that the 1 km × 1 km grid cell configuration used in the gray whale density analysis provided an adequate estimation of density and associated estimates of the number of whales present in a study area. In addition, results of the time interval tests demonstrated that using fewer than 15 consecutive days to sample the density data could introduce bias in the average grid densities and the number of Gray Whale estimated to occur in a study area (IUCN 2007).

Before performing the density calculations, Gray Whale sightings were corrected for two types of bias that typically result in underestimation of animal abundance (Marsh and Sinclair 1989):

- **Availability bias**: The probability that Gray Whales are available to be seen at the surface during a particular survey based on the amount of time an area of water is observed during the survey (dependent on the size of the area in view, and the aerial/vessel survey speed or binocular scanning rate at shore-based stations), and the Gray Whale surface-respiration-dive cycle in the survey year (Würsig et al. 2003; Gailey et al. 2004, 2005, 2006, 2007, 2008. 2009, 2010).
- **Perception bias**: The probability that an observer will perceive an available gray whale.

Distance sampling (Buckland et al. 2001, 2004) was used to analyze the effects of distance and other factors (e.g. sea state and Gray Whale group size) on the probability of detecting an available gray whale. Distance 4.1 (Thomas et al., 2003) and Distance 5.0 (Thomas et al., 2006) were used to model detection functions for the aerial and vessel-based surveys, respectively. The shore-based detection function was assumed to be flat (i.e. the detection probability does not decrease with increasing distance from the observation station) for up to 0.1 reticle radial distance (range 4.5 to 10.8 km) from each shore station, to a maximum of 8 km distance. This detection function is based on an analysis conducted by the University of St. Andrews. The model they fitted included both shore-based and ship-based sightings in a joint analysis to estimate parameters of a shore-based detection function. An important assumption of the analysis is that the detectability of whales from the ship does not depend on distance from shore. In addition, the effects on the shore-based detection function of variables other than distance were not considered. Gray Whale sightings made from shore beyond the maximum distance assumed for a flat detection function at a shore-based observation station were excluded from the density analysis.

A Gray Whale density was estimated for each grid cell that was sampled during a particular survey by summing that survey's corrected Gray Whale sightings in that grid cell, and then dividing by the area that was surveyed in the grid cell. An estimated density of zero was assigned to a grid cell if that cell was surveyed and no Gray Whales were sighted within it. The grid cell Gray Whale densities estimated for each survey were maintained in a database that allowed them to be extracted for selected combinations of survey type and time period. These estimates were then averaged within each grid cell to create Gray Whale density surface maps at several temporal scales (e.g., monthly, yearly) that depicted the Gray Whale spatial distribution and abundance at a resolution of 1.0 km^2 for the surveyed area off the northeast Sakhalin Island coastline. Figure 5-11shows the average Gray Whale density in each surveyed grid cell based on all distribution data from the 2005 to 2009 aerial, vessel and shore-based vehicle surveys.

Gray Whale density estimates and opportunistic vessel Gray Whale sightings during June-July for the years 2005-2007 were used to provide a basis for estimating the boundary of the Piltun feeding area that contained 95% of the Gray Whale population in this area. The 95% boundary (or contour) was then used to delineate the monitoring line at the perimeter of the nearshore feeding area (see Chapter 8) and to predict the proportion of the Piltun feeding area that could potentially be impacted by the planned seismic survey. Data for June-July were used because this is the time period when the proposed survey is planned to occur, and when Gray Whales are migrating into the area and densities are low compared to later in the year. The years 2005-2007 were selected because of the more intensive sampling effort from the shore-based distribution scan surveys, and to exclude data from 2004 when Gray Whales were concentrated in deeper water than usual in the northern part of the feeding area and the distribution was deemed unusual (Vladimirov et al. 2005). Note that there was no shore-based survey effort during June-July in 2008, and little effort during these months in 2009 due to poor weather.

The 95% contour for the Piltun feeding area was estimated using geostatistical methods that utilized all data that have been collected in the study area by different platforms (IUCN 2009). This approach allowed gray whale (Gray Whale) sightings and effort from the opportunistic vessel data set to supplement the systematic survey data. In particular, survey effort from the opportunistic vessel surveys was used to try to 'fill in' the 'zero effort' gaps in the Gray Whale density maps that were created from systematic survey data. A relative (Gray Whale) average density surface for 1 km by 1 km grid cells was first created for each of the two data sets (i.e., opportunistic and systematic). The two density surfaces were calibrated and combined. Geostatistical methods were then used to interpolate and extrapolate whale density for those grid cells with no effort and to provide a smoothed predicted relative density surface for the entire area of interest. Finally, a contour line that enclosed 95% of the estimated Gray Whale densities in the final relative density surface was calculated. A 20 km segment of this contour located adjacent to the 4D seismic survey area was extracted and used as an estimate of the perimeter monitoring line (PML).These data and the 95-percentile boundary for June-July 2005-2007 have been agreed by the WGWAP / SSTF, and have been referenced during engagement on the proposed site survey.

Figure 6-4 overlays sound level contours from JASCO's predictive modelling of the proposed PA-C 2D survey, on the 95-percentile boundary of Gray Whale distribution density – taken as a proxy for the boundary of the Piltun feeding area. The figure shows that – for the shot point closest to shore – per pulse sound levels reduced to ~140 dB re 1μPa^2-s at interception with the 95-percentile boundary of the grey whale distribution, i.e. below the 156dB SEL[82]limit adopted by Sakhalin Energy (and the WGWAP)to trigger specific mitigation measures[83]. Similarly, Figure 6-5 indicates that the 156dB SEL contour from source located at nearshore endpoints of the E-W survey lines would be more than 4 km from the 95-percentile boundary of the Piltun feeding area. Consequently, these modelling studies indicate that whales within the Piltun feeding area would not be exposed to adverse noise levels[84]; potential impact significance of the 2D survey to feeding whales was therefore assessed to be *moderate*, given the high sensitivity of operating in a region utilized by a critically endangered species. Mitigation and monitoring measures were agreed and adopted by Sakhalin Energy (see Chapter 8).

Figure 6-3and Figure 6-5 indicate that marine mammals encountered offshore, within the 2D seismic area would need to be within 200m of the shot point for any risk of exposure to noise levels > 170 dB re 1μPa^2-s per-pulse SEL, i.e., the precautionary cumulative level above which animals may suffer temporary threshold shift (TTS). Notwithstanding the low likelihood that any mysticetes would occur within this radius, the possibility still exists, and therefore potential impact significance of PTS, TTS, collisions, and localized disturbance on Gray Whale was assessed to be *moderate*. These predictions were taken into account during engagement between Sakhalin Energy and the WGWAP SSTF about mitigation and monitoring requirements (see Chapter 8)

6.4.6.2 Odontocetes

The small numbers of individual odontocetes modelled or estimated to be exposed to >160 dB re 1 μPa (rms) during the survey would be small in relation to regional population sizes. Although no PTS or other potential injury of odontocetes is anticipated during an actual seismic survey, due to the natural tendency for odontocetes to avoid exposure to seismic sound levels >180 dB re 1 μPa (rms), it is possible that some animals could approach close enough to experience PTS or TTS.

Although the frequency ranges of the echo-sounder overlap the presumed or known frequency ranges used by odontocetes, these operations are highly unlikely to affect odontocetes other than a potentially small number of temporary behavioural disturbances. This is based primarily on the narrowly focused, generally downward-facing beams of the source and the intermittent and short pulse signal (i.e., the sounds would be off much longer than they are on) combined with the operational speed of the vessel. Consequently, an individual odontocete is highly unlikely to experience more than a few individual brief pulse exposures from this equipment.

[82] As a proxy for the 163dB rms
[83] As already discussed in §6.3.2.2, models of cumulative SEL were used to verify that adopting noise criteria based on single-pulse metrics would not result in the potential exposure of whales to cumulative doses reaching injurious levels.
[84] Consequently, no A-lines were defined – see Chapter 8.

There is a remote possibility that an odontocete could be injured or killed in a collision with a project related vessel; however, most odontocetes are not usually considered vulnerable to ship strikes in these situations.

The impact to odontocetes from the proposed survey is predicted to be of low magnitude, local in scale and of short duration. The overall unmitigated impact of the survey on odontocetes is therefore determined to be *moderate*.

6.4.6.3 Pinnipeds

Impacts to pinnipeds under the proposed project are expected to be limited to short-term behavioural disturbance and short-term localized avoidance of the area near the active airguns. This is expected to have negligible short- and long-term impacts on individual pinnipeds, their habitats, and regional populations of pinnipeds within the analysis areas. There is a remote possibility that animals very close to the array could experience PTS or TTS.

Although the echo-sounder can presumably be heard by pinnipeds, their operation is not likely to affect pinnipeds. The intermittent and narrow downward-directed nature of the source would result in no more than one or two brief pulse exposures of any individual pinniped. Therefore, any given pinniped at depth near the track line would only be subjected to at most a few brief pulse exposures.

There is a remote possibility that a pinniped could be injured to killed in a collision with a project-related vessel or entanglement with in-water equipment.

The impact to pinnipeds from the proposed survey is predicted to be of low magnitude, local or sub-local in scale, and of short duration. The overall unmitigated impact of the survey to pinnipeds is therefore determined to be *moderate*.

6.5 Effects of Noise and Disturbance on Marine Invertebrates and Fish

6.5.1 Marine Invertebrates

Marine invertebrate species range in size from microscopic free-swimming and suspended zooplankton, to macro-benthic crabs and polychaetes, to giant squid that are 18 m long and weigh up to 900 kg. The distribution and abundance of marine invertebrates is closely tied with the biological productivity of marine waters, which in turn influences the distribution and abundance of higher tropic level species such as fish, seabirds, and marine mammals.

Invertebrate groups that are potentially sensitive to low-frequency noise are of interest in impact assessments for marine seismic activities. Limited studies suggest that various invertebrate groups are capable of detecting and may be affected by seismic noise. Among invertebrates, only some crustaceans (decapods such as lobsters, crabs and shrimps, including prawns; e.g., Offutt 1970), and molluscs (cephalopods such as octopuses, squids, cuttlefishes and nautiluses; e.g., Budelmann and Williamson 1994) are known to sense low-frequency sound.

No species of invertebrates are listed as vulnerable, threatened, or endangered within the proposed survey area.

6.5.1.1 Sound Production and Detection in Marine Invertebrates

Sound Production

Many invertebrates are capable of producing sound, including barnacles, amphipods, shrimp, crabs, and lobsters (Au and Banks 1998; Tolstoganova 2002). Invertebrates typically produce sound by scraping or rubbing various parts of their bodies; the sounds produced are primarily associated with territorial behaviour, mating, courtship, and aggression. Details on the underwater acoustic capabilities for some marine invertebrates are provided in Table 6-10.

Table 6-10. Summary of Acoustic Capabilities of Decapod Crustaceans and Cephalopod Molluscs

Group	Sound Production		Detection		
	Frequency Range (Hz)	*Source SPL (dB re 1 μPa-m)*	*Frequency Range (Hz)*	*Dominant Frequency (Hz)*	*Minimum Threshold SPL (dB re 1 μPa)*
Decapods					
Lobsters (*Homarus*)	87-261 [a, b]	18.5 [a, b]		20-5,000 [j]	
Lobsters (*Panulirus*)	3,300-66,000 [c]	50.1-143.6 [c]			
Lobsters (*Nephrops*)				20-200 [k]	
Crabs	100-18,000 [d]				
Shrimps	2,000-200,000 [e]	$166\text{-}172_{(rms)}$ [e]	100-3,000 [f]	100 [f]	$105_{(rms)}$ [f]
Cephalopods					
Octopuses			1-100 [g]		
Squids			1-100 [g]		
Cuttlefishes			20-9,000 [h, i]		

Sources: [a]Pye and Watson III 2004; [b]Henninger and Watson III 2005; [c]Latha et al. 2005; [d]Tolstoganova 2002; [e]Range provided is transformed from 183-189 $_{(Peak\text{-}Peak)}$, as reported in Au and Banks (1998); [f]Lovell et al. 2005; [g]Packard et al. 1990; [h]Komak et al. 2005; [i]Rawizza 1995; [j]Offutt 1970; [k]Goodall et al. 1990.

Sound Detection

In contrast to fish and aquatic mammals, no physical structures have been discovered in aquatic invertebrates (except aquatic insects) that are stimulated by the pressure component of sound. Invertebrates appear to be most sensitive to the vibrational component of sound (Breithaupt 2002). Statocyst organs may provide one means of vibration detection for aquatic invertebrates (Popper and Fay 1999).

More is known about the acoustic detection capabilities of decapod crustaceans than any other marine invertebrate group. Crustaceans appear to be most sensitive to sounds of low frequencies (i.e., <1000 Hz) (Table 6-10) (Budelmann 1992; Popper et al. 2001).

6.5.1.2 Effects of Seismic Sound on Marine Invertebrates

Scientific literature on the impacts of seismic survey sound on marine invertebrates is limited. In particular, there have been no studies of how exposure to seismic survey sound affects invertebrate populations and their viability, including availability to fisheries and to species that prey on marine invertebrates.

Existing studies can be separated into three categories: (1) pathological, (2) physiological, and (3) behavioural. Although considered separately, it should be understood that these three types of effects could interact; for example some physiological effects could result in a pathological effect. Table 6-11 summarizes the available information on known effects of seismic and other survey-related sound[85] on crustaceans, cephalopods, and other commercial resources. Effects are limited predominantly to short-term, non-lethal consequences; the most likely effects from seismic activities include signal masking and changes in behaviour. A few studies have shown that it is possible that invertebrates inhabiting near-surface waters and occurring within several meters of an active, high-energy sound source could be lethally affected or physiologically impaired or injured.

Table 6-11. Summary of Known or Possible Effects of Seismic Survey Sound on Marine Invertebrates (Crustaceans and Cephalopods) and Associated Commercial Resources*

Groups	Pathological Effects	Physiological Effects	Behavioural Effects	Sound Detection Impairment	Effects on Commercial Invertebrates
Crustaceans	• Evidence of sub-lethal effects on snow crab embryos and larvae (e.g., delayed development); supportive data are minimal. • No evidence of adverse effects on adult snow crabs, adult lobster, or adult shrimp; supportive data are minimal.	• Evidence of adverse effects on adult lobster (e.g., decreased levels of enzymes and calcium ions in haemolymph). • No evidence of adverse effects on adult snow crab.	• Evidence of temporary disturbance effects on adult shrimp (e.g., avoidance) and adult lobster (e.g., decreased feeding). • No evidence of disturbance effects on adult snow crab • Masking effects unknown.	Unknown – no relevant data available.	• No evidence of adverse effects on snow crab and shrimp.
Cephalopods	• No evidence of adverse effects on squid.	• No evidence of adverse effects on squid and cuttlefish.	• Evidence of adverse effects on adult squid and cuttlefish (e.g., startle, alarm, and avoidance).	Unknown – no relevant data available.	Unknown – no relevant data available.

Notes: *Effects of sonar sounds are not included because there are no known systematic studies of the effects of sonar sound on invertebrates. See text for references.

Pathological studies. Lethal and sub-lethal injury to organisms depends on at least two features of the seismic survey sound source: the received peak pressure and the time required for the pressure to rise and decay (Hubbs and Rechnitzer 1952 in Wardle et al. 2001). Generally, as received pressure increases, the period for the pressure to rise and decay decreases, and the chance of acute pathological effects increases.

Seismic survey sound may have a limited pathological impact on early developmental stages of crustaceans, including fertilized snow crab eggs (Pearson et al. 1994; Christian et al. 2003, 2004; DFOC 2004b), where a significant difference was noted in the development rate of exposed and unexposed fertilized eggs, although the experiment involved only a single female crab.

[85] Airguns are the sound source most likely to result in adverse effects. Other survey sound sources (i.e., echo-sounder and vessel) are considered to have considerably less potential to interfere with sound production or detection by crustaceans and cephalopods.

Experiments on the larvae of Dungeness crab showed no developmental or mortality differences between exposed and unexposed larvae (Pearson et al. 1994). Controlled field experiments on adult snow crabs (Christian et al. 2003, 2004; DFOC 2004b) and adult cephalopods (McCauley et al. 2000a, 2000b) have not resulted in any significant pathological impacts on the animals. It has been suggested that exposure to commercial seismic survey activities has injured giant squid (Guerra et al. 2004) but there is currently no scientific evidence to support that assertion.

For the seismic airgun array of the proposed 2D high-resolution seismic survey, the pathological (mortality) zone for invertebrates is expected to be within a few meters of the seismic source.

Physiological studies refer to biochemical responses by marine invertebrates to acoustic stress. Such effects could impact invertebrate populations by increasing mortality or reducing reproductive success. Any primary and secondary stress responses (i.e., changes in levels of enzymes, proteins, or the haemolymph or circulatory system) of crustaceans after exposure to seismic survey sounds appear to be temporary (hours to days) (J. Payne, DFOC Research Scientist, St. John's, Newfoundland, Canada, cited pers. comm.). Adult male snow crabs exposed to seismic energy showed no significant differences in terms of the stress indicators (e.g., proteins, enzymes, cell type count) (Christian et al. 2004) compared to unexposed animals. Similarly, egg-bearing female snow crabs exposed to airgun array sounds did not show any acute or chronic (observations continued for 5 months) mortality or alterations to feeding behaviour and embryo survival was not affected (DFO 2004).

Behavioural studies. Changes in behaviour could potentially affect reproductive success, distribution, susceptibility to predation, and catchability by fisheries. Studies assessing the possible behavioural effects of exposure to seismic survey have been conducted on both uncaged and caged crustaceans and cephalopds. In some cases, animals exhibited startle responses (e.g., squid in McCauley et al. 2000a, 2000b), while in other studies no behavioural impacts were noted (e.g., snow crab in Christian et al. 2003; DFOC 2004b). There have been reports of reduced catch rates of shrimp shortly after exposure to seismic survey sound; however, other studies have not observed significant changes in shrimp catch rate (Andriguetto-Filho et al. 2005). Adverse effects on crustacean and cephalopod behaviour due to seismic survey sound are likely dependent on the species in question.

Sound Sources and Characteristics

It is possible that individual invertebrates within several meters of a sound source operating at high levels could potentially be harmed. The airgun, echo-sounder, and/or vessel sounds produced by survey activities overlap known sound detection or sound production range of some – but not all – invertebrate species.

However, it is theoretically possible that the energy of sound outside of detection and production ranges might also be harmful to the animals. The sound characteristics of each of the survey sound sources are described below relative to the minimal information known on sound detection and sound production of invertebrates.

Airguns typically have dominant frequency components < 200 Hz and zero-to-peak nominal source outputs ranging from 240-265 dB re 1 µPa-m. This frequency range overlaps with the frequencies detectable by one crustacean species for which frequency sensitivity has been studied (Lovell et al. 2005) (Table 6-10). However, that study was conducted with a sound source in air and not in water; the applicability to the underwater environment is therefore unknown. Thus, overall, the degree of overlap between the dominant frequencies of airgun sounds and the frequencies detectable by invertebrates is unknown.

The echo-sounder proposed for use on the survey vessel is expected to operate at 11.25-12.6 kHz (the specific model will be known after the tendering process is completed). These frequencies are above the frequency ranges known to be detectable by some crustaceans and cephalopods (Table 6-10), although the frequencies of sounds produced by certain crustaceans do overlap with the sonar frequencies. However, the functionality of these relatively high-frequency crustacean sounds remains unknown.

Ship engines, propulsion systems, and the vessel hull itself emit sounds into the marine environment with frequencies that overlap with the frequencies and thresholds associated with marine invertebrate sound detection. However, virtually nothing is known about the possible effects of vessel noise on invertebrates. The source level of vessel noise (and geotechnical coring for that matter) would be considerably lower than source levels of airguns and echo-sounders associated with the seismic activities (see Chapter3). Furthermore, vessel noise would be at levels expected to cause at most only localized, short-term behavioural changes. Thus, potential effects of vessel noise on invertebrates are not further discussed in detail.

Acoustic Effects

Disturbance

Changes in behaviour that increase mortality, result in reduced reproductive success, or substantially affect commercial species, are considered here.

Airguns could potentially disturb certain invertebrates, although adverse effects to individuals are not considered significant unless a substantial portion of a population is affected. Furthermore, behavioural changes would need to result in an overall reduction in the health, abundance, or catch of a species of concern. In general, the temporal and spatial scale of disturbance of invertebrates would be short-term and limited to the localized area immediately surrounding an active airgun. In addition, effects would be limited to the small portion of invertebrate populations exposed to the active acoustic source as it moves along the survey lines.

The potential disturbance effects of the echo-sounder on the few species that detect sound within the relevant frequency ranges are unknown. However, should disturbance occur, effects may be deemed negligible compared with the potential effects of seismic sound, which are anyway considered insignificant.

Detection Impairment

The received sound pressure level required to induce temporary sound detection impairment in marine invertebrates has never been studied as far as we are aware, and there is currently no scientific evidence that exposure to airgun or sonar sounds can result in such an effect. If detection impairment did occur as a result of survey activities, it is expected to be limited to individuals close to the active acoustic source(s).

Injury

Sounds produced by airguns could cause acute injury and perhaps mortality of some invertebrate species, particularly larval and egg stages in close proximity to the seismic source (i.e., a few meters). Since the proposed seismic acquisition area does not overlap with known critical spawning, migration, and rearing areas of marine animals, any mortality of invertebrate eggs, larvae, juveniles, or adults near the airgun source would be negligible with respect to the overall invertebrate population.

Effects of the echo-sounder on marine invertebrates are unknown. However, given its acoustic characteristics, potential impacts from exposure to the echo-sounder would be expected to be less than those resulting from exposure to airguns.

6.5.1.3 Impact Assessment of the Proposed Survey on Invertebrates

Generally speaking, adverse effects on particular invertebrate species can be considered significant if they result in a reduction in the overall health and viability of a population or significantly impact commercial operations targeting that population. Determining whether or not there is a reduction in the overall health (or abundance) of an invertebrate population is frequently problematic due to the general lack of pre-impact information, the multitude of environmental and other related factors influencing invertebrate populations, and often the large or unknown extent of the habitat in which the invertebrates reside relative to the impact area.

Some invertebrates might detect the particle displacement/motion caused by airgun sounds; the echo-sounder might be similarly detectable, perhaps by a lesser number of invertebrate species. For those invertebrate species capable of detecting such sounds, there is potential for adverse effects at close range, and for behavioural effects extending to somewhat greater, though unknown, distances. The likelihood of these effects depends on the sound level received by the individual; the received sound level is generally related to proximity to the source but is also influenced by other factors as well (e.g., water depth, bottom conditions, airgun array size, etc.).

The potential for pathological effects would be limited to those individual invertebrates within several meters of the active source operating at high levels. On a population level, the potential effects are considered insignificant. Moreover, due to the limited area of the proposed activity, the short duration of the survey and the species present, no interference with any commercial invertebrate fishery is anticipated. Levels of injury and fatality or behavioural changes are considered to be of *negligible* significance.

With respect to Gray Whale food resource, baseline environmental data collected during autumn 2010 for the proposed South Piltun survey area (see §5.8.2) recorded 112 species of macrobenthos; benthos abundance was dominated by a cumacean,a mysid, amphipods, and two polychaetes; biomass was dominated by the sand dollar *Echinarachnius parma*, which contributed 90.5% of biomass in the PA-C area. Only one type of benthos community structure was identified in the PA-C area, dominated by *E. parma*.

Sand dollars have low calorific value, and are not a preferred food source of gray whales. Therefore, any potential negative impact to sand dollars – and there have been no studies of the impact of sound on *E. parma* – in the immediate area of the South Piltun site survey is not expected to have any significant consequence for food resources of Gray Whale.

6.5.2 Marine Fish

Baseline environmental information (§5.8.3 of this report) indicates that 101 species of fish are known to occur in the northeast Sakhalin area. Of interest to this impact assessment are those of ecological or economic concern that occur in or near the survey area, including fish species or groups that are listed under the Red Book of the Russian Federation, have other internationally recognized status, or are considered the basis of important fisheries.

Table 6-12. Summary of the Status, Population Trends, Economic Importance, General Ecology, and General Distribution & Movement of Higher Fish Groups Potentially Occurring within the Survey Area.

Higher Group[(a)]	Status[(b)] IUCN/CITES/RF Red Book	Population Trend[(c)] (↑, ↓, —)	Catch Levels[(d)] (tons/km^2/yr)	Economic Importance[(e)]	General Ecology[(f- h)]	General Distribution/ Migratory Movements[(i-j)]
Hagfish& Lampreys (Agnatha)	0/0/0	Unknown	Unknown	L	S PS	ICS/OCS/BCS ICS, OCS
Sharks, Skates, Rays, & Chimeras (Chondrichthys)	43/3/0	—	<0.1	L	S/I/D, D/P, PV/PN	ICS/OCS/BCS; HM
Sturgeons (Acipenseriformes)	3/2/1	Unknown	Unknown	L	S, D/P, PV	ICS/OCS; HM
Herring-likes (Clupeiformes)	0/0/0	—	<1	H	S, P, PV	ICS; HM
Salmon, Smelts, etc. (Salmoniformes)	1/0/1	—	<0.5	M	S, P, PV/PN	ICS/OCS/BCS; HM
Cod-likes (Gadiformes)	2/0/0	—	<1	H	S/I, P, PV	ICS/OCS; HM
Pipefish& Seahorses (Gasterosteiformes)	7/6/0	Unknown	Unknown	L	S/I, P, PV/PN	ICS/OCS/BCS; NS
Scorpionfish (Scorpaeniformes)	3/0/0	↑	<0.1	L	S/I/D, D/P, PV	ICS/OCS/BCS; NS/IO
Perch-likes (Perciformes)	32/1/0	—	<0.5	M	S/I/D, P, PV	ICS/OCS/BCS; NS
Tuna & billfish (Perciformes)	3/0/0	—	<0.1	L	S/I; P, PV	ICS/OCS/BCS; HM
Flatfish (Pleuronectiformes)	2/0/0	↑	<1	H	S/I, D, PV	ICS/OCS/BCS; NS/IO

Sources: SAUP 2005; CITES 2006; IUCN 2006; NOAA Fisheries 2006a, Krasnaya Kniga 2001.

Notes: [(a)] Higher Groups as defined by SAUP (2005). The names of the relevant orders have been added except in the case of the cartilaginous fishes (Class Chondrichthys) that contains several orders.
[(b)] Number of species listed as critically endangered, endangered, threatened, or vulnerable under each status type.
[(c)] ↑ = increasing, ↓ = decreasing, — = stable; based on catch trends from 1950 – 2003 (SAUP 2005).
[(d)] 2003 catch levels (SAUP 2005).
[(e)] Relative ratings of economic importance based on recent landing values: H = high, M = medium, L = low.
[(f)] Typical water depth: S = shallow (<100 m), I = intermediate (100-1 000 m), D = deep (>1 000 m).
[(g)] Habitat Type: D = demersal; P = pelagic.
[(h)] Feeding behaviour: PV = piscivorous, PN = planktivorous, PS = parasitic, S = scavenger.
[(i)] Horizontal Distribution: ICS = inner continental shelf (<50 m water depth), OCS = outer continental shelf (50-200 m), BCS = beyond continental shelf (>200 m).
[(j)] Distribution Variability: NS = negligible shift, IO = slight inshore-offshore movement, HM = highly migratory.

Potential impacts are further discussed in terms of the sensitivity of marine fish – where known – to low frequency impulse sound associated with seismic surveys. In particular, the ecological implications of seismic survey impacts on fish life cycle and reproductive characteristics are of interest, since these are important determinants of population vulnerability or robustness to disturbance[86]. The status, global population estimates and trends, general ecology, and general

[86] For example, reproduction and nursery requirements of fish influence the vulnerability of fish populations to the effects of various human activities. The reproductive strategies of marine fishes vary significantly; More fecund fishes that have large

distribution and migratory movements of these fish are summarized in Table 6-12 and discussed briefly below.

6.5.2.1 Hearing in Fish

Extensive studies to understand the structures, mechanisms, and functions of animal sensory systems in aquatic environments have been published (Atema et al. 1988; Kapoor and Hara 2001; Collin and Marshall 2003).

All fish have hearing and skin-based mechanosensory systems (inner ear and lateral line systems, respectively) that sense their surroundings (Fay and Popper 2000). Anthropogenic noise that affects fish sensory systems may have significant consequences for fish survival and reproduction; potential effects include masking of important environmental sounds or social signals, displacing fish from their habitat, or interfering with orientation and navigation.

Although hearing data only exist for fewer than 100 of the global 27,000 fish species (Hastings and Popper 2005), current data indicate that most fish species can detect sounds between 500 and 1000 Hz (NRC 2003), with their best hearing sensitivity at or below 3,000 Hz (Popper 2003; Table 6-13). However, some marine species, such as clupeids, are known to be high frequency specialists and can detect sounds above 100 kHz. Reviews of hearing mechanisms and capabilities can be found in Fay and Popper (2000) and Ladich and Popper (2004).

At least two main mechanisms have been identified in relation to the inner ear in fish. The first and most primitive are the otoliths – calcium carbonate masses of the inner ear of fish – that are denser than the rest of the fish and the surrounding water; when the fish moves through a sound field, the denser otoliths lag interact differentially with beds of sensory hair cells that underlie them in the inner ear. This motion is interpreted by the central nervous system as sound.

The swim bladder is the second main mechanism associated with the inner ear in fish. Being more compressible and expandable than either water or fish tissue, the swim bladder contracts and expands more than the rest of the fish in a sound field. The effectiveness with which the swim bladder stimulates the inner ear depends on the amplitude and frequency of the pulsation and the distance and mechanical coupling between the gas bladder and the inner ear (Popper and Fay 1993).

Researchers have noted that fish without an air-filled cavity (swim bladder), or with reduced swim bladders, or with limited connectivity between the swim bladder and inner ear, are able to detect particle motion but not pressure, and therefore have relatively poor hearing abilities (Casper and Mann 2006). These species are known as ‘hearing generalists’ (Popper and Fay 1999).

Most marine fish, including cartilaginous fish (the sharks, skates, rays, and chimeras of the Class Chondrichthys), are hearing generalists and react to sounds <1500 Hz. Experiments on elasmobranch fish have demonstrated poor hearing abilities and frequency sensitivity from 200 to 1000 Hz, with best sensitivity at lower ranges (Casper et al. 2003; Casper and Mann 2006).

In contrast to the hearing generalists, herring and related species (Clupeiformes), some cod and related species (Gadiformes in part), some squirrelfish (Perciform family Holocentridae, in part), and a number of other fish have specialized swim bladders that extend close to the inner ear. These fish have more sensitive hearing and are often referred to as ‘hearing specialists’ and may react to sounds <4000 Hz.

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ranges and high rates of dispersal are usually more resilient to exploitation, disturbance, or other population-level stressors than those that are restricted to smaller areas and specific microhabitats.

The lateral line system of a fish also allows for sensitivity to sound (Hastings and Popper 2005). This system is a series of receptors along the body of the fish (mainly bony fish and elasmobranches) that detects pressure differentials relative to the fish. The sensory unit of the lateral line is the neuromast, which is able to detect low frequency acoustic signals (160-200 Hz) usually within a few body lengths of the animal.

6.5.2.2 Effects of Seismic Sound on Marine Fish

One benefit of using airguns as the standard energy source for marine seismic surveys is that, unlike explosives, they have not been associated with large-scale fish kills. However, existing information on the impacts of seismic surveys on marine fish populations remains limited.

Existing studies can be separated into three categories: (1) pathological, (2) physiological, and (3) behavioural. The specific received sound levels at which permanent adverse effects on fish occur are little studied and largely unknown. And in general, available studies on the impacts of seismic surveys on marine fish relate to individuals or parts of a population at most, not at the population level.

Pathological studies. The potential for pathological damage to hearing structures in fish depends on the energy level of the received sound and the physiology and hearing capability of the particular species. For a given sound to result in hearing loss, the sound must exceed, by some specific amount, the hearing threshold of the fish for that sound (Popper 2005). The consequences of temporary or permanent hearing loss in individual fish or a fish population are unknown.

Little is known about the mechanisms and characteristics of potential injury to fish from exposure to seismic survey sounds. McCauley et al. (2003) found that exposure to airgun sounds caused anatomical damage to the auditory structures of caged pink snapper. This damage remained and had not been repaired in fish examined almost two months post exposure; however the fish were exposed to high cumulative levels of seismic sound that may not be analogous to that experienced by free-ranging fish. Popper et al. (2005) documented TTS in two of three fish species in the Mackenzie River Delta, but also found that broad whitefish that received an SEL of 177 dB re 1 μPa2·s showed no hearing loss.

TTS was also observed in studies involving goldfish and catfish (Amoser and Ladich 2003). In those experiments, fish were exposed to white noise (158 dB re 1μPa) for periods of 12-24 hours and were then tested for post-exposure hearing sensitivity. Both species showed a loss of hearing sensitivity, with sensitivity returning to normal in 3 days for the goldfish and 14 days for the catfish. Smith et al. (2004) reported threshold shift in goldfish after just 10 minutes of exposure to white noise (160-170 dB re 1μPa), with recovery in 14 days.

A number of studies found no fish mortality upon exposure to seismic sources (Falk and Lawrence 1973; Holliday et al. 1987; La Bella et al. 1996; Santulli et al. 1999; McCauley et al. 2000a, b; Thomsen 2002; Hassel et al. 2003; McCauley et al. 2003; Popper et al. 2005). However, other studies have reported, some equivocally, that mortality of fish, fish eggs, or larvae can occur close to seismic sources (Kostyvchenko 1973; Dalen and Knutsen 1986; Booman et al. 1996; Dalen et al. 1996); although it should be noted that in some cases, the treatment examined was very different from any real-world scenario. Saetre and Ona (1996) applied a ‘worst-case scenario’ mathematical model to investigate the effects of seismic energy on fish eggs and larvae. They concluded that mortality rates caused by exposure to seismic surveys are so low, as compared to natural mortality rates, that the impact of seismic surveying on recruitment to a fish stock must be regarded as insignificant.

Physiological studies have focussed on cellular and/or biochemical responses by fish to acoustic stress. Such stress could potentially affect fish populations by increasing mortality or reducing reproductive success. Primary and secondary stress responses of fish after exposure to seismic survey sound appear to be temporary (Sverdrup et al. 1994; McCauley et al. 2000a,b) if detected at all.

Behavioural studies have considered the distribution, migration, mating, and catchability of fish populations in response to noise. Studies investigating the possible effects of sound (including seismic survey sound) on fish behaviour have been conducted on both un-caged and caged animals (Chapman and Hawkins 1969; Pearson et al. 1992; Santulli et al. 1999; Wardle et al. 2001; Hassel et al. 2003). In these studies, fish typically exhibited a sharp 'startle' response at the onset of a sound followed by habituation and a return to normal behaviour after the sound ceased.

There is general concern about the potential reduction in the catchability of fish involved in fisheries due to seismic survey operations. Although reduced catch rates have been observed in some fisheries during seismic surveys, in a number of cases the findings are confounded by other sources of disturbance (Dalen and Raknes 1985; Dalen and Knutsen 1986; Løkkeborg 1991; Skalski et al. 1992; Engås et al. 1996). In some airgun experiments, there was no change in catch per unit effort of fish when airgun pulses were emitted, particularly in the immediate vicinity of the seismic survey (Pickett et al. 1994; La Bella et al. 1996). Wardle et al. (2001) noted startle responses from fish when airguns were firing but noted that the activity had little effect on the day-to-day behaviour of the resident fish. McCauley et al. (2000a, 2000b) also noted that fish behaviour returned to the pre-seismic state within 15-30 minutes of the cessation of seismic activities.

Sound Sources and Characteristics

To assess the potential effect of sound sources on marine fish populations, it is important to identify any overlap in the frequencies detected or produced by these species in relation to the frequencies of the acoustic sources. The behaviour and ecology of fish that use sounds with frequencies different to those of industrial noise sources would in most cases be expected to be unaffected by those sources; an exception might be individuals within several meters of a sound source operating at high levels that could be harmed by the energy of the sound.

Sound frequencies of airguns, ship hull and engines overlap those known to be produced or detected by fish (Table 6-13). The frequencies of echo-sounders generally do not overlap the frequencies used by fish, although some herrings may be exceptions.

Airguns typically have zero-to-peak nominal source outputs of 240-265 dB re 1 µPa-m, and dominant frequency components < 200 Hz. This frequency range overlaps the frequencies detected by many fish species for which hearing ranges have been studied or surmised (Table 6-13). In addition, the nominal source outputs of individual airguns (as well as airgun arrays) are substantially higher than the hearing thresholds for those species studied. Thus, there is potential for adverse effects on some individuals of various fish species.

Ship engines, propulsion systems, and the vessel hull itself emit sounds with frequencies that overlap the frequencies and thresholds associated with sound production and detection in marine fish. Richardson et al. (1995) presented a discussion of vessel-generated sounds; ship-generated sound is an important component of background sound at sea (Urick 1983; Popper 2003) and the magnitude of that component is growing (Andrew et al. 2002; McDonald et al. 2006). However, virtually nothing is known about the possible effects of vessel sound on marine fish. The intensity of vessel sound would be considerably lower than source levels of the pulsed sound associated with seismic acquisition. Therefore, vessel sounds would be expected to cause only possible localized, short-term behavioural changes; thus, the potential effects of vessel sounds on marine fish are not further discussed.

There is considerable literature on the avoidance by fish of fishery survey vessels utilizing fishery sonars (Gerletto and Fréon 1992; Misund et al 1996; Fernandez et al. 2003; Handegard et al. 2003; Mitson and Knudsen 2003; Gerletto et al. 2004). These investigators have reported varying degrees of horizontal and/or vertical avoidance. In no case was there evidence that vessel avoidance was harmful to open-ocean fish populations.

The echo-sounder proposed for use in the seismic survey is expected to operate at 11.25-12.6 kHz. These frequencies are above the known hearing ranges of most marine fish species (Table 6-13), with the exception of herring-like Alosinae that are able to detect ultrasonic (>20 kHz) signals (Mann et al. 2001); non-alosine Clupeoids (sea herrings, sardines, and anchovies, among others) are not known to hear above 4 or 5 kHz (Mann et al. 2001, 2005). As no other fish are currently known to hear such high frequencies, the sonar is not expected to have adverse effects on fish other than, possibly, the herring subfamily Alosinae. For those fish that can hear at these frequencies, the exposures of most individual fish – not very close to the sonar – would be very brief. Therefore, the use of the echo-sounder is unlikely to produce population-level effects in this case.

Table 6-13. Summary of Underwater Hearing and Sound Production Characteristics of Fish.

Species or Group	Sound Production[a]			Hearing	
	Frequency Range (Hz)	*Dominant Frequency (kHz)*	*Source Level (dB re 1 µPa-m)*	*Frequency Range*	*Threshold (dB re 1 µPa)*
Hagfishes & lampreys	Unknown	Unknown	Unknown	Unknown	Unknown
Sharks and Rays	Unknown	Unknown	Unknown		
Sturgeons	<100 – >1 000[1]	Unknown	Unknown	Unknown	Unknown
Herring-likes	Unknown	Unknown	120 – 130[5]	30 Hz or < - 4 kHz[2-8]	110 @ 1– 1.2 kHz[6-8]
Alosine herrings (shads and allies)	Unknown	Unknown	About 130 - 180[5]	200 Hz to 180 kHz[5] or 200 kHz[8]	About 155 @ 40 kHz[5]
Salmon, smelts, etc.	Unknown	Unknown	Unknown	< 1 – 800 Hz[9, 10]	94 @ 100 – 120 Hz[9, 10]
Cod-likes		50 – 1 kHz[11]		< 1 Hz – 1 kHz[10, 12 – 16]	74 @ 200 Hz[10, 14]
Pipefishes & seahorses	Unknown	Unknown	Unknown	Unknown	Unknown
Scorpionfishes	Unknown	Unknown	Unknown		
Perch-likes	30 – 5 000[16, 17]	100 – 3 000[16, 17]	127[16]	85 Hz– > 2 kHz[12 - 20]	
Tuna and billfishes	Unknown	Unknown	Unknown	50 Hz– 1.1 kHz[22, 23]	89 – 111 @ 500 Hz[22, 23]
Flatfishes	Unknown	Unknown	Unknown		

Sources: [1]Johnstone and Phillips 2003; [2]Denton et al. 1979; [3]Schwartz and Greer 1984; [4]Enger 1967; [5]Mann et al. 2001; [6]Mann et al. 2005; [7]Akematsu et al. 2003; [8]Gregory and Claburn 2003; [9]Hawkins and Johnstone 1978; [10]U.S. Navy 2005; [11]Hawkins and Rasmussen 1978; [12]Sand and Karlsen 1986; [13]Chapman and Hawkins 1973; [14]Chapman 1973; [15]Tavolga and Wodinsky 1963; [16]Luczkovich et al. 1999; [17]Gilmore 2003; [18]Ramicharitar et al. 2001; [19]Ramicaritar and Popper 2004; [20]Tavolga and Wodinsky 1965;[21]Iverson 1967; [22]Iverson 1969; [23]Chapman and Sand 1974; [24]Zhang et al. 1998; [25]Fujeida 1996.

Notes: * - Values given are, at best, examples from published and unpublished sources. Sound production and hearing of most fishes in most groups have not been studied. Frequency bins in this table sometimes bracket the low ends of some species and the high ends of other species within a given group. This is particularly true of the very anatomically, behaviourally, ecologically, and bioacoustically diverse Order Perciformes (perch-like fishes) which includes over 9,000 species in 148 families world-wide (fresh and salt water combined), or over one-third of all fish species (Helfman et al. 1997). It includes, besides the tunas and billfishes (listed separately here) basses, tilefishes, remoras, jacks, snappers, grunts, sculpins, porgies and many other groups.

- There is little known about elasmobranch hearing sensitivities and the mechanisms thereof. With the inevitable ambiguities of the relevant stimulus, such as particle motion vs. sound pressure, describing hearing or other mechanosensory thresholds may be meaningless. Some of the problems inherent in making generalizations involving different data sets collected in different ways on different or even the same fishes are reviewed by Hawkins (1981).
- In cases where cells are left blank it is the opinion of the preparers that the group represented is so species diverse and/or the available data sets are so different in nature as to make such a brief description meaningless or misleading. A more complete treatment is available in U.S. Navy (2005).
- Due to the physical limitations of recording and measurement equipment and environments wherein fish will produce natural sounds, source levels are often difficult or impossible to obtain and are usually not available.

Acoustic Effects
Masking

Currently, there are no reports confirming that seismic surveys result in masking effects in fish species (Table 6-14). Theoretically, airguns, echo-sounder, and vessel sound all have the potential to contribute to masking of sound detection in some fish species. However, in general, the potential for masking is expected to be localized and temporary due to the pulsed nature of seismic survey sounds as well as the movement of the seismic vessel relative to individual fish, and would be insignificant at the population scale.

Disturbance

While acoustic impulses from airguns could disturb some species (see discussion of behavioural studies above), disturbance is generally brief and some evidence indicates habituation. Furthermore, the temporal and spatial scale of these effects would be short-term and localized to the area around the active sound source, thus limiting any possible effects to a relatively small portion of the fish population.

The echo-sounder is less likely to cause disturbance since most studied fish species, with the exception of *Alonisae*, do not produce / hear sound at these frequencies. Nevertheless, if fish in the area at the time of the survey are dominated by *Alosinae*, disturbance effects could result. However, the disturbance potential of the echo-sounder is considerably less than the disturbance potential of the airguns, which are anyway not considered significant at the population level.

Hearing or Detection Impairment

In theory, sounds produced by the airguns could cause TTS or PTS in some fish species. However, all but two studies of these effects (see above) involved conditions unrealistic to those of an actual seismic survey.

Similarly, an echo-sounder could cause TTS or PTS in the few fish species that can detect its emitted frequency range if the fish were located sufficiently close to the source. However, evidence of this effect has not been reported. Given the narrow beam characteristics, related effects would be even more localized than those of the airguns, with no significant impacts on marine fish populations.

Non-Auditory Injury or Mortality

Theoretically, sounds produced by the airguns could potentially result in acute injury and mortality of some species of fish, their larvae, and/or eggs, particularly those in very close proximity to the source. Pressure trauma would be most probable and severe in fish with gas pockets such as swim bladders. Such gas pockets would expand and contract in conjunction with the ambient pressure changes and could cause haemorrhaging, tearing, or bursting of the pocket. If these effects occur, they would most likely be restricted to a relatively small number of individual fish within ~1-2 m of an airgun.

Since the sound levels emitted by sonar typically used in seismic surveys are lower than those emitted by airguns, and considering the narrow beam characteristics of an echo-sounder and the brief period the transiting seismic vessel, non-auditory injury or mortality are less likely to result from exposure to sonar sound. Again, such effects would only be expected within very close proximity to the source.

Fish could conceivably be injured and killed by collisions with vessels or their associated equipment. The extent to which this occurs is unknown but would be expected to be insignificant.

Non-auditory injury or mortality impacts on marine fish are expected to be insignificant at the population scale.

6.5.2.3 Impact Assessment of the Proposed Seismic Survey on Marine Fish

Generally, adverse effects on a particular species can be considered significant if they result in a reduction in the overall health and viability of a population or significantly impact fisheries targeting that population. This is the general criterion used to determine the significance of effects on fish in this EIA. However, on the ocean-basin or regional scale, determining whether or not there is a reduction in the overall health (or abundance) of a fish population is problematic.

As noted above, potential effects of seismic survey activities on fish are based on a very limited number of studies and species (Table 6-14). Available information indicates that most effects would be limited to short-term non-lethal impacts, such as changes in behaviour or short-term stress reactions. The seismic vessel underway at 4–5 knots, emitting short (<1 s duration) airgun sound pulses typically spaced >20 s apart is highly unlikely to expose fish to more than 1 or 2 pulses that could have potential impacts. The possible exception is that a relatively small number of fish that may occur within several meters of an active sound source with high output levels could be adversely affected or physiologically impaired or injured.

Although some fish species are potentially capable of hearing the frequencies of the echo-sounder, the extremely short duration of the transmission and narrow beamwidth of this system is expected to produce only short-term effects on individual fish that are very close to the active acoustic source. No population-level effects are expected.

Hirsh and Rodhouse (2000) reviewed studies of the impact of seismic survey sounds on fishing (usually commercial) success. In most cases, these studies (e.g., Pearson et al. 1992; Skalski et al. 1992; Engås et al. 1996) found that fishing catch of one or more target species declined with the onset of seismic survey operations and remained depressed throughout this activity and for some time thereafter. Commercial fisheries activities are not anticipated in close proximity to the proposed seismic survey and therefore interference with fisheries is unlikely.

In conclusion, injury, fatality or behavioural changes to marine fish due to the proposed survey are considered to be *minor* significance.

Table 6-14. Summary of Known Effects of Seismic Survey Sound on Marine Fish and Related Fisheries

Higher Group	Masking or Disturbance*	Hearing or Detection Impairment*	Auditory Tissue Damage*	Non-Auditory Injury or Mortality*	Physiological Effect (stress)	Fishery Effects*
Hagfishes & lampreys	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown
Sharks, rays, & chimeras	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown
Sturgeons	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown
Herring-likes	Limited evidence of short-term behavioural effects for caged herring	Unknown	Unknown	Limited evidence of increased mortality of eggs (anchovy) at close range (<10 m) to multiple exposures to airguns.	Unknown	Herring, no significant effect on distribution (Slotte et al. 2004).
Salmon, Smelts, etc.	Negligible behavioural response of Atlantic salmon to small airgun array (Thomsen 2002).	None in one salmonid (Popper et al. 2005)	Unknown	• Some evidence of swim bladder damage to young Arctic cisco to pulsed airgun sound at < 2 m but no mortality observed; • No evidence of lethal effects to caged coho salmon.	Unknown	Unknown
Cod-likes	• Evidence of short-term behavioural effects for hake with evidence of habituation; • No behavioural response observed for pollock, saithe, juvenile cod (Wardle et al. 2001)	Unknown		• Evidence of injury to caged cod and plaice from continuous near-field exposure (<4 m); • Evidence of injury and mortality to eggs and larvae of cod, turbot, plaice.	Unknown	• Blue whiting – no significant effects on distribution, moved deeper (Slotte et al. 2004). • Evidence of reduced catch rates for cod, haddock (Engås et al. 1996).
Pipefishes & seahorses	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown
Scorpionfishes	Evidence of short-term behavioural effects for rockfish (Pearson et al.	Unknown	Unknown	Unknown	Unknown	• Evidence of reduced catch rates for rockfish (Skalski et al. 1992)

Higher Group	Masking or Disturbance*	Hearing or Detection Impairment*	Auditory Tissue Damage*	Non-Auditory Injury or Mortality*	Physiological Effect (stress)	Fishery Effects*
	1992)					
Perch-likes	• Evidence of short-term behavioural effects for sea bass (Santulli et al. 1999); • Short-term behavioural response in sandeels (Hassel et al. 2003, 2004). • No behavioural response observed for mackerel (Wardle et al. 2001)	Unknown	Evidence of permanent structural change in a pink snapper from many exposures to airguns (McCauley et al. 2003).	• No evidence of injury to sea bass (Santulli et al. 1999); • Evidence of increased mortality of eggs (red mullet, blue runner) at close range (<10m) to multiple exposures to airguns.	Evidence of short-term increase in stress-levels of sea bass (Santulli et al. 1999).	No evidence of reduced catch rates for bass (Pickett et al. 1994).
Tuna & billfishes	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown
Flatfishes	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown

*Unknown indicates no studies. See text for further details and citations for the studies summarized in this table.

6.6 Effects of Noise and Disturbance on Seabirds

This assessment is restricted to the nine taxonomic families of seabirds that plunge-dive in search of prey within the study area, potentially exposing themselves to underwater sound generated during the seismic survey. The conservation status, population trend, general ecology (including dive depths), general distribution and migratory movements of these seabird families are summarized in Table 6-15.

The global conservation status of the nine taxonomic families reviewed in this assessment, including CITES, IUCN[87], and Russian Red Book rankings are indicated in Table 6-15. Three species with Russian Red Book status occur within these families, viz. Marbled Murrelet, Black-Throated Diver, and Aleutian Tern.

General population trends are also indicated. There are numerous causes for declines in some species of seabirds: persecution as competitors for fish, breeding habitat alteration and destruction, egg and nestling predation, oiling, collision, longline/net bycatch, net-cable collisions, and plastics ingestion are known or suspected to contribute to seabird mortality or reduced reproductive output.

[87] BirdLife International (BLI), an international bird conservation organization, uses the IUCN rankings.

Table 6-15. Summary of the Status, Population Trends, General Ecology, and General Distribution & Movement of Seabirds Potentially Occurring within the Survey Area

Group (Family)*	Status** CITES/ IUCN-BLI/Red Book RF	Population Trend** (↑, ↓, —)	General Ecology	General Distribution/ Migratory Movements
Loons (Gaviidae)	-/ LC Status 2	↓, —	Lone pairs breed mostly on or near freshwater; winter alone or in large groups in near shore marine waters; surface-dives 2-10 m for small fish.	Circumpolar in Holarctic; highly migratory between Arctic and inland breeding areas and temperate near shore marine areas.
Grebes (Podicipedidae)	-/ LC	—	Lone pairs breed mostly near freshwater; some species winter alone or in groups in near shore marine waters; shallow dives for invertebrates and fish.	All regions except Antarctic; highly migratory between inland breeding areas and (primarily) temperate near shore marine areas.
Albatrosses (Diomedidae)	-/ NT, VU, E, CR	↑, ↓, —	Highly pelagic; most species breed in colonies on islands; breeding cycle can last up to 1 year from nest to fledgling; annual and biannual breeding species; mature slowly (e.g., some species first breed at 9-10 years); usually forages alone; plunge- and surface-dives up to 1 m in pursuit of squid, fish, offal.	Circumpolar in Southern Ocean; throughout the Pacific Ocean and into the southern half of the Bearing Sea; disperses widely between island breeding colonies and offshore feeding areas; uses land only for breeding.
Petrels/Shearwaters (Procellariidae)	-/ LC, NT, VU, E, CR	↑, ↓, —	Highly marine; most species breed in colonies on islands; mostly gregarious outside breeding season; some shearwaters can plunge- or surface-dive up to 20 m in pursuit of invertebrates, fish, offal.	Cosmopolitan, in all oceans; many species are highly migratory between island breeding colonies and offshore and near shore feeding areas.
Cormorants (Phalocrocoracidae)	-/ LC, NT, VU, E	↑, ↓, —	Highly gregarious year-round; colonial breeders in marine and freshwater environments; surface-dives in pursuit of invertebrates and fish (likely to depths of several meters or more).	Cosmopolitan, with greatest diversity in tropical and temperate zones; stretches of open water, both coastal and inland; some migrate but most species are sedentary or are locally/regionally dispersive after breeding.
Gulls (Laridae)	V(1)/ LC, VU, NT, E	↑, —	Most species highly gregarious year-round; colonial breeders at marine and inland locations; make shallow surface- or plunge-dives (to max. depths of 1 m) in pursuit of invertebrates, fish, and offal.	Cosmopolitan; mainly coastal but also inland; some species migrate or disperse considerable distances between breeding areas and near shore and offshore feeding areas.
Terns/Noddies (Sternidae)	-/ LC, VU, NT, E, CR	↑, ↓, —	Highly gregarious year-round; most species breed in colonies; some species make shallow plunge-	Most terns are migratory, some are nomadic during non-breeding season; most that breed in

Group (Family)*	Status** CITES/ IUCN-BLI/Red Book RF	Population Trend** (↑, ↓, —)	General Ecology	General Distribution/ Migratory Movements
	Status 3		dives in pursuit of invertebrates and fish.	north temperate region winter in tropics or S Hemisphere; occurs in near shore and offshore marine environments.
Auks/Murres/Puffins (Alcidae)	-/ LC, VU, NT, E, CR Status 3	↓, —	Highly social, with most species breeding in colonies or loose aggregations; all species surface-dive in pursuit of plankton or fish; larger species dive up to 100 m deep; smaller species to 20 m; some species avoid disturbance (e.g., vessels) by diving rather than flying away.	Circumpolar north of Tropic of Cancer; exclusively marine, neritic and pelagic; depending on species and area, can be sedentary, dispersive and migratory during post-breeding period.
Seaducks (Anatidae: Mergini)	-/ LC, VU, E, CR	↓, —	Gregarious during non-breeding period; lone pairs nest at inland freshwater and marine environments; dive (likely <10 m) for vegetation, benthic and pelagic invertebrates, fish.	Circumpolar north of Tropic of Cancer; highly migratory during post-breeding period; can occur in large numbers in near shore marine environments.

Sources: del Hoyo et al. 1992; Zavalaga and Jahncke 1997; BirdLife International (BLI) 2006; CITES 2006; IUCN 2006; Krasnaya Kniga 2001; USFWS 2006a.

Notes: *Limited to birds that use marine habitats.
**Global status of marine bird species within each group. E = endangered, T = threatened, VU = vulnerable, CR = critically endangered, LC = least concern, NT = near threatened, - = none listed. ↑ = increasing, ↓ = decreasing, — = stable.
Red Book of the Russian Federation: Status 1: endangered and under threat of extinction; 2: vulnerable; 3: rare and numbers declining; 4: small population, numbers difficult to estimate and/or species is at limits of it's range.

6.6.1 Hearing in Birds

Birds are less sensitive to the high and low ends of their frequency ranges than are mammals. However, mid-frequency bird hearing is similar, spanning 1-5 kHz with the greatest sensitivity to sounds at ~2-3 kHz (Dooling et al. 2000); the normal range of human hearing is ~20-20,000 Hz, with greatest sensitivity ~1-4 kHz. Most birds have an upper limit of <15 kHz (Dooling 2002).

Little is known about the hearing abilities and sensitivities of seabirds. Available information suggests that the avian ear is adapted to in-air hearing, although seabirds are believed to be able to hear underwater. For example, Melvin et al. (1999) found that underwater acoustic pingers operating at 1.5 kHz with a pulse duration of 300 ms every 4 s at 120 dB re 1 μPa deterred diving seabirds (viz., Common Murre and Rhinoceros Auklet) from gill nets used to catch salmon.

For the purpose of impact assessment, it is assumed that the in-air hearing of seabirds is similar to that of other birds that have been tested. It is also assumed that the avian ear is better adapted for hearing in-air sounds than those underwater. Consequently, like other animals that have evolved to primarily hear in-air, but that are capable of hearing underwater (e.g., northern fur seal [Moore and Schusterman 1987] and humans [Parvin 1998]), frequency-dependent hearing thresholds of birds should be higher underwater than in-air.

6.6.2 Effects of Seismic Sound and Other Activities on Seabirds

There is little scientific literature on the effects of airguns and sonar on seabirds. The following sections summarize the few studies regarding implications of seismic surveys for marine birds.

6.6.2.1 Sound Sources and Characteristics

Sounds generated by the airguns and vessel engines in the frequency range 1-5 kHz would be audible to seabirds below and above the water. Sounds produced by the echo-sounder are well above the known upper frequency limit of bird hearing and are therefore unlikely to be heard by birds; due to the lack of underwater audiograms for seabirds, however, this is uncertain.

6.6.2.2 Acoustic Effects

Few investigations into the effects of airguns on seabirds have been published. Stemp (1985) did not find any conclusive evidence that seismic surveying affected the distribution or abundance of Northern Fulmars, Black-legged Kittiwakes, or Thick-billed Murres. In a more intensive and directed study, Lacroix et al. (2003) investigated the effect of seismic surveys on moulting Long-tailed Ducks in the Beaufort Sea, Alaska. They did not detect any effects of near shore seismic exploration on ducks in the inshore lagoon systems. Seismic activity also did not appear to significantly change the diving intensity of Long-tailed Ducks. Neither Stemp (1985) nor Lacroix et al. (2003) observed any bird injuries or mortalities resulting from seismic surveying with airguns.

Birds might be affected by seismic survey sounds, but the impacts are not expected to be significant to individual birds or to their populations. The types of acoustic and other impacts that are possible are discussed in brief below.

Masking

The extent to which masking occurs – of seabirds' acoustic environment by seismic survey noise – cannot yet be predicted. However, even if birds exhibit some dependence on underwater sounds, the brief pulses of airgun sounds are not expected to cause masking. The output from the echo-sounder, as noted previously, is expected to be inaudible to birds, so no masking is expected. Further, sonars associated with the proposed site survey have a narrow beam width and operate beneath the vessel where the probability of a bird encountering the sound field is considered negligible.

Disturbance

Possible disturbance of seabirds by the vessel moving through the area could result in temporary displacement or disruption of feeding. However, any consequence resulting from such disturbance would be negligible and have no population level impact. Disturbance of seabirds breeding onshore during the summer months of the proposed survey is also considered highly unlikely; the survey areas are located > 5 km offshore. Impacts to prey species targeted by seabirds are considered unlikely or transitory and are expected to have no impact on foraging.

Temporary Hearing Impairment

Many species of marine birds feed by diving to depths of several meters or more; flocks of feeding birds may consist of hundreds or even thousands of individuals. Also, some seabirds (particularly alcids) escape approaching boats by diving. It is theoretically possible that, during the course of normal feeding or escape behaviour, some birds could be near enough to an airgun to experience TTS; however, there is no available evidence to confirm this, and it is considered highly unlikely that marine birds would dive near enough to a sound source to experience TTS.

Injury

If seismic activity disorients, injures, or kills prey species, or otherwise increases the availability of prey species, marine birds could be attracted to within approx 10 m of active airguns. Birds very close to an airgun may be at risk of induced PTS or other injury due to the intense pressure pulses of the airgun discharges at such close range (sounds levels necessary to induce PTS in seabirds are unknown). However, available evidence from other seismic surveys has not shown a pattern of fish (or other prey) kills from airguns (Turnpenny and Nedwell 1994) (see §6.5.2). During a seismic study involving underwater explosives and airguns, Stemp (1985) reported that Northern Fulmars and Black-legged Kittiwakes “persisted in hovering over the float bags [seismic survey gear]”; however, no indication of feeding activity was reported. Presumably, that portion of Stemp’s study involving explosives (individual charges ≤125 kg) could have killed or stunned fish that in turn attracted seabirds. Also, during thousands of hours spent conducting biological observations from operating seismic vessels, LGL personnel have seldom observed birds being attracted to an airgun array (e.g., Smultea and Holst 2003; Holst 2004; Smultea et al. 2004; Holst et al. 2005a,b; Ireland et al. 2005). During the few occasions when seabirds were seen near active seismic arrays, it was not clear that stunned prey attracted the birds.

No evidence is available on the physiological effects (e.g., stress) of underwater acoustic sources on seabirds.

6.6.2.3 Collision, Entanglement and Ingestion

Seabirds have been injured or killed by entanglement in net-cables associated with fishing vessels (Wilson et al. 2004). Collisions and entanglement are usually precipitated by foraging opportunities provided by discarded offal, catch spillage, and baited gear. Since seismic survey vessels do not present such foraging opportunities, the potential for seabirds to be struck by, or become entangled in, survey gear is considered negligible.

For those species that dive to escape disturbance (e.g. alcids), it is possible that the vessel or its gear could strike them. The extent to which this occurs is unknown but is expected to be insignificant.

Many seabird species (primarily members of the families Procellariidae and Alcidae) are attracted to offshore rigs and vessels by light (Bertram 1995; Montevecchi et al. 1999; Black 2005). Bird mortality has been documented as a result of collision with oil platforms, oiling, and incineration in flares (Wiese et al. 2001), and as a result of light-induced attraction and subsequent collision with vessels (Bertram 1995; Black 2005). Black (2005) reported that birds regularly strike ships at night, but that mortality is usually low.

The planned site survey will take place from mid-June till mid-July and it is believed that the migration of Procellariidae and Alcidea peaks end May.Waste management practices that effectively prevent discard overboard of plastics, Styrofoam, or other non-degradable solid waste during a seismic survey would prevent opportunities for ingestion by seabirds or other marine animals. Sakhalin Energy has a no “discharges to sea” policy and all waste from vessel is returned to shore for responsible disposal at approved sites.

6.6.3 Impact Assessment of the Proposed Survey on Seabirds

In considering potential impacts of the Surveillance Towed Array Sensor System Low Frequency Active (SURTASS LFA) Sonar on seabirds, the U.S. Navy (2005) concluded that birds did not warrant detailed evaluation because, 1) there is no evidence that birds use sound underwater, 2) birds in that project area are shallow divers, and 3) birds can rapidly disperse away from the noise source if disturbed.

In the current impact assessment, it is assumed that animals very close to the acoustic source (e.g., within a few meters) would be at risk. Potential impacts from disturbance, collisions, and entanglement were hypothesized according to documented ecological aspects of seabirds, and documented interactions with analogous components of the proposed survey (e.g., lit vessel at night).

In the absence of quantitative sound-energy criteria to assess the impacts of airguns or sonar on seabirds, impact thresholds estimated for other impulsive sources (e.g., Teachout 2006) were considered, but found to be too speculative for this case.

As a result of exposure to survey related sounds, seabirds may experience short-term behavioural effects. However, little to no exposure to airgun or echo-sounder sounds are anticipated due to expected low numbers of diving birds in the immediate vicinity of the survey vessel, and the fact that it is unlikely that birds would dive in close proximity to the equipment. The potential for the survey vessels to cause seabird mortality via collision is also considered *negligible*. Levels of injury and fatality or behavioural changes to birds resulting from the proposed survey are therefore considered to be *negligible*.

6.7 Interaction with Other Users of the Area

The proposed seismic survey has the potential to interfere with other users of the area and socio-economic interests. The following issues have been identified and are considered further:

- Disruption to commercial fishing activities;
- Interference with subsistence hunting and fishing activities;
- Effects on the local social environment and economy;
- Interaction or interference with marine traffic;
- Interference with or damage to submarine infrastructure and offshore oil and gas production facilities;
- Damage to marine archaeology and cultural heritage; and
- Interference with military uses of the area.

6.7.1 Commercial Fishing Activities

6.7.1.1 Commercial Fish Resources

As described in §6.5.2, available studies indicate that fish responses to seismic sources are species-specific and may differ according to the species' life stage. Immediate mortality and physiological damage to eggs, larvae, fry, and adult and juvenile marine fishes is unlikely to occur, unless the fish occur very close to the sound source. Behavioural changes resulting from increased noise levels may include disorientation, displacement, interruption of important biological behaviours (e.g., feeding, mating), and alarm / startle responses. Some fish may be displaced from suitable habitat for hours to weeks, depending on the intensity and duration of the seismic survey work.

The zone of ensonification that could elicit a response from fish is likely limited to the immediate vicinity around the airgun array during firing. Thus, a large area of coastal/offshore waters would remain outside of the main impact zone, and would therefore not be disturbed during seismic firing to the extent that the migratory behaviour of salmonid fish would be disrupted. It is expected that potential migratory routes for salmon to coastal lagoons and river mouths would remain open and the available resource would not be diminished as a result of the survey.

Available science and management literature demonstrates that, at present, there are no empirical data to demonstrate potential impacts to fish that reach a population-level effect and the information that does exist (see §6.5.2) indicates that seismic surveys would be highly unlikely to result in significant impacts to marine fish or related issues (e.g. impacts to migration/spawning, rare species, fishing). Therefore, it is considered that although the seismic survey may have very localised and adverse impacts on fish in the immediate vicinity of the airgun array, the effect on the resource available to commercial fisheries would be negligible and any effect would be of a short-term nature. This conclusion is particularly relevant to the potential displacement of fish during migration through or adjacent to the survey area and their continued availability with regard to fisheries.

In addition to the effects of increased noise levels, other potential impacts on fish may be caused by anchor or cable deployment and the accidental spillage of fuel/oil from vessels.

A coarse filtration system will be fitted to the seismic survey vessel, which will prevent the entrainment of fish into the seawater intakes. As a result of this measure, although there may still be some entrainment of small, pelagic fish via the seawater uptake, the effects of this on available resources will be *negligible*.

6.7.1.2 Commercial Fishing Practices

As described in Chapter 5, the majority of fishing conducted in the Piltun-Astokhskoye area is subsistence, and is conducted close to shore. Although offshore waters in the area do support occasional commercial fishing for various fish, shrimp and crab, detailed information on the extent of this activity in the area is lacking; it appears that the area is not intensively fished and that only a small number of local boats occasionally use the area (SEIC, EIA Addenda 2005).

The proposed site survey has the potential to interfere with fishing activities and damage fishing equipment (e.g. nets, lines, fixed gear) in the area. Damage to fishing equipment is a concern from both a safety perspective (i.e. potential risk to personnel on the fishing vessel and the survey vessels) and in terms of adverse reactions/complaints and subsequent compensation claims from fishermen whose equipment has been damaged (i.e. loss of equipment and temporary loss of earnings/livelihood). Damage to the streamers from fishing gear, the loss of streamer fluid (if used) and resulting impact on marine biota is also a concern (see §6.9.1 on accidental spills and leaks). Given the limited use of the area for commercial fishing, it is considered that the likelihood of significant interaction with fisherman is very low and the unmitigated risk is considered *minor*.

Given the temporal and spatial boundaries of the survey, any potential effect on fishing activity would be short-term and limited to a relatively small part of the total nearshore fishing area available to local fisherman.

Nevertheless, to avoid any potential conflicts, notifications will be issued prior to the start of the survey to alert fishermen who operate in the vicinity to avoid the survey area during the period of operations. It is expected that any compensation claims and conflicts with fishing activities will be resolved by the survey contractor in line with requirements of the Sakhalin Oblast Administration.

Provided these measures are implemented, the likely impact on both the ability of fisherman to realise potential quotas (i.e. maintain fishing effort) and the integrity of their fishing equipment is predicted to be of *minor* significance.

6.7.2 Subsistence Fishing and Hunting

6.7.2.1 Subsistence Fishing

The most important subsistence fishery is for salmon, with the majority of the fishing in north-east Sakhalin coinciding with the migration of pink and chum salmon during the summer-autumn months.

In northeast Sakhalin, the peak migratory period for pink salmon – and therefore the peak of fishing effort – generally occurs from end-July/mid-August to the beginning of September, although some fish may start arriving in offshore waters at the beginning of July (SakhNiro 1998).

For chum salmon, there are two migratory movements during the year: in summer and in autumn. The summer run, which takes place in July, is the lesser of the two runs; fish are much more abundant during the autumn run in the north-east. Peak migration activity during the autumn occurs from mid September to early October, with the beginning of the run occurring in mid-August in the majority of years (SakhNiro 1998).

The seismic survey is proposed to take place over a three-week period, during June to July; it would therefore occur outside of the main migratory period for pink salmon and would avoid the main autumn run of chum salmon. There might be some overlap with the summer run of chum salmon and the early part of the pink salmon run. However, from a resource perspective it is considered that if any disturbance were to occur, the majority of the resource and potential fishing effort (i.e. undertaken during the main runs) would remain unaffected. The potential for disruption of migratory salmon populations and the resource available to local people in the north-east of the island is therefore considered negligible. If the survey were delayed until later in the summer, the potential exists for an increased risk of disturbance to migratory fish populations, although it would remain highly unlikely that it would be of such extent that local fisherman were not able to realise their subsistence quotas.

It is also important to note that disturbance to migratory populations of salmon would be highly unlikely to occur during the seismic survey.

On this basis, it is considered that given the location and timing of the seismic survey work, that the potential for disruption to migratory salmon populations and the resource available to local people in the north-east of the island is *negligible*. If the survey were to be delayed until later in the summer, the potential exists for an increased risk of disturbance to migratory fish populations, although as stated previously it is considered that any such effect is unlikely. In this situation, while the level of risk of disturbance may be slightly raised, it would be highly unlikely to be of such extent that local fisherman were not able to realise their subsistence quotas.

6.7.2.2 Marine Mammals and Waterfowl

Seal hunting generally occurs at specific locations (e.g., seal haul-out areas) and at certain times of year. As described in Chapter 5, very little hunting of marine mammals occurs in the vicinity of the Piltun-Astokh area, with most taking place in the bays and coastal areas of Chaivo, Nyisky, Nabil and Lunsky, at seal haul out sites during the winter, spring and summer months.

Airborne noise levels from the seismic survey would not significantly propagate to the coastal areas, and therefore disturbance to seals at haul-out areas by this aspect would be highly unlikely to occur. Likewise, only low levels of underwater noise generated by the survey are predicted to reach the shore (see §6.3), and therefore this aspect is also highly unlikely to cause a significant reduction in local populations.

Any potential slight disturbance, should it occur, would be of a short term and localized nature, with no implications for use of established haul-out areas beyond the period over which the seismic survey extends. On this basis, the survey work would have a negligible impact on either the resource or the ability of local people to continue with traditional hunting practices.

The hunting of waterfowl would not be affected, as the seismic survey work will be undertaken outside of the hunting season for waterfowl. No long-term impacts on coastal waterfowl populations as a result of the survey work are anticipated.

As hunting effort is largely centred away from the Piltun-Astokh area, the extent to which the planned survey could affect hunting activities is therefore low.

Additionally, there is only limited land-based activity associated with the seismic work (e.g. behaviour monitoring team) and therefore no direct impact on the capability of local hunters to access hunting sites in the Piltun area or disturbance to seal haul outs. The only possible source of impact is therefore restricted to potential noise levels during the seismic work and any effect that this may have on the use of haul out areas by seals (e.g. displacement of animals from traditional haul out sites through noise associated disturbance).

6.7.3 The Local Social Environment and Economy

Since site survey activities are almost all vessel-based, and since typical support measures (e.g. marine mammal observers) are already part of the existing fabric, contact with local communities on Sakhalin Island should be minimal, increasing only if an unplanned event occurs where the vessel/personnel may be forced to visit a local port/facility.

Stresses to local village infrastructure, health care, and emergency response systems are therefore expected to be negligible. It is also anticipated that there will be no significant impact on natural resources (i.e. regularly hunted animal species) that local people may utilise (see §6.7.2).

We are not aware of any diving or marine-based tourist or recreational activities in the Piltun-Astokh area. As a precautionary measure, warnings of the proposed activities will be issued to relevant parties (Notice to Mariners) and a vigilant watch will be maintained throughout survey activities.

No adverse impacts on local communities, amenities, the local economy, recreational activities and tourism are therefore predicted.

6.7.4 Marine Traffic

The majority of ports are located towards the south of Sakhalin Island where they remain free of sea ice for most of the year. Therefore, no merchant shipping routes are known in the vicinity of the Piltun-Astokhoye area. Levels of marine traffic in these areas are expected be very low: mainly local fishing boats and some oilfield-related traffic.

The proposed PA-C site survey area is indicated in Figure 6-6 in relation to existing Sakhalin Energy vessel transit corridors; it includes an area that overlaps part of the crew change vessel corridor between the PA-A and PA-B platforms; a slight intercept of the navigational corridor to the east is also evident. All vessels involved in the survey will adopt standard warning and navigation equipment and procedures in order to reduce the risk of collisions with other vessels. These will include the use of radar, foghorns, and issuing a Notice to Mariners to warn that the survey is taking place and conveying the limited manoeuvrability of the survey vessel.

Although these risks will be controlled by the use of standard navigation procedures, the unmitigated risk of collisions is considered *moderate*.

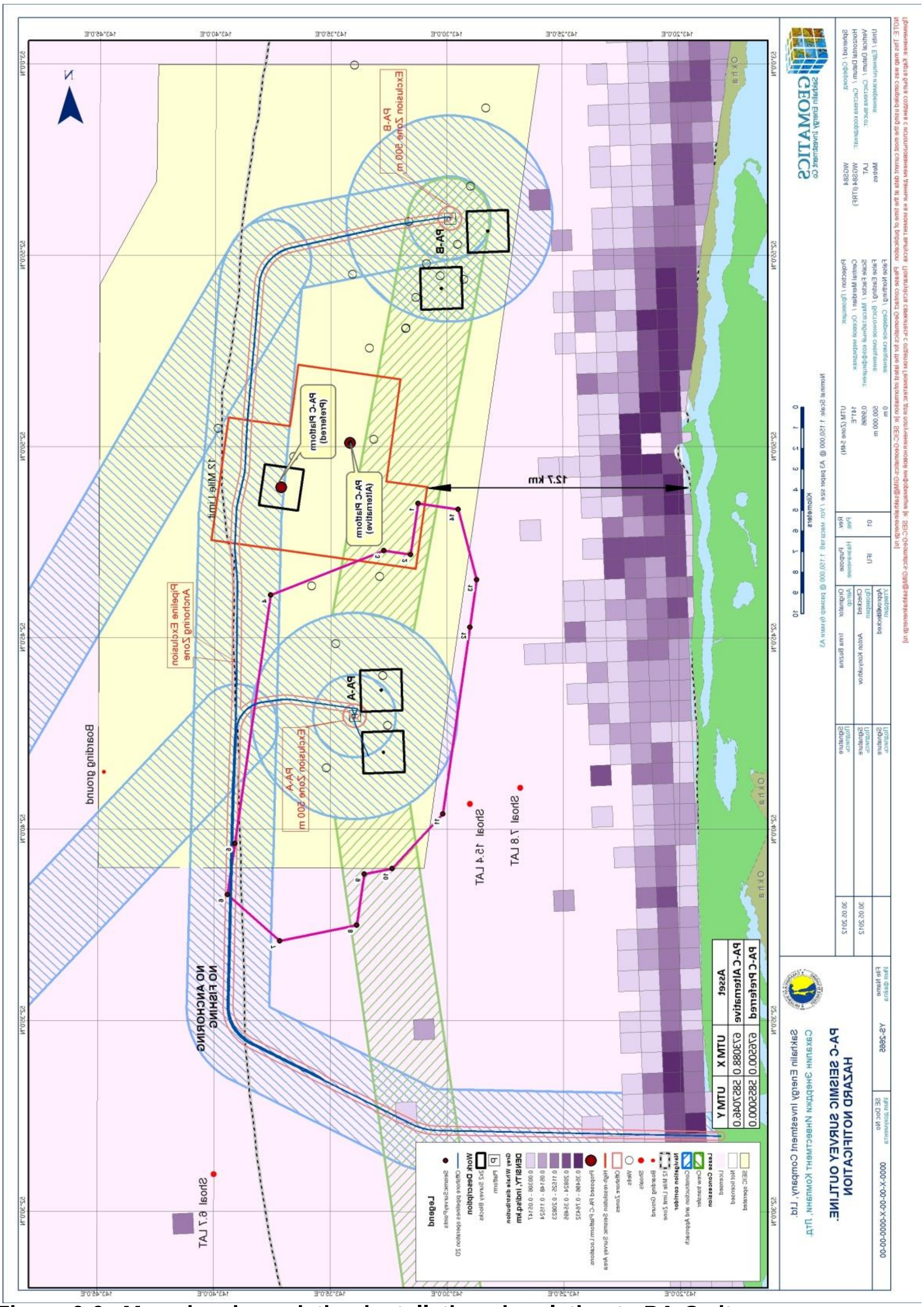

Figure 6-6. Map showing existing installations in relation to PA-C site survey area.

6.7.5 Submarine Infrastructure and Offshore Production Facilities

The main, offshore infrastructure currently in the Piltun-Astokh area is depicted in Figure 6-6: the PA-A platform in the southern Astokh area, the PA-B platform in the northern Piltun area, offshore pipelines and cables, and SALM[88]. The PA-A platform is located at 52°42'58"N, 143°33'56"E (about 16.5 km from the coast in water depth of ~30 m), the PA-B platform is at 52°55'58.94"N, 143°29'53.92"E (about 12.5 km from the coast in water depth of ~ 30 m), and the SALM is at 52°41'56.498"N, 143°33'21.831E.

Seventeen producing and water-injection wells have been drilled from PA-A, while 14 have been drilled from PA-B. Pipelines have been installed to transport the oil and gas from PA-B to shore, via the PA-A platform some 24 km to the south. These pipelines have been laid west to east from PA-B and then turn south at 143°39'E. The landfall for the pipelines is located at the northern end of Chaivo lagoon, approximately 30 km to the south-west of the PA-A platform.

According to Sakhalin Energy's *Marine Operating Procedures and Guidelines*[89], two "exclusion zones" have been established:

- A 200 m zone centred on the SALM position and either side of the pipeline; and
- A 500 m zone around the PA-A and PA-B platforms.

Under no circumstances is any vessel allowed to anchor in the vicinity of the pipeline / SALM. Anchoring within the platform exclusion zones is permitted only with the permission of platform OIM. An Operational Safety Zone of 5,000 m has been established around PA-A; all vessels are required to report to PA-A Radio when entering this zone.

The proposed PA-C site survey area is shown in Figure 6-6 in relation to existing infrastructure and safety/exclusion zones. Provided that marine operating procedures and guidelines are adhered to (including defined exclusion zones), the potential risk of vessel interaction with the platform (e.g. collision) or trenched pipeline (e.g. by way of anchoring) is considered to be *negligible*.

6.7.6 Marine Archaeology and Cultural Heritage

Survey vessels and associated equipment may damage features of marine archaeological and cultural heritage as a result of collision or the effects of pollution (e.g. accidental fuel / oil spillage). However, no features of archaeological or cultural heritage importance are known to exist in the offshore vicinity of the Piltun-Astokh area. Impacts are predicted to be *negligible*.

6.7.7 Military Use

There is no known military interest or activity in the Piltun-Astokh area and therefore no impacts are predicted. However, as a precautionary measure the Russian military will be notified of the details and schedule of the operations to avoid any potential conflicts. Impacts are predicted to be *negligible*.

6.8 Effluent Discharge, Emissions, and Waste Disposal

Effluent discharges, emissions, and waste disposal could impact environmental receptors if uncontrolled. These could include:

- Oil-contaminated drainage and sanitary effluent may affect water quality resulting in adverse effects on marine organisms;

[88] Although the Single Anchor Leg Mooring (SALM) has not been used in production since commissioning of Sakhalin 2 Phase 2, the unit remains on the seabed for possible deployment should unlikely, abnormal operating conditions require it.
[89] Document number 1000-S-90-90-P-0017-00 Revision 5

- Residual chlorine in discharges from sewage treatment or water generator systems may also affect marine organisms;
- Toxic effects on marine organisms in the event of an accidental release of solid or scheduled wastes into the marine environment;
- Physical damage to marine organisms and impacts on water quality and the coastal environment as a result of inappropriate waste management and disposal methods; and
- Short-term localised increases in down wind pollutant concentrations and reductions in local air quality.

6.8.1 Drainage System Discharges

Drainage effluents such as rainwater and sea spray runoff from uncontaminated deck areas will have no effect on the water quality and ecology of the receiving waters. Drainage from cable handling areas, machinery spaces, bilges, *etc*. may be contaminated with oil (e.g. diesel, cable oil, lubrication oil). These drainage fluids shall be processed through an oil/water separator prior to discharge in compliance with MARPOL Annex I requirements (maximum discharge concentration of 15 ppm). After processing, the residual hydrocarbons in the effluent discharge will be diluted and disperse rapidly in the receiving waters so that any reduction in water quality will be localised and temporary. The potential effects of discharge of drainage system waters on marine biota are therefore considered to be *negligible*.

6.8.2 Sanitary Effluent

Sewage generated onboard the survey vessels will likely be treated using aerobic methods, settlement, and the neutralisation of pathogens, prior to discharge. Discharged effluent should exert only a negligible biological oxygen demand on the receiving waters. Because of natural dispersion by wave action, current flow and the assimilative capacity of the water column, these localised and temporary increases in organic material are expected to have a *negligible* impact.

All solid wastes will be transported to shore for waste disposal and no solid waste will be permitted to be disposed overboard by any vessels. There will therefore be no impact on marine water quality from these sources.

6.8.3 Chlorinated Water Discharges

Discharges from vessel service water systems and sewage treatments may contain residual concentrations of chlorine. Typical concentrations are estimated to be approximately 1.0 ppm. Chlorine is harmful to aquatic life even at low concentrations, with toxic thresholds for fish in the range of 0.1 to 0.4 ppm (International Hydrological Programme 1979). However, any residual chlorine in discharge to vast offshore marine waters would disperse rapidly, and result in chlorine concentrations below potentially harmful levels. Impacts on marine organisms as a result of residual chlorine in effluent discharges are therefore considered to be localised, short term (i.e. will only occur for the duration of the survey works) and of *negligible* significance with respect to marine ecology.

6.8.4 Cooling Water

Heated engine cooling water from the survey vessels will be discharged to the marine environment, usually after a once-through pass, forming a plume with a temperature greater than the ambient water. This heated water will rapidly lose thermal energy to the surrounding water column, reducing the plume temperature, and ensuring that a significant thermal plume cannot form. No impacts are predicted to occur as a result of this discharge.

The intake of seawater for cooling purposes and service water use (e.g. potable water production and deck wash down) could entrain marine biota in the uplift stream and damage them. Weakly swimming or free floating planktonic populations are likely to be affected by the intake, experiencing mortality and injury as a result of mechanical and thermal effects. However, the level of mortality likely to occur would not constitute a significant effect; the generally ubiquitous nature and abundance of planktonic organisms in offshore waters, the high level of natural mortality, and the very localised nature of any impact (i.e. confined to the volume of water in the immediate vicinity of the intake), should be taken into consideration in this impact assessment. The overall impact of this effect during the survey is therefore considered to be *negligible*.

6.8.5 Solid and Scheduled Wastes

Scheduled wastes such as lubrication oil and oily slops generated by survey vessels will be returned onshore and disposed of at an appropriate facility when the vessels return to port. The handling, management and disposal of these wastes will be conducted in accordance with appropriate legislative requirements and Sakhalin Energy procedures where relevant. Hazardous materials (e.g. lithium batteries) will be stored onboard and returned to the supplier.

There have been numerous reports of animals ingesting wastes in marine waters. Floating debris can be 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. Foreign objects can obstruct the gastrointestinal tract and cause gastric inflammation, nausea, and loss of appetite, which may result in starvation and death. 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. Consequently, the moderate risk of uncontrolled waste disposal must be managed, but with a “no discharge to sea” policy this is primarily a third party control issue.

The seismic survey vessel is likely to have onboard facilities for the compaction and incineration of solid wastes (including food wastes). Non-combustible wastes and incineration residues will be stored onboard and returned to port for disposal. The waste management procedures in place onboard the survey vessels will be designed to ensure that there will be no fouling or contamination of the marine environment as a result of solid and scheduled wastes generated during survey operations. As long as these procedures are fully implemented there should be *negligible* impact from the generation of on board waste.

6.8.6 Air Quality

The principal emission sources from the survey operations will be exhaust gases from vessel propulsion systems and incinerators, power generation equipment, and from the incineration of solid wastes, if applicable. The primary emissions from these sources will include carbon dioxide, carbon monoxide, nitrogen oxides, hydrocarbons, sulphur dioxide and particulates. Ozone depleting substances are not expected to be used onboard the vessels, but may be used as refrigerants in older vessels where closed recovery systems are in place. No release of ozone depleting substances is therefore anticipated during survey operations.

Emissions from the vessel propulsion and power generation systems together with intermittent releases from the onboard solid waste incinerator will result in slight increases in downwind pollutant concentrations. Exceedance of ambient air quality criteria is not expected to occur, and given the transient nature of the survey operations, the volatility of the air emissions and the generally high winds, emissions would be expected to undergo rapid dispersion resulting in only localised, very short term and therefore *negligible* impacts upon air quality.

Under Sakhalin Energy’s Marine Operating Procedures, it is expected that Masters of the survey vessels will report the fuel consumption of their vessels and the sulphur content of the fuel used.

6.9 Accidental Spills, Leaks and Dropped Objects

6.9.1 Release of Harmful Substances

Release of potentially polluting contaminants may affect receiving marine water quality and biota. The level of significance would depend to a large degree on the scale of the release and also the nature of the substance. Accidental spills and leaks may arise for a variety of reasons, including vessel collision (with other vessels, equipment or natural features), poor management of equipment or processes, and natural events. The vast majority of potential accidents, and therefore environmental impacts, can be prevented through the adoption and implementation of appropriate HSE procedures and measures onboard survey vessels during survey operation. The following sections provide an assessment of the potential impacts associated with the most likely sources of spills and leakages.

6.9.1.1 Streamer Fluid Release

Streamer cables may contain streamer fluid – typically a kerosene-like fluid which predominantly consists of C12-C15 isoparaffinic hydrocarbons – to provide buoyancy; individual sections may contain approximately 20 litres, while the total volume per streamer can be100-200 litres.

Damage to one or more of the streamers during the survey may cause the release of streamer fluid; the risk of damage depends on the hazards in the area (e.g. fishing equipment, submerged wrecks, *etc*.), weather conditions, and operating procedures. Complete breaks in cables are rare and typically only occur when currents whip cables around a structure such as an oil platform; damage to segments of the streamers may occur more frequently – usually once every three to six months on average.

Damage that results in rupture may cause the release of small amounts of fluid (20 litres or more depending on the number of sections damaged); in practice, the full volume of fluid within a segment is rarely lost. If such an accident were to occur, the potential environmental effects would be limited to:

- Localised and temporary reduction in water quality: the fluid would be expected to have a short residence time in the marine environment due to its light and volatile nature, and the effect of wave and wind activity assisting evaporation. Although the liquid may evaporate within a few hours under moderately warm conditions, residence times would be greater in the colder Sea of Okhotsk.
- Physical impacts on benthic communities arising from the cable and associated equipment sinking to the seafloor: streamers have automatic flotation devices that activate at a depth of approximately 50 m, and therefore it is unlikely that any physical impacts would occur.
- Potential chemical/biological impacts on demersal and pelagic communities: ecotoxicological studies on freshwater fish indicate that kerosene-like fluids have an observable adverse affect at concentrations >5 mg/l, although low-level mortality does not tend to occur until concentrations exceed 10 mg/l (American Petroleum Institute 2003). Under the conditions of open-water deployment, such concentrations are highly unlikely to occur given the relatively small amounts of accidental release and rapid dilution. Pelagic, free swimming organisms would also be able to actively avoid any contaminated waters and/or pass through such areas rapidly, without the potential for suffering any acute effects.

Because of the nature of the streamer fluid, expected weather and sea-state conditions, and the relatively small volumes likely to be released, spillages of streamer fluid are likely to disperse and weather rapidly. As a result, it is considered that there will be minimal opportunity for any adverse effects on water quality or biota in the survey area. Significant smothering, spreading and fouling effects would not be predicted to occur from the release of streamer fluid due to its volatility. The risk associated with small releases of harmful substances is therefore considered *minor*.

6.9.1.2 Bunker Fuel, Diesel, Lube Oil and Oily Sludge Release

It is estimated that approximately 1.25 million tonnes of oil enter the sea each year, due to sea-based activities (GESAMP 2007). Operational discharges from ships make up 45% of the input, followed by shipping accidents at 36% of the input. Fuel oil sludge from vessels is the major routine operational input (~186,000 tonnes per year); oil tankers contribute 4.2% of inputs due to oil in ballast waters. Tanker and barge accidents release ~158,000 tonnes per year, even with the decline in large spills in recent years.

Discharge of oily wastes into the marine environment due to minor accidents (e.g. failure of spill containment systems, separation of fuel hoses during bunkering operations) or discharge of bilge water prior to treatment do impact water quality and marine ecology. The impact depends on the type of oil released, the volume of oil, the location of the spill and the prevailing weather and tidal conditions. Larger releases of bunker fuel, diesel or kerosene, as a result of vessel grounding, collision or other accident-types may have potential to cause significant impact to marine life and – depending on weather and coastal conditions – nearby coastal areas.

As soon as oil is spilled on water, it starts to spread out over the sea surface, initially as a single slick. The speed at which this takes place depends partly on the viscosity of the oil; low viscosity oils spread more quickly than high viscosity ones. Spreading is rarely uniform and large variations in the thickness of the oil are typical. Slicks tend to break up quite rapidly as a result of wind and wave action and water turbulence, and the rate of spreading is also determined by sea temperature, currents, tidal streams and wind speeds.

Lighter components of the oil evaporate to the atmosphere. The amount of evaporation and the speed at which it occurs depend upon the volatility of the oil. Evaporation can increase as the oil spreads, due to the increased surface area of the slick. Rougher seas, high wind speeds and high temperatures tend to increase the rate of evaporation.

Waves and turbulence at the sea surface can cause all or part of a slick to break up into fragments and droplets of varying sizes that become mixed into the upper levels of the water column. Some of the smaller droplets can remain suspended in the sea water while the larger ones tend to rise back to the surface, where they may either coalesce with other droplets to reform a slick or spread out to form a very thin film. Natural processes such as dissolution, biodegradation and sedimentation occur on oil that remains in suspension.

Light oil products, such as diesel, No. 2 fuel oil, and kerosene, are narrow-cut fractions that have low viscosity and spread rapidly into thin sheens when released on water. They do not tend to form emulsions except under very cold conditions. Evaporation may be relatively rapid; up to 70-100% of volume may be lost within a few days. They tend to disperse readily into the water column by even gentle wave action, and thus have the highest potential of any oil type for vertical mixing. There is also a greater potential for dissolution to occur, from both surface sheens and droplets dispersed in the water column. Thus, spills of fuel oil and diesel have the greatest risk of impacting water-column receptors; water-soluble fractions are dominated by two- and three-ringed polycyclic aromatic hydrocarbons (PAHs) that are moderately volatile and may affect aquatic life. Light oil products do not tend to adhere strongly to sediments or to shoreline habitats. Loading potential on the shoreline remains relatively weak because of the thinness of sheens and the low adhesion of stranded oil. The constituents of these oils are light to intermediate in molecular weight and can be readily degraded by aerobic microbial oxidation; long-term persistence in sediments is greatest under heavy loading and reducing conditions where biodegradation rates are lower than under aerobic conditions.

Heavier oil types that could be accidentally released include No. 6 fuel oil, bunker oil, and heavy sludge oils[90]. These oil-types typically lose < 10% of their volume through evaporation. Some of these products are so viscous that they cannot form emulsions, although many do emulsify shortly after release. They show low natural dispersion because the oil is too viscous to break into droplets. These oils have the lowest water-soluble fraction; thus, loadings to the water column are generally low under slicks. Spills of heavy distillate quickly break up into thick streamers and then fields of tar balls that are highly persistent. The weathered products of these oil spills can be transported hundreds of miles, eventually intercepting shorelines, where, depending on volume and extent, may pose significant impacts to birds and other marine animals. Because of their high density, these releases are more likely to sink after picking up sediment, either by mixing with sand in the surf zone or after stranding on sandy shorelines.

6.9.1.3 Potential Effects of Oil Spills

The effects of petroleum hydrocarbons in the marine environment can be acute or chronic. *Acute toxicity* is defined as the immediate short-term effect of a single exposure to a toxicant. *Chronic toxicity* is defined as either the effects of long-term and continuous exposure to a toxicant or the long-term sub-lethal effects of acute exposure. Oil spills in marine waters can lead to direct mortality of marine organisms, reduce their fitness through sub-lethal effects, and disrupt the structure and function of marine communities and ecosystems. Such effects have been well studied in laboratories, but the subtler long-term effects on populations, communities and ecosystems at low doses and in the presence of other contaminants is more difficult to assess and poses a significant scientific challenge.

The most toxic components in oil tend to be those lost rapidly through evaporation when oil is spilt. Because of this, lethal concentrations of toxic components leading to large-scale mortalities of marine life are relatively rare, localised and short-lived. Sub-lethal effects that impair the ability of individual marine organisms to reproduce, grow, feed or perform other functions can be caused by prolonged exposure to a concentration of oil or oil components far lower than will cause death. Sedentary animals in shallow waters such as oysters, mussels and clams that routinely filter large volumes of seawater to extract food are especially likely to accumulate oil components. It should be noted that there is no clear relationship between the amount of oil in the marine environment and the likely impact on wildlife. A smaller spill at a particularly sensitive time/season and in a vulnerable environment may prove much more harmful than a larger spill at another time of the year in another or even the same environment.

In relation to the nearshore Piltun area, the main groups of organisms of interest in potential oil spills are fish, marine birds and marine mammals. The following text provides a brief summary of the effects of oil spills and contamination of marine waters on these groups; throughout, the description is biased towards the assumption that any spills are likely to be small, the oil involved is likely to be relatively volatile, and the effects would be short term.

There is no definitive evidence to indicate that fish populations are affected by oil in the open sea; in open waters, fish have the ability to move away from an area of pollution, and are therefore either unaffected by oil or affected only briefly (White and Baker 1998). However, fish can be substantially affected in some circumstances, especially when light oil is released into shallow or confined waters; as the oil begins to weather it enters the water column and fish become directly exposed. Consequently, fish kills may occur as a result of high exposure to emulsified oil in shallow waters and gross oil pollution may clog fish gills causing asphyxiation.

Fish species at particular risk include bottom-dwellers such as flounders, which are exposed to sediments that become contaminated with sunken oil. Fish can accumulate hydrocarbons in tissues or body fluids through exposure from contaminated sediment, water or food. The

[90] Heavy fuel oils typically contain between 1 percent and 5 percent sludge or waste oil, which cannot be burned as fuel.

bioavailability of hydrocarbons from sediments and food is less than that from solution in water. If there is widespread dispersal of oil in the water column it may be taken up through their gills or eaten resulting in an accumulation in the stomach, gall bladder and liver. In commercial species this may lead to the flesh having a tainted flavour making it inedible (Clark 1997). Although some hydrocarbons may persist in the body for some time, most are rapidly lost when the fish are no longer exposed to the pollution.

Oil poses a much greater threat to fish eggs and larvae that cannot actively avoid or escape a pollution event. As fish eggs and larvae are mostly planktonic, they can be affected by all early stages of a spill, and many cleanup techniques (IPIECA 2000). These life stages are extremely vulnerable to the toxicity of both oil and chemical dispersants, and heavy mortalities often result. Even low concentrations of hydrocarbons can have marked effects on the proportions of eggs that hatch and on the growth rates and development of larvae. Lethal effects on the population as a whole are rare but long term, sub-lethal effects are possible, particularly if a major spawning area is affected.

Marine mammals and birds can be affected by oil in the sea through several ways. As air-breathing organisms that obtain much or all of their food from beneath the surface of the sea, marine birds and mammals must frequently pass through the water's surface. Fouling by oil may affect the insulating characteristics of feathers and fur and lead to death from hypothermia.

Whales exposed to oil are generally less 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 (Geraci 1990; St. Aubin 1990). Preliminary laboratory tests show that gray whale baleen, and possibly skin, may be fairly 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 impacting their benthic food supply.

Whales that ingest oil with contaminated water or food could expel it in vomit or faeces, but some is likely to be absorbed and could cause toxic effects (Geraci 1990); however, whales exposed to an oil spill are unlikely to ingest enough oil to cause serious internal damage. Whales could also absorb oil through the respiratory tract. Crude oil could also coat the baleen of mysticetes and reduce filtration (and thus feeding) efficiency; however, effects may be reversible within a few days and therefore minor (see Geraci 1990 for a review).

Seabirds and pinnipeds may be poisoned when they ingest oil-contaminated prey, or during the course of trying to remove oil from their feathers or pelage. Marine mammals (and possibly seabirds) may inhale toxic doses of petroleum vapour when at the surface in the vicinity of an oil spill (Geraci 1990; Geraci and Williams 1990), although there appear to be few data indicating that this is an important cause of mortality. Seabirds can also transfer oil from their feathers to the surface of their eggs during incubation; depending on the toxicity of the oil, embryos in the affected eggs may fail to develop. Oil can also indirectly affect the survival or reproductive success of marine birds and mammals by affecting the distribution, abundance or availability of prey (NRC 2003).

In seabirds, ingestion of oil or oil-contaminated prey may lead to immuno-suppression haemolytic anaemia, which compromises the ability of the blood to carry oxygen. This effect persists long after the birds appear to have recovered from exposure (Fry and Addiego 1987). Large spills that occur over the deeper ocean in open water that has little bird life will have a lesser effect on seabirds than a small spill in a critical habitat where high numbers of birds are aggregated on the water. The season in which a spill occurs is also critical (Hunt 1987). If the spill occurs when birds are aggregated during breeding or migration, the impact will be much greater than if they are widely dispersed at sea.

In addition to significant evidence of the impacts of contamination associated with a large oil spill which occurrence in itself is very low, there is increasing evidence that chronic, low-level exposures to hydrocarbons can have a significant effect on the survival and reproductive performance of seabirds and some marine mammals. Sublethal effects of oil in seabirds include reduced reproductive success, and physiological impairment, including increased vulnerability to stress (reviewed in Fry and Addiego 1987; Briggs et al. 1996). In contrast, in marine mammals, sub-lethal exposure to petroleum hydrocarbons has been shown to cause minimal damage to pinnipeds and cetaceans (e.g., Geraci 1990; St. Aubin 1990), although sea otters appear to be more sensitive (Geraci and Williams 1990). Because both marine birds and marine mammals have the enzymes necessary for detoxifying and eliminating petroleum hydrocarbons, parent compounds of petroleum hydrocarbons are not accumulated and sequestered in tissues. Toxic metabolites produced by metabolism of PAHs, however, may accumulate and induce toxic effects. SEIC annually monitors for these types of impact and to date levels remains at -or below background values.

6.9.1.4 Impact Assessment of Release of Harmful Substances

Collision with ice is unlikely to occur because the work will be conducted in relatively ice-free conditions. Collision between vessels, or equipment-entanglement problems, are also unlikely to occur because vessels are required to maintain a minimum separation of 15 nautical miles. It is assumed that there would be no authorized discharge from the seismic vessel or support vessels.

Accidental release, such as a spill of fuel oil during a fuel transfer or damage causing the release of streamer fluid, is possible. Such incidents are considered unlikely to occur, but if they do, the volume of material released would be small.

Small spills of diesel and light fuel oil would undergo evaporation and dilute and disperse rapidly, and therefore are unlikely to cause fouling of seabirds or cause internal damage to marine mammals. Some mortality of planktonic fish eggs and larvae might occur in the immediate vicinity of the spill, but long-term chronic effects to fish would be unlikely. Due to the effects of evaporation and dispersion, a minor offshore spill of diesel or fuel oil would not be expected to cause significant effects to shoreline or coastal habitats and species. It is therefore predicted that a small hydrocarbon spill would have a limited, minor impact with respect to marine water quality and biota.

While large spills of diesel or fuel oil could cause significant mortality to young lifecycle stages of fish, it is unlikely that such a spill would lead to population level effects or longer-term chronic effects. As with smaller spills, it is unlikely that marine mammals and seabirds would be significantly impacted. However, as noted above the effects of the inhalation by marine mammals of oil vapour at the sea surface are largely unknown and in this respect if the spill covers an extensive area and prevents movement of animals away from the affected area the impact could be significant. With light oils the potential for fouling of plumage and the consequent loss of insulation is significantly less than for heavier oils and spillages of diesel and light fuel oil would be unlikely to lead to mortality at a level that would cause concern at the local population level. The timing of the seismic survey during the early summer months falls outside the main period of seabird assemblage in nearshore waters. Thus, the potential for a significant impact on seabird populations would be reduced, although it would be expected that some very minor impacts on seabirds in the immediate vicinity of the spill might occur.

Spillage of heavier oils such as oily sludges, e.g. accidentally released during maintenance, may have a longer residence time in the water column. As these oils are less likely to be lost through evaporation and have a much greater potential to form emulsions, their presence on the water surface may cause fouling of seabirds present in the area at the time of the spill, or in areas to which any oil is transported by wind and currents. Because of their greater residence time in the water, these oil types also have more potential to impact coastlines, particularly where spills occur in the nearshore. Of particular concern would be potential effects of deposited oil on the migration and spawning of salmonid fish, on wader and waterfowl populations and habitats, and on pinniped haul-out areas. Although the impact of oil spills, even of a relatively small size, can be significant in the short term, numerous studies have documented recovery in the medium to long term.

Also of concern would be the potential for heavier oils to impact coastal and seabed sediments. In northeast Sakhalin, significant impact to sediments that support benthos in known Gray Whale feeding areas would be considered a major effect; amphipod communities are sensitive to heavy oil spills and significant mortality can occur. Typically, recovery of these infaunal and epifaunal communities is relatively rapid; 1-2 years, as documented for the Sea Empress spill in 1996 (Edwards and White 1998). However, recovery would likely not occur within the summer when the whales would be feeding, and the temporary loss of part of this resource could have moderate[91] implications.

The overall unmitigated risk of a large release of a harmful substance, such as oil or fuel, is considered *low*

6.9.2 Impact of Dropped Objects

Any survey equipment lost overboard may foul or create obstructions on the seabed and may act as a future source of pollution. Streamer sections are unlikely to be lost during the course of the survey operations due to automatic devices that inflate when the streamer falls below a certain depth. It is predicted that three plastic 'birds' (depth control units) of approximately 1 m in length will be lost over a thirty-day survey period. If solid-filled streamers are used, a small number of lead weight strips used to control buoyancy, are predicted to be lost during the course of the survey. These objects are not considered to be a risk regarding the potential for obstruction or release of contaminants and losses of this nature are predicted to have a *negligible* impact. The loss of larger objects and cargo would be predicted to have a *moderate* impact on marine organisms or other vessels.

[91] Considering the relatively small volumes and offshore location of potential release during the proposed survey; otherwise major.

6.10 Cumulative Effects

Preceding sections of this chapter address the potential effects of the site survey on Valued Ecosystem Components (VECs). Those sections focussed on environmental aspects of the survey that, in some instances for clarity, did not include all cumulative considerations. Therefore, the current section further discusses potential cumulative effects of the planned survey and other activities that are reasonably foreseeable. Figure 6-7 shows a risk matrix assessing Gray Whale related issues of potential long, medium and short-term effects on particularly the Gray Whale population.

Activities that may contribute to impacts on the identified VECs (marine mammals, fish, invertebrates and birds) include fishing operations, shipping, other seismic operations and industry activities, research surveys, and naval activities.

A full analysis of the Cumulative impacts of Sakhalin Energies activies on the Offshore shelf was presented at the Western Gray Whale Advisory Panel Meeting in February 2012 and is available on the IUCN website (http://www.iucn.org/wgwap/wgwap/meetings/wgwap_11/). This addressed the historical concerns as identified in the Sakhalin II project and also gave a perspective on the risks mitigated and unmitigated including cumulative impacts. Table 6-7 provides a summary of that assessment.

Figure 6-7 The risk matrix presents the key issues associated with the Company's activities. It shows how each issue is assessed in terms of potential long, medium, and short-term effects on the Gray Whale population. Both unmitigated and mitigated risks and effects were considered.

Key Issues	Activities																			
	Construction (dredging, pipe laying, CBGS & topsides, vessels)				Logistics (support & crew-change, ROVs, monitoring, helicopters)				Operations (drilling, maintenance, scour protection)				Seismic Acquisition				Abnormal / Emergency Situations			
	Unmiti-gated		Mitigated		Unmiti-gated		Mitigated		Unmiti-gated		Mitigated		Unmiti-gated		Mitigated		Unmiti-gated		Mitigated	
	R	I	R	I	R	I	R	I	R	I	R	I	R	I	R	I	R	I	R	I
Noise	● red	⅄ green	● green	⅄ green	● orange	⅄ green	● green	⅄ green	● orange	⅄ orange	● green	⅄ green	● red	⅄ orange	● green	⅄ green	● red	⅄ orange	● orange	⅄ green
Benthos	● green	⅄ green	● green	⅄ green	● green	⅄ green	● green	⅄ green	● green	⅄ orange	● green	⅄ green	● green	⅄ green	● green	⅄ green	● red	⅄ orange	● orange	⅄ green
Collision	● orange	⅄ green	● green	⅄ green	● orange	⅄ green	● green	⅄ green	● green	⅄ orange	● green	⅄ green	● green	⅄ green	● green	⅄ green	● red	⅄ orange	● orange	⅄ green
Oil Spill	● green	⅄ green	● green	⅄ green	● orange	⅄ green	● green	⅄ green	● orange	⅄ orange	● green	⅄ green	● green	⅄ green	● green	⅄ green	● red	⅄ orange	● orange	⅄ green
Cumulative	● orange	⅄ green	● green	⅄ green	● orange	⅄ green	● green	⅄ green	● orange	⅄ orange	● green	⅄ green	● orange	⅄ green	● green	⅄ green	● red	⅄ orange	● orange	⅄ green

Key: **R** = Risk; **I** = Impact; ● red = High Risk; ● orange = Medium Risk; ● green = Low Risk;

⅄ red = Long-term impact to Gray Whale (> 2 seasons); ⅄ orange = Medium-term impact to Gray Whale (1 through 2 seasons); ⅄ green = Short-term impact to Gray Whale (< 1 season)

6.10.1 Marine Mammals

6.10.1.1 Commercial Hunting

Historically, commercial whaling undoubtedly had the most significant impact on their populations, resulting in the depletion and endangerment of the gray whale, North Pacific right whale, bowhead, and fin whale – all of which are still listed in the Russian Red Book.

The North Pacific right whale was once abundant in the Sea of Okhotsk, with pre-whaling numbers of ~10,000. Despite the fact that commercial whaling was banned in the 1930s, numbers have remained depressed. Current population estimates are largely speculative and range from 100 to the low thousands, however, most authorities tend toward the lower end of this range (Brownell et al. 2001).

Bowhead whales had an estimated pre-whaling population in the Sea of Okhotsk of 3,000-6,500 (Mitchell and Reeves 1982; Ross 1993); they are now estimated to number 300-400 (Vladimirov 1994) – although, likewise, the data is limited. And although fin whale population figures were not recorded, they were once considered one of the most numerous of the great whales. The population was drastically reduced by intensive whaling, and is currently estimated at 2,700 individuals in the Sea of Okhotsk (Vladimirov 1994).

Many cetacean populations are considered to be in a recovery phase from commercial whaling.

With respect to commercial hunting of pinnipeds, there is an ongoing harvest of some species in the Sea of Okhotsk.

6.10.1.2 Seismic Surveys

Seismic surveys have been extensively conducted in the Sea of Okhotsk. During 2004 to 2007, DMNG acquired approximately 28,000 line-km of 2D seismic data offshore Sakhalin Island. According to Figure 6-7, 2D surveys conducted near the Piltun-Astokh field included SAKH06, SA07 (7,800 km), SA05, SA04 (9,647 km), and SA06.

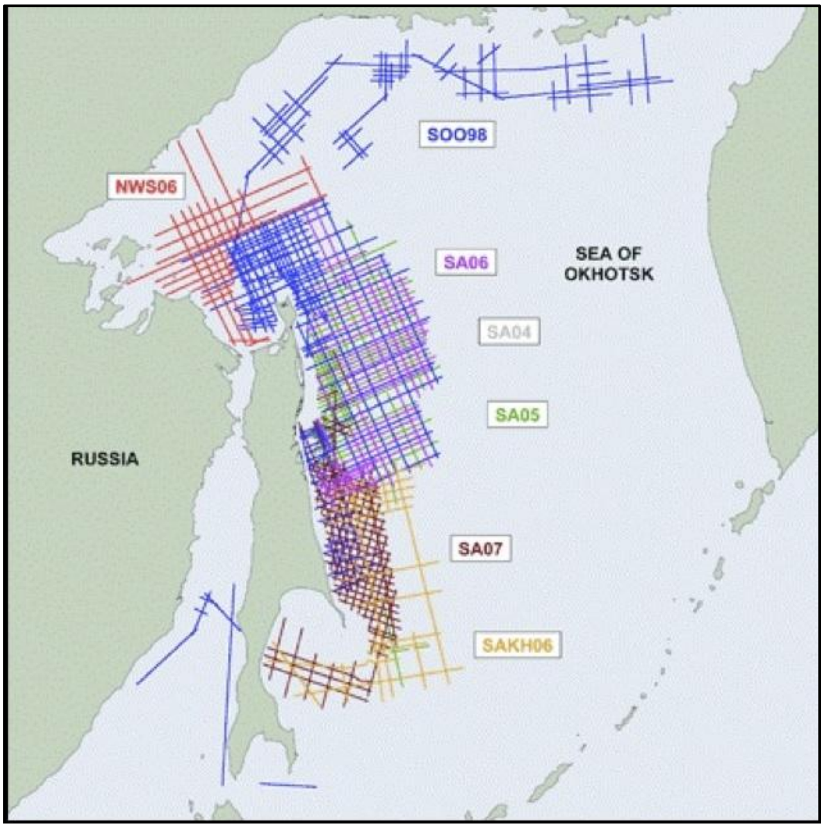

Figure 6-7. Russian Far East geophysical 2D survey data from http://www.tgsnopec.com/data_library/dataLibrary.asp?mid=2173

Table 6-16 summarises the details known to Sakhalin Energy of historical and planned 3D seismic surveys during 2009-2014 (M. Boekholt, pers. comm.); note little detail available for planned surveys by other operators. Also, details of airgun arrays are unknown for other operators, although are likely to be at least as large as Sakhalin Energy's 2,620 in^3 array in their 2010 Astokh 4D seismic survey.

Table 6-16. Summary of 3D Seismic Surveys 2009-2014 known to Sakhalin Energy

Year	Operator	Acquisition	License	Location
2009	Rosneft	DMNG/PGS	Sakhalin V	Schmidt Block, Field Kaigan (to the North of Odoptu)
2009	Gazflot	DMNG/PGS	Sakhalin III	Veninsky Block, Field Veninsky (to the North of Lunskoye)
2009	Gazflot	DMNG/PGS	Sakhalin III	Kirinsky Block, Field Kirinsky (to the South of Lunskoye)
2009	Gazflot	SMNG	Sakhalin III	Kirinsky Block, Field South-Kirinsky (to the South-East of Lunskoye)
2010	SEIC	DMNG/PGS	Sakhalin II	Piltun-Astokh Block, Field Astokh
2010	Rosneft		Sakhalin I	Lebedinskoye field
2010	Gazflot	DMNG/PGS	Sakhalin III	Veninsky Block, Field unknown, outside 12 nm zone (to the Northeast of Lunskoye)
2011	Gazflot	SMNG/PGS	Sakhalin III	East Odoptu Block, Field East Odoptu. Seismic survey vessel *Pacific Explorer* towing six cables 5,500 m long 1 Sep through 1 Nov.
2014	SEIC		Sakhalin II	4D Astokh, 4D Piltun, 4D Lunskoye (notionally planned for 2013)

Of particular interest here are the two 3D surveys carried out in 2010 in the vicinity of the Piltun feeding area: viz., Sakhalin Energy's Astokh survey, and Rosneft's Lebedinskoye survey (Table 6-16). Details of these surveys have already been discussed in §6.4.2 of this report; the western boundary of Sakhalin Energy's survey area was ~4 km from the eastern boundary (95 percentile hybrid PML) of the Piltun feeding area; Rosneft's marine element was located inside the northern part of the feeding area (Figure 6-8).

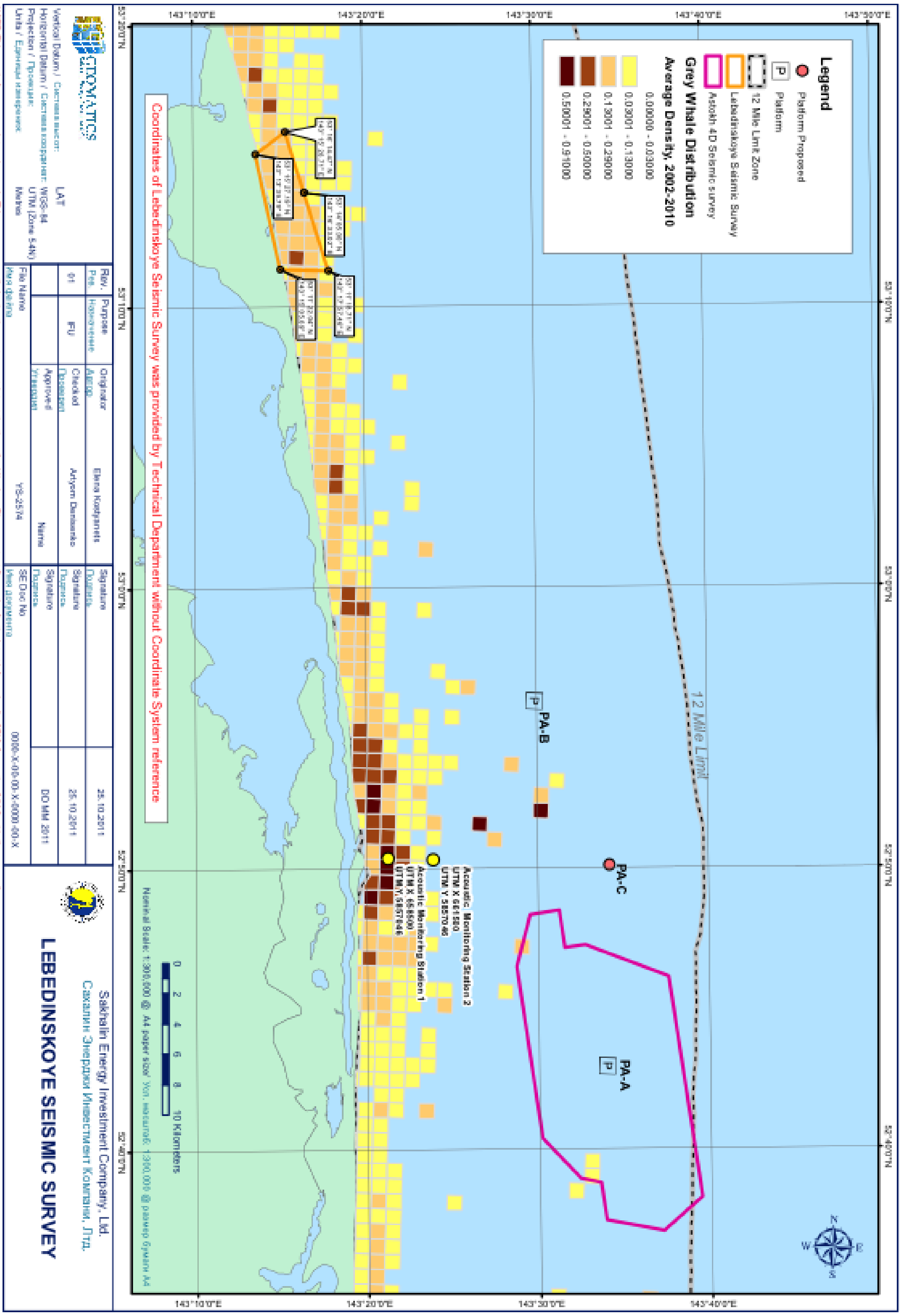

Figure 6-8. Locations of 2010 Astokh and Lebedinskoye seismic surveys

As the Lebedinskoye survey (August-November) was timed to occur immediately after the Astokh survey (June-July), there was concern that Gray Whale would be exposed, while attempting to feed in the Piltun feeding area, to cumulative disturbance over an extended period that could be detrimental at the population level; a letter signed by 12 Commissioners on behalf of the IWC was submitted to the Russian Ministry of Natural Resources informing them of the IWC and WGWAP's belief that "the postponement of the Lebedinskoye survey until at least 2011 is necessary and appropriate."

The Russian authorities considered the IWC's submission, but upheld approval of the 2010 Lebedinskoye survey, stating, "based on the conclusions of the state ecological inspection the acoustic effect which will be exerted on the whales is considered to be acceptable"; the MNR justified their response with reference to the monitoring and mitigation programme attached to the approval[92].

This case probably provides one of the best practical examples of the challenging circumstances associated with prediction, decision-making, management, and effects of cumulative events; it would be unfortunate if it were not more fully analysed and documented in future. No data from Rosneft-Shelf-FarEast (RNSFE) for the Lebedinskoye survey are yet in the public domain; Sakhalin Energy is still analysing their data from the Astokh survey. According to the preliminary NGO Report (WGWAP9/19[93]), fewer whales were sighted by NGO observers during the Lebedinskoye survey than immediately before it. Initial information from the Astokh survey (WGWAP SSTF-6 Report[94]) does not indicate an impact on whale densities; counts of gray whales increased from 3–18 whales/day during the pre-seismic period to an average of 44 whales/day during the last few days of the seismic activity (27 June–1 July), consistent with the arrival of Gray Whale in the feeding area. Sakhalin Energy also reported that shut-down was initiated in accordance with approved mitigation measures on four occasions; twice when whales were observed in the A-zone, and twice when 'aberrant' behaviour (multiple breaching) was observed.

Results from the 2011 Gray Whale monitoring programme will provide further information about possible cumulative effects of the 2010 Astokh seismic survey on Gray Whale. At the time of compiling this EIA Report, field teams were still analysing data. Preliminary indications[95] are (i) that whale densities in the Piltun feeding area appear to be higher in 2011 than in previous three years, and (ii) that numbers of cow-calf pairs in the Piltun area also seem to be higher in 2011 (17 cow-calf pairs) than in previous years..

Following the Astokh 4D and Lebedinskoye 3D surveys in 2010, Gazflot has conducted a 3D survey in the East Odoptu field in 2011(Table 6-16). In 2012, as stated in this report, Sakhalin Energy plans to conduct relatively small 2D surveys near the Piltun feeding area[96].These historical, current and planned seismic surveys present cumulative impact potential if gray whales are harmed or disturbed by associated noise frequencies and levels. However, there is no conclusive evidence to date that they have been significantly impacted by the surveys listed in Table 6-16; Gray Whale continue to use the feeding areas off the northeast coast of

[92] See copies of letters at http://www.iucn.org/wgwap/wgwap/meetings/wgwap_9/
[93] http://www.iucn.org/wgwap/wgwap/meetings/wgwap_9/
[94] http://www.iucn.org/wgwap/wgwap/task_forces/seismic_survey_task_force/
[95] It must be strongly emphasized that the 2011 data remains to be analyzed and finally reported, and therefore conclusions should not be drawn from this preliminary information.
[96] Although there is no confirmation of plans by other operators to conduct seismic surveys near the Piltun feeding area in 2012, the possibility cannot be ruled out. The spatial separation of additional seismic surveys would likely limit the ensonification of WGW in their relevant feeding areas. Although marine mammals, in general, may be affected by additional surveys resulting in their possible movement away from the source of disturbance, their reactions would depend on factors similar to those described previously in this chapter. It is assumed that approval agencies would take cumulative effects into consideration during the approval process, and that any approved seismic surveys would, depending on their location, be required to adopt mitigation measures similar to those outlined in Chapter 8.

Sakhalin despite the historical activities that have occurred there, and the population is reportedly increasing (see §5.9.1.1). Furthermore, precautionary principles considered, the impact assessment discussed §6.4 concludes that it is very unlikely that Gray Whale will be impacted in their Piltun feeding area by noise from Sakhalin Energy's proposed 2012 2D seismic surveys; the airgun array that Sakhalin Energy proposes to use for the 2D surveys has a much smaller total volume (160 in^3 [97]) than typical 3D surveys (2,500-3,500 in^3), and produces much lower sound levels. The sound levels from Sakhalin Energy's proposed 2D surveys have been modelled, and are predicted not to disturb Gray Whale inside the Piltun feeding area[98].

Additional points under this section for consideration:

- The Russian authorities are responsible for legal approval of offshore seismic surveys and are therefore generally understood to be responsible for assessing potential cumulative effects.
- Different operators do not usually share details about their survey plans; the industry has not set up a mechanism (e.g. forum) to jointly plan seismic survey activities with an objective to minimise cumulative environmental effects; nor is it likely to do so.
- Although most individual operators have environmental management systems, and are committed to comply with Russian law, there remains a driving commercial force to minimise costs. Costs are quantifiable and universally understood within management structures; cumulative environmental effects are not easily quantifiable nor as well understood.
- The annual whale numbers, condition of individuals, general behaviour and wider population dynamics, although variable, appear to be unaltered by the activities of the company. In fact population estimates and observation of the numbers of calves indicate the population is growing faster than initially presumed (4%/year) and 2011 showed a record number of mother-calve pairs. In this context, cumulative risks from the company's mitigated measures can be described as low.[99].
- In essence, the potential cumulative impact on the gray whales is a significant concern that International scientists, by the WGWAP, by IWC, IPEE and IUCN need closer and tighter co-ordiantion and greater unity between these International organisations and the Russian Federation Government including MNR (Ministry of Natural Resources). This is mentioned in the WGWAP appraisal of 2011 and the various entities recognize what needs to happen for the programs to be effective. Greg Donovon of the IWC recently said. "It is clear that we need to re-examine our understanding of the population structure of gray whales in the North Pacific and any conservation and management implications that arise from that understanding..[100].

6.10.1.3 Other Oil and Gas Exploration and Production Activities

Detailed, historical information on industrial activities on the Sakhalin shelf is not readily available. Exploration on the shelf was initiated in 1975 following a General Agreement

[97] SIEC is currently investigating the possibility of using 3 X 60 in^3 gun array and will advise following modelling work should this be a more optimum configuration

[98] The response of marine mammals to seismic surveys and other oil and gas activities is discussed in §6.4.2-6.4.5 of this report. The impact assessment presented in §6.4.6 is based on WGW population density maps (2005-2007) that reflect gray whale distribution on the NE Sakhalin shelf, in an environment that includes industrial, commercial, and possibly military activities; thus, this impact assessment takes into consideration data that reflect historical, cumulative effects on the WGW population in this area.

[99] Sakhalin II Phase 2, An overview of the issues and risks to gray whales from new oil and gas development off the north-east coast of Sakhalin Island in the Sea of Okhotsk, *Response to WGWAP Recommendation 020 from Meeting 9*, February 2012

[100] Sakhalin II Phase 2, An overview of the issues and risks to gray whales from new oil and gas development off the north-east coast of Sakhalin Island in the Sea of Okhotsk, *Response to WGWAP Recommendation 020 from Meeting 9*, January 2012

between the USSR and Japan for cooperation in exploration and production. Between 1975 and 1983, joint prospecting within the framework of the General Agreement resulted in more than 30,000 running meters of seismic surveys, and the drilling of 25 wells. The Odoptu field was discovered in 1977 and the Chaivo field in 1979. Lunskoye was discovered in 1984, Piltun-Astokhskoye in 1986 and Arkutun-Dagi in 1989. Between 1975 and 1998 approximately 80 wells were drilled on the Sakhalin shelf.

Only two licence areas on the Sakhalin shelf are currently producing hydrocarbons: Sakhalin I and Sakhalin II. Sakhalin Energy has no information on other operators' plans for drilling of exploration or production wells in their license areas during 2012 or beyond. Under the Sakhalin II project, there will be ongoing drilling from the PA-A, PA-B, and LUN-A platforms throughout 2012. That production drilling would be concurrent with the proposed site survey (including 2D seismic, seabed surveys, and geotechnical coring).However, the distances between the PA-C site survey and the drilling activity at existing platforms will result in negligible cumulative noise / disturbance; the PA-A relief well survey would be expected to add to noise from that platform for the very short period of that survey. Any unlikely cumulative effects are expected to be localised and short-term.

6.10.1.4 Vessel Traffic

Cumulative traffic noise arising from shipping generally dominates ambient noise at frequencies from 20 to 300 Hz (Richardson et al. 1995); mysticetes are thought to be more sensitive to sound at these lower frequencies than are odontocetes.

Most of the vessels in the area of the proposed site survey are associated with industrial activity (supply and crew change vessels, etc.) or fishing. The proposed short-term survey is expected to require one vessel for the seismic and sonar, and one vessel for the geotechnical coring; these vessels would be additional to other vessels used by the Sakhalin II project, which include logistics, emergency response, monitoring and research vessels. Fewer vessels would be required for the proposed 2012 2D survey than were used during the 2010 Astokh 4D survey (Table 3-1). According to the timetable of activities (Table 3-2), survey vessels will be active during 2012 at different times. Thus, the proposed 2012 site survey will not contribute significant numbers of additional vessels to pre-existing traffic.

While it is likely that many marine species have habituated to ambient noise levels, there may be some avoidance of vessels that operate near the proposed seismic area (see §6.4.2-6.4.5 for more details). However, the short duration of the planned survey and the implementation of mitigation measures (see Chapter 8) will limit the cumulative scale of impact.

6.10.1.5 Subsistence and Commercial Harvesting

Entanglement

There are cases where marine mammals have become entangled (or hooked) in fishing gear, leading to injury or mortality. Many of these cases have gone unreported, making it more difficult to assess the scale of the impact. However, the impact of entanglement on the Gray Whale population is of special concern. During 2005-2007, four whales (all female) were entangled in fishing nets on the Pacific coast of Japan (Brownell 2007; Brownell et al. 2007; Weller et al. 2007); population modelling allows for this level of mortality will not cause population decline if it continues (Cooke et al. 2009). Although there are no reports of such events in Russian waters, potential synergistic impacts by industrial activities (e.g. seismic surveys) must be managed and mitigated in conservation efforts to facilitate recovery of the population and regulatory enforcement and prevention of illegal fishing offshore Sakhalin is required. (IUCN WGWAP report #11)

Harvesting

There is no direct harvest of cetaceans in Sakhalin waters, although pinnipeds are still harvested in some areas. The cumulative effects of the proposed site survey on these species are not expected to be significant.

6.10.1.6 Military Activities

It is not known if any vessels of the Russian Navy will be operating in the region during the planned seismic survey. Additive cumulative effects may result, especially if such vessels operate sonar near to the feeding area immediately before, during, or after the planned seismic survey; concerns about the effects of MF sonar on whales have been discussed in §6.4.2-6.4.4. However, it is considered unlikely that naval vessels would operate MF sonar at this location and time, and potential cumulative effects are therefore not anticipated.

6.10.1.7 Conclusions

Marine mammals in the Sea of Okhotsk may be ever so slightly affected by the proposed site survey, as well as by other industrial, commercial, and military activities on the Sakhalin shelf. However, the proposed survey is not expected to add significantly to the impacts from past, present, and future activities on marine mammals.

6.10.2 Marine Invertebrates and Fish

6.10.2.1 Seismic Surveys

Potential impacts to marine invertebrates and fish were reviewed in §6.5.1 and 6.5.2. Impacts to marine invertebrates and fish by past seismic surveys in the Sea of Okhotsk were not monitored or studied, and therefore it is not possible to determine to what extent these populations were influenced or affected.

Additional seismic surveys conducted in 2012 could be expected to add an incremental degree of adverse but not significant impacts to marine invertebrate and fish resources.

6.10.2.2 Vessel Traffic

Vessel traffic introduces noise into the marine environment that could potential alter the behaviour of some species of marine invertebrates and fish (see §6.5.1 and 6.5.2). However, the northeast Sakhalin shelf is not a major shipping route, and most vessels in the area would be associated with the proposed project, monitoring activities, or other support activities for the Sakhalin I and Sakhalin II oil fields. Cumulative impacts of vessel traffic to marine fish and invertebrates are considered *negligible*.

6.10.2.3 Other Oil and Gas Exploration and Development Activities

Current oil and gas exploration and development on the Sakhalin shelf is briefly described in §3.2, and summarised in the cumulative effects section for marine mammals, above. Impacts on marine invertebrates and fish from exploratory drilling and field development are limited but typically involve noise, increased turbidity, disturbance, and the physical loss of habitat. Impacts to populations are typically minor if the respective population is of sufficient size to absorb any direct or indirect mortality.

Any synergistic cumulative effects between the proposed seismic survey and other oil and gas industrial activities on marine fish and invertebrates are expected to be extremely localised and short-term, and are therefore considered to be *negligible*.

6.10.2.4 Subsistence and Commercial Harvesting

The majority of fisheries in the Piltun-Astokh area are of a subsistence nature and conducted close to shore. Detailed information on the extent of commercial fishing in the area is not readily available, although it is reported that the area is not fished intensively and that only a small number of local boats sometimes use the area (SEIC, EIA Addenda 2005). Although the acoustic monitoring in 2011 shows increased fishing vessel movements in the area and the loss of an acoustic buoy, thought to have been dragged away by bottom trawling.

Since harvesting removes individuals from the population, synergistic effects may occur with other impacts. However, the cumulative impacts of noise generated by vessels and equipment used during the short site survey are not expected to be significant with respect to populations of marine fish and invertebrates.

6.10.2.5 Military Activities

Military vessels may use active or passive sonar and echo-sounders during their operations and these systems, as well as vessel sources will add to noise to the marine environment. Active sonar is known to kill, stun, or displace fish in close proximity to the source. However, as noted above, it is considered unlikely that Russian Navy vessels will be operating in the region during the planned seismic survey.

6.10.2.6 Conclusions

Fish and marine invertebrate resources on the Sakhalin shelf are potentially affected by a variety of activities, primarily fishing activities and military activities. The proposed short-duration site survey is not expected to add significantly to the past, present or future impacts on fish and marine invertebrate populations.

6.10.3 Seabirds

6.10.3.1 Seismic Surveys

While seabirds may be slightly affected by the proposed survey (see §6.6.3), any impacts are expected to be negligible. Cumulative effects of other seismic surveys may occur on the Sakhalin shelf in 2010 but are not expected to affect fish prey species to an extent that would be harmful at the population level.

6.10.3.2 Vessel Traffic

Additive cumulative effects of the seismic survey on marine vessel traffic and movements are highly unlikely to cause significant localization, displacement, or disruption of marine birds. Any disturbance that does result would be similar to that caused by other vessels passing through the area and any cumulative adverse impacts would be considered negligible.

6.10.3.3 Other Oil and Gas Exploration and Development Activities

As noted above, impacts on birds from exploration and production drilling, and field development is limited. Typical aspects relevant to marine birds include noise, increased turbidity (which may affect prey abundance), disturbance, physical loss of habitat, and injury or mortality due to collisions or incineration in flares. Potential additive and synergistic effects by the proposed seismic survey are considered to be negligible at a population level.

6.10.3.4 Subsistence Harvesting

As noted in §6.7.2, some subsistence hunting of waterfowl occurs in coastal regions; the significance of these activities on the regional population is unknown. However, subsistence hunting itself will not be affected by the proposed seismic survey, and any additive or synergistic effects are not expected to result in long-term impacts to coastal waterfowl populations.

6.10.3.5 Military Activities

Impacts to seabirds from military activities would be comparable to those of other vessels in the region. Cumulative impacts are not anticipated.

6.10.3.6 Conclusions

Seabirds in the immediate area are unlikely to be affected by the proposed site survey as well as by other anthropogenic activities on the Sakhalin shelf. However, the short proposed survey is not expected to add significantly to the impacts from past, present, and future activities, and additive and synergistic impacts to birds are not expected at the population level.

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7 ANALYSIS OF ALTERNATIVES

7.1 Survey Scope

Sakhalin Energy holds a concession to develop and produce hydrocarbons from the Piltun-Astokhskoye field on the northeast shelf of Sakhalin Island. The company currently has two operating platforms in the field: the PA-A (or *Molikpaq*) platform located in the southern Astokh area, and the PA-B platform located in the northern Piltun area; oil and gas production from the PA field is limited to reserves that are accessible from these existing platforms, which are located approximately 25 km apart.

Sakhalin Energy is currently undertaking subsurface and engineering studies to determine technically-feasible and commercially-viable development plans for the central oil and gas accumulation – the South Piltun field. A feasibility study was carried out, and is followed by a concept select phase (mainly engineering studies). The results of these studies will be reported, when completed, as part of the Impact Assessment (IA) for the overall South Piltun field development. The range of development options being assessed includes an additional platform located between the existing PA-A and PA-B facilities, referred to as PA-C.

In order to properly prepare the platform option for concept selection, Sakhalin Energy requires:

- High-resolution (HR) and ultra-high-resolution (UHR) 2D seismic data for evaluation of shallow gas hazards;
- Acoustic imagery to identify seabed hazards in the vicinity of the potential platform and along the required pipeline routing;
- Geotechnical coring to determine seabed properties for platform structural design calculations.

This information is essential for the company to confirm if the option of the PA-C platform is feasible. It is standard engineering practice, and is required in terms of Russian Federation law.

Sakhalin Energy has also proposed to survey in 2012, six sites – two near each existing platform[101] – for emergency use by jack-up rig to drill relief wells in the very unlikely event of well control failure and a non-accessible / non-functional platform. For alternatives, the company considered:

- No relief well sites;
- One relief well site per platform; or
- More than one relief well site per platform.

The company considered international best practice and its commitment to emergency preparedness and response, and decided that two potential relief well sites should be surveyed per platform in case the jack-up rig is unable to use one of them during an emergency situation. Similar data are required for the relief well sites i.e. high-resolution 2D seismic[102], acoustic imagery, and geotechnical properties of the seabed.

7.2 Existing Data

As an alternative to HR 2D seismic acquisition over the whole of the South Piltun area, Sakhalin Energy used existing 3D seismic data from 1997 to examine potential shallow gas accumulations deeper than 200 m (see Chapter 3), providing a nominal location for the PA-C platform. Therefore, a much smaller area of HR/UHR 2D seismic data is now required to assess hazards shallower than 200 m.

[101] PA-A, PA-B, and LUN-A platforms.
[102] Only required for PA-A; already exists for the PA-B and LUN-A platform areas.

Existing 2D seismic data for PA-B and LUN-A platforms were used to examine shallow gas hazards for the jack-up rig. Consequently, only a very small area near the *Molikpaq* platform need be surveyed in 2012.

7.3 Alternative Technologies

Sakhalin Energy has carried out a comprehensive evaluation of all available techniques, within the requirements of the Russian Federation regulations and engineering standards for safe platform location.

Due to those regulations and standards, the suite of data to be acquired is fixed and does not allow for any alterations.

7.4 Seismic Survey Type

Seismic acquisition is a specialised technical field in which alternative methods and technologies are limited.

The required information on the shallow gas hazard can be obtained from a combination of HR 2D seismic and conventional 3D seismic data. While conventional 3D seismic data can be used to assess with sufficient confidence the shallow gas hazard for depths greater than ± 200 m, for the very shallow subsurface strata (sea bed to ± 200 m) HR 2D or HR 3D seismic data are essential.

High-resolution 3D seismic data are acquired with substantially more effort (and therefore greater environmental exposure) than HR 2D seismic data. In combination with conventional 3D seismic data, HR 2D seismic data would be sufficient for the shallow gas assessment. In order to minimize the duration of the work and associated noise, Sakhalin Energy decided to acquire HR 2D instead of HR 3D seismic data.

Furthermore, in specific circumstances, conventional 3D seismic data can yield the high resolution required to assess shallow gas hazards. Those circumstances are:

- Deep water (typically more than 300 m water depth are required);
- Plus specific acquisition parameters as acquired with shallow sources and receivers or with combined hydrophone/geophone receivers.

The shallow sea depth in the South Piltun area and the acquisition parameters of the existing 3D seismic volume did not allow for a reliable shallow gas assessment from the existing 3D seismic volume only. Hence it is necessary to acquire the HR 2D seismic data set.

Marine HR 2D surveys typically entail a purpose-built craft that tows receivers housed in one streamer at a shallow depth beneath the sea surface. Because of the delicate nature of this equipment, such surveys can only occur in ice-free conditions and calm seas. Moreover, problems with winter acquisition include hazards associated with mobilising vessels in variable thick ice, the mobility of the ice itself, and the formation of reflected wave fronts between the under surface of the ice and the seabed surface that mask the signal from subsurface geology. The winter ice conditions in the vicinity of Piltun and Astokh are complex, variable and are markedly different from land-fixed ice where trials of winter seismic acquisition have been undertaken (e.g. Alaska). Therefore, for technical and safety reasons, it is not possible to undertake a conventional streamer survey if any free ice is present in the survey area.

A commonly employed alternative to marine streamer acquisition is the use of ocean bottom cables (OBC). This OBC technology, however, does not give the required resolution for a shallow gas assessment.

7.5 Sound Sources, Source Optimisation, and Array Design

A variety of sound sources have historically been used for seismic surveys, including explosives (e.g. dynamite), water guns, vapour guns and airguns. Airguns are now the most commonly used technique for offshore seismic surveys as they are the most reliable and, when compared to other sources, are considered to cause the least impact to aquatic life (National Environmental Protection Committee of the Russian Federation 2000). Other technologies, such as marine vibrating sources, are under development but are not available commercially, and would not give the required resolution for shallow gas assessment.

Optimization studies regarding the use of a 4 x 40 in^3 airgun array compared to a single 150 in^3 airgun revealed that the airgun array produces a more even frequency spectrum and more laterally isotropic signal. For those reasons, the 4 x 40 in^3 airgun array is preferable over a single larger source.

High-resolution (HR) seismic shall be acquired using standard acquisition parameters as specified below:

Nr. of channels	120
Record length	3.0 seconds
Sample rate	1 ms
Shot point interval	6.25 m
Group length	6.25 m
Fold coverage	60
CMP distance	3.125 m
Cable length	750 m
Source to near trace distance	< 50 m
Source depth	2.5 m
Streamer depth	2.5 m
Gun pressure	2000 psi
Gun volume	air gun array 4 x 40 $inch^3$

The source for the UHR 2D seismic will be a single airgun with volume of 40 in^3 or less, producing a fraction of the sound level which is produced from the 4 x 40 in^3 airgun array used for the HR seismic. Ultra-high resolution 2D seismic gives the required link between the images obtained from the acoustic tools and the HR 2D seismic. Its penetration in the earth is typically only 50 m, and streamer and source are towed even at shallower water depth than the HR seismic (1.5 m) to obtain the required increase in resolution[103].

Ultra-high-resolution (UHR) seismic shall be acquired using standard acquisition parameters as specified below:

Nr. of channels	120
Record length	1.0 seconds
Sample rate	0.5 ms
Shot point interval	3.125 m
Group length	6.25 m
Fold coverage	60
CMP distance	3.125 m
Cable length	750 m

[103] The resolution of marine seismic data depends on the depth of the source and the streamer. Reflection of the seismic waves at the water surface causes a cancellation of the seismic signal at a given frequency due to interference effects (‘ghost’). This results in the limitation of the usual bandwidth to a maximum frequency of about 750Hz/source or streamer depth (in m). As an example, for the HR survey with source and streamer planned at 2.5 m depth, the usable spectrum extends to 300 Hz, and for the UHR survey to 500 Hz.

Source to near trace distance	< 50 m
Source depth	1.5 m
Streamer depth	1.5 m
Gun pressure	2000 psi
Gun volume	single air gun 25 $inch^3$

7.6 Spatial and Temporal Considerations

7.6.1 Area of the Survey

The perimeter of the planned survey area is defined by all possible options for the platform location, plus suitable coverage to the sides and required lead-in and lead-outs to produce a sensible and reliable subsurface image for shallow gas assessment. As the South Piltun area is known to contain accumulations of shallow gas (Chapter 3), the subsurface image has to include a wide enough area to confirm the geologically plausible and statistically valid geometry of the shallow gas accumulations and the absence of shallow gas below the chosen platform.

The HR 2D lines at and around the nominal platform location will be acquired first in the survey. Should on-board seismic data processing and evaluation be possible and the nominal location is shown to be without shallow gas hazards, the survey area might be slightly reduced from 6 km x 10 km to 4.5 km x 10 km. The resulting acquisition area will be the smallest possible whilst still achieving the technical objectives of the survey.

7.6.2 Number and Orientation of Seismic Survey Lines

Line spacing was optimized to reduce the survey effort away from the notional platform location, in order to reduce the cumulative noise produced.

7.6.3 Timing

For marine seismic surveys in the Piltun and Astokh areas on the north-eastern Sakhalin shelf, a key timing consideration is the potential presence of migrating or feeding Gray Whales. As discussed in Chapter 5, Gray Whales migrate in spring and early summer to their feeding grounds to the north of the Astokh Field, and migrate to overwintering grounds during the autumn. The period when Gray Whales are most likely to be encountered within or near the survey area is between June and September, thus, from an environmental standpoint, seismic acquisition during the winter months would have the benefit of reducing potential disturbance to Gray Whales. However, acquisition during winter is not technically feasible; the survey-timing window at Piltun-Astokh is limited to the ice-free season, which is typically between June and October. Meteorological conditions such as strong winds and high waves in spring and autumn further restrict optimal timing to the summer months (June to September). Furthermore, the water temperature must be above freezing point (preferentially above 4° C) to allow the material used for the survey to function properly and acquired data to be within technical specifications.

This technical optimisation is compatible with environmental objectives. According to the WGWAP, the most effective available mitigation measure to minimise (or eliminate) the exposure of whales to noise, is to ensure that the seismic survey is completed as early in the ice-free season as possible (WGWAP 2008, 2009, 2010). Information presented at the fourth meeting of the WGWAP showed that the number of whales that might be found within the 163 dB re μPa RMS sound contour was six to eight times higher in August to September than June to July.

7.7 'No-Go Option'

The planned 2D seismic survey will provide data that are critical for the full feasibility assessment of a South Piltun platform; this will be weighed against the other options. The survey will also provide critical information about the location of relief well sites for emergency use by jack-up rig.

If the site survey were not conducted (the 'no-go option'), then Sakhalin Energy would not be able to properly assess the feasibility of the platform option, would be unable to conduct its design, or to obtain approval from the Russian Federation for the platform; plans to develop South Piltun using the platform option would likely be abandoned.

In addition, the data needed to drill relief wells in the very unlikely event of well control failure would not be acquired, potentially compromising emergency response and recovery efforts.

7.8 Alternatives for Marine Mammal Monitoring

7.8.1 Introduction

Various marine mammal monitoring methods were reviewed for implementation during the proposed 2D seismic survey. The following sections describe some of these alternatives and the rationale for their exclusion.

7.8.2 Vessel-Based Behaviour Monitoring

Vessel-based whale behaviour monitoring has been employed during seismic acquisition where potential adverse impacts to critical behavioural aspects have been identified.

Vessel-based monitoring can supplement shore-based effort where natural visual limitations, incorrect distance estimation and poor visibility conditions may compromise real-time behavioural assessment and associated mitigation. However, a vessel positioned closer to the subject introduces new hazards such as increased levels of noise and associated disturbance, increased collision risk, and safety risks.

Given that predicted sound levels within the Gray Whale feeding area would be significantly lower during Sakhalin Energy's proposed 2D survey than during their 2010 Astokh 3D survey, and below 156 dB SEL (see §6.3.2.2), it was agreed that real-time acoustic monitoring[104] would not be necessary for the proposed 2D survey. It was also agreed that, if the same acoustic criteria were applied for the proposed 2D survey as for the Astokh 3D survey, there would be no need for vessel-based monitoring of the feeding area.

However, there remains an opportunity and a need to obtain further data on the possible effects of seismic sound on whale behaviour at a wide range of received levels. Therefore, the WGWAP agreed that it would be necessary for archival acoustic monitoring along with shore-based behavioural monitoring during the proposed 2D survey (WGWAP 9[105]).

7.8.3 Manned Aerial Surveys

Manned aerial surveys in marine areas usually use twin-engine aircraft to survey predetermined transects in different parts of defined study areas. Regional surveys cover broad areas surrounding license blocks and are important in establishing a broader context for studying the distribution and abundance of marine mammals in the area of interest. Local surveys provide more site-specific (seismic block or license area specific) information, and are

[104] As specified for the 2010 Astokh 4D survey – related to the determination of A-lines and associated mitigation measures
[105] http://www.iucn.org/wgwap/wgwap/meetings/wgwap_9/

best evaluated in the context of the broader regional surveys. Systematic aerial surveys quantitatively document the regional and local distribution of marine mammals.

Manned aerial surveys can be used to support a seismic programme by flying pre-, during, and post-the seismic survey. Data collected before seismic acquisition can be used to determine which lines should be shot first by directing the seismic vessel to those areas with few or no whales within a specific distance; however, the usefulness of the data is limited in time due to the mobility of the animals. Aerial survey data can also be used to map changes in whale distribution before, during, and after the seismic survey.

Advantages of manned aerial surveys include the ability to scan large areas over relatively short periods of time, while disadvantages include cost, weather limitations, mechanical failure of the survey equipment, and safety issues.

The scale and duration of the proposed 2D survey does not warrant such an aerial survey; the disadvantages outweigh the advantages. Furthermore, the MMO programme is designed to monitor the exclusion zone around the seismic vessel and is considered suitable for the purposes of this investigation.

7.8.4 Unmanned Aerial Vehicles

The use of unmanned aerial vehicles (UAVs) for marine mammal monitoring is being researched, particularly for surveys in remote and/or hazardous locations such as offshore Arctic and sub-Arctic waters. Some UAVs are capable of digital photography and real-time video transmission, but the reliability and limitations of the aircraft under a variety of conditions need to be assessed, as well as the use of cameras in various lighting conditions. Unmanned aerial vehicles have the potential to replace manned aerial surveys and thus reduce the risk to air crews and extend the functional range of marine mammal monitoring programmes.

The U.S. Federal Aviation Administration currently prohibits the use of UAVs for commercial or private purposes, although some petroleum companies have been actively pursuing the required permits for testing UAVs offshore Alaska. It is possible that similar difficulties would arise in other jurisdictions such as the Russian Federation.

7.8.5 Thermal Imaging

Thermal imaging is a type of infrared (IR) imaging whereby thermographic cameras detect radiation in the IR range of the electromagnetic spectrum (900-14,000 nanometres) and produce images of that radiation. Thermography depends on the difference in temperature between the object or animal of interest and its environment. This method has potential for determining the presence of whales during periods of darkness or poor visibility, although only surfacing animals can be detected. Thermal imaging could potentially be conducted from shore, vessel, or aircraft.

There are a variety of thermal imaging devices available for marine mammal monitoring (Cuyler et al. 1992; Perryman et al. 1999; Baldacci et al. 2005; Butterworth 2006). In most cases, they are constrained by environmental conditions, such as humidity and sea state, and by technical limitations. Some images collected by thermographic cameras can be difficult to interpret accurately, even with experience, and unless visual identification is also made, it is unlikely that species identification would be possible from a thermal image. In addition, many thermal imaging devices are manufactured in the U.S. and are not currently available for export.

7.8.6 Satellite Imaging

While satellite tags are routinely used to track the movements of individual marine mammals, the use of satellite imaging to identify marine mammals is still being investigated. Most satellites provide images in lower spatial resolutions that are not fine enough to resolve a single animal. Real-time use of this technology for a seismic survey is of limited feasibility, and obtaining satellite images of restricted Russian waters may also prove problematic.

7.8.7 Passive Acoustic Monitoring

Passive acoustic monitoring (PAM) involves deploying hydrophones (usually towed or bottom-mounted) to listen to underwater vocalisations by marine mammals. PAM systems that are most often used during seismic surveys are towed systems, due to the mobile nature of the source vessel. Autonomous underwater vehicles have been successfully equipped with PAM systems permitting the monitoring of marine mammals with a mobile unit.

With appropriate experience and the use of specialised software, it is often possible to accurately identify and locate a variety of vocalising marine mammal species that may not always be visually observed from a vessel. However, the use of PAM is limited by the difficulties in recognising some marine mammal sounds both real-time by an operator and using detection algorithms, by the level of ambient and anthropogenic noise in the environment that affects detection ranges and that can mask the lower frequencies used by baleen whales, and by false alarm rates. It is also often difficult to determine the range and direction of vocalising animals. PAM is further limited by the vocalising behaviour of the subject animals. PAM works best with high vocalisation rates and may offer limited usefulness for relatively quiet species such as Gray Whales; for such species visual observation remains the most reliable method of determining presence.

7.8.8 Active Acoustic Monitoring

Active acoustic monitoring involves the use of sonar to detect whales close to a vessel. Sound pulses are emitted by the sonar system and are bounced back to the receiver to generate a 3D image of the water column. A trained operator can then visually identify large objects that are reflecting the sound and determine whether they are biological or physical in nature.

While active acoustic monitoring has the potential to identify whales close to a source vessel, it does not allow for species identification, false positives can occur, and it involves the generation of an additional sound source into the marine environment.

7.8.9 Night-Vision Equipment

During periods of low visibility or darkness, visual monitoring of marine mammals becomes largely ineffective. Night-vision devices operate in the darkness by amplifying existing visible (or near-visible) external radiation (from moonlight, starlight, sky-glow, etc.), but may be unreliable for detecting marine mammals. These systems operate very well if there is sufficient external illumination, however, they cease to operate altogether in absolute darkness or in deep shadows. Typically, devices do not function as well as thermal imagers through smoke, dust, or haze. Night-vision devices have an effective range of approximately 100 m (Weir and Dolman 2007). Marine mammal observers using night-vision devices are also limited by the field of view that further reduces the likelihood of spotting marine mammals as they surface in the dark.

7.8.10 Conclusion

The review of marine mammal monitoring alternatives concludes that most of these methods are neither suitable nor viable for the proposed 2D survey.

Instead, technical optimisation and survey timing, together with onshore behaviour monitoring that is supported by a marine mammal observer programme, is considered appropriate for this survey.

7.9 Literature Cited

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8 MONITORING AND MITIGATION

A mitigation and monitoring programme has been developed – based on the impact assessment – and will be integrated into the survey programme to minimise impacts on the marine environment, as agreed with the WGWAP. This programme includes requirements for seismic survey conduct, MMO provisions, whale behaviour and acoustic monitoring.

Specific monitoring/mitigation requirements for the sonar investigation and geotechnical coring will be specified in the Russian Federation licences and permits issued for these activities.

These monitoring and mitigation measures modify the impact assessment reducing the impact potential from Moderate to Minor or in some cases negligible, compared with leaving them unmitigated. These mitigation measures have been extensively discussed with the Western Gray Whale Advisory Panel at meetings #10, #11 and in Seismic Task Force and Noise Task Force meetings #1 and #2. The advice and protocols are reported on the IUCN website and available to the general public. Items 8.1 to 8.1.11 describe how the monitoring and mitigations are implemented and how the impact itself is mitigated.

8.1 Marine Mammal Mitigation and Monitoring

There are various mitigation measures and monitoring protocols used, or considered for use, during seismic surveys.

Weir and Dolman (2007) summarise the statutory marine mammal mitigation measures currently in force around the world. While there are no internationally accepted mitigation measures for seismic operations, a number of jurisdictions (e.g. U.K., Australia, U.S.) have developed guidelines with varying degrees of regulatory oversight. Guidelines from the U.K. Joint Nature Conservation Committee (JNCC), the High Energy Seismic Survey Team (HESS), Environment Australia, and the U.S. Minerals Management Service have been used by industry.

In 2001, Exxon Neftegas Limited (ENL) conducted a 3D seismic survey of the Odoptu licence area (overlapping a portion of the Gray Whale Piltun feeding area) that employed “among the most complex and intensive mitigation programmes ever conducted for any marine mammal” (Johnson et al. 2007):

- Two buffer zones were established to protect whales from physical injury or undue disturbance during feeding: a 1 km exclusion zone around the seismic source, and a 4–5 km buffer zone to avoid displacing gray whales from feeding areas. Trained Marine Mammal Observers (MMOs) onboard the seismic vessel had the authority to shut down the air guns if whales were sighted within these buffers.
- The seismic survey was re-scheduled from June–August to August–September to avoid interference with the spring arrival of migrating gray whales[106].
- The survey area was reduced by 19% to avoid certain waters < 20 m deep where feeding whales concentrated and where seismic acquisition was a lower priority.
- The number of air guns and total volume of the air guns were reduced by about half (from 28 to 14 air guns and from 3,390 in3 to 1,640 in3) relative to initial plans.
- “Ramp-up” procedures were implemented.
- Aerial and vessel-based surveys determined the distribution of whales before, during, and after the seismic survey: daily aerial reconnaissance helped verify whale-free areas and select the sequence of seismic lines to be surveyed; a scout vessel with MMOs aboard was

[106] Note that this 2001 rationale contradicts the present opinion of the WGWAP who recommend that noisy activities be completed as early in the season as possible, before whale densities peak.

positioned 4 km shoreward of the active seismic vessel to provide better visual coverage of the 4–5 km buffer and to help define the inshore edge of the 4–5 km buffer; and a second scout vessel remained near the seismic vessel.

- Shore-based observers determined whale numbers, distribution, and behaviour during and after the seismic survey. Acoustic monitoring documented received sound levels near and in the main whale feeding area.

Based on these guidelines and the recommendations of the Western Gray Whale Advisory Panel (WGWAP 2008), a suite of mitigation measures (comparable to those employed by ENL during their 2001 Odoptu survey), and monitoring programmes were developed for Sakhalin Energy's 2010 Astokh 3D survey. In developing mitigation for the proposed 2012 2D survey, Sakhalin Energy together with the WGWAP (see WGWAP-9 and WGWAP-10 Reports) and its SSTF (see SSTF-6 and SSTF-7 Reports), used the Astokh MMP as a template to design a plan commensurate with the scale, duration and risk associated with the 2D survey. Details of the plan are provided in the sections below and are summarised in Table 8-1.

8.1.1 Seismic Survey Area

The perimeter of the planned survey area[107] is defined by possible options for the new platform location, plus suitable coverage to the sides and required lead-in and lead-outs to produce a sensible and reliable subsurface image for shallow gas assessment. As the South Piltun area is known to contain accumulations of shallow gas, the subsurface image has to include a wide enough area to confirm the geologically plausible and statistically valid geometry of the shallow gas accumulations and the absence of shallow gas below the chosen platform site.

The HR 2D lines at and around the nominal platform location will be acquired first in the survey. Should on-board seismic data processing and evaluation be possible and the nominal location is shown to be without shallow gas hazards, the survey area might be reduced. The final acquisition area will be the smallest possible to achieve the technical objectives of the survey. This helps reduce the overall footprint of the survey and time duration of the acquisition.

8.1.2 Seasonal Restrictions and Seismic Survey Duration

An effective method of mitigating the potential impacts of seismic activities on marine mammals is by conducting the survey when low numbers of marine mammals are present in the region.

The ice conditions off north-east Sakhalin pose technical, safety and logistical challenges that preclude seismic acquisition until the mobile pack ice retreats with the onset of open water conditions in June. To limit the period of potential interaction with marine mammals, Sakhalin Energy plans to commence their seismic survey 25 June and conclude 15 July, before Gray Whale numbers peak during August and September. Periods of fully active pulsed seismic source will be interspersed with intervals of reduced activity (such as during line changes of approximately 10-15 minutes) or complete inactivity (such as vessel downtime during rigging-up, poor weather conditions, or as a result of Gray Whales occurrence near the survey vessel). Every effort will be made to limit the duration of the survey to as short as technically and logistically feasible, without compromising implementation of the mitigation procedures. Note: in line with WGWAP recommendations and to avoid problems experienced during the 2010 survey, the seismic vessel should be adequately prepared to operate under cold conditions. All monitoring equipment should be satisfactory deployed and functioning properly prior to the survey.

[107] This section addresses the area of the PA-C site survey. The planned survey area for the PA-A relief wells requires much less effort – 7 north-south lines and 6 east-west lines, see Figure 3-9.

8.1.3 Orientation and Selection of Seismic Lines

The orientation of seismic lines can, under certain circumstances, be tailored given local bathymetry, to aid the mitigation of noise impacts. Noise modelling shows no seismic lines, or parts thereof, are expected to ensonify the Gray Whales feeding area with levels exceeding 163dB RMS (equivalent to 156 dB SEL) during the survey.

8.1.4 Airgun Array Configuration and Specifications

Many jurisdictions require operators to use the lowest volume of airguns feasible. In addition, many authorities request that operators minimise unnecessary high frequency sound or horizontal sound propagation (Weir and Dolman 2007). It is theoretically possible to tune the source array design to minimise undesired higher frequency broadside emissions while maintaining downward propagated energy and S/N at the target levels.

Sakhalin Energy's geotechnical survey will consist of an HR and UHR 2D seismic grid and various acoustics/sonar measurements at the PA-C site, an HR 2D seismic grid and various acoustics/sonar measurements at the PA-A relief well sites, and a coring programme. Of the proposed activities, the small airgun array for the 2D seismic will produce the highest sound levels. However, the 4-source airgun array (4 x 40 in^3) is significantly smaller in volume and sound output than for a conventional 3D seismic survey. Sound modelling based on experiments carried out during the acquisition of the Astokh 3D seismic data in 2010 predict that the expected noise levels in the established feeding areas of Gray Whale will be far below the threshold for significant behavioural responses agreed for the 2010 survey.

8.1.5 Marine Mammal Observers

Along with seasonal restrictions and minimisation of survey area and its duration, together with visual detection of marine mammals, the adherence to the protocols agreed with Western Gray Whale Advisory Panel (in terms of the number of marine mammal observers (2 x shifts), operating) and shut-down criteria and the small air gun size the mitigation measures deployed are effective in reducing the potential impacts of seismic surveys. Operating according to these protocols, the impact risk significance is reduced from Moderate (unmitigated) to Minor (mitigated) Dedicated Marine Mammal Observers (MMOs) are almost universally deployed on seismic vessels to document the occurrence (species and numbers) and behavioural characteristics of marine mammals, and to liaise with the seismic operator on appropriate action when required. By taking such actions the reduction in collision risk and avoidance of marine mammals is greatly enhanced. The effectiveness of MMOs is dependent on their competence to perform this function and the number of MMOs deployed on a vessel; other important factors are length of shifts, position of observation stations, weather and sea state, and communication protocols between the MMOs and the seismic operator to facilitate timely responses to marine mammal sightings. Consequently the MMOs undergo extensive training prior to the operations commencing and where possible experienced MMOs are deployed.

Standard procedures call for MMOs to work no longer than four-hour shifts to avoid observer fatigue. For summer surveys at high latitudes, this typically requires the deployment of at least three observers on a source vessel. The WGWAP have recommended for this survey that two shifts of two observers (four in total) be available and this will be implemented by Sakhalin Energy.

Four competent and experienced MMOs will be stationed on the seismic vessel for the duration of Sakhalin Energy's 2D survey. Two MMOs will be on active duty at any given time during ramp-up, shooting, and for the 20 minutes before start of ramp-up. Where feasible, MMOs will also record observations during daytime non-seismic periods so that data on species abundance and behaviour can be compared with data recorded during seismic periods. To prevent fatigue, MMOs will be limited to a maximum two-hour continuous shift with a minimum of one hour between shifts.

The MMO observation platform should be located at the highest elevation available on the seismic vessel with the maximum, clear, viewable range from the bow to 90° port/starboard of the craft. Use of the bridge will be avoided due to obscured views and potential distractions. An optimal location is usually the 'flying bridge'. Daytime observations will be made using reticule binoculars and the naked eye.

MMOs will undertake extensive training prior to deployment. They will follow the Sakhalin Energy Marine Mammal Protection Plan and use the Marine Mammals Observers' Handbook. Procedures include observation of the exclusion zone for 20-minutes prior to the array being activated, and initiating shutdowns if marine mammals are observed within specified distances. The MMOs shall also document, in a standardised format, all marine mammal observations, operations status, as well as the basis for, and details of, corresponding actions where they were required (e.g. course alteration, power-down or shutdown).

Specifically, when a sighting is made, the following information will be recorded:

- Species, group size, age/size/sex categories (if determined), behaviour when first sighted and thereafter (particularly in relation to the incidence of seismic activity), heading (if consistent), bearing and distance from seismic vessel, sighting cue, apparent reaction to the airguns or vessel (e.g. none, avoidance, approach, paralleling, etc.), and behavioural pace; and
- Time, location, heading, speed, activity of the vessel, sea state, visibility, and sun glare. These parameters will also be recorded at the start and end of each observation period, during a watch whenever there is a change in conditions, or if an entry in the data sheet has not been made for 30 minutes.

Data will be verified by the MMOs at sea, and preliminary reports will be prepared during the field observation period; summaries will be provided to the seismic operator. Data from the MMOs will be used to estimate the numbers of marine mammals exposed to received sound levels and to assess associated behavioural effects where these were observed.

Prior to deployment, all MMOs will be made aware of the communication procedures to ensure prompt response to sightings and concerns (e.g. observation of adverse marine mammal behaviour in relation to operations). Single-point authority for operational shutdown lies with the Senior MMO. Where problems in communication are encountered, these will be raised with company representatives. The MMOs will file daily reports with a nominated Environmental Focal Point.

By adopting the processes described above and following them both for previous surveys and where applicable for vessel traffic in general, Sakhalin Energy is able to state, with confidence that to date, there have been no collisions with Gray Whales resulting in any injury or fatality as a result of their operations.

8.1.6 Vessel Exclusion Zone

The exclusion zone is typically defined as the radius around an airgun source within which real-time mitigation measures are implemented if a marine mammal is detected. In some jurisdictions, pre-determined exclusion zones apply regardless of the source level employed, while in others the exclusion zone varies depending on the source level of the airguns. Specified exclusion zones range from 500 m in the U.K., Gulf of Mexico, and Canada, to 3,000 m in Australia (Weir and Dolman 2007). In the U.S., the National Marine Fisheries Service specifies a potential injury threshold for cetaceans at 180dB RMS and a potential disturbance threshold of 160dB RMS, while the potential injury threshold for pinnipeds is set at 190dB RMS. Although Sakhalin Energy's 2D survey is planned seaward of the near shore Gray Whale feeding area, there is always the possibility of encountering a Gray Whale at close range. Therefore, an exclusion zone will be monitored during the survey to prevent marine mammal exposure to sound levels that could result in hearing damage.

Determination of the exclusion zone for Sakhalin Energy's 2010 Astokh 3D survey was an extensive exercise and carefully specified in terms of modelling of the range at which the full airgun array acoustic level dropped below 180dB RMS at the broadside maximum, plus a precautionary margin of 20% and verification and update if needed in the field. At SSTF-6 and at WGWAP-9, there was extensive discussion of the appropriate value for the exclusion zone for the proposed 2D survey. Given the sound exposure criterion for the 2010 survey, the exclusion zone for the 2D survey could be reduced significantly given the lower sound source, and if acoustic damage was the sole concern. Other factors were, however, taken into consideration, including:

- MMOs can miss whales;
- Estimating distance at sea is difficult;
- There is always some risk of collision (an increasing problem at short distances);
- Applicable Russian Federation regulations or guidelines and any conditions attached to the permit need to be followed; and
- It may be difficult to explain to the public why the exclusion zone for whales from an endangered population in a sensitive area should be smaller than that for animals from other populations in other areas (1,000 m being a de facto global and industry standard).

Based on the modelling results for the 2D survey, Sakhalin Energy initially calculated an exclusion zone of less than 110 m, but extended this to 500 m to allow an increase in the safety margin. The WGWAP, however, recommended that the exclusion zone for the 2D survey should be 1,000 m (provided this would not conflict with relevant regulations, guidelines or precedents)[108]. Sakhalin Energy has agreed in principle to adopt the 1,000m exclusion zone in line with the Panel's recommendation. However, should conditions of poor visibility extend the survey duration to unreasonable levels, then Sakhalin Energy will notify the WGWAP of the need for deviation to allow 500m exclusion zone during poor visibility[109].

It is equally noted that behavioural changes in marine mammals may occur at distances greater than the defined exclusion zone.

At the second meeting of the Noise Task Force on 9-10 February 2012, with respect to the specific details of the 2012 2D surveys, the NTF **recommended** retention of the precautionary 1km exclusion zone provision agreed at WGWAP-10. However, given that the primary mitigation measure is to complete the survey as early in the season as possible, it also **agreed** that should conditions (e.g. fog) mean that visibility falls below 1km, it was permissible for operations to continue provided that visibility was not less than 500m (i.e. remaining consistent

[108] WGWAP-10 Report (May 2011) page 8; WGWAP SSTF-7 Report (May 2011) pages 16-17

[109] Note two goals of mitigation are: to complete the survey as early in the open-water season as possible, and to keep the survey as short as logistically possible. Sakhalin Energy believes that it is important to complete the survey as quickly as possible while implementing appropriate and adequate mitigation measures. There are obviously two advantages to an efficient survey: commercial and environmental. A shorter survey would cost less, and would result in less vessel activity, presenting less exposure of environmental receptors to aspects of the survey (e.g. noise, collision risk, waste, accidents / emergencies). Reducing the exclusion zone under deviation to 500m would seem reasonable given the small size of the array (160 in^3) and the results of modelling studies which show that the range at which acoustic injury would occur is likely to be well within 500m.

with the recommendation above). This measure, which does still include an additional safety margin beyond exposures predicted to result in TTS, is to prevent the survey from being extended into periods of high whale abundance.

8.1.7 Shutdown Procedures

Airgun shutdowns are typically required whenever a specific species/species group enters the exclusion zone around the sound source. In several jurisdictions, shutdowns are implemented only for whales and not for all marine mammal species (Weir and Dolman 2007), while in the UK, shutdowns are not required if animals approach the source vessel.

For the proposed 2D survey, shutdown is to be initiated if a whale (excluding porpoises and dolphins), or an endangered pinniped is observed in the defined exclusion zone. A precautionary power-down is to be initiated if a whale/endangered pinniped is observed to be on course to enter the exclusion zone. Airgun activity would not resume until the animal has cleared the exclusion zone.

8.1.8 Pre-Shoot Observation

When shutdown is implemented, most jurisdictions require a 20-30 minute MMO observation period before restarting the survey to ensure that the animal is no longer within the exclusion zone (Weir and Dolman 2007). For Sakhalin Energy's 2D survey, initiation of ramp-up procedures from a shutdown period[110] of 20-minutes or longer will require MMOs to first conduct a 20-minute pre-shoot observation of the full array exclusion zone.

8.1.9 Ramp-up and Line Changes

Seismic vessels do not typically operate continuously; operational shutdowns may occur for maintenance and repairs. In many regions, it is standard practice for seismic vessels to increase gradually the source level of an airgun array after a period when the airguns have been silent. This practice, known as a "ramp-up" or "soft-start" is intended to "warn" any marine mammals that are close to the array to move away before the array reaches full intensity. The same rationale supports the continued firing of a single airgun (usually the smallest) during line changes. Although there is no documented evidence that marine mammals will avoid a single-firing gun, or that soft starts do warn marine mammals to move out of the area, this practice is frequently adopted as a "common sense measure." Generally, the smallest airgun is fired first, with other guns added over at least 20 minutes, typically with a 6 dB incremental increase in output per minute as each gun is activated (Weir and Dolman 2007).

For the 2D survey, ramp-up procedures will be implemented after more than 20 minutes of inactive source[111]. This will involve a 20-minute pre-shoot observation followed by the activation of individual airguns in a progressively larger combination over a period of several minutes. During ramp-up, the MMOs will monitor the exclusion zone of the full array. If marine mammals are sighted, decisions about course/speed changes, power-down and shutdown would be implemented as though the full array were operational.

It is expected that at least one airgun will remain active during line changes, in line with WGWAP-SSTF agreement[112]. As long as at least one airgun activity is not interrupted for more than 20 minutes, ramp-up will take place prior to sequential line acquisition without a 20-minute pre-shoot observation.

[110] Period of inactive source.
[111] Source inactivity means no airguns firing (i.e. all airguns off).
[112] WGWAP-9 Report (December 2010) page 26.

8.1.10 Poor Visibility and Night Operations

During poor weather conditions (fog, rain, wind, haze, glare), the ability to detect marine mammals declines significantly. Marine mammals are unlikely to be observed at or above sea state four, which is often the operational limit for a seismic vessel. Therefore, seismic operations will not be commenced in sea states greater than three metres.

During the survey period (early summer), approximately six hours darkness can be expected per 24-hour cycle. Visual observations of marine mammals are considered unfeasible during true hours of darkness[113]. Ineffective observation during darkness may be prolonged by limited visibility during adverse weather.

Shut-down of seismic acquisition during poor visibility (i.e. during night-time, fog etc.) would significantly increase survey duration, thereby risking coincidence of the survey with the period of peak whale abundance.

To allow data acquisition during poor visibility[114], the whole line must have been surveyed in good visibility conditions (while sailing an adjacent line) during the preceding six hours without any Gray Whales sightings within the full exclusion zone. If poor visibility hinders the scan of the entire line, then the line will not be acquired. Operations will be shut down for the low visibility period if whales are sighted during this scan. Under poor visibility conditions, after more than 20 minutes of source inactivity, operations will not be re-commenced due to the inability to conduct an adequate visual scan.

8.1.11 Monitoring

A significant aspect of Sakhalin Energy's 2010 seismic survey MMP was the recognition that information on the effects of sound on gray whales was extremely limited; mitigation was based on the best available data, and the MMP afforded a useful opportunity to collect information to improve understanding and enhance mitigation in the future. It was thus important to obtain empirical data for use in analyses of whale responses to sound.

The 2012 survey provides, once more, a valuable opportunity to obtain such data, particularly given that observations could be made on animals at a wide range of sound levels including animals relatively far from the sound source and thus exposed to lower sound levels.

The principle aim of this monitoring programme is, therefore, to examine behaviour of gray whales before, during, and after the 2D seismic survey in relation to known sound levels, recognising these will be primarily below 156dB SEL. This requires synchronised archival acoustic monitoring and visual behaviour monitoring.

8.1.11.1 Acoustic Monitoring

Given the projected sound levels at the seaward edge of the Piltun feeding area (i.e. at the PML), *real-time* acoustic monitoring as specified for the 2010 survey was considered unnecessary for the 2012 survey from a mitigation perspective.

Instead, two archival acoustic monitoring buoys will be placed for passive recording of generated sound during HR 2D seismic data acquisition – one at the 20 m and one at the 10 m isobath. Positions of the acoustic buoys are based on the modelled sound levels in relation to

[113] Night-vision binoculars and thermal imaging devices are considered ineffective during unfavourable environmental conditions.
[114] As per WGWAP SSTF-6 Report (December 2010) page 28.

the calculated visual range of the onshore behaviour monitoring team. The same measures will be applied to the PA-A relief well site survey[115].

The acoustic buoys will be positioned and confirmed functioning properly prior to the survey. Data will be stored and retrieved from archival acoustic recorders at the end of the field season.

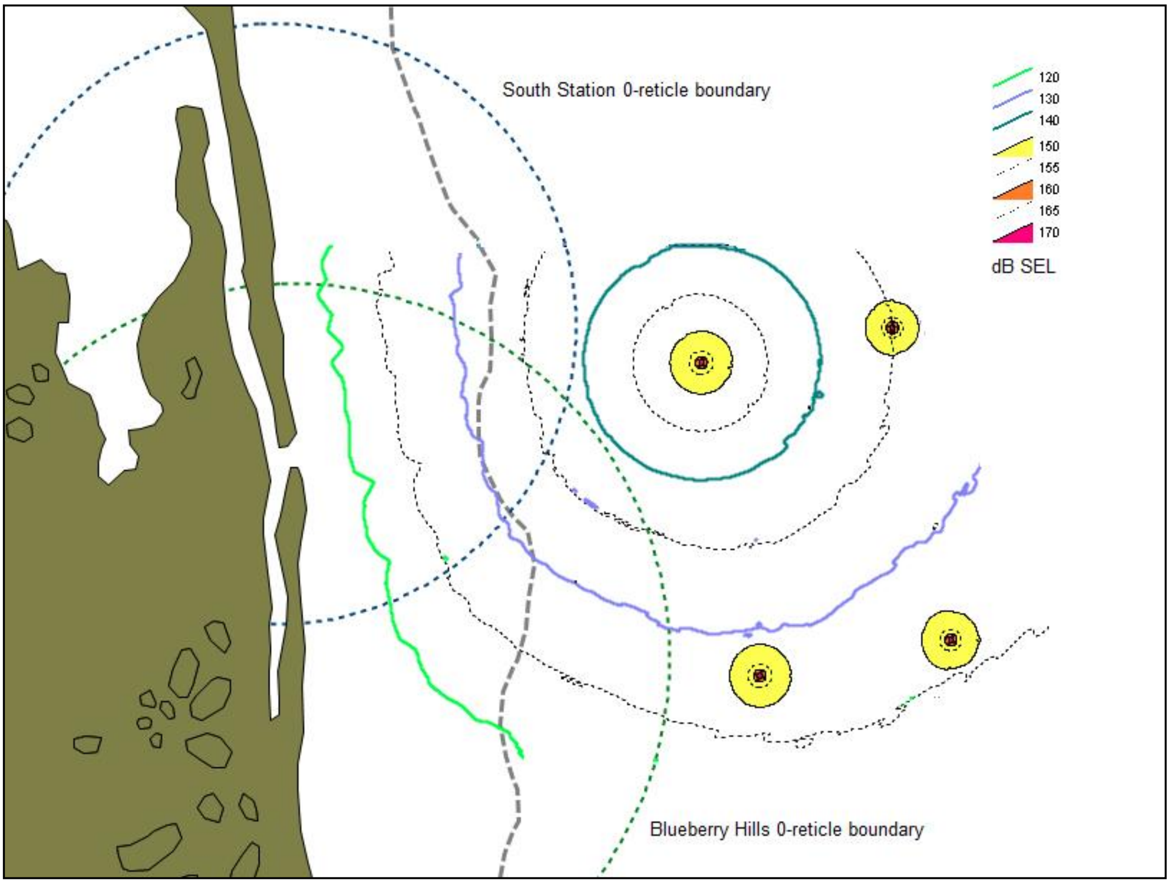

Figure 8-1. Projected sound levels and projected (maximum) visual range (green and blue dotted lines) for the two behaviour site options for the PA-C survey.

8.1.11.2 Behaviour Monitoring

Whilst acknowledging the value of two behaviour sites and teams, it is recognised that logistically, the most feasible option is to establish one behaviour station manned by an experienced behavioural team, in line with WGWAP agreement[116].

The equipment and observation team are to be in place before commencement of the seismic survey. It is also intended to have at least one week of coverage after the survey is completed, weather permitting.

[115] Reasonable notional positions of the AUARs for the PA-C and PA-A relief well sites have been determined as Easting 661500 Northing 5857046 (20 m isobath), Easting 658500 Northing 5857046 (10 m isobath), and Easting 661000 Northing 5843500 (20 m isobath), Easting 658000 Northing 5843500 (10 m isobath), respectively. Coordinates may be corrected prior to the survey to more accurately align locations to 10 and 20 m isobaths.
[116] WGWAP-9 Report (December 2010) page 28

The ideal location for the behaviour observation site to monitor the PA-C survey is Blueberry Hill as it has good elevation; an alternative site is located further north, at South Station, but this would require an observation tower. Site(s) to monitor Gray Whale behaviour during the PA-A relief well survey will be selected using the same principles as for the PA-C survey.

Table 8-1. Summary of Marine Mammal Monitoring and Mitigation Measures

Pre-Survey Planning	
Design	Site survey area optimised. Gray Whale feeding area boundary (PML) calculated according to the month for which the survey is planned. No seismic activities are planned to conducted inside feeding area boundary defined by PML
Timing	Survey to commence as early as logistically possible in open-water conditions.
Duration	As short as logistically possible.
Equipment	Acquisition equipment to be effective in cold water conditions. Archival acoustic recorders deployed and confirmed functioning.
Survey Conduct	
Exclusion Zone	Exclusion zone around seismic source established at 1,000 m, provided there is no conflict with permit specification. Should poor visibility extend the survey duration to unreasonable levels, then Sakhalin Energy will change the exclusion zone to 500m in accordance with the WGWAP recommendation.
Shutdown	Shutdown to be initiated if a cetacean (excluding porpoises and dolphins), or endangered pinniped is observed in the defined exclusion zone. A precautionary power-down will be initiated if a specified marine mammal is observed to be on a course that will result in its entering the exclusion zone.
Pre-Shoot Observation	MMOs will be required to conduct a 20-minute pre-shoot observation of the full array exclusion zone to ensure no specified marine mammals are present within exclusion zone before start of “ramp-up” procedures from shutdown.

Ramp-Up	Ramp-up required after more than 20 minutes of inactive source. (*Inactive source* defined as no guns active; if one or more guns are active – e.g. during a line-change – then this is considered an *active source*). Ramp up to occur across a period of time such that a progressively larger gun combination is activated over a period of several minutes.
Line Changes	At least one airgun will remain active during line changes.
Poor Visibility	Seismic operations can continue in periods of poor visibility (night, fog etc.) under certain defined circumstances: To acquire a line in poor visibility, it must have been scanned while shooting an adjacent line in good visibility conditions during the preceding six hours, without any Gray Whale sightings along the line(s) to be aquired. If poor visibility hinders the scan of the entire line, then the line will not be acquired. In poor visibility, operations will not recommence after more than 20 minutes of source inactivity due to the inability to conduct a visual scan.
Monitoring	
Archival Acoustic Monitoring	Two archival acoustic recorders to be installed; one on the 10 m isobath and one on the 20 m isobath for both the PA-C and PA-A relief well site surveys.
Seismic Vessel Visual Monitoring	Four experienced MMOs on the seismic vessel for duration of the survey. Minimum of two active MMOs on the seismic vessel at any given time during ramp-up, shooting, and for the 20 minutes before start of ramp-up. MMOs limited to a maximum 2-hour continuous shift with a minimum of 1-hour between shifts. MMO observation platforms will be located at the highest elevation available on the vessel with the maximum viewable range from the bow to 90 degrees port/starboard of the vessel. Single point authority for shutdown will lie with the senior MMO.
Shore-Based Visual Monitoring	Shore-based behaviour-monitoring teams will be stationed prior, during and post survey of the PA-C and PA-A relief well sites. Locations of the observation stations to be confirmed prior to the survey.

8.2 Control of Interaction with Other Users of the Area

8.2.1 Fishing Operations

Fishing activity in the Piltun-Astokh area is marginal, and the potential impact of the survey on fisheries is negligible. However, to reduce interference with fishing operations, the following precautionary measures will be adopted:

- The Sakhalin Oblast Administration will be advised of the planned activities including information on the vessels, schedule, and location; and

- A Notice to Mariners will be issued and radio broadcasts will inform fishermen of the proposed activities.

It is expected that any compensation claims and conflicts with fishing activities will be resolved by the survey contractors in line with requirements of the Sakhalin Oblast Administration.

8.2.2 Shipping and Navigation

To prevent collisions and to reduce interference with shipping activities, the following controls will be implemented:

- The Sakhalin Oblast Administration will be advised of the planned survey activities and a Notice to Mariners alerting shipping to the survey operations will be issued;
- Radar and navigational systems on the survey vessels aim to prevent collisions with other vessels;
- A radar reflector and flashing lights will be provided on the acoustic streamer tail buoy; and
- Depth controllers or 'birds' will allow the acoustic streamer to be rapidly raised or lowered in the event of a potential collision.

Any interactions with vessel traffic will be reported to the Sakhalin Oblast authorities.

8.2.3 Military Activity

The Piltun-Astokh area is unlikely to be used for military purposes, however, as a precautionary measure, the Russian Federation military will be notified of the details and schedule of the survey to avoid any potential conflicts.

8.3 Control of Effluent Discharge, Emissions and Waste Disposal

8.3.1 Effluent Discharge

Impacts resulting from routine effluent discharge during the survey programme are predicted to be negligible. The survey vessels are required to comply with the requirements of MARPOL 73/78, Annex I. Specifically, the vessels will have an International Oil Pollution Prevention (IOPP) Certificate and maintain an Oil Record Book (ORB) with details of how, when and where any waste oil or oily effluent is disposed. Oily effluent from bilges and machinery spaces will be processed using an oil/water separator to a 15 ppm oil content specification prior to discharge; oily slops storage will be provided with secondary containment.

Operational procedures shall be in place for all activities that generate effluent during routine and maintenance activities. Procedures shall specify how effluent is to be collected, stored, and treated (including what methods will be used to achieve effluent discharge criteria) prior to disposal or discharge overboard. Procedures shall comply with relevant Russian Federation requirements and MARPOL.

No sanitary or domestic sewage generated on the survey vessels shall be discharged within four nautical miles (7 km) of land. Sewage for discharge between four and 12 nautical miles (21 km) from land shall be stored, treated and discharged in accordance with MARPOL and Russian Federation legal requirements, whichever is more stringent. No effluent discharges will be made within 100 nm (185 km) of the Gray Whale feeding areas.

Effluent treatment equipment/devices shall be maintained and confirmed in good working order.

8.3.2 Air Emissions

Impact on air quality resulting from emissions during the survey is expected to be negligible. Therefore, no specific mitigation measures have been developed. Nevertheless, best-practice to manage emissions will be implemented as follows:

- All vessel propulsion systems, exhaust systems, power generation equipment and incinerators shall be maintained properly and operated efficiently;
- The vessels shall adhere to maximum permissible emissions (MPEs) as specified in relevant permits and associated legislation;
- Consideration shall be given to fuel type (low-sulphur) to minimise greenhouse gas emissions (fuel consumption and sulphur content shall be recorded); and
- Ozone depleting substances shall not be used, unless closed recovery systems are in place.

8.3.3 Solid & Hazardous Waste Management

Contamination of the marine environment is not expected provided that wastes generated onboard the survey vessel are managed and disposed of in accordance with MARPOL as it applies to offshore operations and vessels under Sakhalin Energy control.

The following controls will be implemented:

- All waste generated will be managed (i.e. appropriately stored, handled and disposed of) in accordance with MARPOL 73/78 and the regulations of the receiving port and the flag nationality of the survey vessel. Under no circumstances will solid and hazardous waste be disposed of to sea;
- Where the survey vessel is licensed to use an onboard incinerator, ash shall be collected, secured and returned to shore for disposal at an appropriate licensed facility;
- Any hazardous waste returned to shore will be stored, labelled and disposed of in accordance with local legislation (no hazardous waste will be disposed of to a facility that is not fully equipped to receive, store, treat and dispose the waste);
- Prior to entry into port, local authorities will be notified as to the type and quantity of waste to be disposed;
- Where possible, waste will be collected for reuse and recycling;
- Accurate and detailed waste manifests and safe disposal records shall be maintained.

8.4 Control of Spills, Leaks, Dropped Objects and Fire

Accidental events including vessel collisions, vessel grounding, spills and leaks of hydrocarbons, uncontrolled discharge of waste, losses of equipment, and fire may have adverse environmental consequences. Therefore, survey activities will be conducted in accordance with relevant operational and safety standards and guidelines (e.g. the International Association of Geophysical Contractors Environmental Manual for Worldwide Geophysical Operations 2001). Procedures will be in place onboard the vessels to cover abnormal and emergency scenarios. Responsibilities of crew will be clearly defined and communicated. Specifically, an Emergency Response Coordinator and support crew competent in responding to emergencies will be appointed.

The potential for accidental spills is considered to be low given the implementation of appropriate controls and procedures. In the event of a spill, however, support is available from existing Sakhalin Energy facilities. An approved Oil Spill Response Plan (OSRP) is in place for Sakhalin 2's PA-A and PA-B platforms in accordance with Russian Federation requirements. As part of its oil spill response system, Sakhalin Energy maintains offshore response equipment on the OSR vessel "Irbis", which is presently located at PA-A (the Molikpaq) on a standby basis during the production season. Oil spill response planning undertaken by the Company has considered a number of spill scenarios from vessels including losses of diesel during ship-to-ship transfer, and vessel collision not involving a tanker. Appropriate responses to deal with these spills are set out in the OSRP.

The Piltun-Astokhskoye OSRP contains “Wildlife Response Guidelines” as the region provides habitat to various marine mammals and marine and coastal birds. The document outlines priority areas for wildlife protection including:

- Coastal bays and lagoons, due to the presence of salt marshes that sustain a high level of fauna and attract migrating birds, wildlife etc;
- Large concentrations of shorebirds and/or seabirds (e.g. migration stopovers and wintering areas of migratory birds, seabird colonies, and major seabird feeding areas);
- Concentrations of marine mammals (e.g. seal haul outs, pupping and moulting seasons, entrances to bays, particularly in the spring); and
- Ice leads used by whales as migration pathways.

The document also provides guidelines for the safe handling and treatment of oiled wildlife.

Taking into account the low risk of spill occurrence, the likelihood that any such spill would be of a small volume and also involve light oil products (e.g. diesel or light fuel oil), together with the oil spill response measures, it is considered that the impact of a small spill would be minor. If a larger spill occurs, and which also involves heavier fuel oil, then the impact would be expected to be higher. However, the significance of any such impact depends on a range of other factors that cannot be adequately quantified except during the event itself. Preventing accidental spills in the first instance is of paramount importance and all appropriate measures will be implemented during the survey to ensure that situations likely to increase the risk of spills are avoided and that suitable responses to spills are readily available and rapidly deployed.

The following measures are also intended to reduce the risk of accidental events:

- A health, safety and environment (HSE) management plan shall be developed and implemented incorporating key management components (risk/hazard identification, roles and responsibilities, training and communication, operational controls, and performance monitoring);
- Bathymetric sonar, radar, navigation and communication systems shall be used to prevent collision and vessel grounding;
- Survey operations shall be suspended during adverse weather conditions;
- Petroleum products and hazardous substances (including marine fuel, lubricants, kerosene, lithium batteries etc.) shall be stored according to regulations and manufacturers’ directions in approved, labelled containers, and provided with secondary containment. Incompatible substances shall be stored separately. Safety Data Sheets shall be available and communicated to crew;
- Engineering machinery and components (e.g. pumps, filling equipment, streamers etc.) will be maintained and checked regularly for leaks;
- The cable deck and acoustic streamer storage area will be bunded – spills and surface water will drain into a holding tank and treated according to MARPOL requirements;
- All deployed equipment will be made highly visible. The acoustic streamer will be fitted with a depth controller to allow rapid raising/lowering to avoid obstructions and snagging. In addition, inflatable devices installed on streamer sections will be activated when a streamer section sinks to an unacceptable depth. Location devices will be in place on the tail buoy and streamer to aid location and recovery in the event of loss;

- Waste materials and equipment lost overboard will be recorded and recovered (where possible). If required, regulatory agencies and marine traffic will be notified of equipment losses;
- The vessels shall have available an International Oil Pollution Prevention certificate as well as a Shipboard Oil Pollution Emergency Plan – spill kits will be available on board, and emergency response training including drills will be conducted;
- Depending on the nature and volume of a spill, assistance may be requested. Sakhalin Energy shall support the availability and timely deployment of adequate emergency response resources where the survey vessels do not have the capacity to respond to a large spill caused by major tank rupture (e.g. should a vessel run aground or collide with another vessel or infrastructure);
- Relevant authorities will be notified (according to legislative requirements) on detection of a spill. The location of the spill, prevailing winds, currents and sea state will be identified and recorded;
- Remedial actions to prevent further leakage will be employed where possible (e.g. plug the leak, transfer spilling fluids on a breached tank, or listing/trimming of the vessel to bring an area of damage above the water line);
- Where possible, the spill will be contained using downwind placement of a containment boom and application of absorbent pads (dispersants may not be applied unless approved for use by relevant authorities). Contaminated waste materials shall be disposed of as per regulatory requirements;
- Smoking or open lights will be restricted on board the vessels;
- Appropriate personal protective equipment and fire fighting apparatus shall be maintained and accessible on the vessels. Crew shall be competent in the use of fire fighting equipment and emergency response procedures;
- Incidents shall be recorded and reported as required, and subject to investigation in cooperation with regulatory agencies.

8.5 Contractor Management

In operating its core business, Sakhalin Energy procures services from external contractors that can pose significant HSE risk. Therefore, Sakhalin Energy has specific procedures in place to define minimum levels of HSE performance for its contractors to ensure that such risks are managed in a manner that is consistent with its HSE-MS.

Sakhalin Energy’s interface with contractors will begin during tender evaluation and continue through mobilisation, supply and demobilization of the survey vessels. By placing an emphasis on HSE risks prior to the survey, Sakhalin Energy seeks to manage the HSE risks in a proactive way, rather than simply monitor the performance of its contractors. Sakhalin Energy’s requirements for managing contractors are defined in its contracting and procurement procedures.

Specialist geophysical/geotechnical contractors will carry out the survey. Selected contractors will be pre-qualified against industry best practice HSE standards. The contractors will be required to prepare an HSE Management Plan and comply with all mitigation measures and other mandatory requirements specified in the contract. Specifically, Sakhalin Energy personnel will be onboard the seismic vessel to ensure compliance with all required specifications. HSE related information will be communicated regularly between contractors and contract holders; records (e.g. daily logs, MMO reports, incidents etc.) shall be maintained.

8.6 General Requirements

Owners or managers of the vessels on hire or contracted to Sakhalin Energy, or on hire or contracted to Sakhalin Energy contractors and subcontractors, are responsible for ensuring that their vessels comply with international and Russian Federation legislation, and remain in compliance for the contract period. In addition, contractors shall provide competent and experienced crew. The number of crew (and officers) on board shall be sufficient to ensure the safe running of the vessels and shall not be less than the requirements of the Safe Manning Certificates.

Sakhalin Energy's Marine Operating Procedures and Guidelines (SEIC 2007) and Marine Mammal Protection Plan (SEIC 2009) shall be implemented. These procedures include information on navigation corridors and vessel conduct offshore Sakhalin Island. Relevant Sakhalin Energy standards shall be implemented where required.

8.7 Literature Cited

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