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Sakhalin Energy Investment Company Ltd.

Biodiversity Action Plan

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Executive Summary

Background

Biodiversity is defined as the variability among living organisms of terrestrial, marine, and other aquatic ecosystems. Biodiversity and its associated ecological complexes are essential for effective functioning of healthy environments that provide services to support human life and livelihoods. It has received increasing emphasis by public and corporate organisations in recent years due to its key role in sustainable development.

This emphasis is reflected in the *National Strategy for the Conservation of Biodiversity in the Russian Federation*, issued by the Russian Academy of Sciences and the Ministry of Natural Resources, which recognises the important role that commercial companies have in managing biodiversity through project activities and partnering with relevant organisations to achieve biodiversity goals. The conservation and protection of biodiversity is also addressed by the National *Strategy for the Conservation of Rare and Endangered Species of Plants, Animals and Mashrooms*, approved by the Ministry of Natural Resources of the Russian Federation in 2004.

In line with these principles, Sakhalin Energy Investment Company (Sakhalin Energy, or SEIC) is committed to managing aspects of biodiversity that may be affected by its project activities. This commitment is reflected in Sakhalin Energy's Commitment and Policy to Health, Safety and Environment, and in its Standard on Biodiversity, which states that Sakhalin Energy shall comply with applicable Russian Federation laws and regulations relating to biodiversity.

Sakhalin Energy's Biodiversity Action Plan (BAP) sets out Sakhalin Energy's approach for fulfilling its commitments in respect of the management of biodiversity and ecological impacts arising from the construction process and during operations. It has been developed in conformance with corporate standards for biodiversity management, and in response to Lender requirements as specified in Sakhalin Energy's Health, Safety, Environment and Social Action Plan (HSESAP). The structure and content of the BAP follows the guidelines of the International Petroleum Industry Environmental Conservation Association (IPIECA) for the development of biodiversity action plans, and also aligns with other international norms for BAP.

Objectives

The objectives of the BAP are to identify opportunities and actions to:

- Minimise ecological impacts and to conserve biodiversity that could be affected by Sakhalin II's activities;
- Support the management of ecosystems essential for biodiversity conservation on Sakhalin; and
- Engage with stakeholders to deliver both Sakhalin Energy's commitments towards biodiversity interests and develop and support programmes / subjects of mutual interest.

The BAP describes the identification and assessment of biodiversity interests potentially affected by Sakhalin II, and in a systematic and verifiable manner, the process of developing, implementing and monitoring actions that will contribute to the maintenance or enhancement of those interests. It presents a breadth and depth of detail, including significant work that has been undertaken to collate and assess existing data, to determine effects at the project level, and to provide management mechanisms for BAP implementation, particularly in relation to stakeholder interests.

Determining Priorities for Management

The BAP describes the rationale for the evaluation and determination of biodiversity priorities. Key criteria for priority selection include the social and ecological value placed on species and habitats, and the protection afforded them via legislation. Other considerations that were taken into account in determining priorities are: threatened species or ecosystems (including those not covered by legislation); areas of 'natural' or relatively intact habitat; habitats and areas supporting high species / habitat diversity; environments sensitive to potential impact; species and habitats where significant declines in populations and area have been documented and may be continuing; species of economic or social value; and areas and habitats that are considered important for providing and maintaining ecological processes and ecosystem function. While some biodiversity interests can be specifically singled out as having importance in relation to a single aspect, there is significant overlap between the various prioritisation criteria.

Identified Biodiversity Priorities

Accordingly, the following biodiversity priorities have been identified in relation to Sakhalin Energy's environmental footprint:

Species (and species groups)

- All relevant species protected under Russian federal and local legislation, but with a particular focus on:
  - Steller's sea-eagle
  - Siberian spruce grouse
  - Sakhalin taimen
  - Western Gray whale
- Coastal and wetland birds of the Chaivo peninsula, including breeding Sakhalin subspecies of dunlin, Aleutian tern, spotted greenshank (if confirmed as breeding in the area) and migratory waterfowl;
- Breeding birds of coniferous forest, including Siberian spruce grouse, long-billed murrelet, and black-billed capercaille;
- Breeding birds of river valley mixed woodland, including spot-bill duck, mandarin duck and several species of owl; and
- Salmonid fish populations of selected river systems (i.e. those that support significant areas of spawning and other habitat).

Habitats

- Dark coniferous forest – remaining blocks / areas of this habitat, particularly in the north of the island;
- Larch-ledum forest – areas of intact habitat and well developed secondary forest;
- Well developed and largely intact areas of secondary spruce-fir forest (e.g. Makarov mountains);
- Mixed primary or well developed secondary deciduous-coniferous forest along river valleys;
- Tracts of peatland and swamps supporting characteristic vegetation communities;
- River catchments with significant areas of intact forest habitat and those supporting important salmon populations;
- Shallow coastal lagoon systems and fringing wetland habitats; and

- Coastal and marine waters in Aniva Bay and the northeast Sakhalin shelf.

Determining Actions

Significant effort has been made to avoid or minimise potential impacts on biodiversity interests during planning and construction of the project; many of the biodiversity priorities listed above are already recognised, managed and monitored via Sakhalin Energy's HSE Management System. The BAP therefore aims to facilitate the management of biodiversity issues into and through the operations phase.

The evaluation undertaken during the development of this BAP also considered the effectiveness of existing mitigation measures, and identifies the actions required to meet objectives for biodiversity management in relation to these impacts. Thus, actions have been identified to further manage habitat modification and fragmentation, the ecological effects of erosion, invasive species, induced access and disturbance. This BAP also highlights the need for oil spill response plans to address sensitive habitats and species.

Implementation

Implementation of the BAP requires an integrated approach. Already, commitments that are relevant to the management of biodiversity interests are included in Sakhalin Energy's HSE-MS by way of the company's Environmental Standards, the Environmental Monitoring Project (EMP), and HSESAP, all of which set the basis of the company's obligations for environmental management.

By using the existing strategies, plans, standards, procedures, and programmes of the HSE-MS, plus new action plans to cover gaps, biodiversity interests can be managed and monitored by a combination of elements conceptually understood as a *biodiversity control framework*. Thus, information on each priority will be consolidated into habitat and species action plans, including objectives and activities for protection of the biodiversity interest. Importantly, HAPs and SAPs will cross-reference existing controls under the HSE-MS.

Sakhalin Energy manages biodiversity interests through an adaptive approach, using monitoring and baseline information to assess the biodiversity situation and achievement of BAP objectives. Ecological monitoring and analysis considers relationships between biotic and abiotic elements and evaluates trends in the health and integrity of species populations, communities, habitats and ecosystems, providing information for decision-making. The BAP therefore provides an overview of the company's biodiversity monitoring programmes in relation to existing monitoring frameworks, such as those under the EMP and the HSESAP.

Resource requirements for HAPs and SAPs (many of which are related to existing programmes) are considered during the company's budget cycle, and revised annually based on results of monitoring and effects assessment, changes to legislation, stakeholder engagement, and prioritisation.

Although the BAP is owned and will be implemented by Sakhalin Energy, the value of collaborating with other stakeholders in the development and implementation of specific plans, and in the broader context of regional biodiversity management, is recognised. Successful partnerships and engagement with stakeholders can also contribute to managing the company's reputation (both locally and internationally). The establishment of the Sakhalin Biodiversity Group provided important input to the development of this BAP, and together with other initiatives may enhance management of biodiversity on Sakhalin Island.

PREFACE

This Biodiversity Action Plan (BAP) for Sakhalin II sets out the process and provides focus for Sakhalin Energy's ongoing work to minimise its potential effects on biodiversity.

There is no legal requirement for this document. It has been developed in conformance with corporate standards for biodiversity management, and in response to Lender requirements as specified in Sakhalin Energy's Health, Safety, Environment and Social Action Plan.

The structure and content of this BAP follows the guidelines of the International Petroleum Industry Environmental Conservation Association (IPIECA) for the development of biodiversity action plans, and also aligns with other international norms for BAP.

Accordingly, it describes the identification and assessment of biodiversity interests, and the corresponding actions to maintain or enhance those interests. It describes, in a systematic and verifiable manner, the process of developing and implementing actions that will contribute to achieving biodiversity commitments, as well as the measures to monitor progress and report against adopted objectives. It presents a breadth and depth of detail, including significant work that has been undertaken to collate and assess existing data, to determine effects at the project level, and to provide management mechanisms for BAP implementation, particularly in relation to stakeholder interests.

To facilitate an understanding of the structure and content of this document, and the location of specific information that may be of interest to the reader, the following description summarises the focus of each section:

Section 1 provides a general introduction to the importance and value of biodiversity in the context of sustainable development.

Section 2 describes the frameworks for biodiversity planning at international, national, regional and industry levels, and provides details about the basic structure and components of a BAP.

Section 3 sets the purpose and scope of Sakhalin Energy's BAP, providing an overview of the Sakhalin II Project and its footprint (spatial and temporal boundaries) of potential influence that was taken into consideration during the development of this BAP.

Section 4 describes the steps followed in the development of this BAP.

Section 5 outlines the consolidation and assessment of data from baseline surveys, monitoring and other available non-project sources, enabling biodiversity interests within Sakhalin II's footprint to be described and prioritised in subsequent sections.

Section 6 describes the environment and biodiversity of Sakhalin Island, and thus provides contextual information that is fundamental to understanding the interests.

Section 7 describes the rationale for evaluation, and defines the priorities for biodiversity management in relation to Sakhalin Energy's footprint. The biodiversity interests summarised at the end of this section will form the focus of habitat and species action plans.

Section 8 presents the effects assessment, describing the impacts that the Company has had or may have in relation to the biodiversity interests identified in Section 7. Taking into consideration the control mechanisms already in place, and the monitoring data described previously, Section 8 concludes the actions that are required to meet short term and long term objectives for biodiversity management at habitat and species levels.

Section 9 provides an overview of the further development of biodiversity monitoring programmes in relation to existing monitoring frameworks, such as those under the Environmental Monitoring Project and under the HSESAP.

Section 10 emphasizes that implementation of the BAP requires an integrated approach if its objectives are to be achieved. Accordingly, Section 10 describes the integration of biodiversity actions into Sakhalin Energy's HSE management system.

Section 11 describes the elements and process of stakeholder engagement, which formed an important input to the development of this BAP. The Sakhalin Biodiversity Group, the Wild Salmon Centre, and the Aniva Bay Partnership are initiatives that have interests in biodiversity management.

A list of acronyms and references are included at the end of this document.

CONTENTS

1 Introduction

1.1 The Importance of Biodiversity

Biological diversity (biodiversity) encompasses the variety of life on Earth, from genetic diversity among species populations through to the functioning of entire ecosystems. In this context, biodiversity is not just about the rare or the unusual, but the entire natural world from the most common species and their supporting habitats to the critically endangered species and the issues that threaten their continued existence.

Biodiversity is integral to and essential for the effective functioning of the Earth's environment and the provision of services that support human life and livelihoods. It contributes both directly (through biological products such as food, medicines, and building materials) and indirectly (through ecosystem services) to the welfare of human beings. Ecosystem services represent the processes and conditions inherent to natural ecosystems and which are important in sustaining human life, such as the filtration and delivery of water, maintenance of climatic conditions, absorption and breakdown of waste, and the maintenance of soil structure and fertility. The instrinsic value of biodiversity is important in its own right, in addition to providing significant social and economic benefits to the human population.

Anthropogenic activity is essentially, and to a considerable extent irreversibly, responsible for accelerated changes to the environment, and as such poses the greatest threat to biodiversity. In many cases, such changes manifest themselves as a loss of biodiversity and as an alteration of ecosystem services. In most instances, the causes of these changes are habitat transformation through land conversion and reclamation, poorly planned and managed resource exploitation, modification of rivers, pollution, introduction of alien invasive species and climate change.

2 Framework for Biodiversity Planning

2.1 Introduction

It is commonly accepted that long-term policies to conserve and maintain biodiversity will not succeed unless the underlying causes are addressed. Therefore, managing biodiversity requires commitment at a number of levels ranging from international and institutional policies, down to grass-roots level actions at specific locations and by specific parties.

2.2 International Frameworks

Approaches to the management of biodiversity operate at all levels, with the authority required for the development of specific programmes and the implementation of management measures largely being driven through policies and legislation developed by governments. In turn, these laws and policies are often framed by guidance and regulations that have been adopted by governments as signatories to international conventions and agreements. These international frameworks have developed to recognize the cross-boundary nature of ecosystem management and the fact that biodiversity loss is a global problem. Most direct actions to halt or reduce biodiversity loss need to be taken locally or nationally, but international agreements may provide increased commitment to implementation of activities that effectively conserve biodiversity and promote sustainable use of biological resources.

Numerous treaties and agreements have now been established. The Convention on Biological Diversity is the most comprehensive, but numerous others are also relevant, including the World Heritage Convention, the Convention on International Trade in Endangered Species of Wild Fauna and Flora, the Ramsar Convention on Wetlands, the Convention on Migratory Species, and the United Nations Framework Convention on Climate Change. The most important of these agreements are briefly described below, although it can be argued that the international agreements with the greatest impact on biodiversity are not those dealing with the environment but rather those relating to economic and political issues.

2.2.1 Convention on Biological Diversity

At the 1992 Earth Summit in Rio de Janeiro, world leaders agreed on a comprehensive strategy for "sustainable development", one of the key agreements adopted at Rio being the Convention on Biological Diversity. This Convention sets out commitments for maintaining the world's ecological systems in the context of economic development and establishes three main goals *viz*. the conservation of biological diversity, the sustainable use of its components, and the fair and equitable sharing of the benefits from the use of genetic resources. The Russian Federation joined the Convention in April 1995.

The responsibility to implement the Convention lies with individual countries, and to a large extent, compliance depends on informed self-interest and peer pressure from other countries and from public opinion. The objectives of the Convention are translated into policies and concrete action through the agreement of international guidelines, the implementation of Convention work programmes and development of national Biodiversity Strategies and Action Plans. The Convention's ultimate authority is the Conference of the Parties (COP), consisting of all governments (and regional economic integration organisations) that have ratified the treaty. This governing body reviews progress under the Convention, identifies new priorities, and sets work plans for members. The COP can also make amendments to the Convention, create expert advisory bodies, review progress reports by member nations, and collaborate with other international organisations and agreements.

In April 2002, the COP adopted the target to “achieve by 2010 a significant reduction of the current rate of biodiversity loss at the global, regional, and national level as a contribution to poverty alleviation and to the benefit of all life on earth".

2.2.2 Convention on Wetlands (Ramsar Convention)

The Convention on Wetlands is an intergovernmental treaty adopted on the 2nd February 1971 in the Iranian city of Ramsar, and was the first modern global intergovernmental treaty on conservation and wise use of natural resources. The official name of the treaty – *The Convention on Wetlands of International Importance especially as Waterfowl Habitat* – reflects its original emphasis on the conservation and wise use of wetlands primarily to provide habitat for waterbirds. Subsequently, the scope of the Convention has broadened to cover all aspects of wetland conservation and wise use in recognition of the important role that wetland ecosystems play in biodiversity conservation and the well-being of human communities.

The USSR joined the Convention in 1977, and a total of 35 sites, located in all regions of the Russian Federation, have now been designated as *Wetlands of International Importance*.

2.2.3 CITES

This Convention on International Trade in Endangered Species of Wild Fauna and Flora, commonly referred to as CITES, is an international agreement with the aim of ensuring that international trade in specimens of wild animals and plants does not threaten their survival. Levels of exploitation of some animal and plant species are high and the trade in them, together with other factors such as habitat loss, is capable of heavily depleting their populations and even bringing some species close to extinction. The effort to regulate this trade requires international cooperation to safeguard certain species from over-exploitation.

CITES was drafted as a result of a resolution adopted in 1963 at a meeting of members of the IUCN (The World Conservation Union). The Convention was agreed at a meeting of representatives of 80 countries in Washington DC on 3 March 1973, and on 1 July 1975 CITES entered into force. CITES is a voluntary international agreement (although legally binding on the signatory Parties), the principles and resolutions of which have to be implemented through domestic legislation. The Russian Federation (formerly under the USSR) has been a Party of the Convention since 1976.

2.2.4 The Convention on the Conservation of Migratory Species of Wild Animals

The Convention on the Conservation of Migratory Species of Wild Animals (also known as CMS or the Bonn Convention) is an intergovernmental treaty that aims to conserve terrestrial, marine and avian migratory species throughout their range. Since the Convention's entry into force, its membership has grown steadily to include 106 parties (as of November 2007) from Africa, Central and South America, Asia, Europe and Oceania.

The Russian Federation is not a signatory to the CMS, but is participating in the CMS agreement on the Siberian crane.

2.3 Biodiversity Planning in Russia

The Government of the Russian Federation is committed to a policy of sustainable development, and the conservation of biodiversity is an integral part of the country's sustainable development agenda. A *National Strategy for the Conservation of Biodiversity in the Russian Federation* has been produced by the Russian Academy of Sciences and the Ministry of Natural Resources, which was adopted in 2002. This national strategy was based, in large part, on the First National Report of the Russian Federation on Biodiversity Conservation in Russia (1998), produced by the State Committee of Russian Federation for Environment Protection, and sets out principles, priorities and policies and an Action Plan detailing specific measures for the conservation of priority habitats and species groupings at the federal level. The strategy also provides information on the legislative context and describes a system of organisational, administrative, financial, and economic mechanisms to ensure conservation and sustainable use of biodiversity in Russia.

The National Strategy also describes a framework for the development of regional biodiversity strategies. It is proposed that, where developed, these should be based on the principles of the National Strategy, but at the same time must take into consideration specific natural and socio-economic conditions of individual regions. The following principal stages in the development of a regional plan are envisaged:

- Inventory of regional biodiversity and analysis of its condition;
- Identification of priorities for conservation;
- Analysis of natural and anthropogenic factors, including socio-economic conditions, directly and indirectly influencing biodiversity;
- Identification of factors responsible for any noted deterioration in biodiversity;
- Description of existing biodiversity conservation planning and actions and estimation of the adequacy of these measures;
- Identification of priority socio-economic actions;
- Proposed methods for conservation of biodiversity priorities;
- Estimation of ecological and economic efficiency of proposed conservation methods;
- Elaboration of a regional action plan; and
- Development of a publicity campaign in support of proposed biodiversity conservation measures.

To date, regional strategies have been developed for a number of areas in the Russian Federation including the Lake Baikal region, Nizhny Novgorod, Volgograd, Republic of Severnaja Osetija, Republic of Jakutia and Penza region. There is presently no regional strategy or Biodiversity Action Plan for Sakhalin Island or the Sakhalin Oblast.

The national strategy does not explicitly state the need for the private sector to recognise the importance of biodiversity through the development of specific plans relating to commercial activities. However, the strategy does recognise the important role that commercial companies may have in managing the conservation of biodiversity through better management of project activities, partnering with relevant organisations to achieve biodiversity goals (e.g. the State, NGOs, public) and potential mechanisms for funding.

Furthermore, while there are no Russian Federation or Sakhalin Oblast legal requirements for the development of a dedicated Biodiversity Action Plan for an individual project, laws relating to the protection of nature and the environment have been established. The combined intention of these laws is to ensure that ecological interests, and in particular protected habitats and species, are fully considered during environmental assessment and the development and implementation of a project.

Another key document at the national level is the *Strategy for the Conservation of Rare and Endangered Species of Plants, Animals and Mashrooms*, approved by the Ministry of Natural Resources of the Russian Federation (Order # 323 of 6 April 2004), and developed for implementation of mechanisms and methods for species conservation.

The *Strategy* provides for long-term planning and defines goals, tasks, priorities and main directions for conservation of rare and endangered species of plants, animals and mashrooms. It includes scientific, legal and organisational basics, and practical mechanisms for conservation at federal and regional levels. It is based on: the *Ecological Doctrine* of the Russian Federation (approved by RF Government Resolution # 1225-p of 31/08/2002); the

National Strategy for the Conservation of Biodiversity in the Russian Federation; clause 42 of the RF Constitution; RF Federal Law "On the Protection of the Environment"; RF Federal Law "On Wildlife"; other laws and regulations of the RF; international environmental conventions and agreements ratified by the RF; as well as on:

- Fundamental scientific knowledge in biology, ecology and allied sciences;
- Assessment of the current status of rare and endangered plants, animals and mushrooms and of their exposure to limiting factors;
- The need to create and implement economic and financial mechanisms for conservation of rare and endangered species;
- The significant importance of ecological awareness for conservation of rare and endangered species;
- The need to engage the broadest range of partners to conserve the rare and endangered species.

The *Strategy* also takes into consideration the recommendations of the 1992 Earth Summit in Rio de Janeiro and other international summits on environment and sustainable development, as well as the Convention on Biological Diversity, which was adopted at this Summit and signed by the RF in 1995.

Defining the scientific basics methods and approaches to the conservation of rare and endangered species, the *Strategy* underlines the priority of the **population principle** of the conservation of species in their natural environment. Priority measures to conserve rare and endangered species are:

- Conservation of populations in their natural environment;
- Conservation and restoration of environment, reconstruction of habitats;
- Restoration of lost populations.

Based on scientific principles for the conservation of rare and endangered species, the *Strategy* determines the following activities:

- Development and implementation of categories and criteria for identifying rare and endangered species, as well as for setting priorities for their conservation;
- Establishment of state control, state cadastre, and state monitoring of rare and endangered species;
- Development of databases for rare and endangered species;
- Inclusion (or exclusion) of rare and endangered species in the Red Data Book of the RF;
- Development and implementation of special conservation measures, including organisation of protected areas, creation of breeding centres and genetic banks for rare and endangered species listed in the Red Data Book of the RF;
- Development of state programmes for conservation of rare and endangered species as well as their natural habitats.

As the tool for determining the main directions of state policy for the conservation of rare and endangered species at the federal level, the *Strategy* also serves as a basis for the development of regional strategies and action plans for the conservation of rare and endangered species.

The Russian Federation has defined a number of requirements for the protection of flora and fauna, and establishes liability for damage to protected species and to their living environment. This regulatory framework provides the legal foundation for biodiversity conservation. The following documents provide the basis for these requirements:

- Russian Federal Law "On Protection of the Environment", 10 January 2002, No. 7-FZ;
- Russian Federal Law "On Wildlife", 24 April 1995, No. 52-FZ;
- Russian Federal Law "On Specially Protected Natural Areas", 14 March 1995, No. 33-FZ;
- Russian Federal Law "On the Continental Shelf of the Russian Federation", 30 November 1995, No. 187-FZ;
- Russian Federal Law "On Ecological Expertise", 23 November 1995, No. 174-FZ; and
- 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", No. 372, 16 May 2000.

These laws also provide 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.

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.

2.4 Biodiversity Planning and the Oil and Gas Industry

Global demand for energy is expected to grow by 60% between 2002 and 2030 (and potentially triple by the year 2050). In the short and medium term, a significant proportion of this demand will have to be met through the use of oil and gas until renewable or other energy resources have the potential to act as the primary source of energy for the world. With this increase in demand, oil and gas activities are likely to grow over the next few decades, leading to concerns of continued and increased risk of damage to ecosystems and biodiversity. As an example, the likely increase in the use of natural gas will require a greater need for pipelines to transport the gas. Pipelines are often viewed as having a significant impact on biodiversity due to the potential for habitat fragmentation and secondary impacts related to construction in relatively undeveloped areas.

Biodiversity conservation has risen rapidly up the environmental and political agenda and now represents one of the most important challenges of the 21st century. Numerous international agreements to safeguard biodiversity have come into being (see Section 2.2) and governments all over the world have developed and implemented national legislation in response to concerns regarding biodiversity loss and ecosystem degradation.

Despite this global and national response to biodiversity conservation, the loss of habitats and species continues at a high rate (World Resources Institute, 2005). While oil and gas exploration and production is often not the biggest threat to biodiversity in an area, it can have a wide range of negative impacts on ecosystems, including soil, air and water contamination, habitat fragmentation and conversion, deforestation, erosion and sedimentation of waterways. Furthermore, oil and gas exploration and production are often pioneer economic activities in relatively undeveloped areas, and can lead to further economic and social activities that can cause even more harm to biodiversity through secondary impacts.

Increasingly, many areas that are potentially valuable sources for oil and gas development are also being recognized and valued for their biodiversity and this juxtaposition represents significant challenges for the energy industry, society and conservation organisations. For energy companies this requires that ways have to be found to meet the continued demand for oil and gas and, at the same time, meet society's expectations for corporate social and environmental responsibility, including the protection of biodiversity that may be affected by industry activities.

The oil and gas industry has acknowledged for some time that all environments in which it operates are sensitive to its activities and that due care should be adopted to avoid or mitigate for potential ecological and environmental impacts. Since 1974, industry forums such as the International Petroleum Industry Environmental Conservation Association (IPIECA) and the International Association of Oil and Gas Producers (OGP) have examined the potential impacts of the industry in a variety of operational environments and produced good practice guidelines for those operationsas exemplified, for example, by the estabishment of the Energy and Biodiversity Initiative (EBI).

Energy companies are now finding that, in addition to legal and regulatory incentives to focus on the conservation of biodiversity, there are a number of other reasons why biodiversity issues are being integrated into their management activities. With global awareness of biodiversity loss, public interest in oil operations has grown to the point where an increasing number of activities are subject to scrutiny, and failure to operate in an environmentally and socially responsible manner can present significant risks to a company's operations and reputation. Due largely to this societal pressure (as manifested through the influence of shareholders, customers, potential financiers and government regulation) the industry is responding to a number of challenges relating to its potential environmental impacts and the way in which these issues and the industry itself are perceived at all levels of society.

Among the potential risks to a company from real or perceived environmental and social problems are delays and disruptions at project sites, damage to company reputation, loss of a societal license to operate, and loss of access to business resources such as oil and gas resources, land, capital and employees. Increasingly, earning a social license to operate from communities potentially affected by a project – as well as a broader range of interested parties, from local citizen groups to international NGOs – is as important to the continued viability of a project as legal permits from the host government. Public concern about the loss of biodiversity is an issue that should be recognised as an important business risk, and a company's timely response to this concern is a key factor in ensuring that projects are executed without problems or delay.

Furthermore, partly in response to public pressure, international financial institutions, commercial banks and export credit agencies, either have in place, or are beginning to develop, standards and conditions for lending to large infrastructure developments, such as oil and gas projects and are increasingly emphasizing good environmental performance in their screening practices and covenants for lending. Companies that incorporate better biodiversity practices and environmental standards into their operations may have greater access to capital from these financial organisations. A number of financial institutions, including the World Bank and the International Finance Corporation (IFC), have safeguard policies, guidelines and compliance requirements on environmental and social issues, several of which relate to biodiversity conservation.

The challenges to the oil and gas industry in accessing sensitive ecosystems in the future will lie mainly in providing assurance that it can minimise its ecological footprint and prevent major incidents such as large oil spills, and also in recognising and mitigating the potential for cumulative and secondary impacts (although these issues are not the sole responsibility of the oil and gas industry). In addition to assessing the impact of oil and gas companies on biodiversity, important though this is, increasing emphasis will be given to the interaction with and reliance on ecosystem services (which is particularly pertinent given that oil and gas represent the products of ancient ecosystem processes).

2.5 Biodiversity Action Plans

The original impetus for the production of biodiversity management plans arose from the 1992 Convention of Biological Diversity (the Rio Convention, see Section 2.2.1), although plans for the conservation and protection of individual species and habitats have been in existence in various countries and forms for many years prior to this. In effect, the Rio Convention provided a global call for a greater recognition of the value of biodiversity in the face of significant concerns regarding species and habitat loss, and a biodiversity action plan (BAP) was formulated as a mechanism for a co-ordinated response to these concerns.

Although they vary significantly in their content and approach, a BAP typically comprises the identification and assessment of biodiversity interests, and the corresponding actions to maintain or enhance those interests. A BAP will describe, in a systematic and verifiable manner, the process of developing and implementing actions that will contribute to achieving biodiversity commitments, as well as the measures to monitor progress and report against adopted objectives.

Since the initial conceptualisaiton of BAPs, they have been developed to suit a wide range of purposes and scales including the protection and conservation of rare and endangered species, specific habitats, areas of ecological importance (e.g. National Park, biological reserve etc.), entire administrative areas (e.g. individual states, authorities) and the activities and influences of individual companies or organisations. Despite the variety of purpose and approach, the BAP process is effectively the same throughout and is focused on maintaining and, in many cases enhancing biodiversity, as part of the overall management of human activity and influence on the natural environment.

For a Company, a BAP provides an opportunity to implement a fully integrated process to address biodiversity issues in a coordinated and consistent manner (rather than in relation to individual components of a project or company wide activities) and can enhance the biodiversity aspects of environmental management. Typically, for a specific project or activities, the basic structure and components of a BAP are:

- A desktop assessment and literature review to contextualise a project site and important environmental features;
- A summary of baseline surveys and information to record original environmental conditions;
- Impact assessment to determine potential project effects, thereby defining the project's environmental footprint (i.e. zone of influence);
- Identification of ecosystems, habitats, and species as priorities for management action;
- Development and implementation of action plans (if appropriate);
- Monitoring and evaluation against performance objectives; and
- Communication and reporting structures.

3 Sakhalin Energy and Biodiversity Planning

3.1 Overview of the Sakhalin II Project

The Sakhalin II Project comprises the development of two oil and gas fields located 10-20km offshore of north-east Sakhalin Island (see Figure 3.1), *viz*. Piltun-Astokhskoye, primarily an oil field with associated gas, and Lunskoye, predominantly a gas field with associated condensate and an oil rim. The estimated resources that will be developed over the 40-year lifetime of Sakhalin II are enormous. Development and exploitation of these gas and oil resources will establish Sakhalin as a strategic gas and oil supplier through the Pacific Basin and will open up markets for Russian gas in Asia for the first time.

Phase 1 of the Project focused on oil development from the Astokh feature of the Piltun-Astokhskoye field. Production, which started in 1999, is carried out at the Vityaz Production Complex, which is built around the Molikpaq production platform. Until recently, oil was transported from the Molikpaq to a floating storage and offloading unit (FSO), from where it was transferred to export tankers for delivery to foreign markets. Under these conditions, the occurrence of sea ice around the Vityaz Production Complex limited production from Phase 1 to approximately 6 months a year. However, in 2008, the Molikpaq was tied in to the Phase 2 offshore pipeline system that delivers production from Phase 1 and Phase 2 platforms to Prigorodnoye via onshore facilities (see below), allowing production to continue year-round.

Phase 2 is an integrated oil and gas development that includes a second offshore platform at the Piltun Astokhskoye (PA) field to develop the Piltun feature and a platform at the Lunskoye gas field. All three platforms are linked to shore by offshore oil and gas pipelines. The landfall for the PA platforms is located south of the PA Field near Chaivo Lagoon and the Lunskoye landfall occurs due west of the platform near Lunskoye Bay. The oil and gas is transported by an onshore pipeline system from the north of Sakhalin Island via an onshore processing facility (OPF), near Lunskoye, to a liquid natural gas (LNG) plant and oil and LNG export terminals at Prigorodnoye in the south. The oil and gas pipeline systems each cover a distance of over 800 km, much of which through forested land, but also crossing through approximately 125 km of wetland habitat, traversing 110 km of mountainous terrain, and crossing more than 1,000 watercourses, of which around 150 are of importance for the wild salmon populations they support.

Construction work began in 2003 and was largely completed in 2009 with first LNG export.

3.2 Environmental Assessment Process

As part of the environmental assessment process for Sakhalin II, a significant amount of information on the natural environment of Sakhalin has been collected through specific survey work and collated from available sources. This process began in 1996 and was formalised in 2001 with the publication of a preliminary Environmental Impact Assessment (EIA). In September 2002, a Technical and Economic Substantiation for Construction (TEOC), a requirement of the Russian approvals process to take into account the results of public consultation, was produced. As part of this process, the Russian Government also established an Expertiza (a panel of experts) to undertake a specialist review of this document. The provision of information for the Expertiza required a much greater level of detail and a more scientific style of presentation. Additional material was therefore provided in Environmental Protection Sections (EPS) of the TEOC submission, covering each project asset and including baseline data, a project description, impact assessment information, mitigation measures, and fisheries damage compensation calculations.

In 2002, Sakhalin Energy commissioned an international-style environmental, social and health impact assessment (ESHIA) to bring the impact assessment work in line with international standards. Details of the environmental impact assessment process are described in the EIA report, but essentially it followed a typical process of assessment (baseline characterisation, option appraisal, identification of potential impacts based on project activities, determination of scale and magnitude of the impact, identification of mitigation measures and assessment of residual impact). In addition to the ESHIA, two very focused EIAs were conducted in 2002, specifically to address potential project impacts with respect to the western gray whale population that feeds offshore of north-east Sakhalin during the summer months.

Subsequent to the production of the international EIA, further analysis and assessment of the potential impacts of the Project have been undertaken and a number of EIA Addenda have been produced covering a variety of subject areas, including biodiversity-related aspects such as rare and migratory birds, marine mammals and protected areas. Further environmental data has also been collected pre- and during construction as part of the approved construction monitoring programme. This data is often more detailed than the baseline data collected for the purposes of environmental assessment, but is also, in many instances, more localised in its extent.

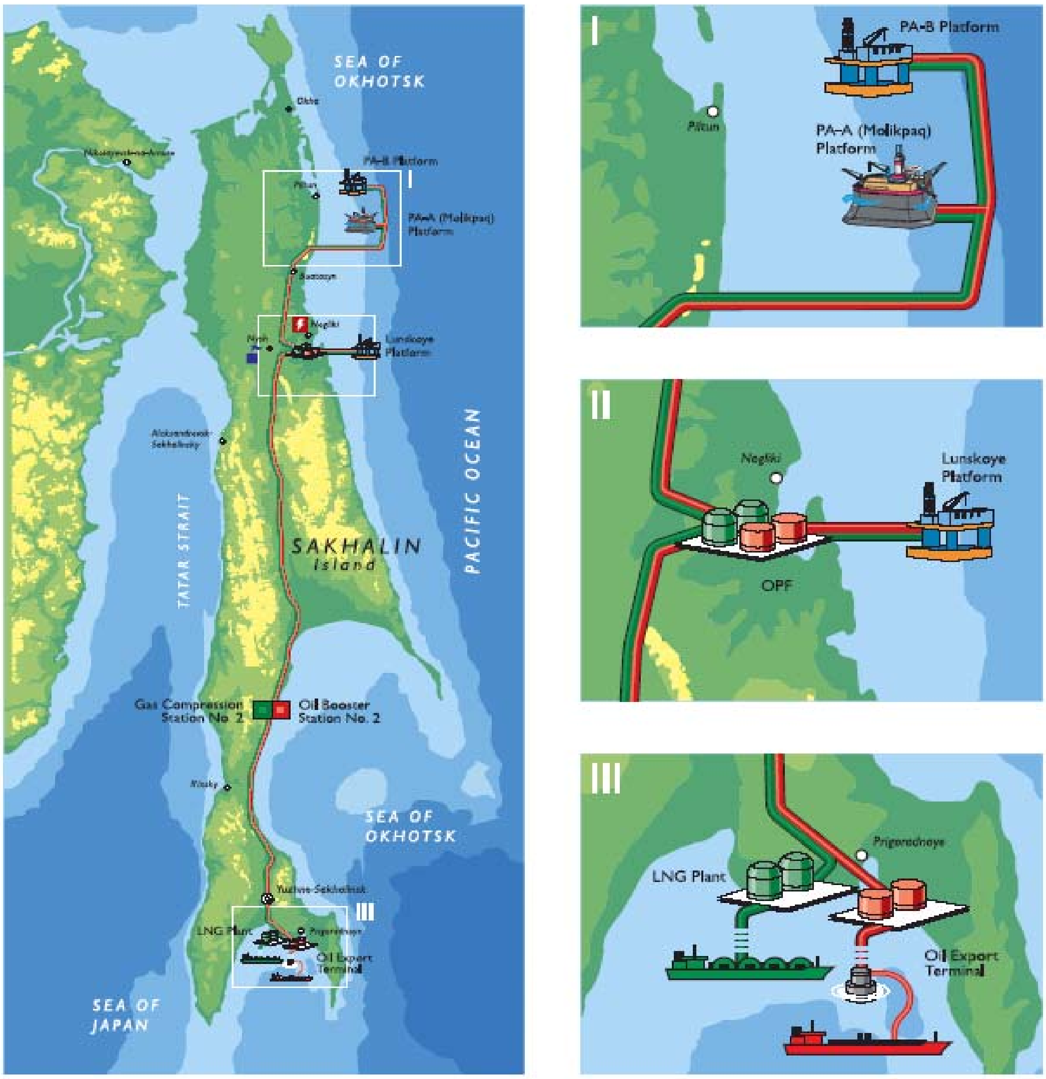


Figure 3.1 Representation of the infrastructure components of Sakhalin II.

3.3 Purpose and Scope of Sakhalin II's BAP

Sakhalin Energy is committed to maintaining biodiversity that may be affected by its project activities so as to promote sustainable development and to ensure the continuous provision of ecosystem services and values for current and future generations. This commitment is reflected in Sakhalin Energy's Environmental Policy and its Standard on Biodiversity, in which it states that Sakhalin Energy shall comply with applicable Russian Federation laws and regulations relating to biodiversity, EP Global Environmental Standards, and the Group Biodiversity Standard.

While mitigation measures derived from the EIA process (see Section 3.2) are being implemented for individual project assets and other specific work components, these focus only on minimising impacts on Red Data Book and protected species as required by RF legiuslation and do not necessarily address effects at the ecosystem level. The development of a biodiversity action plan offers the opportunity to implement a fully integrated process to address biodiversity in its entirety, in a coordinated and consistent manner.

This document, the Sakhalin Energy Investment Company Biodiversity Action Plan (BAP), sets out the overall approach being taken by Sakhalin Energy towards fulfilling its commitments in respect of the management of biodiversity and ecological impacts arising from the construction process through to and during operations. This includes providing an overview of project-related activities and associated effects on species, habitats and ecosystems occurring within the project footprint.

As presented in Section 8, assessment of potential project impacts has been undertaken and a large number of mitigation measures adopted and implemented to address identified needs. This work has largely been based on impact assessment at the asset level (i.e. individual components of the overall project) and with regard to individual parameters rather than systems and also with a strong focus on rare and protected species. By integrating data across the project and considering project effects at an ecosystem or habitat level, the hope is that the BAP process will enable any outstanding project-related biodiversity issues to be identified and addressed. Furthermore, the BAP provides an opportunity to align the aims and objectives of the project with national biodiversity priorities and strategies, and also to serve as an example for managing biodiversity issues associated with any future project expansion or new hydrocarbon exploration and production projects.

To summarise, the BAP is a tool that will assist Sakhalin Energy to:

- Minimise the ecological impacts of Sakhalin II and any future associated development;
- Identify opportunities and actions for conserving biodiversity that could be affected by Sakhalin Energy's activities during the lifetime of the project;
- Support the management of ecosystems essential for biodiversity conservation on Sakhalin; and
- Engage with stakeholders to deliver both Sakhalin Energy's commitments towards biodiversity interests and develop and support programmes / subjects of mutual interest.

3.4 Coverage of the BAP

The scope of the BAP is determined by its spatial and temporal boundaries, which are based on interaction of Sakhalin II with the physical, ecological and, to an extent, socioeconomic characteristics of Sakhalin.

Spatial boundaries are defined by the project's footprint. These include all areas occupied by the assets and supporting / ancillary infrastructure (such as lay-down areas, site camps, bridges, access roads and rights of way), as well as areas that may be influenced or affected by project activities (such as catchments, emission fall-out zones, and remote sites subject to increased exposure and disturbance through improved accessibility). More specifically, the zones of interaction between ecological components and project activities determine the BAP's spatial boundaries. These zones may be characterised by changes in species distribution and behaviour (such as migration and breeding habits), and in many instances, may extend beyond the purely physical (infrastructure) elements of the project (e.g. downstream effects in rivers crossed by the onshore pipeline).

Temporal boundaries are defined according to the project's phases (e.g. construction, commissioning, operations, and decommissioning). Consideration is also given to the period of project-biodiversity component interaction, which will be influenced by life-cycle stages and seasonal variation (e.g. breeding, dormancy, migration and the requirements for ecosystem services during these periods), or the time required for an impact to become apparent, for it to cease and for recovery to occur.

4 Development of the BAP

4.1 Introduction

The main aims of the BAP are to provide a focus for the ongoing work that Sakhalin Energy is undertaking to address the minimisation of potential effects on biodiversity, and to set out the approach and framework by which such work can be undertaken. The BAP also provides the context for this process and describes the situation with respect to the construction stage of the project. Thus, significant work has been undertaken in collating and assessing existing data, determining effects at the project level, and ensuring that management mechanisms are available and practical in order to deal with BAP implementation, particularly in relation to stakeholder interests.

4.2 Steps in the Process

A number of key steps in developing the BAP were initially identified, that largely mirror the standard approach to impact assessment, but which also take into account the structure and process used in biodiversity planning at national and individual project levels (see Sections 2.3 and 2.4). The schematic shown in Figure 4.1 summarises the framework and approach that has been taken in producing this BAP.

It is important to bear in mind that the BAP represents the first attempt at consolidating a project-wide approach to dealing with potential impacts on biodiversity. The data that provide the structure and content of the BAP have been obtained largely for the purposes of EIA and therefore relate to the construction phase of the project. As the project moves through into the operational phase, these data will continue to be forthcoming via monitoring surveys and specific projects, where these are developed in response to identified biodiversity plan requirements. The BAP should therefore be viewed as a living document that will evolve as additional information becomes available. This aspect of the BAP process is evident in the relationship between monitoring and the determination of required actions for managing biodiversity interests.

The BAP does not contain all of the information and background data that has been analysed, described and assessed in order to establish the necessary content / results at each step in the process. Instead explanation, relevant information, summaries of data and outputs from various studies and individual components in the process are provided in the following sections.

Data Collation and Assessment

Biodiversity of Sakhalin Island
An overview of the biodiversity of Sakhalin and summary of fauna and flora data collected during surveys for the Sakhalin II Project. This provides contextual information for assessment of BAP priorities and potential management actions.

Description of Project Activities
Description of the Sakhalin II infrastructure and main activities in relation to local environmental features and characteristics. This provides a reference for the likely spatial extent of project effects (i.e. the 'footprint' of the project).

Prioritisation of Biodiversity Interests

While the overall objective is to minimise potential project effects on biodiversity it is recognised that certain legislative requirements need to be met and that there are also ecological and potentially social priorities for action. Criteria for prioritisation of biodiversity interests and management effort are therefore required. The results of this prioritisation process are the focus for further assessment and the development of specific management plans where these are considered appropriate.

Description and Assessment of Project Effects

A description of key effects associated with construction and operation of Sakhalin II in relation to biodiversity interests. This is based upon the extensive environmental impact assessment, survey and monitoring work undertaken for the project and available information on the ecological impacts of oil and gas resource development in similar environments. Assessment of likely effects is undertaken at a relatively broad level and with respect to the project as a whole rather than in relation to individual project facilities.

Determination of Required Actions

If assessment reveals that existing measures for minimising impact on biodiversity interests are unlikely to be sufficient to meet determined priorities or objectives then additional management action may be required. This may include the development of new and / or the revision of existing mitigation measures and / or monitoring programmes. Where measures related to specific ecosystem components (e.g. habitats or species) are needed, then these may be best managed through the development and implementation of specific actions.

Monitoring

Consistent and reliable data collection and analysis is necessary to measure the effectiveness of measures developed to mitigate for potential project effects on biodiversity interests and to monitor trends in the status of ecosystems, habitats and species. Monitoring data will support informed decision making to adjust planning processes and alter management actions to maintain and conserve biodiversity.

Stakeholder Engagement

Due to the complexities of ecological interactions, actions implemented in isolation may not always be sufficient to deal with potential impacts on biodiversity. The development of successful partnerships and engagement with stakeholders can therefore help facilitate the long-term success of biodiversity projects. Such engagement can also promote trust, avoid potential conflict and is a means of managing the company's reputation.

Figure 4.1 Schematic showing steps in Sakhalin Energy's approach to the management of biodiversity.

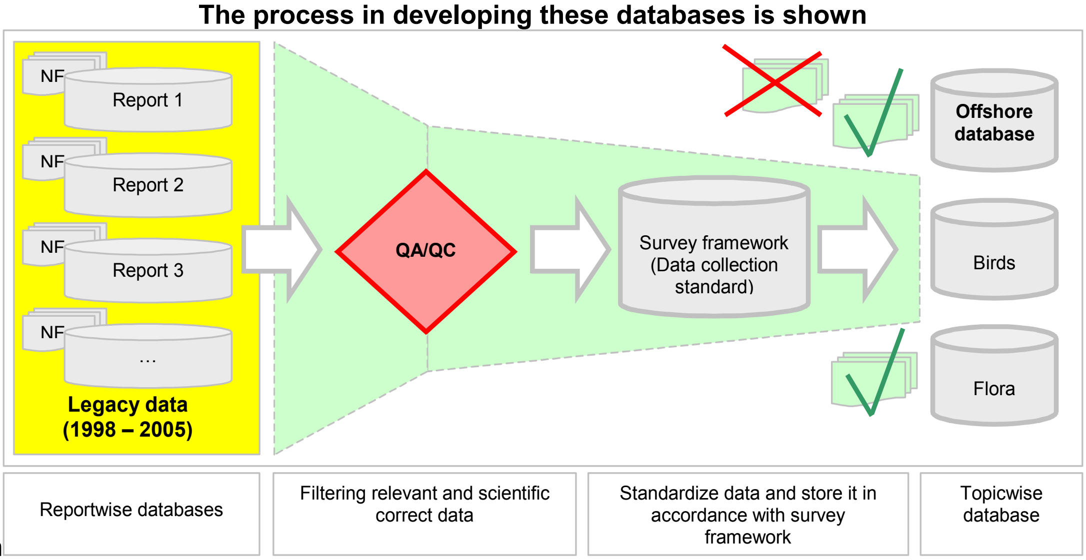
5 Data Collation and Assessment

The provision and analysis of ecological data collected specifically to understand and manage the potential effects of Sakhalin II on biodiversity is at the centre of the BAP. This data, derived from baseline surveys, monitoring and other available non-project sources, provides the context and background through which the need for further actions to safeguard biodiversity interests can be identified.

A significant amount of data on the ecological characteristics of the habitats and some of the main species groups in areas in which Sakhalin II activities are occurring has been collected through baseline characterisation and monitoring surveys during construction. Much of this data has been collected to meet Russian Federation requirements, specifically with respect to the potential presence and status of Red Data Book species in areas that could be affected by the project.

Currently, available biodiversity data is being consolidated, updated and mapped through the development and population of environmental databases and the use of GIS. This is an ongoing process and involves the continued input of data derived from monitoring and other project-related surveys as the project progresses. The development and population of environmental databases facilitates the identification, quantification and prediction of drivers of biodiversity change and potential issues where management action may be required.

Sakhalin Energy has developed and is progressing with a systematic approach to environmental data management and analysis in support of the identification and mitigation of potential impacts on the environment. All relevant baseline data provide a medium through which the data can be visualised and analysed, and provide information that could address most queries related to Sakhalin II's environmental issues. In the first instance, historical data has been made available and accessible. Spatial data from the large number of environmental surveys undertaken between 1995 and 2006 (more than 500) have been extracted and entered into so-called "report-wise" databases and all metadata has been captured to enhance document search capability. The process in developing these databases is shown



in

Figure 5.1.

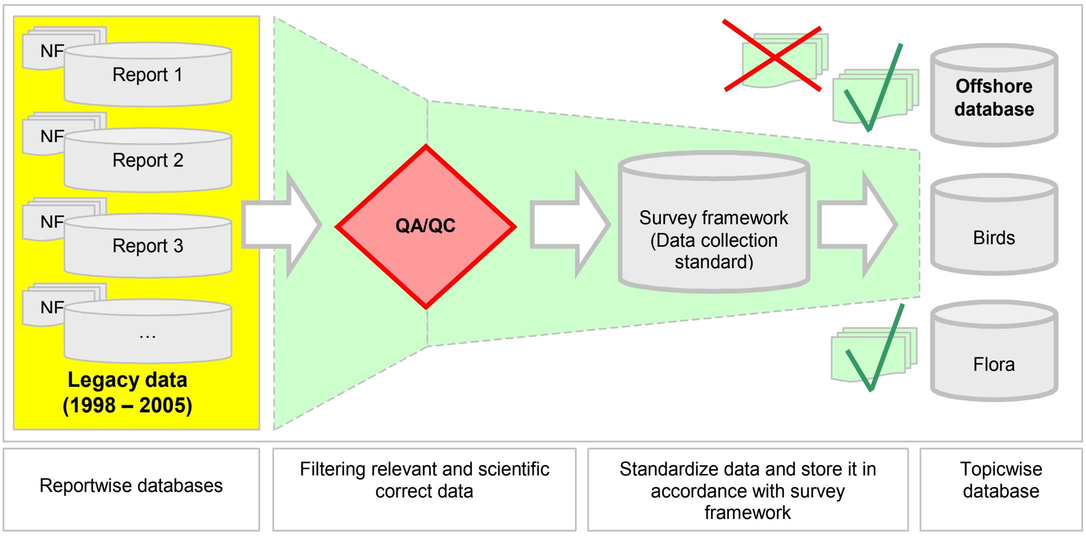


Figure 5.1 Process of environmental database development.

The consolidation and assessment of data available from the baseline surveys and monitoring work undertaken to date has enabled biodiversity interests within Sakhalin II's footprint to be described and has provided data to assess the impact of the various effects of the project. The collated ecological data is summarised in the description of the biodiversity of Sakhalin Island in Section 6. This summary is based upon available literature but takes into account the specific data obtained for project EIA and monitoring purposes.

The assessment of data thus far has highlighted some challenges such as inconsistency in survey and sampling methodologies and localities, as well as some inaccuracies and gaps in baseline data. These aspects have been considered when developing and commissioning further surveys during the monitoring phase of the project.

A summary of the surveys, the parameters covered and a basic synopsis of the data are provided in Table 5.1.

Table 5.1 Summary of Ecological Monitoring.

Ecological Parameter	Project Coverage	Purpose	Survey and Data Synopsis
Vegetation and Flora	OP, OPF and LNG	Baseline and monitoring	Surveys undertaken in 1999-2001 covering all of the project facilities. Vegetation mapped using a combination of satellite (Landsat) imagery and ground surveys. Covers a 2km corridor either side of the onshore pipeline. Location of RDB species noted at survey sites along pipeline and around LNG, OPF. Survey undertaken in 2004 for the re-routed section of pipeline at Chaivo. Monitoring plots selected to determine change to populations of RDB species, with monitoring undertaken during 2003, 2005 and planned for 2008.
Terrestrial Invertebrates	OP and LNG	Baseline	Basic data collected during initial baseline surveys at the LNG and at selected locations along the pipeline ROW in 2000. No monitoring surveys.

Ecological Parameter	Project Coverage	Purpose	Survey and Data Synopsis
Amphibians and Reptiles	OP, OPF and LNG	Baseline	Basic data collected during initial baseline surveys at the LNG, OPF and at selected locations along the pipeline ROW in 2000. Surveys also undertaken for Chaivo pipeline re-route and Gastello booster station. No monitoring surveys.
Terrestrial Birds	OP, OPF and LNG	Baseline and monitoring	Significant number of surveys undertaken since 1998, including: North-east lagoons – autumn migration studies in 2000, 2001 and breeding birds in 2003. Pipeline ROW – Baseline surveys in 1999, 2000, 2001. Monitoring of selected routes and plots where RDB populations present in 2003, 2005 and planned for 2008. OPF – Baseline and specific surveys for Siberian spruce grouse and Long-billed murrelet (2005-2007). LNG – Baseline survey in 2000. Monitoring surveys of selected plots and routes in 2003, 2005 and 2007. Chaivo re-route – Baseline in 2004 and additional monitoring spring and autumn surveys in 2005, 2006 and 2007.
Seabirds	Platforms and TLU	Monitoring	Some bird data collected by marine mammal observers during installation of PA-B and LUN-A platforms. Specific migratory survey undertaken during installation of TLU in Aniva Bay.
Steller's sea-eagle	OP and OPF	Baseline	Baseline data collected during 2000, 2001 in north-east coastal lagoon area. Sea-eagle research project started in 2004 with comprehensive annual spring and summer surveys of eagle breeding sites around north-east coastal lagoon systems, adjacent to pipeline ROW and at the OPF.
Terrestrial Mammals	OP, OPF and LNG	Baseline	Basic data collected during initial baseline surveys at the LNG, OPF and at selected locations along the pipeline ROW in 2000. Data Surveys also undertaken for Chaivo pipeline re-route and Gastello booster station. No monitoring surveys.
Freshwater (river) invertebrates	OP	Baseline and monitoring	Baseline data collected for selected rivers known to be of importance for supporting significant areas of salmon spawning habitat. Monitoring of same rivers pre and post pipeline river crossings.
Freshwater (river) fish	OP	Baseline and monitoring	Baseline data collected for selected rivers known to be of importance for supporting significant areas of salmon spawning habitat. Monitoring of same rivers pre and post pipeline river crossings.
Salmonid Spawning Habitat	OP and LNG	Baseline and monitoring	Baseline data collected for rivers known to be of importance for supporting significant areas of salmon spawning habitat. Monitoring of same rivers pre and post pipeline river crossings (2003 onwards).

Ecological Parameter	Project Coverage	Purpose	Survey and Data Synopsis
Marine Benthos	Offshore Pipelines, Platforms and LNG	Baseline and monitoring	Characterisation surveys undertaken for north-east Sakhalin shelf and Aniva Bay in 1999, 2000. Monitoring surveys for platforms and offshore pipelines (pre and post construction). Specific benthos surveys undertaken in relation to western gray whale feeding areas in north-east nearshore area (Piltun). Monitoring studies in Aniva Bay undertaken in relation to dredging and disposal operations for LNG jetty, TLU and pipeline (2005-2007).
Marine Fish Communities	Plat, OfP and LNG	Baseline	Trawl surveys undertaken during characterization studies for north-east Sakhalin shelf and Aniva Bay (2000, 2001).
Marine Mammals	Offshore Pipelines, Platforms and LNG	Baseline and monitoring	Sightings by Marine Mammal Observers made during characterization surveys (baseline) and for all marine construction activity undertaken. Significant and intensive surveys undertaken in relation to western gray whale.

6 Environment and Biodiversity of Sakhalin Island

6.1 Physical Environment

6.1.1 Topography

Sakhalin Island is located off the coast of Far East Russia, between the Sea of Okhotsk to the north and east, and the Sea of Japan to the south. It is separated from the Russian mainland by the Tatar Strait (which is 8km wide at its narrowest) and from Hokkaido, the northernmost island of Japan, by the La Pèrouse or Soya Strait (43km wide at its narrowest part). Sakhalin is a long thin island with an average width of about 100km (although it decreases to 6km at the Okhinsky Isthmus in the north and 27km at the Poyasok Isthmus in the south) and a length of 948km. The island occupies an area of about 76,600 sq km (29,500 sq miles), and together with the Kuril Islands, forms the Sakhalin Oblast (an oblast is a Russian province) of the Russian Far East.

The large-scale structure of Sakhalin Island is controlled by its location along the junction of the Eurasian and North American tectonic plates. It is characterised by a series of north-south trending, relatively low (1,000-1,600m) mountain ranges, hills and intervening, generally waterlogged, lowlands. The West Sakhalin Mountains comprise a group of parallel mountain chains and ridges extending along the western coast. The main one is the Kamyshovy ridge that reaches heights of 1,000 to 1,300m. The East Sakhalin Mountains comprise the Lopatinsky mountain juncture with its radially extending ridges that reach heights of 1,000 to 1,600m. Sandwiched between these mountain ranges are the extensive low-lying wetlands of the Tym-Poronai lowland. In the south of the island, the Susanaisky and Tonino-Anivsky Ranges form the distinct peninsulas on either side of Aniva Bay.

Plains and lowlands occupy approximately 25% of the island, the largest being the Northern Sakhalin Plain, which is characterised by a rolling terrain with hills from 200 to 400 m high. Coastal areas of the northern and north-eastern parts of the island comprise swampy lowlands and large coastal lagoons separated from the open sea by sandy spits and bars. The Tym-Poronai lowland, between the Eastern and Western Sakhalin mountains, is a flat waterlogged plain occupied by the middle and lower reaches of the rivers Tym and Poronai, the two largest rivers on the island. Typically, this lowland area is at a height of 60 to 70m above sea level, but increases to about 160m at the divide between the rivers. In the south the Susunaiskaya lowland extends from Aniva bay in the south to the estuary of the river Naiba in the north. Its width in the middle reaches is 20 km, increasing to 40 km at the coast of Aniva Bay.

6.1.2 Climate

In general, Sakhalin is subject to a moderate monsoonal climate with damp winters and cool, rainy summers. The cooling effect of the Siberian continental monsoon system during the winter and the cold waters of the Okhotsk Sea in the summer make the local climate cooler and more severe than other locations at the same latitude (46-54° N). Summer monsoons bring moist oceanic air and considerable precipitation during the summer and autumn. Parts of the east coast of Sakhalin are cooler than would be expected due to the presence of cold-water currents, while the southwest of the island is influenced by the warmer waters of the Tsusima Current.

The average air temperature during January varies between -17.7 to -24.5°C in the north of the island, and between -6.2 to -12°C in the south. Winter usually lasts 5-7 months and summer 2-3 months. The average air temperature during August varies between +10.9 to +15.6°C in the north of the island, and between +16 to +19.6°C in the south. Fog occurs frequently in the coastal zone during summer while frequent typhoons and storms occur during the autumn.

Average annual precipitation in the central part of the island is 500-750 mm, in the north it is over 400 mm (rising to 1,000-1,200 mm in mountainous areas) and in the south it is 1,000 mm. Most precipitation (65 to 78%) occurs between April and October, with September considered the wettest month, as this is normally the period of intensive typhoon activity.

6.1.3 Geology

The region from Sakhalin in Russia to the eastern edge of the Japan Sea lies at the margin between the Eurasian and North America crustal plates, as evidenced by the often large earthquakes and active crustal movements that are prominent in the zone. A system of major north-south trending faults (or fractures) in the rock sequences of Sakhalin demarcate the Eurasia - North America tectonic plate boundary. NE-SW trending normal faults and NW-SE trending thrusts and folds complement the major N-S shear faults associated with the plate boundary. Most known hydrocarbon accumulations along the East Sakhalin shear zone (the boundary zone between the two plates) of the island's eastern side are associated with these structural features, especially those of compressional origin.

The central core to Sakhalin Island is formed from Cretaceous (65 – 145 million years ago) and older rocks that comprise deformed and metamorphosed sedimentary rocks that are characteristic of the accretion and folding associated with plate collision tectonics. In parts of western Sakhalin and north-east Sakhalin small outcrops of Jurassic-Cretaceous volcanic and intrusive rocks occur.

Overlying these Cretacous rocks is a thick sequence of Tertiary (2 – 65 million years ago) sediments associated with deposition from the precursor to the Amur River system. These rocks have been deformed through tectonic movements into numerous oil and gas trapping structures and form the main reservoir rocks in which oil and gas is present on the island and offshore. The near-surface geology consists of sedimentary drift deposits of the Quaternary era (10,000 – 2 million years ago). These geologically recent deposits largely comprise alluvial and marine clays, silts, sands, and gravels in variable proportions and represent the products of terrestrial erosion and deposition from periods of marine transgression. In the north of the island a whole series of marine 'terraces' associated with changes in sea-level over the past few million years can be traced at various heights. The thickness of these Quaternary deposits typically ranges from 15 to 20 m, but can be thousands of metres thick in coastal depressions such as the Tym-Poronaysk lowland. Locally, extensive deposits of lacustrine silts and clays that can be up to tens of metres thick, occur in some lowland areas.

6.1.4 Soils

Sakhalin Island is located within the Far Eastern Taiga-Forest Bioclimatic Region. In most instances, soils tend to be boggy, fragile and podzolised, although soil type varies across the Island in line with vegetation, relief and climate. Generally, peaty, podzolic, loamy and clayey soils dominate in lowland areas with alluvial and gley-type soils occurring in river valleys. The mountainous areas are characterised by podzolised and non-podzolised forest, brown soils. Despite the diversity, it is possible to define areas that are characterised by similar chemical and hydrologic soil composition:

- In the North-Sakhalin Lowland, free-draining sands predominate in coastal areas and on former marine terraces, while poorly-draining loams and clay-rich soils occur in the river valleys;
- In the West-Sakhalin, East-Sakhalin Mountains, the Susunai and Tonino-Aniva Ridges, friable soils occur, largely derived from eroded sediment deposited as alluvial fans and other depositional landforms. These soils are generally permeable and free-draining;
- Depressions / lowland areas between mountain / hill ranges are characterised by loamy and clayey alluvium. These types of soil are relatively impermeable and retain a lot of

moisture; and

- Low coastal zones are characterised by loamy and clayey soils. These types of soil are found adjacent to lagoons, river mouths and enclosed depressions and are poorly-draining. Permeable, marine sands are present along the low-lying coastal zone.

6.2 Overview of Sakhalin Flora and Fauna

Historically, Sakhalin used to be connected to both the Russian mainland (about 7,000 years ago) and to Hokkaido Island (about 12,000 years ago). These land bridges allowed species migration, providing opportunity for genetic exchange between connected areas. As a result, the level of endemism in Sakhalin is low; only one rodent, the Sakhalin vole (*Microtus sachalinensis*), and one freshwater fish, the Polyakov stickleback (*Pungitius polyakovii*), are classified as endemic. *Miyakea* is the only endemic plant genus. Some other plant species are also considered to be endemic, but they are not well separated from related taxa, hence true endemism is questionable. Similarly, dozens of insects and other invertebrates are considered endemic (i.e. they were described in Sakhalin and have not been recorded elsewhere), but this classification may be due to the limited knowledge of far-eastern invertebrates (especially arthropods) and the scarcity of zoological collections from the Russian Far East.

The vascular flora of Sakhalin Island numbers more than 1400 species, of which about 1200 are indigenous. In addition, 43 species are under cultivation. One hundred and four Sakhalin plant species are included in the Regional Red Data book, and 25 of these are listed in the Russian Federal Red Data Book. The flora of Sakhalin is, however, considered significantly poorer than that of Hokkaido or neighbouring mainland territories such as Khabarovsk or Primorye.

The diversity of terrestrial vertebrates on Sakhalin is poor relative to the neighbouring Russian mainland and Japan. For example, only 13 rodent species are found on the island, three of which are introduced. The native fauna excludes most ungulates (such as red deer, elk, and roe deer, which are widespread on the mainland), wolves, and many other species. The colonization of the island by terrestrial mammals, reptiles and amphibians, has been restricted because of its location and harsh climate, in particular, deep snow cover. Habitat loss and hunting have also led to the loss of some species (e.g. Lynx (*Lynx lynx*)) and significant reduction in the populations of others (e.g. wolverine (*Gulo gulo*)). Currently, the number of mammal species inhabiting the island is 44 species, with a number of these having been introduced either for the fur trade or for hunting. Two reptile species and five amphibian species have been recorded on the island.

A variety of terrestrial, wetland and coastal habitats are present on Sakhalin Island, all of which support distinct bird assemblages. The total number of birds registered on Sakhalin is 378 of which 201 species are known to nest on the Island. Many of these species are migratory and appear on the island during the early spring-summer before leaving for climatically more benign areas during late summer. The geographical position of Sakhalin Island indicates its potential as a bridge for migratory birds travelling between Japan and the Far Eastern mainland. However, whether Sakhalin is a bridge for birds originating from Khabarovsk Krai and the Russian North (e.g. many species of passerines) or whether the migratory population is largely comprised of local birds is not fully known. Certainly, it is apparent that some species make use of Sakhalin as a staging ground during both spring and autumn migrations. Notable examples include Bewick's swan (*Cygnus columbianus bewickii*) and whooper swan (*Cygnus cygnus*), which congregate in large numbers in the north-east and the extreme south of the Island prior to moving to wintering grounds in Japan or breeding grounds in northern Russia. Indeed, the importance of the Island in this respect is reflected by the fact that a significant number of birds recorded from Sakhalin are included in the international convention on migrating birds signed between Russia and Japan.

The resident bird fauna (i.e. present all year round) is typical of northern boreal forests and comprises approximately 20-30 species. These birds are typically carrion feeding birds (e.g. jungle crow, *Corvus macrorhynchus*) or raptors (falcons, eagles and owls) that can take live mammal prey, ground dwelling forest birds such as grouse and capercaille and seed eating passerines.

The major part (about 70%) of Sakhalin's rare bird fauna is represented by wetland (lake-swamp and littoral-marine) species reflecting the extensive presence of these habitats across the island and in particular the dynamic and productive coastal ecosystem of the north east of the Island. Terrestrial species, representative of the mountainous and forested interior of the island and human-influenced habitats (e.g. commercial forestry or agricultural land) make up the remainder of the rare bird fauna.

Sakhalin Island is located between two seas, the Sea of Okhotsk to the north and east and the Sea of Japan to the south and west. These marine areas possess different characteristics and give rise to a range of conditions around Sakhalin. Due to convergence of the nutrient-rich cold waters of the Sea of Okhotsk and the warmer currents of the Sea of Japan, the southern coastal waters around southern Sakhalin and the Kuril Islands are some of the most productive in the World.

In coastal waters, diatoms are the predominant phytoplankton, while brown algae (*Laminaria* sp. and *Fucus* sp.), red algae (*Ahnfeltia* sp.) and seagrasses (*Zostera* sp. and *Phyllospadix* sp.) are the most abundant and diverse plant groups of the littoral zone, particularly in the south. The fauna of the littoral zone is diverse and largely controlled by a combination of sediment type and climatic (water mass) characteristics. As much of the coastal zone around Sakhalin comprises soft sediments, the invertebrate fauna is largely sediment dwelling and is dominated by annelids, bivalves, echinoderms and crustaceans. The fish fauna is relatively diverse and as a result of the high productivity of the area, populations of some species are also abundant. There are still large populations of several species of Pacific salmon (*Oncorhynchus* sp.) along with other economically important species such as herring (*Clupea* sp.), pollack (*Theragra* sp.), cod (*Gadus* sp.), flatfish (*Pleuronectidae*), saffron cod (*Eleginus gracilis*), capelin (*Mallotus villosus*) and smelt (*Osmerus mordax*). Numerous species of marine mammal inhabit the area and the fauna comprises those which remain in the area all year round (e.g. several species of arctic seal and whales) and others that are migratory and visit the area to feed in the rich waters during the summer months (e.g. western gray whale (*Eschrichtius robustus*) and fin whale (*Balaenoptera physalus*).

The western gray whale (*Eschrictius robustus*), Steller's sea-eagle (*Haliaeetus pelagicus*) and Sakhalin taimen (*Parahucho perryi*) are considered the most notable protected animals that occur on and around Sakhalin Island.

6.3 Terrestrial Ecosystems

6.3.1 Vegetation

Sakhalin Island is biogeographically divided by *Schmidt's line*, which was established by Japanese botanists Miyabe and Tatewaki during the 1930s. The line begins on the western coast at about 51 degrees latitude, extending south-southeast, and reaching the eastern coast at about 49 degrees latitude. Schmidt's line marks the border between distinct changes in vegetation and faunal communities on the island. Specifically, the line is considered to define the border between the circumboreal and the East Asian (northern temperate) floristic regions. This boundary is not demarcated by an abrupt change in flora, but is characterised by the presence or absence of certain plant genera and the general incoming of a deciduous and more warmth-loving flora with distance southwards. The flora to the north of the line comprises genera that occur only in this part of the island. This includes *Acetosa* sp., *Andfrosace* sp., *Arenaria* sp., *Armeria* sp., *Papaver* sp., *Phyllodoce* sp., *Pinguicula* sp., *Sagittaria* sp. and *Trichophorum* sp.

Various classification schemes have been developed to describe the characteristics and distribution of the terrestrial vegetation of the Russian Far East. At a broad level, Sakhalin falls within the Boreal forest (taiga) biome, a suite of ecologically related habitats and species communities, which is best represented by the extensive forest, lake and wetland habitats that encircle the Earth at high northern latitudes (generally above 55^{o}N). Within this biome a number of distinct vegetation types are recognised, reflecting variations in physical conditions, notably climate, soils and topography. Sakhalin effectively lies in the southernmost zone of the Boreal biome, with most of the island falling within the Boreal (Western Okhotian), dark coniferous zone. In this zone, Yezo spruce (*Picea ajanensis*) is the dominant species although it often forms mixed stands with Sakhalin fir (*Abies sachalinensis*).

Above latitude 51.3N, larch (*Larix* sp.) replaces Yezo spruce as the dominant tree species. Other significant components of the flora within this larch forest subzone include Japanese stone pine (*Pinus pumila*) and lichens (*Cladonia* spp.), which are abundant in open woodland on the dry, sandy soils, sometimes covering up to 90% of ground cover. Large tracts of larch forests occur in the Smirnykhovsky, Okhinsky, Nogliksky, northern parts of Poronaysky and Tymovsky Districts. In these districts they are interrupted only by floodplain forests and areas of habitat modified by man. In the northern section of the pipeline route the larch forests are more open with Japanese stone pine forming the ground storey. At the coast, in the north-east, the open larch forests undertake transition to mixed grass and small reed grass meadows with associated coastal species such as *Angelica gmelinii, Ligusticum scoticum* and *Lathyrus pilosus.*

Spruce-fir forests are typical of temperate and moist habitat on slopes as well as on the plateaus of low-hills where they form complex, high-density stands in varying proportions. From the Dolinsk area northwards to latitude 51.3N, *P. ajanensis* is the dominant tree species. East Asian species disappear, and species of Manchurian distribution type reach their northern limits, e.g. *Juglans ailanthifolia, Quercus mongolica* and *Ulmus japonica* north of Dolinsk. Successional broadleaved woodlands occur on river terraces. Along the pipeline route, these types of forests occur irregularly and are mainly developed in Nogliksky District (in the Nysh-Lunsky area and to the west of Nabil Bay), where they occupy an area of about 40 km^2. Where, in this area, clearance of the dark coniferous forest has occurred, openings now often support a shrub layer comprising Ledum or ferns. Another large tract of spruce and fir forest occurs in Makarovsky District in the basin of the Lesnaya River and upper reaches of the Lazovaya River. In other districts spruce and fir forests are fragmented. At the LNG site two areas of spruce and fir forest with the rare Glehn's spruce (*Picea glehnii*) were recorded. This species may form small stands in wetland areas in southern Sakhalin.

In the southern part of Sakhalin, coniferous forests are largely of secondary origin with Sakhalin fir often dominating along with Yezo spruce. Species of eastern Asian sub-oceanic distribution (e.g. bamboo, *Sasa* spp., and Kamchatka bilberry, *Vaccinium praestans*) often form important components of the forest vegetation. In some areas where the original coniferous forest has been cleared, open, meadow-woodlands have developed, particularly on lower mountain slopes and plains in Poronaysky District and mountain slopes in Makarovsky District. These meadow open woodlands are composed of birch and mountain ash, with occasional conifers and large open areas with *Osmundastrum asiaticum, Aruncus dioicus,* and *Calamagrostis langsdorffii*.

In basins between mountains *Larix* spp. dominate with some *Picea ajanensis* and *Abies sachalinensis*. Except in the far north of the island (within the larch forest subzone) birches, (white birch, *Betula platyphylla* and stone birch, *B. ermanii*), poplar (*Populus suaveolens*), chosenia (*Chosenia arbutifolia*), rowan-tree (*Sorbus aucuparia*), elms (*Ulmus laciniata* and *U. japonica*), maples (*Acer mayrii* and *A. ukurunduense*), alder (*Alnus hirsuta*), Japanese yew (*Taxus cuspidata*) and several willow species may also occur amongst the conifers (FESU, 2000a).

In river valleys the basic vegetation comprises larch with a mixture of broadleaved tree species, notably *Populus maximowiczii*, chosenia and *Salix udensis*. The largest areas of such broad-leaved forests are in the Tym River basin. In the south, on the lowest parts of valleys the moist lowlands are occupied by wet meadows with *Carex thunbergii*, *Calamagrostis langsdorffii*, and *Myrica tomentosa* fringed by *Alnus japonica–Fraxinus mandshurica* forests. The understorey of these wooded areas is characterised by species such as skunk cabbage (*Lysichiton camtschatcense*), *Symplocarpus renifolius*, *Trillium camschatcense* and several fern species including *Dryopteris crassirhizoma*. These willow-alder forests occur throughout the length of the pipeline route and occupy quite extensive areas, not just in river valleys, but variants also occur in areas where the original vegetation cover has been disturbed (e.g. lowland areas no longer under agricultural production).

Meadow vegetation is widely distributed within the corridor of the pipeline and is most commonly represented by various combinations of reed-grass (*C. langsdorffii*) and reed-grass and herb meadows. Significant tracts of these meadows appear in Tymovsky District, on river terraces and foothill plains. In Dolinsky and Anivsky Districts these meadows are one of the main vegetation types and occupy extensive areas under agricultural production on the plains of the Susunayskaya Depression. Other meadow types are not so widespread. Meadows with tall herbage occupy significant areas in Dolinsky and Anivsky Districts. Hygrophilous sedge meadows occur rarely along the pipeline route, occupying areas of low marine terraces in the south of Dolinsky and Anivsky Districts. In Korsakovsky District this type of meadow was observed at the LNG / OET site. A particular type of meadow comprising reed-grass with species preferring well-drained soils occurs in small blocks in Makarovsky and Poronaysky Districts on the slopes of low mountains, where the forests have undergone clearance or affected by fires. The combination of meadows with *Leymus mollis* was recorded at the coast at Lunsky (near the OPF) and at the LNG / OET site, where it forms narrow strips approximately 100m wide along the coast (FESU, 2002a).

6.3.1.1 Wetland Vegetation

Large areas of wetland habitat have developed since the last ice age on the alluvial plains and fans that flank the main mountain chains along either side of the Island and in the inter-montane basins (e.g. the Poronai lowlands). These alluvial deposits have formed through the deposition of sediment eroded from more mountainous areas by mass transport and fluvial processes. In the north, these alluvial plains support open larch (*Larix cajanderi*) woodlands interspersed with open treeless areas.

The majority of wetlands on Sakhalin are peatlands (wetland ecosystems which accumulate dead organic matter, where the depth of organic matter is generally greater than 30cm). Conservation of peatland systems have been the subject of recent focus worldwide, largely due to the significant loss of this habitat type due to peat extraction and drainage for agriculture. In Sakhalin, peatland areas have been broadly classified as:

- True peat bogs with peat thickness of 1.5 to 5m or greater, frequently saturated, with vegetation in various states of decomposition;
- Peaty soils, frequently found on floodplains or in incised valleys associated with the many rivers and streams; and
- Alluvial boggy soils, exhibiting various stages of hydromorphism, which are also associated with river and stream flood plains.

It is generally thought that while not unique (apart from the ornithological aspects of the coastal wetlands), the variable wetland areas represent an important component of the overall ecological interest of Sakhalin Island.

From an ecological perspective the peatland and wetland areas can be categorised into oligotrophic, mesotrophic and eutrophic types – fundamentally on account of their hydrology and hydrochemistry. In reality, there is a continuum in the physical and biological parameters and processes across these wetland types and definitive 'type' classification may not be applicable to all of the wetlands present. The situation is also confused by the fact that oligotrophic-eutrophic conditions may be exhibited within an individual wetland area. However, broadly, there is a north to south change in the predominance of wetland type, with a shift from oligotrophic in the north to mesotrophic-eutrophic in the south. This change largely reflects climatic attributes and is mirrored by the overall change in the composition of the dominant vegetation types (from north to south).

The key vegetative characteristics of each of the main wetland types together with information on their distribution along the pipeline route is provided in the following paragraphs (adapted from FESU, 2000a).

Waterlogged larch forests (*Larix gmelinii*) - two variants of this community occur. An 'open' woodland type is present on low weakly drained waterlogged river terraces and is typified by the presence of reedgrass (*Calamagrostis langsdorffii*), sedge (*Carex schmidtii*), cottongrass (*Eriophorum russeolum*), mosses (*Sphagnum girgensohnii, S. squarrosum, S. teres, S. fallax, S. fimbriatum* and *S. capillifolium*) and hygrophilous shrubs (e.g. marsh tea, *Ledum palustre* and cranberry, *Oxycoccus palustris*).

A more 'closed' community type commonly occurs in intermontane lowlands and depressions on poorly drained, wet soils on high river terraces. The forest stand is dominated by larch and the shrub layer is well developed with birch (*Betula middendorffii*), bilberry (*Vaccinium uliginosum*), leatherleaf (*Chamaedaphne calyculata*), spirea (*Spiraea beauverdiana*), western mountain ash (*Sorbus sambucifolia*) and *P. pumila*. The grass and dwarf woody plant layer is also well developed with diagnostic species such as *Calamagrostis langsdorffii*, *Ledum palustre* and cloudberry (*Rubus chamaemorus*). Wetland vegetation of this type is distributed in most districts crossed by the pipeline route, excepting the more mountainous Makarovsky and Korsakovsky districts, although it is more prevalent in central to northern Sakhalin.

Hygrophytic meadows and 'herb' bogs - Communities of this type are commonly found on excessively soggy neutral soils, in floodplains and medium sized depressions on marine terraces. Along the pipeline route this wetland community is encountered only in the northern section in the regions of Okhinsky, Nogliksky and Tymovsky. Typically areas may be groundwater fed, with water levels remaining above the soil surface for the majority of the growing season. This wetland type occurs mainly in northern and central Sakhalin, although occasionally, similar associations occur in the south of the Island. Major species are *Calamagrostis langsdorffii*, the fern (*Osmundastrum asiaticum*) and *Ledum palustre*. Other important grass stand elements are the horsetail (*Equisetum sylvaticum*), sedges (e.g. *Carex schmidtii* and *Carex limosa*), false lily-of-the-valley (*Maianthemum dilatatum*) and bunchberry dogwood (*Chamaepericlymenum canadense*). Rock cranberry (*Vaccinium vitis-idaea*) is also a frequently occurring species as is blueberry.

Oligotrophic peat moss bogs - Oligotrophic peat bogs occur all along the pipeline route, commonly in association with a number of other vegetation communities in complex mosaics of wetland habitats. Oligotrophic conditions often predominate in wetland clearings within larch or spruce forest. In these situations, areas of oligotrophic bog can often be recognised by the sparse and stunted tree growth that they support. Typically, communities of this type occur in floodplains, depressions in marine terraces and on marshy alluvial plains. The water table is invariably at a shallow depth and water levels usually remain above the soil surface for the greater part of the growing season.

In the central part of Sakhalin, sphagnum bogs with dwarf woody plants occur extensively in the lowlands of the Tym-Poronaiskaya basin, with the most extensive peat formation occurring in the southern part of this area, including the Poronai River and its valley. The grass and dwarf woody plant layer is dominated by *Ledum palustre,* sweetgale (*Myrica tomentosa*) and crowberry (*Empetrum sibiricum*). Other prominent species of this vegetation layer include cotton grasses (*Eriophorum gracile* and / or *E. vaginatum*), birch trees (*Betula exilis* and *B. middendorffii*), grass of Parnassus *(Parnassia palusris)*, loose-flowered sedge (*Carex rariflora*), *Rubus chamaemorus*, *Maianthemum dilatatum* and *Chamaepericlymenum canadense*. The mosses (*Sphagnum fuscum*, *S. palustre*, *S. magellanicum*) and the rarer S. *anqustifolium* form the dominant groundcover.

In the southern part of Sakhalin, the vegetation of oligotrophic bogs is often characterised by the presence of the sedge *Carex schmidtii* and reedgrass, which between them may represent up to 60% of the grass layer. Other important elements of the grass layer include the fern (*Osmundastrum asiaticum*), Japanese burnet (*Sanguisorba tenuifolia*), *Maianthemum dilatatum* and *Chamaepericlymenum canadense*.

Mesotrophic-Eutrophic peat bogs - In the south of the Island, particularly in the Yuzhno-Sakhalinsk area, bogs with higher nutrient levels (mesotrophic-eutrophic) commonly occur and are also present, to a lesser extent, in the central part of the Island. In reality there is a continuum between oligotrophic and eutrophic conditions and many bogs exhibit a range of nutrient levels. Changes in nutrient status are usually well reflected by the plant species assemblages that are present within the bogs.

In eutrophic conditions, cotton alder (*Alnus hirsuta*) is a characteristic species and is often associated with white skunk-cabbage (*Lysichiton camtschatcense*), blue flag (*Iris setosa*), kneeling angelica (*Angelica genuflexa*), Kamchatka thistle (*Cirsium kamtschaticum*), meadowsweet (*Filipendula kamschatica*), Aleutian ragwort (*Senecio cannabifolius*), flat-leaved nettle (*Urtica platyphylla*) and a number of species of sedge (e.g. *Carex rostrata* and *C. laevirostris*). Mosses adapted to the more nutrient-rich conditions prevail, including several species of *Sphagnum* (*S. squarrosum, S. fimbriiatum* and *S. girgensohnii*) and a number of other characteristic forest mosses such as *Pleurozium schrebri, Hylocomium proliferum* and *Ptilium crista castrensis*.

Under more mesotrophic conditions, bogs typically support larch (18-21m high) with a shrub layer comprising *Ledum palustre*, *Vaccinium uliginosum*, sedges (*Carex* spp.), horsetail (*Equisetum arvense*), *Menyanthes trifoliata*, *Eriophorum* spp. and *Calamagrostis* spp. Mosses such as *Sphagnum obtusum*, S. *riparium* and *Hypnum* spp. form the groundcover. Bogs of this type are widely distributed, but largely occur in the south and central sections of the Island.

6.3.1.2 Anthropogenic Transformation of Vegetation

The vegetation of Sakhalin Island has been significantly modified through human activity. Originally, the island was characterised by coniferous forests, where Yezo spruce, Sakhalin fir and Cajander's larch were the dominant species, with Japanese dwarf pine (*Pinus pumila*) and the Kurile bamboo (*Sasa kurilensis*) occuring on the upper parts of the mountains. During the period between the world wars, the southern region was clear-cut, leaving only small areas of old-growth fir forests growing on the Susunaiskiy Ridge between Dolinsk and Yuzhno-Sakhalinsk, with fragments remaining on the Krilon Peninsula in the south west. Similarly, much of the northern half of the island has been clear-felled by the Russian timber industry. Although replanting has taken place across much of the island, this has not kept pace with the rate of forest loss and in many areas establishment of new forest has been limited. Some of the former forest areas have been replaced by herb and grass meadows where constant fires and / or pasturing prevent forests from regenerating. In the absence of fires and anthropogenic influence these meadows are comparatively quickly (20–30 years) replaced by forest vegetation (FESU, 2000a & 2002).

Plantations of pine, larch and spruce occur in the central and southern part of the island, from

Makarovsky District southwards. There are significant areas of pine plantation in the Lazovaya and Vostochnaya river basins and a large area to the north of Dolinsky Districts between the settlements of Tikhoye and Vzmorye. Further to the south pine plantations occur in small fragments almost everywhere. The largest larch and spruce plantations are close to the Pugachevo mud volcano. In Korsakovsky District (from Mitsulevka to Solovievka) larch and spruce plantations stretch almost continuously for 12 km. Many of the pine, larch and spruce plantations are overstocked with a limited ground flora and as a consequence are relatively species poor. Major tracts of larch plantations occur in Korsakovsky District.

Fires are considered to be an important and natural part of the vegetation succession in the northern spruce forests. In areas affected by fire, the dominant spruce-fir vegetation is replaced by secondary larch forest, with the eventual replacement of larch by spruce after 100-300 years. In recent decades, large-scale fires in northern and central Sakhalin have led to the damage of several hundred thousand hectares of forest habitat. There are large areas of burnt larch forest with Japanese stone pine in the southern part of Okhinsky and northern part of Nogliksky Districts. These areas demonstrate very poor re-establishment of vegetation following the fires, the majority of which have been attributed to human activities. Many of the areas burnt during 1998 had been previously affected by fire, making the re-establishment of forest vegetation extremely difficult.

Agricultural land within the pipeline corridor occurs largely in the central and southern sections of Sakhalin Island in the Tymovsky, Smirnykhovsky, Poronaysky, Makarovsky and Anivsky Districts. The largest continuous section (approximately 9km long) of land under agricultural production occurs to the southwest of Yuzhno-Sakhalinsk. Pasture and hay meadows predominate, and occupy approximately 70% of the total agricultural resource. Land under arable production is largely limited to the south of the island, where potatoes and other vegetables (carrots and beet) are grown. The decline in agriculture over the past 15 years has resulted in a large part of former agricultural lands becoming overgrown and unused.

6.3.2 Flora

According to “USSR Flora” (1934-64) and “Vascular plants of the Soviet Far East” (1985-1996) the Sakhalin territory is divided into two floristic areas *viz*. North-Sakhalin and South-Sakhalin. The northern flora belongs to the Okhotsk-Kamchatka province of the Boreal floral region, and the southern to the Sakhalin-Hokkaido province of the East-Asian floral region. The Sakhalin II pipeline route crosses the border between these two areas in the region of the Palevsky Hills, between the Tym and the Poronai Rivers. Although the island straddles these two floral regions, the flora of Sakhalin is less rich than the neighbouring Japanese island of Hokkaido or the mainland Russian territories of Khabarovsk or Primorye, and comprises approximately 1400 species, of which about 1200 are indigenous.

The overwhelming majority (approximately 95%) of species are angiosperms (flowering plants) with vascular cryptogamic plants (ferns and horsetails) and gymnosperms (conifers and cycads) making up the remaining 5%. This general breakdown is comparable to that observed in other Russian Far East floras and the Holarctic temperate flora as a whole (Yurtsev, 1968). On Sakhalin, the monocotyledons (grasses, orchids, lilies and sedges) make up approximately 20% of the angiosperm flora and are represented by a comparatively small number of families and genera.

In general, the Holarctic flora comprises only a few plant families and just 10-15 families dominate the bulk of the flora. This situation is observed on Sakhalin, where the *Asteraceae* are the predominant family (12% of the flora), as it is in the Holarctic. The leading role of *Poaceae* (10%) and *Cyperaceae* (8%) is characteristic of floras in the Boreal region (Yurtsev, 1968; Tolmachev, 1974) and the northern part of the East Asian region (Tolmachev, 1986). Generally these three families contain almost one third of the species encountered during surveys undertaken along the pipeline route. Species belonging to the *Ranunculaceae*, *Rosaceae* and *Ericaceae* are also relatively well represented on the island and again mirror the situation that occurs on the mainland. In terms of genera, the sedges (*Carex*) form the largest group and although this genus prevails in wetland habitats, species are represented in all types of vegetation. Other genera that are well represented include *Artemisia*, *Salix* and *Calamagrostis*, again all genera that are characteristic of the boreal flora.

Herbaceous perennial plants prevail (70%) in the flora and are the main components of bog and meadow habitats and the lower storeys of forest vegetation, while herbaceous annual and biennnial plants make up about 13% of the flora. This latter group occurs mainly in non-forest habitats such as meadows, bogs, pastures and plantations and many are alien (introduced) species. Woody plants include a number of shrub species (7% of the flora) and 34 species of trees, which play the leading role in forming vegetative cover. Four genera effectively provide the general vegetative character of the island, namely *Larix* and *Abies*, each represented by one native species, *Picea* by two and *Betula* by three. Dwarf, perennial shrubs numbering 56 species (6.5 % of the flora) are noticeable in spruce-fir forests and sphagnum bogs (especially species of *Ericaceae*). In the southern part of the island, six species of woody liana occur, imparting an East-Asian feel to the forests where they grow.

From an ecological perspective, species characteristic of damp conditions (i.e. typical of forests and damp meadows) predominate, followed by species that favour semi-permanent to permanently wet habitats. Species characteristic of dry conditions, such as dry meadows or light-open larch forests on well-drained soils are relatively poorly represented (approximately 13% of the flora) and reflect the limited extent of these conditions across the island. The major part of the Sakhalin flora comprises species that are widely distributed in one vegetation type. These are mostly perennial herbaceous plants typical of damp conditions in forest habitats. Such species occur both in native spruce-fir, larch forests and in secondary deciduous forests, which developed in their place as a result of felling and fires. A considerable part of the meadow vegetation consists of species that also occur in forest, largely as a result of the replacement of forested areas by meadows following tree felling.

Rare species tend to occur in habitat types that are uncommon on the island or are representative of some groups of plants (e.g. orchids) for which the prevailing climatic and physical conditions are generally not conducive. Several tree and shrub species (e.g. *Aralia elata*, *Acer mayrii*, *Padus ssiorii*, *Skimmia repens*) that also rarely occur are present at the northern edge of their range. The rarest species are the Sakhalin endemics and are confined to very specific habitat conditions, notably mountainous areas and the Pugachevo mud volcano which supports a number of species including the primrose (*Primula sachalinensis*) and the grass *Deschampsia tzvelevii*. The endemism of the Sakhalin flora is not high, reflecting the fact that it has only been separated from the mainland for several thousand years. There is one endemic genus, with one species, *Miyakea integrifolia*, a species of pasque flower. Some botanists consider that it does not warrant its own genus and should belong in the genus *Pulsatilla*, along with other pasque flowers.

A significant number of species (approximately 100) are associated with human activity and anthropogenically altered habitats, and are typically considered as weeds and may be invasive in the native habitats of the island. The most obvious of these species are the commercial plantations of Scot's pine (*Pinus sylvestris*), which is widespread across the island, Jack pine (*Pinus banksiana*), present in the south, Japanese larch (*Larix leptolepis*) and Siberian spruce (*Picea obovata*) in the Makarovsky District. Though these species have self-seeded it is unlikely that they possess the adaptive capabilities to spread significantly of their own accord. Other planted species include Siberian crabapple (*Malus baccata*), Siberian peashrub (*Caragana arborescens*) and ninebark (*Physocarpus opulifolia*), which have been used in creating protective strips along the railroad. However, their poor condition suggests that they are unlikely to be capable of naturalisation. The meadow grasses *Dactylis glomerata* and *Festuca pratensis* brought to Sakhalin by Russian and Japanese farmers grow well on artificial meadows and also have spread into forest edges and light forests. Such species, and others like burdock (*Arctium lappa*) move into forests via tracks and clearings, although they tend not to infiltrate into forest blocks and as a consequence do not considerably alter the composition of the local vegetation. Some species of non-native plants, such as dandelion (*Taraxacum officinale*), yellow rattle (*Rhinanthus aestivalis*), perennial sow thistle (*Sonchus arvensis*), common sowthistle (*S. oleraceus*), creeping bentgrass (*Agrostis stolonifera*), colonial bentgrass (*A. tenuis*) and others now form integral parts of the flora of Sakhalin fields and meadows. However, even if seemingly confined to anthropogenic habitats, both widespread and rare weeds that possess a high reproductive ability can quickly occupy considerable areas. An example is coltsfoot (*Tussilago farfara*), which was introduced into Sakhalin in the 1970s and then quickly spread through Yuzhno-Sakhalinsk and out into surrounding areas. It now occurs in practically every forest type, in meadows and pastures over Sakhalin and in many artificial fir, spruce and larch plantations. Its rapid and widespread dissemination resulted from a function of its ability for prolific reproduction and the widespread availability of forest habitat disturbed through felling and fires. In some forest areas in the south, it covers parts of the forest floor at the expense of the native ground flora.

6.3.3 Terrestrial Invertebrates

While Sakhalin's invertebrate fauna includes more than ten thousand species (it is estimated that 8,000 are insect species), the diversity is lower than on the Russian mainland. For example, the number of leaf beetles (*Chrysomelidae*) on Sakhalin is more than three times less than in Primorye (96 and 306 species respectively). Other groups of insects demonstrate a similar relationship.

Baseline studies of the invertebrate population along the pipeline corridor recorded 702 species; 692 of these were insects (FESU, 2000b). Beetles were found to be the most numerous group encountered during sampling of a variety of habitats, but were particularly common in open areas such as agricultural plots, forest clearcuts, clearings, and under forest canopies. Two groundbeetle species registered in the Red Data Books of Russia and Sakhalin were collected outside of the pipeline corridor; *Carabus lopatini* and *C. avinovi* were recorded from the southern part of the route in the 4th and 5th segments of the Makarovsky and Dolinsky districts. One Sakhalin Red Book butterfly, *Papilio bianor*, was also noted in the southern part of the island.

6.3.4 Amphibians and Reptiles

In total, five species of amphibian are known to inhabit Sakhalin Island (in comparison to seven on the Russian mainland) and two species of reptile (22 species on the mainland). None of the reptile or amphibian species found on the island are classified as endangered or threatened.

The Siberian salamander (*Hynobius keyserlingi*) is distributed throughout the island where it generally occupies the river valleys and lowland wetlands. Survey data from along the onshore pipeline route shows that it reaches its highest population levels in riparian-floodplain habitats in Smirnykhovsky and Poronaisky regions (131 animals per hectare) and meadow-swamp habitats mainly along the margins of peat bogs in the Okhinsky region (113 animals per hectare). In similar habitats elsewhere on the island population levels are lower and recorded at 7-25 individuals per hectare. It does not appear to be present in coastal habitats or dark coniferous and larch forest (FESU, 2000b).

The common or gray toad (*Bufo bufo*) occurs throughout Sakhalin Island although during surveys along the pipeline route it was not recorded in northern Okhinsky and Nogliksky regions. The main habitats for this species appear to be the riparian floodplain habitats of the central and southern part of the island where it was recorded as reaching population densities of three to six animals per hectare. Unlike the Siberian salamander, the common toad occurs in the dark coniferous forests of the central and southern parts of the island and in the larch forests of Tymovsky and Dolinsky regions.

Both species of frog, the Asiatic grass frog (*Rana amurensis*) and the Siberian wood frog (*R. semiplicata*) are widely distributed in Sakhalin. *R.amurensis* is common and even numerous in the riparian-floodplain and meadow-swamp habitats of the northern and central parts of the island. It is rather common in the larch woodland of the Nogliksky Raion (ten individuals per hectare) but does not occur in dark coniferous forest of in the south of the island. *R. semiplicata* occurs commonly in the southern part of the North Sakhalin Plain, particularly in the riparian-floodplain and meadow-swamp habitats of the Nogliksky Raion (16 animals per hectare) and, especially, in the Tymovsky Raion (up to 36 individuals per hectare). It is even more numerous in the south, where in riparian-floodplain habitats it was recorded during surveys at a density of 44 animals per hectare. This species is uniformly distributed in larch woods throughout the island at a population density of three to five individuals per hectare.

Of the two reptile species, the viviparous lizard (*Lacerta vivipara*) is more widespread and occurs in greater numbers than the common adder (*Vipera berus*). Typically, the viviparous lizard reaches high population levels in open patches (e.g. forest clearings and areas affected by forest fires) of a range of habitat types, such as floodplain meadows, sparse pine plantations and open larch woodland with *Ledum*. In riparian-floodplain habitats, survey data indicates that numbers increase from north to south, reaching highest values in Dolinsky (61 individuals per hectare), Anivsky and Korsakovsky Raions (72 individuals per hectare). This lizard is also common in meadow-swamp habitats throughout the island. In forested habitats it occurs in reasonable numbers in the larch forests of Noglisky Raion (11 individuals per hectare), but is absent from dark coniferous forests. Although the common adder is relatively widespread on the island it does not occur in the far north or reach the population levels observed for the viviparous lizard. It appears to be locally common in the far south of the island, where it inhabits riparian-floodplain habitats and open areas / edges of sparse pine and larch plantations, but rarely occurs in similar habitats in Poronaisky and Makarovsky Raions (FESU, 2000b).

It is apparent that for both species of reptile, climatic factors play a limiting role in distribution and population abundance. In the north, where conditions are harsher, populations are more localised and occur in open patches of habitat (e.g. forest cuts, margins of recent burns) where higher daytime temperatures are likely to occur. Further south, where temperatures are higher, populations are not so restricted to local habitat patches and may occur more widely throughout habitat complexes.

6.3.5 Terrestrial Birds

The wide variety of terrestrial habitats (including wetland and coastal habitats) present on Sakhalin Island, support a range of distinct bird assemblages. Studies undertaken for Sakhalin II along with previous research and field studies have enabled the main bird assemblages that characterise many of these habitats (i.e. those ones potentially influenced by project activities) to be identified. In combination with vegetation data, relatively detailed characterisation of habitats and their associated bird assemblages have been developed.

Much of the survey and monitoring work undertaken for Sakhalin II has, in line with regulatory requirements, focused on the potential impact of the project on rare and protected species (i.e. those species listed in the Russian RDB). The list of birds included in the *Red Data Book of Sakhalin Oblast* and which are present, or recorded from, Sakhalin Island (i.e. excluding the Kuril Islands) consists of 90 species. Out of these, 19 species are included in the *Red Data Book - Threatened Birds of Asia*, and 42 species are included in the *Red Data Book of the Russian Federation*. A significant number of these species are also listed in the Japan-Russia Migratory Bird Treaty (1973).

By the very nature of their rarity, the majority of the RDB listed species are characterised by small populations and an uneven distribution, linked to either very specific habitat requirements, or other influencing factors such as human disturbance. Because of this, and issues associated with survey feasibility and access to often remote and difficult working areas, definitive information on the status of many species is lacking and knowledge of many populations on Sakhalin is limited. However, for some species, this is not the case and there is significant data available for highly visible (from a conservation perspective) species such as white-tailed sea eagle (*Haliaeetus albicilla*) and Steller's sea eagle, which have been well studied. Other species that have a distribution closer to the main areas of human population in the south of the Island have also been more intensively studied, for example, Japanese robin (*Erithacus akahige*) and Latham's (Japanese) snipe (*Gallinago hardwickii*). In total, the surveys so far undertaken for Sakhalin Energy have recorded the presence of at least 43 species of birds listed in the Sakhalin Oblast RDB within the area covered by project activities.

The major part (about 70%) of Sakhalin's rare bird fauna is represented by wetland (lake-swamp and littoral-marine) species reflecting the extensive presence of these habitats across the island and in particular the dynamic and productive coastal ecosystem of the north-east of the Island. Terrestrial species, representative of the mountainous and forested interior of the Island and human-influenced habitats (e.g. commercial forestry or agricultural land) make up the remaining 30% of the rare bird fauna.

The geographical position of Sakhalin Island indicates its potential as a migratory bridge for birds travelling between Japan and the Far East mainland. Some bird populations that utilise habitats in northern Russia and Kamchatka during the spring-summer for breeding undoubtedly migrate to wintering areas through the Komandorskiye Islands and Kuril Islands and do not fly through Sakhalin. Whether Sakhalin is a bridge for other Palearctic birds originating from Khabarovsk Krai and the Russian North (e.g. many species of passerines) or whether the migratory population is largely comprised of local birds is not fully known. Certainly it is apparent that some species make use of Sakhalin as a staging ground during both spring and autumn migrations. Notable examples include Bewick's swan (*Cygnus columbianus bewickii*) and whooper swan (*Cygnus cygnus*), which congregate in large numbers in the north-east and the extreme south of the Island prior to moving to wintering grounds in Japan or breeding grounds in northern Russia. The importance of the Island in this respect is reflected by the fact that a significant number of birds recorded from Sakhalin are included in the international convention on migrating birds signed between Russia and Japan.

A bird-ringing project in Primorskiy Krai, jointly undertaken by the Amur-Ussuri Centre of Bird Biodiversity (Vladivostok) and the Department of Environment Protection of Toyama (Japan) prefecture has ringed about 30,000 birds since 1998. However, to date not a single record of a bird ringed from this area has been received from Japan or south-east Asia (FIRC, 2000a). This suggests that the migratory traffic between Japan and the Russian mainland (apart from a few exceptional species such as Japanese crane and hooded crane) is not as significant as assumed or that the so-called marine route of bird migration from the mainland over the Sea of Japan is not the most important for Far East Russian birds. This evidence again highlights the possibility that Sakhalin is an important migratory route for a number of bird species. Particular focus has centred on the presence of small flocks of chestnut bunting (*Emberiza rutila*) recorded during ringing / migration studies. This is a mainland Russia species that does not breed on Sakhalin and its presence on the Island may support the idea of the migration of northern mainland passerine birds through Sakhalin and then onto Japan and south-east Asia.

Bird ringing has also been undertaken on Sakhalin as part of the Amur-Ussuri study and data from this provides some evidence for a direct migration route between the Island and Japan. Between 1998 and 2004, 13 birds (buntings and snipe) ringed on Sakhalin were caught in Japan and two birds ringed in Japan were caught on Sakhalin (bird ringing and migration studies are far more widespread and intensive on Japan than on Sakhalin). This data clearly indicates that there is a migratory route between Sakhalin and Japan and that this route is used by a wide range of birds, from passerines through to waders and birds of prey. The migration of waders has been studied in Sakhalin in more detail than for any other group of birds and three main spring migration directions have been identified. The first one is a northern route running from Hokkaido Island to Tonino-Anivskiy Peninsula and Aniva Bay. Some of these birds then fly further north along the eastern coast. The second route is along the mainland Russian coast up to Lazarev cape and from there over to Nevelsky on Sakhalin, with further progress to the north or even to the south along the western and eastern coasts. The third direction is an eastern route going along the valley of the Amur River up to its delta with further movement over the Amur Strait to Sakhalin Island and along the west coast to Viakhtu Bay or along the eastern coast up to Lunsky Bay (Nechaev, 1991). In autumn these directions reverse. It is likely that many passerine birds also follow the same routes.

6.3.5.1 Description of Main Habitat and Associated Bird Assemblages

Water bodies (rivers and lakes) - The bird assemblage of rivers, lakes and ponds is relatively small, but characteristic wherever present across the Island. Species such as common sandpiper (*Actitus hypoleucos*), kingfisher (*Alcedo atthis*) and grey wagtail (*Motacilla cinerea*) are usually dominant in riverine habitats and are evenly distributed across Sakhalin. In Tymovsky Raion, low numbers of brown dipper (*Cinclus pallasi*) occur on rivers. Characteristic duck species found on rivers are mandarin duck (*Aix galericulata*), goldeneye (*Bucephala clangula*) and goosander (*Mergus serrator*). Mandarin duck breed in the forested valleys of small mountain rivers, typically like those crossed by the pipeline route. Goldeneye often occur at river mouths, primarily in the north of the Island, while goosander occur in the middle reaches of the larger rivers such as the Pilenga and Tym.

There are only a few large lakes close (within 5km) to project activities, the main one being Lake Lebyazhie, which is located in the central part of the island to the north-east of Poronaisk. This water body is a nesting ground for many aquatic and wetland species and an important stopover for migrating sandpipers, ducks and other waterbirds en-route to or from the north of the Island, or the Russian arctic. Species that are regularly recorded here include osprey (*Pandion halieatus*), white-tailed fish eagle (*Haliaeetus albicilla*), Aleutian tern (*Sterna camtschatica*) and whooper swan. Long-billed murrelet (*Brachyramphus perdix*) is also known to use Lebyazhie Lake.

Meadows and arable agricultural land - The bird fauna of this habitat grouping consists of elements of both meadow communities and woodlands in which hay meadows have been created. In arable areas, the typical meadow assemblage largely disappears and is only present around the margins of land under arable production. Other than a number of resident species, this habitat type typically provides foraging grounds for species such as jungle crow (*Corvus macrorhynchos*) and carrion crow (*Corvus corrone*) as well as rufous turtle dove (*Streptopelia orientalis*). These species do not nest here owing to a lack of suitable trees. Although data is generally scarce, the meadow habitat of these largely lowland areas is likely to support populations of the RDB Japanese quail (*Coturnix japonica*), which has been recorded on several occasions during survey work.

Tall grass / herb meadows - Tall grass / herb communities are typical of Sakhalin's southern and central regions. This habitat type does not occupy large tracts of land, but because of its diverse structure and composition tends to provide suitable conditions for a wide range of foraging and nesting bird species. Often this habitat type is found in close proximity to rivers and streams and is invariably surrounded by forest / woodland. As a consequence, the bird assemblage comprises a large number of species that typify more open forest and valley woodland habitat, for example brown thrush (*Orpheus rufus*), with woodpeckers, narcissus flycatcher (*Ficedula narcissina*), black-faced bunting (*Emberiza spodocephala*) and rufous turtledove being commonly present. Small coppices of trees within the meadows often provide suitable nesting habitat for woodpeckers, turtle-doves and grey-capped greenfinches (*Chloris sinica*). Meadows adjoining areas of forest are often included in the nesting or feeding grounds of forest birds that permanently forage in these areas, for example species of tits, siskins

(*Spinus spinus*), bullfinches and Pallas's willow warblers (*Phylloscopus proregulus*). Japanese snipe (*Gallinago hardwickii*), may often nest on the periphery of tall grass meadows and hay meadows. Although structurally similar, tall reedgrass growth in forests / woodland of the Okhinsky and Nogliksky regions supports an impoverished bird fauna in comparison, although several of the species inhabiting tall grassland further to the south are present.

Wet sedge meadows and bogs - The peatlands characteristic of northern Sakhalin and many of the river plains cover a considerable area (approximately 25,000km² in Okhinsky Raion alone), but support a relatively impoverished breeding bird fauna in comparison to other habitats, with only five to seven species being definitively linked to this habitat type. Species such as lanceolated grasshopper warbler (*Locustella lanceolata*), Middendorff's grasshopper warbler (*Locustella ochotensis*), green-headed wagtail (*Motacilla taivana*) and yellow-breasted bunting (*Emberiza aureola*) dominate the assemblage. These typical wetland species are complemented by other species found in adjacent and transitional habitats (open water, shrub, grassland and forest), giving rise to an overall assemblage with about 10 to 15 representative species (FESU, 2002b). Areas of open water and stands of reed / emergent vegetation within the peatlands may also provide habitat for a range of other characteristic species such as ducks, waders, grebes etc. Of particular note is the potential for this habitat to support rare species such as Japanese snipe and Schrenk's little bittern (*Ixobrichus eurhythmus*).

Larch / Ledum marshland - The waterlogged larch-ledum complex is one of the most widely represented habitat types along the pipeline route, particularly in the north of the Island, and supports a characteristic bird assemblage, often comprising an intermixture of species from several associated habitats. The presence of larch means that representative species from larch forests are often encountered in these marshy areas, notably nuthatch (*Sitta europea*), Siberian bluechat (*Tarsiger cyanurus*), Pallas's willow warbler, coal tit (*Parus ater*) and Mugimaki flycatcher (*Ficedula mugimaki*). These species primarily inhabit the periphery of the marshland areas where this habitat merges into larch forest or the tree density increases. Other species typical of open ground usually occur within the main marsh areas and include yellow-breasted bunting, brown shrike (*Lanius cristatus*), stonechat (*Saxicola torquata*), dusky willow warbler (*Phylloscopus fuscatus*) and lanceolate grasshopper warbler. Of particular interest is the potential for this habitat type to support breeding long-billed murrelet in the Nogliksky and Dolinsky (in the vicinity of Lake Lebyazhie) Raions.

On the north-east coast, both wet sedge marsh / bogs and larch / ledum forest habitat types may also support a number of other breeding species that are characteristic 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 spotted greenshank (*Tringa guttifer*), which inhabits sparse waterlogged larch forest close to the lagoons. Areas of open water in the north-east coastal wetland complex also provide habitat for several species of duck, for example teal (*Anas acuta*), mallard (*Anas platyrhynchos*)), grebes and divers. The coastal wetlands of the north-east coast are particularly important during the spring and autumn when large numbers of waterbirds (ducks, swans and waders) congregate here en route to breeding or wintering grounds. A significant number of RDB species are recorded from this habitat during migration, for example, several species of sandpiper, whooper and Bewick's swan, swan goose (*Cygnopsis cygnoides*), Baikal teal (*Anas formosa*) and spot-billed duck (*Anas poecilorhyncha*).

Lagoon / wetland ecosystem of the north-east - The wetland complex of coastal lagoons and associated wet larch / Ledum forest and bogs of the coastal plain support a diverse bird assemblage including the highest diversity of RDB species for any one particular ecosystem. Breeding birds of particular note include Steller's sea-eagle, white-tailed sea-eagle, spotted greenshank, the Sakhalin subspecies of dunlin, Aleutian tern, swan goose, ruff (*Philomachus pugnax*) and long-toed stint (*Calidris subminuta*). The area also supports large populations of waterbirds on migration (both spring and summer) including Bewick's swan, whooper swan, spoon-billed sandpiper (*Eurynorhynchus pygmeus*), Baikal teal, sharp-tailed sandpiper and red-necked phalarope (*Phalaropus lobatus*).

Alder-willow floodplain forests - The bulk of the bird assemblage associated with this habitat comprises species typical of woodland-shrub complexes, including Radde's (*Phylloscopus schwarzi*) and dusky willow warblers, Siberian rubythroat (*Luscinia calliope*), lanceolate grasshopper warbler and others. Also present are species typical of coniferous and mixed forests such as Siberian bluechat, goldcrest (*Regulus regulus*), Oriental bullfinch (*Pyrrhula griseiventris*) and coal tit. Tits are generally common in this habitat type and from the beginning to the end of summer they begin moving along river valleys in large multi-species flocks. Large areas of the river valleys in North Sakhalin are covered with coniferous and mixed forests, the presence of which also lead to the introduction of additional species into the bird assemblage of adjoining alder-willow forests.

Poplar-willow forest - The characteristic assemblage of broadleaved river valley poplar-willow forests is represented by 27 to 29 bird species, with about another 17 to 18 species also being regularly recorded. As in alder-willow forests, many of the secondary group of species comprises representatives of tree-shrub growth habitat on the edges of the valley forests. Small areas of remaining forest comprising Manchurian ash, wych-elm and other broad-leaved tree species are of particular importance as they play an important role for a number of rare and protected species, notably all rare breeding owls, osprey, white-tailed sea eagle, Japanese sparrow hawk (*Accipiter gularis*), mandarin duck as well as commercially valuable birds such as hazel grouse (*Tetrastes bonasia*), woodcock (*Scolopax rusticola*) and tree-nesting ducks. The majority of the tree-nesting species require old, tall and large-diameter tree trunks with hollows for nesting. Therefore, the removal of these trees could potentially have an adverse consequence on these breeding populations. It should also be noted that valley forests (both poplar and alder) also support high numbers of birds on passage during seasonal migration.

Japanese stone pine with larch and lichens - In relation to the area influenced by Sakhalin II, this habitat type is present only in Okhinsky and Nogliksky Raions. A number of birds are specifically associated with Japanese stone pine, in terms of distribution and ecology, notably redpoll (*Acanthis flammea*), Pallas's rosefinch (*Carpodacus roseus*), pine grosbeak (*Pinicola enucleator*), dusky willow warbler and nutcracker (*Nucifraga caryocatactes*). In areas where larch is present the assemblage includes elements typical of this forest habitat such as willow ptarmigan (*Lagopus lagopus*), three-toed woodpecker (*Picoides tridactylus*), great grey shrike (*Lanius excubitor*), Pallas's rosefinch and the RDB hawk owl (*Surnia ulula*). On the coast, Japanese stone pine with a lichen understorey may dominate completely and is often found growing on shingle / sand ridges. Such habitat is important for breeding Aleutian tern, particularly in the Lunsky Bay area.

Japanese stone pine growths are frequently affected by fires, tree felling and other human activities. These changes in the habitat can lead to fluctuations in the associated bird fauna, particularly with respect to the populations of some species such as great grey shrike and willow ptarmigan, which take advantage of the differing habitat conditions brought about through vegetation clearance and the subsequent successional processes.

Larch / Ledum forests – Larch / ledum forest is one of main habitat types present in the interior of the Island and supports one of the richest and most diverse bird faunas. Up to 75 bird species were observed in larch / ledum forests, with their number varying from 51 in Dolinsky and Makarovsky Raions to 69 in Nogliksky Raion (FIRC, 2000b). This diversity can be explained by the high degree of transformation and significant level of fragmentation of this habitat. As a consequence, birds from a variety of other adjoining habitat types are also present in, and make use of, these larch forests. Typically the bird assemblage therefore comprises a significant number of species that are temporary inhabitants of this habitat type. The larch / ledum forests of Sakhalin's southern, central and northern raions have differing importance as bird habitats. Mature northern larch forests, particularly in Nogliksky Raion, are typical habitats of a number of rare, protected or species with small populations, for example, Siberian spruce grouse (*Falcipennis falcipennis*), black billed capercaillie (*Tetrao uragalloides*), Tengmalm's (*Aegolius funereus*), pygmy (*Glaucidium passerinum*) and northern hawk owls, as well as white-throated needletailed swift (*Hirundapus caudacutus*). There is also very strong evidence to suggest that long-billed murrelet is breeding in this habitat in the north of the island.

The bird assemblage of dark coniferous forests (spruce / fir and larch) is also compositionally similar to that of larch / ledum forests, largely due to its fragmented nature and mosaic relationship with other habitat types.

Forest habitats affected by fires - In the north of the Island, significant areas of larch / ledum and Japanese stone pine habitat have been modified by forest fires. These sites now support bird assemblages which combine elements of the original habitat type and species that are typical of disturbed and more ephemeral vegetation of a particular successional stage (e.g. willowherb or reedgrass). These latter species include olive-backed pipit (*Anthus hodgsoni*) and Siberian rubythroat, both species of scrub vegetation across the island. Other species include Radde's and dusky willow warblers, brown shrike (*Lanius cristatus*), lanceolate grasshopper warbler, black-faced bunting, black-browed reed warbler (*Acrocephalus bistrigiceps*) and stonechat (*Saxicola torquata*). Also commonly present is the common cuckoo (*Cuculus canorus*), which is a nest parasite of the Siberian rubythroat and black-browed reed warbler, and the Himalayan cuckoo (*C. saturatus*), which is a nest parasite of dusky willow warbler and black-faced bunting. Dead trees within the burnt areas provide feeding habitat for several species of woodpecker, notably black woodpecker (*Dryocopus martius*) and great spotted woodpecker (*Dendrocopos major*).

Dry herb meadows - This habitat occurs in the south of the Island (Korsakovsky to Poronaisky Raions). The assemblage includes birds associated with grassy-shrubby vegetation of open spaces and which are present practically all over Sakhalin, for example Radde's and dusky willow warblers, grey-capped greenfinch, Siberian rubythroat, black-browed reed warbler, long-tailed rosefinch (*Uragus sibiricus*), black-faced bunting, etc. Other, temporary species of the assemblage comprise foraging species from adjacent forest / woodland habitats.

Pine and larch plantations - Coniferous plantations have a scattered distribution across the Island and, as a rule, typically occupy relatively small areas. The specific diversity and nesting density (both total and by species) in plantations is determined by four basic parameters *viz*. age, planting density, size and diversity and nature of surrounding habitats. Mature very low-density growth pine plantations with an admixture of other coniferous trees and shrub understorey are characterized by a higher diversity of species, largely due to the penetration and use of atypical species, for example, Radde's willow warbler, olive-backed pipit and Siberian rubythroat. The main core of the assemblage (i.e. found throughout the range of the habitat) comprises species typical of dark coniferous forest such as Himalayan cuckoo, Oriental bullfinch and Pallas's willow warbler. These plantations may be of importance as foraging habitat for post-nesting and migrating flocks of passerines (e.g. tits, warblers and flycatchers).

6.3.5.2 Steller's Sea-Eagle

Steller's sea-eagle (*Haliaeetus pelagicus*) is the largest of eight species of sea and fish eagles in the genus *Haliaeetus*. In terms of overall distribution, it occurs only in eastern Asia, breeding in eastern Russia and wintering mainly there and northern Japan. Small numbers of *H. pelagicus* have been recorded in winter in North Korea, South Korea and north-east China (Birdlife International, 2001).

The entire population of this species nests near to the coast of eastern Russia mainly on the

Kamchatka peninsula (Koryakia and Kamchatka) and in Magadan and Khabarovsk (on the coast and islands of the Sea of Okhotsk and Bering Sea coasts as well as large inland lakes along the lower Amur south into the Gorin River). Smaller numbers nest in Chukotka and on the north of Sakhalin Island, the Shantar Islands and at least some of the Kuril Islands. Estimates of the total global population of Steller's sea-eagle vary, but the most recent data suggests that there are in the region of 1,800-1,900 breeding pairs and that the total population is probably 4,600-5,100 individuals (Birldife International, 2001).

Its breeding range is mainly around the coasts of the Sea of Okhotsk but some breed in the lower Amur River drainage. The wintering range is, to some extent, congruent with the breeding range. Many individuals are resident within the breeding range and move only to areas adjacent to open water in winter (coastal areas, as noted above, are adjacent to open water). Others gradually move south in autumn and by winter appear outside the breeding range. The timing, duration and extent of migration depend on ice conditions and the availability of food. Each winter, drifting ice on the Sea of Okhotsk drives thousands of sea eagles south. On the Kamchatka peninsula most birds are resident throughout the year. On north Sakhalin, the Shantar Islands and Amur, on the other hand, the species is a temporary visitor and moves from summer breeding sites to wintering areas on Hokkaido, southern Primorye and Ussuri River valley, arriving in late October-early November.

Throughout the breeding range, nests are usually built in trees and occasionally on cliffs. Nests are often used for several years in succession, but alternate nests are often built, usually within one kilometre of the previous nest. The start of the breeding season depends on the conditions at the end of winter, but is typically late February / early March. Hatching occurs between mid-May and mid-June, and the young fledge in August or early September. Average breeding success is around 0.5 young per pair *per annum*. The breeding range is shared with the closely related white-tailed sea eagle *H. albicilla.* Nesting Steller's sea-eagles are most common in the coastal zone, where rocky shorelines, wooded river valleys, bays and inlets are preferred. In the interior, nesting occurs less frequently in river valleys and on lakes.

The diet of Steller's sea-eagles consists principally of salmon taken alive or scavenged. The species' distribution and seasonal appearances are dictated largely by the availability of the salmon supply. The remainder of the diet is highly variable and important only when the principal food supply is scarce.

Since 2004, Sakhalin Energy has funded and managed a Sea Eagle Research Programme (SERP). This programme is itself based on a significant amount of field research undertaken since 1998 by Dr Masterov and his team from Moscow State University. Following surveys in the 1990s, Masterov (1998) estimated that there were 110 nesting pairs and 160 non-breeding birds on Sakhalin Island. This estimate was then refined following survey work undertaken around the coastal lagoons in the north-east of the island, the core breeding area for this species on Sakhalin. Masterov *et al.* (2000), using a predictive model to determine the spatial distribution of suitable nesting habitat, calculated that there were 434 potential nesting territories on Sakhalin. It was also estimated (using data from transect counts and aerial surveys) that the total number of birds in north-east Sakhalin was 560, comprising 64.2% adults (i.e. 359 adults, and therefore potential breeding birds). This figure was calculated through extrapolation of bird density data for surveyed sections of coastline to unsurveyed sections of coastline showing similar habitat characteristics.

Detailed field monitoring of the breeding population of Steller's and white-tailed sea-eagles in the coastal lagoon systems of Piltun, Chaivo, Nyiski, Nabilskii and Lunskyi Bays has been undertaken since 2004. This work has included studies on species distribution, migration and breeding habits. The focus of this work has been two fold. Firstly, to gain a greater understanding of the population dynamics and breeding ecology of Steller's sea eagle in the area and secondly, to use this knowledge to develop appropriate mitigation measures to ensure that breeding sites and birds are not adversely affected by construction activity associated with Sakhalin II. Data from the surveys undertaken to date have been uploaded to a database that provides information on the spatial distribution of nesting sites and nesting success, and which enables population trends in the north-east lagoon system area to be monitored. On the basis of the surveys undertaken between 2004 and 2006, 580 nests and 248 nesting areas have been identified and recorded. In 2006, an independent panel of ornithological experts endorsed the research programme and recommended its continuation with a focus on environmental conditions, breeding success, and the potential impacts of human activities and bear predation.

The SERP involves two surveys being undertaken each breeding season. An early season survey is conducted in April each year to assess the status of nesting areas during the early nesting period. On the basis of this spring survey, measures to minimise any potentially negative effects associated with construction activity (e.g. potential disturbance to birds setting up nesting sites) are formulated or updated, depending on need. Typically, nesting sites within 1km of construction activity are considered to be within a zone of potential disturbance and any such sites are the focus for mitigation effort during the breeding season. For active nests, a 500m buffer zone is put in place in which no construction activity is permitted during the breeding season. A second survey is then undertaken during the summer (July and August) to assess the breeding success of the Steller’s sea-eagle population, again with a particular focus on nesting sites within potential zones of construction influence.

In 2007, the reproduction rate of the north-east lagoon population was calculated at 0.4 chicks per occupied nesting area. A higher reproduction rate was recorded for active nest sites within the zone of construction activity. In 2007, thirteen nesting areas were occupied by breeding pairs in the 1000m-zone along the pipeline route, from which 11 chicks successfully fledged by September. The relative success of birds within the 1km zone has been attributed to a significant reduction in bear predation, as bears are less likely to be present in the construction areas. Recorded bear predation of chicks in 2005 and 2006 was very high and was the single greatest cause of mortality, resulting in the loss of chicks from 43% of active nests during these years. This behaviour has not been recorded from the Russian mainland and its appearance on Sakhalin may be due to the activity of a single bear or a mother and the learned behaviour of her offspring.

In addition to the spring and late summer surveys, surveillance has been undertaken to observe sea-eagle behaviour and chick status during the breeding season at particularly sensitive sites (e.g. the OPF at Lunskoye). At these sites appropriate measures to limit disturbance to nesting pairs as a result of construction have been implemented and contributed to successful breeding.

6.3.6 Terrestrial Mammals

In comparison with mainland far-east Russia the mammal fauna of Sakhalin Island is less diverse with 44 known species. This relative impoverishment probably results from a combination of the separation of Sakhalin from the mainland following the end of the last main glacial period (approximately 10,000 years ago) and large-scale habitat loss and hunting pressure, particularly over the past 200 years. As a result of anthropogenic activities, the population levels and distribution of many species have been affected such that those species that are characterised by high adaptability tend to dominate the fauna while those with more restricted ecological requirements have been significantly reduced in numbers or completely lost from the island fauna, for example, wolf (*Canis lupus lupus*) and possibly European lynx (*Lynx lynx*).

These anthropogenic effects on the mammal fauna are reflected by the survey data collected from the sites of the project facilities *viz*. pipeline route, LNG site and OPF site. Of the 36 species of mammals recorded during survey work (FESU, 2000b), the most common mammals registered along the pipeline and at the LNG site were insectivores, namely the long-clawed and Laxmann's shrews (*Sorex unguiculatus* and *S. caecutiens*), and rodents, such as the red-backed (*Clethrionmys rutilus*) and grey-sided (*C. rufocanus*) voles and the Korean field mouse (*Apodemus peninsulae*). These species are found throughout the area covered by the project facilities, however, their distribution varies depending on the condition of the habitat and the season; the majority of shrew and rodent species are highly adaptable and tend to inhabit a variety of forested and semi-wooded habitats although their distribution across the island is variable.

Most of the shrew species found on Sakhalin prefer forested habitats, with the exception of the large-toothed shrew (*Sorex daphaenodon*), which tends to occur more commonly in river floodplain habitats and in meadows. The Least shrew (*Sorex minutissimus*) appears to inhabit a range of habitats and, although not a frequently recorded species, tends to occur more in the northern half of the island. Laxmann's shrew is probably the most commonly encountered species and dominates the small mammal fauna of the north of the island. As with many of the shrew and rodent species, Laxmann's shrew exhibits significant seasonal and annual fluctuations in abundance related to variation in climatic conditions and food availability.

Rodent assemblages are dominated by Korean field mouse, red-backed vole and grey-sided vole, all of which inhabit a range of habitat types and are distributed throughout the island. These species typically show seasonal changes in abundance and also inter-annual fluctuations on 2-4 yearly cycles. The Sakhalin vole (*Microtus sachalinensis*) has a generally central distribution and inhabits open wetland habitats, particularly in the Tym-Poronaisk lowlands. The Siberian chipmunk (*Tamias sibiricus*) occurs throughout the island, but is more common in the north. Survey data indicates that while it occurs in a number of habitat types it reaches its greatest abundance in the Japanese stone-pine thickets of the far north. The jumping mouse (*Sicista caudata*) is distributed across the southern half of the island and although widespread is not common; during survey work along the pipeline route (FESU, 2000b) this species was recorded in small numbers, mainly from fir-spruce forests. The house mouse (*Mus musculus*) and common rat (*Rattus norvegicus*), while apparently distributed throughout the island, are clearly associated with human habitation and adjacent altered habitats.

Two rodent species entered in the Russian Red Data Book occur on the Island. The Shikotan field vole (*Clethrionmys shikotanensis*), a species of wet meadows, arable land and plantations, is found in southern Sakhalin and was recorded on one occasion during a survey of the pipeline route. The wood lemming (*Myopus schisticolor*) has a northern distribution on Sakhalin where it inhabits coniferous forests (primary and secondary). During surveys it was recorded from sparse larch woodland at Chaivo and from woodland near Pobedino Village, towards the central part of the island.

Seven species of bat are known to occur on Sakhalin, although only four of these occur with any regularity. The commonest bat is Daubenton's bat (*Myotis daubentoni*), which occurs throughout the Island where it inhabits river valleys and areas of open water. It roosts and nests in tree hollows and under bark during the summer and hibernates in caves. Three species, long-eared bat (*Plecotus auritus*), great tube-nosed bat (*Murina leucogaster*) and Ikonnikow's bat (*Myotis ikonnikovi*) occur in open-forested habitats, where they hunt at night along the margins of forests. All three species hibernate in caves and hollows in suitable areas and away from summer breeding and feeding areas.

Of the larger mammals, several species are widely distributed and occur across all of the main habitat types. These include fox (*Vulpes vulpes*), brown squirrel (*Sciurus vulgaris*), mountain hare (*Lepus timidus*), and brown bear (*Ursus arctos*). Brown bear, in particular, can be found in virtually all habitats and actively migrates between habitats to take advantage of seasonal food resources (e.g. migrating salmon in rivers during the summer-early autumn and forest / mountain berries during the late autumn-early winter). All of these mammals were recorded at various locations where project activities were planned or being constructed.

Several larger mammal species are all associated with river and wetland habitats and are therefore not as widely distributed as species such as fox, but generally occur throughout the island. Muskrat (*Ondatra zibethica*) is a North American species and was introduced into Sakhalin for the fur trade. Following escape from fur farms it has become naturalized on the island since the 1950s. It now occurs throughout much of Sakhalin along sections of slow-flowing rivers, cut-off meanders, lakes, ditches and drains on agricultural land and coastal river deltas. Like the muskrat, the American mink (*Lutreola vison*) was introduced for fur farming during the 1950s. It is now naturalized and occupies similar habitats to muskrat although it also occurs along faster-flowing rivers where it tends to inhabit the middle-lower reaches (FESU, 2000b). The otter (*Lutra lutra*) is another riverine species but can also be found in lakes and ponds and along the coast. It occurs in relatively low densities (1-2 animals per 3-4 small tributaries) and tends to favour the middle-upper sections of the larger rivers and their tributaries. Signs of this species were recorded at various locations along the entire length of the pipeline route. The raccoon dog (*Nyctereutes procyonoides*) appears to have a southerly-central distribution on the island, where it largely occupies river valleys. Signs of this species were regularly encountered on the banks of rivers during survey work along the pipeline route. Mature forest habitat (deciduous and mixed coniferous-deciduous) along river valleys provides suitable habitat for flying squirrel (*Pteromys volans*). This species nests in holes in large trees and due to the fragmented and general rarity of this habitat it occurs in low numbers, but is widely distributed across the island. During survey work it was recorded from six locations from suitable habitat within the corridor of the pipeline route (FESU, 2000b).

Other, rarely encountered species include sable (*Martes zibellina*), a dark-coniferous forest species that is actively hunted for its fur, least weasel (*Mustela nivalis*) that occurs rarely throughout the island in lowland, lightly wooded habitats, and ermine (*Mustela erminea*) that occurs sporadically in the larger river valleys. Signs of all three species were recorded during survey work undertaken for the project.

Two species of deer, the European reindeer (*Rangifer tarandus*) and the Sakhalin subspecies of musk deer (*Moschus moschiferous sakhalinensis*) are listed in the Sakhalin Red Data Book. Reindeer are restricted to the north of the island although up until the 12th century they probably ranged across the whole Island. The present wild population is estimated at about 4,000 animals, down significantly from an estimate of 10,000 at the beginning of the 20th century, largely as a result of uncontrolled hunting, habitat loss and competition for available food resources with domesticated reindeer. In the north-eastern coastal plain in the Piltun-Chaivo area, pasturing of domestic reindeer has completely eliminated the wild population from its former feeding grounds. The wild population inhabits the upper reaches of rivers in the mountain foothills during the winter months and then makes short migrations during the spring-summer to calving and feeding areas in the lower river valleys and the coast. The musk deer is rarely seen and probably occurs in very small numbers (<500) in forested habitats in the east and south of the island. Signs of this deer were recorded from the Makarovsky area (Lesnaya River) during survey work along the pipeline route (FESU, 2001).

6.4 River Ecosystems

The relatively high levels of precipitation, limited moisture loss as a result of evaporation processes and the general topography of Sakhalin Island has resulted in the development of an extensive and dense river network. One of the peculiarities of the river systems on Sakhalin is the significant dissociation of the catchments. The absence of one or several major common catchments is explained by the fact that most of the rivers and lakes are divided by mountain chains and intervening ridges.

At a high level, the watercourses can be divided into two groups. The northern group includes the two major rivers of Sakhalin, the Tym River (359 km long) and the Poronai River (350 km long), both with relatively large catchments (7,850 and 7,990km^2 respectively). In contrast, the rivers of the southern group are relatively short and small. The majority of rivers originate in mountainous areas and therefore upper reaches and tributaries tend to be of the higher gradient, faster flowing upland type while lower reaches are more lowland in character (meandering, with lower flow velocities). Many rivers are thus of mixed type, apart from the smaller, mountain rivers that issue from the eastern slopes of the Eastern Sakhalin Mountains and which fall rapidly to the coast (as in the Makarov area).

The river network is generally distributed unevenly along the length of the Island. The highest density of watercourses occurs in the south-eastern coastal area, the basins of the Poronai River right tributaries, in the upper reaches of the Pilenga River, Vladimirovka River and some other rivers along the eastern coast, where the density varies between 1.5 - 2.3 km of river/km^2. In the central part of the Island, river density is in the region of 1.2 - 1.5 km/km^2 and it only increases in the basins of some of the rivers (Naiba, Orlovka, Makarova) to 1.7 - 2.0 km/km^2. The lowest river network density occurs on the North-Sakhalin Lowland and in the southern part of the Poronai River basin, where in most cases it does not exceed 1.0 km/km^2 and only increases in some of the river basins to 1.4 km/km^2. All of Sakhalin's rivers flow into the Sea of Japan, the Sea of Okhotsk, or the Tatar Strait.

Four phases of hydrological condition are typical for Sakhalin rivers. These conditions are largely influenced by the variable nature of precipitation received within the catchments (Sakhhydromet, 1998 and 1999). Water supply sources change over the year. In spring most of the water comes from melting snow; in summer and autumn it comes mostly from precipitation, while in winter the only source of water is from groundwater.

Water levels in the rivers generally vary seasonally: spring flood (April - June), summer low water (July - August), autumn flood (September – November) and winter low water (December - April). All Sakhalin rivers receive their water resources mainly from melting snow. The exception is the rivers of the North-eastern Lowland, which receive most of their water from groundwater aquifers (over 50% of the annual water resource). Because of the nature of inputs, the river systems of Sakhalin are characterised by a very variable distribution in annual catchment flow. The difference between the maximum and the minimum water flow rate varies from several dozen times (rivers of the North-Sakhalin Lowland and boggy and wooded rivers of southern Sakhalin) to several thousands times (rivers of the Terpeniya Bay southern coast and left tributaries of the Poronai river). The maximum flow rate in most rivers occurs in the warmer seasons of the year (April-November) and represents 90-96% of the annual flow rate. The flow rate in the winter season (December-April) decreases to 4-10%. Exceptions are the rivers flowing on the North-Sakhalin Plain, which have a significantly greater percentage of flow during the winter (15-25%).

Spring floods are generated mostly by melting snow, which contributes the greatest volume of water to the rivers on an annual basis. The start of high flow volumes associated with the spring snowmelt varies from south to north. The duration of spring floods is from 40 to 75 days. Floods associated with high rainfall occur mostly in the autumn, and often, maximum flow rates during this period exceed spring flood rates. Smaller rivers, with catchment basins less than 50 km^2 often dry up in periods of low rainfall or freeze up to the riverbed in very cold winters.

The processes that affect soil and rock weathering and sediment loadings in Sakhalin rivers are diverse. The most frequent ones are: rain wash, river wash (reworking of fluvially deposited sediment) and landslides. These processes frequently occur in the river basins in the southern and central part of the island. River wash and rain-wash are not very intensive in the river basins of the North-Sakhalin Lowland. The differing occurrence and intensity of these processes, along with soil, bedrock and vegetation cover conditions across the island, leads to considerable spatial variation in average suspended sediment concentrations and river water turbidity. Low suspended sediment concentrations (SSC) values are recorded for the rivers of the North-Sakhalin Lowland (up to 50 mg/l), while further to the south levels are several times higher. Maximum values occur in rivers in those areas characterised by large amounts of precipitation that activates rain-wash and river wash processes.

Suspended sediment load and turbidity varies significantly over the year. Generally, it is the lowest in winter, from December to April, when there is no rain-wash from the river basin surface. Maximum SSC levels are observed, as a rule, during the spring snowmelt periods and in the southern rivers can rise up to 5,700 mg/l or sometimes higher. High rainfall also leads to significantly increased SSC (up to 5,100 mg/l) during the summer and autumn.

A comprehensive programme of biological and physical surveying of watercourses crossed by the oil and gas pipelines has been undertaken. Given the significant extent of the pipeline route a total of nearly 1100 watercourses have been crossed, representing the full range of river types present on the island. Survey of a representative number of these watercourses prior to and during construction has provided a significant dataset on the ecological characteristics of these freshwater systems. Of particular interest is the composition and distribution of in-stream fauna and flora and how this relates to the physical attributes of the various watercourse types present on the island.

Small woodland brooks and springs, with variable bottom substrates (rocks, pebbles, gravel, sand, detritus and silt in low flow areas) generally support a mixed assemblage of crustaceans including amphipods such as *Gammarus lacustris* and isopods such as *Asellus hilgendorfi*, small bivalves of the genus *Euglesa*, oligochaete worms, and some species of stoneflies, caddisflies and mayflies. Biomass is usually low and is on average 3-4g/m^2; only in-stream sections occupied by the Gammarus-Euglesa community does biomass sharply increase (e.g. *Gammarus* sp. - to 9,000 ind./m^2, 190 g/m^2 and *Euglesa* sp. - to 3,000-4,000 ind./m^2, 37-45 g/m^2).

The majority of small-medium sized rivers on Sakhalin are characterised by relatively high flow rates and well-oxygenated waters with rocky, pebbly and / or sandy substrates. Only in areas of slack current does detritus and silt form the channel substrate. In-channel vegetation is generally uncommon apart from various species of unicellular and filamentous encrusting algae (e.g. diatoms). The macro-invertebrate assemblage of these rivers is relatively diverse and comprises various species of crustaceans (amphipods and isopods), small bivalves, oligochaetes and fly (diptera) larvae. The Sakhalin freshwater pearl clam *Dahurinaia laevis* is a specific representative of rivers on the lower hill slopes, the Tym-Poronai basin forming its main area of distribution. The biomass of these invertebrate communities is not very large and usually varies from 1 to 10 g/m^2. However, in areas where the Sakhalin pearl clam occurs, the biomass may rise considerably and reach levels of 15 - 20 kg/m^2 (SakhNIRO, 2000). In cut-off channels where standing water is present, aquatic vegetation is more plentiful and the invertebrate fauna is correspondingly diverse and more abundant. Snails (gastropods), chironomid midge larvae and bivalves (e.g. *Euglesa* sp.) often form the basis of the assemblage in these areas, but water mites, isopods, mayflies and the larvae of dragonflies and water beetles are often common in small numbers.

In addition to the general characteristics of the invertebrate fauna described above, the species assemblages can be grouped into several zoogeographic provinces and within these broader groupings by specific hydrological and physio-chemical parameters (SakhNIRO, 2000). From an aquatic ecological perspective, the island can be split into two provinces *viz*. the Orelian (the Amurian subregion of the Sino-Indian region) and the Aniwan (the Japanese subregion of the Sino-Indian region). The boundary between these provinces on the island is located approximately along the watershed of the Tykhmenovka River (Poronai River Basin) – Gastellovka River (Terpeniya Gulf Basin).

The Orelian (Palaeamurian) province embraces the northern part of Sakhalin, which formed part of the Amur River Basin during the early Holocene (6,000-10,000 years ago). The species found here are boreal / Palaearctic species associated with the Amur River and generally cooler to colder climatic conditions. In mountain and foothill streams, these species typically include the pearl clam *Dahurinaia laevis*, the crustacean (gammarid), *Gammarus lacustris*, mayflies of the genus *Ephemerella* (*E. kozhovi* and *E. mucronata*), *Baetis* (*Baetis vernus*, *Baetis acinaciger*) and *Heptagenia* (*Heptagenia flava* and *Heptagenia fuscogrisea*), stoneflies (*Pictetiella asiatica* and *Pictetiella zwicki*), and the chironomids *Cricotopus trifasciata* and *Smittia sedula*.

The Aniwan province covers the southern part of Sakhalin, which used to have connections with northern Japan. This assemblage includes more heat-loving southern boreal species. In the mountain and foothill watercourses in this area, the main indicators of this species complex are the bivalve (*Dahurinaia kurilensis*), the amphipods (*Gammarus koreanus* and *Sternomoera* sp), mayflies (*Baetis fenesratus*, *B. gnom*, *Cloeon bifidum* and *Epeorus pellucidus*) the chironomid midge (*Cardiocladius capucinus*) and the stonefly (*Paraleuctra cercia*), among others.

Available information suggests that the aquatic flora of Sakhalin is relatively impoverished (compared with mainland Russia). It comprises approximately 50 species, including pondweeds (20 species), duckweeds (3 species), frogbits (wild celery), species of the families Callitrichaceae, Nymphaeaceae and water milfoils, as well as a few species of other families (e.g. water smartweed, watercress and water buttercups).

Many common aquatic plants, such as several species of water lilies, and the water chestnut, are absent and others are rare, such as water buttercups (*Ranunculus* spp.) and water smartweed. White water lilies are presented only by two species *viz*. *Nymphaea tetragona* and *Nuphar pumila*. Pondweeds are relatively diverse, but are seldom common in comparison with continental water basins. Vascular water plants are generally absent in most of the mountain and foothill rivers while aquatic plant assemblages of any importance only tend to occur in the lowland sections of the larger rivers (such as the Tym and Poronai) and ponds formed from cut-off meander loops and abandoned channels. A number of factors, but notably high acidity and the lack of dissolved potassium and calcium ions in watercourses, are probably responsible for the low diversity of Sakhalin's aquatic flora.

6.4.1 Freshwater Fish

The fish fauna of Sakhalin's watercourses is generally poorly studied, although the basic characteristics of the fauna are known, as are the assemblages typical of the main hydrological conditions. In particular, the freshwater fish fauna of Sakhalin is generally less well studied than that of mainland Russia. Recent survey work and analysis of available literature suggests that the fauna of fresh and brackish waters comprises 79 species, belonging to 12 classes, 28 families and 50 genera. The most numerous representatives belong to the families *Cyprinidae* (20 species, forming 23.0% of the total fauna), *Salmonidae* (11 species, 12.6%), *Gobiidae* (9 species, 10.3%), *Osmeridae* (7 species, 8.0%), and *Gasterosteidae, Cottidae*, and *Pleuronectidae* (4 species each, 4.6%). The rest of the families are represented by one to three species each (1.2 to 3.5%).

The freshwater ichthyofauna of Sakhalin Island has been split into six faunal complexes (as listed below) that reflect habitat types, hydrologic conditions and biogeographic influences (SakhNIRO, 1998):

- Arctic freshwater – e.g. Dolly varden (*Salvelinus malma*), white-spotted (east Siberian) char (*Salvelinus leucomaenis*), Ussuri whitefish (*Coregonus ussuriensis*) and Arctic (rainbow) smelt (*Osmerus mordax dentex*); burbot (*Lota lota*)
- Ancient upper Tertiary – Asiatic brook lamprey (*Lampetra reissneri*) and arctic lamprey (*Lethenteron japonicum*), kaluga sturgeon (*Huso dauricus*), Soldatov's toothed gudgeon (*Gobio soldatovi*), Amur bitterling (*Rhodeus sericeus*), sazan (*Cyprinus carpio carpio*), silver cyprinid (*Rastrineobola argentea*), Amur loach (*Misgurnus anguillicaudatus*), Amur fresh-water cat fish (*Parasilurus asotus*) and several other cat fish;

- Boreal foothill - lenok (*Brachymystax lenok*), grayling (*Thymallus thymallus*), Sakhalin taimen (*Parahucho perryi*), common minnow (*Phoxinus phoxinus*), Amur minnow (*P. lagowskii*), Siberian stone loach (*Nemacheilus barbatulus toni*), several other loach species;
- Boreal plain - Amur sturgeon (Acipenser schrenckii), Amur ide (Leuciscus waleckii waleckii), silver carp (Hypophthalmichthys molitrix), lake minnow (Phoxinus perenurus), Amur pike (Esox reichertii), spined loach (Cobitis taenia);
- Chinese plain - spotted barbel (Hemibarbus maculatus), common skygazer (Erythroculter erythropterus), white Amur bream (Parabramis pekinensis), silver carp (Hypophthalmichthys molitrix), yellow cheek (Choerodon anchorago), Chinese perch (Siniperca chuatsi); and
- Indian plain – yellow (banded) catfish (*Pseudobagrus fulvidraco*), and Chinese slipper (sleeper-rotan) (*Perccottus glehni*).

In addition, the freshwater ichthyofauna can also be divided into six zoogeographical regions *viz*. northwest, extreme north, east, Tym and Poronai Rivers Basin, west and south, and southeast of the Island. Of these areas, four are of particular relevance to the Sakhalin II Project (i.e. they are areas in which project activities occur) and are described in more detail below. As a whole, species diversity is generally poor, with one to three freshwater species (i.e. excluding anadromous fish) being typical for the greater part of the Island, particularly in the western, southern and eastern areas, with the exception of the Tym and Poronai Rivers Basin. Generally, it can also be stated that the shorter the river the less diverse the species assemblage.

Freshwaters of the northern extremity of the Island - (from the coastal line delimited by the Val River to Baikal Bay, embracing the whole of the Schmidt Peninsula). Anadromous species include pink salmon (*Onchoryhnchus gorbuscha*), southern malma (*Salvelinus malma krascheninnikova*), Sakhalin char, Arctic smelt, and three-spine stickleback (*Gasterosteus aculeatus*) as well as the semianadromous brook malma (or dolly varden). These species belong to the arctic freshwater complex (southern malma, rainbow smelt and others) and the boreal foothill complex (salmon of the genus *Oncorhynchus*).

Freshwaters of eastern Sakhalin - (including water bodies from Terpeniya Cape to Nabil Bay). Typical anadromous species include: arctic brook lamprey, salmon (pink, chum (*Onchorhynchus keta*), masu (*O. masou*) and silver/coho (*O. kisutch*), southern malma, Sakhalin char, Sakhalin taimen, arctic smelt, redfins (*Triblodon brandti* and *Triblodon hakonensis*) and three spine stickleback. Semi-anadromous species include brook malma and arctic brook lamprey. Survey work indicates that species such as the brook malma are ubiquitous in mountain-streams, often occurring in relatively small watercourses (SakhNIRO, 2000). Resident freshwater species are Siberian stone loach and sculpins (*Cottus* sp.). This fish assemblage forms part of the arctic freshwater complex (southern malma, rainbow smelt and others) and the boreal foothill complex (salmon of the genus *Oncorchynchus*, Siberian stone loach and others).

The basins of rivers Poronai and Tym - (including the coastal area northwards to the Val River). Anadromous species include arctic lamprey, salmon (pink, chum, masu and coho), southern malma, Sakhalin char, Sakhalin taimen, Ussuri whitefish, rainbow smelt, redfins (three species) and three-spine stickleback. Semi-anadromous species include brook malma and arctic brook lamprey. Typical freshwater species include Amur pike, golden carp, Amur ide, Lagovsky.s minnow, Amur bitterling, spiny loach (*Cobitis taenia taenia*), Amur loach, Siberian stone loach, burbot, Sculpins, and Sakhalin stickleback (*Pungitius tymensis*). The ichthyofauna of these rivers is representative of the arctic freshwater complex (southern malma, arctic smelt, burbot and others), the boreal foothill complex (representatives of genus *Oncorchynchus*, Siberian stone loach and others), the boreal plain complex (Amur pike and ide, Sakhalin lake minnow and others) and the ancient upper tertiary complex (Amur loach and bitterling).

Freshwaters of south-eastern and southern Sakhalin - (from Cape Krilyon, including the coast of Aniva Bay, to Gastellovka River (Terpeniya Gulf). Typically anadromous species include salmon (pink, chum, masu, coho), southern malma, Sakhalin char, Sakhalin taimen, arctic smelt, redfins (three species), and three-spine stickleback. Semi-anadromous species include dolly varden, arctic brook lamprey and Asiatic brook lamprey. Species inhabiting exclusively fresh waters include Siberian stone loach, Sakhalin stickleback (endemic to the fresh waters of the majority Sakhalin regions), and several species of gobies (*Chaenogobius urotaenia, C. castaneus, Rhodonuchthyslaevis, Rhinogobius brumleus* and *Tridentiger brevispinis*). The ichthyofauna is mainly representative of the arctic freshwater and boreal foothill complexes.

There are several freshwater fish species that are notable for their rarity or limited distribution (e.g. species or subspecies endemic to Sakhalin Island). The majority of these species are listed and described in the Russian Red Book. Two fish species listed in the Red Book may either potentially be present in watercourses along the pipeline route or, on the basis of available data, are known to occur in some watercourses. These are Lagowsky.s Manchurian minnow (*Phoxinus lagowskii oxycephalus*) and the Sakhalin taimen (*Parahucho perryi*), the ecology and distribution of which are described in further detail below. Two rare species of sturgeon are also known to inhabit the coastal/estuarine and fresh waters of Sakhalin, although the status of both species is currently unknown. The Sakhalin (or green) sturgeon (*Acipenser medirostris*) was known from the lower reaches of the Tym River, although there is no recent evidence to suggest that it is a breeding species (SakhNIRO, 2000). An artificial breeding programme for this species has been initiated and is based at the Okhotsk hatchery (Tunaytsha Lake basin). The Kaluga sturgeon (*Husco dauricus*) is one of the largest freshwater fish species reaching a length of 5m and a mass of 1000 kg. It is known to inhabit the Amur River Basin from the mouth of the estuary up into the rivers Shilka, Argun and Onon. Occasional specimens have also been recorded from the mouth of the Tym River and at Niysky Bay. There is no evidence to indicate that this species is spawning in any of the rivers of northern or eastern Sakhalin.

6.4.1.1 Lagowsky’s Manchurian Minnow

The ecology of the *oxycephalus* subspecies of the Manchurian minnow has not been well studied. On Sakhalin, it inhabits the headwaters of streams and rivers in the central part of the Island (e.g. rivers found in the Palevsky Hills, headstreams of the Tym and the Poronai rivers) in cut-off channels with low current velocities. This species was recorded from a small tributary of the Berezovaya River (three individuals) and from an oxbow lake on the Pilenga River (one individual) during survey work by SakhNIRO (SakhNIRO, 2000). It appears that where it occurs it forms small shoals, which remain close to the channel bottom amongst any vegetation or debris. Spawning apparently occurs in June when eggs are laid on vegetation or small pebbles. All known locations for this species and its main habitat are located upstream of the pipeline corridor.

6.4.1.2 Sakhalin Taimen

This species of salmonid is one of the world’s largest and most ancient species of salmon. It is a migratory species, with a restricted global distribution being found only in Sakhalin, the Amur Basin and northern Hokkaido. On the basis of historical and recent data on the abundance of the species across its range it was recently listed by the IUCN as Critically Endangered (Rand, 2006). Estimates for the total population present in Sakhalin vary, but Rand (2006) consider that there are probably only several thousand adult fish now present in the rivers of Sakhalin.

This Sakhalin taimen is a long-lived species, slow growing and exhibits delayed age at maturity relative to other salmonids. The species is iteroparous (i.e. repeat spawns), and reaches sexual maturity at ages six to eight, and achieves peak fecundity at approximately age 15.

On Sakhalin it appears to be generally distributed in rivers of the central and northern part of the island and occurs rarely in the smaller-medium 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. Spawning areas are located in areas of cobble-large gravel substrate in the well-defined channel sections of rivers (in middle and lower courses of small rivers, and in upper courses of large rivers, typically 3-4 m wide) in water depths greater than 1m and with current velocities of 0.3-0.5 m/s (SakhNIRO, 1998 and 2000). 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 characteristics of wintering habitat in river systems for juveniles are poorly known, but it is likely that similar conditions to those sought out by silver salmon (i.e. areas of cover in slower moving water, such as cut-off channels) are utilised. Young fish mainly feed on benthic invertebrates and insect larvae until body length reaches approximately 20 cm, when they then begin to prey on other fish. Maturation takes 8-10 years and a fully mature fish can measure up to 2m in length.

Because of its protected status, fishing for Sakhalin taimen is not permitted. The presence of Sakhalin taimen in the watercourses in areas affected by the Sakhalin II Project has been determined from a number of sources, notably available data from previous fish surveys undertaken by fisheries agencies and records obtained during specific ecological surveys for the Sakhalin II Project. This data backs up the general information on the distribution of this species on Sakhalin. Of those rivers the pipeline crosses and in which taimen is known to be present, 51% occur in Section 1 of the pipeline route (most northerly section), 25% in Section 2, 13% in Section 3 and 11% in Section 4, reflecting the more northerly distribution of the species.

6.4.2 Salmon (*Oncorhynchus* sp.)

The Island has earned a reputation for an extraordinary abundance of Pacific salmon (*Oncorhynchus* spp.). It is known that salmon enrich terrestrial and aquatic ecosystems, benefiting the ecology of riverine systems. Eggs and carcasses deposited in freshwater habitats by spawning salmon make a significant contribution to the available nitrogen content in these systems. The spawning migration of salmon represent a mechanism of nutrient transport from the highly fertile, North Pacific marine ecosystem to the relatively nutrient-poor, freshwater ecosystems of Sakhalin. These additional nutrients not only benefit productivity within the rivers, but it has also been shown that they contribute to the growth of terrestrial vegetation along river corridors. Bilby, *et al.* (1996) found that 18% of the nitrogen in the foliage of riparian plants along a stream where silver (coho) salmon spawned was of marine origin. These nutrients may be made available to terrestrial plants by removal of the fish from the stream by scavengers, deposition on the floodplain during high flows, or migration of dissolved nutrients into riparian soils.

The abundant and productive salmon populations of Sakhalin are also of great importance to the local economy and for the livelihoods of many people, including indigenous people in the north of the island. The two most common species involved in the commercial fishery are chum salmon or dog salmon (*Oncorhynchus keta*) and pink or humpback salmon (*O. gorbusha*). Together these two species constitute approximately 95% of the total commercial catch on Sakhalin Island, with cherry salmon (*Oncorhynchus masou*) and silver (coho) salmon

(*Oncorhynchus kisutch*) making up the rest.

Given the commercial importance of salmonids, significant research, surveying and monitoring has been undertaken over the last 50+ years by Soviet and Russian fisheries agencies and research institutions in order to assess the status of stocks, the distribution and quality of spawning areas and the general biology of these species. On Sakhalin, this effort has focused on pink and chum salmon because of their overwhelming importance as a natural resource to the economy.

6.4.2.1 Pink Salmon

This is a typical anadromous fish (those that spend most of their lives in the ocean but migrate to fresh water to spawn) with a two-year life cycle, shorter than other salmon species. As a result pink salmon is the smallest of the Pacific salmon, averaging 1.3-1.4 kg at maturity and seldom growing larger than 3-4kg.

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 timing of the spawning migration varies slightly across the island, with the run starting earlier in the east and south and lasting longer in the south. Once they begin to spawn, male pink salmon develop a prominent hump in front of the dorsal fin. For this reason, pink salmon are commonly called humpback salmon.

They usually spawn in-streams that are not fed by lakes and typically their spawning grounds are only a short distance from the ocean. Spawning sites are characterised by clear water with gravel/pebble substrate and minimal sand content. Water depth at pink salmon spawning grounds varies from 0.2 to 1.6 m and current velocity 0.2-1.1 m/s (SakhNIRO, 1998). Pink salmon redds (depressions in the gravel where eggs are laid) require a continuous water flow (up-welling or hyporheic flow) through the gravels for successful hatching to occur. Approximately 45 to 90 days after spawning, the eggs hatch and the young fish (alevins) remain buried in the substrate, surviving on their yolk sac. From early-mid April young fish (fry) start to leave the gravel bed and move into the water column and begin migration to the sea, where they feed for over a year before returning to streams in the area occupied by the stock.

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 1950.s 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, which has occurred since the 1970s, the natural recovery of stocks 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 the growing and timing of release of fry. The renovation of hatcheries has also helped to ensure that stocks and catches of pink salmon have been at very high levels during the 1990s and into the first decade of the 21st century, with catches of over 120,000 tonnes being recorded in 2005-2007.

6.4.2.2 Chum Salmon

The chum salmon is the most widely distributed of the Pacific salmon species, breeding on both sides of the north Pacific. On Sakhalin Island the chum salmon ranks second, in terms of abundance and commercial importance, to the pink salmon. Although it occurs throughout the rivers of Sakhalin, this species only attains relatively high abundance in the river systems of the northeast, particularly the Tym, and some rivers in the southwest of the island.

Chum salmon spawning runs occur twice a year, in the summer and autumn, with the number and location of migrating fish varying according to the season. The summer chum salmon spawning run begins during the first half of July, simultaneously with the pink salmon spawning run. The run peaks at the end of July to the beginning of August. Summer chum salmon spawn in similar in stream habitats to pink salmon; i.e. clean gravels with hyporheic flow. The autumn chum salmon spawning run is larger and more economically important than the summer run and takes place in river basins from the end of August till November. The largest autumn runs occur in the Tym River and in the rivers of southwest Sakhalin; however individuals can be found in almost all Sakhalin rivers (SakhNIRO, 1998). Autumn spawning chum salmon prefer to spawn in sheltered places in small rivers where the bottom is covered with fine pebbles and gravel. Water temperature is also an important factor in spawning site suitability and, while river water temperature during the spawning period usually falls from 8 to 1°C, spawning sites are selected where upwelling waters wash the redds with water at a constant temperature of 3-4°C for the entire winter period (SakhNIRO, 2000).

Juveniles (fry) come out of the gravel substrate at the beginning of April and then feed in the area of their spawning grounds for one to two months eating microscopic or near microscopic plankton, as they grow they start to eat small insects and insect larvae that fall into the water. In May, 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 nearshore waters prior to moving out into the open ocean. Fish will spend 3-4 years feeding in oceanic waters before migrating back to their natal rivers.

As noted above, the commercial importance of this species 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. Traps and coastal fishing gear are normally used but at sites where artificial cultivation (hatcheries) takes place, they are caught next to fish screens.

6.4.2.3 Silver (Coho) Salmon

This species has a distribution throughout the North Pacific Ocean from central California, Alaska, through the Aleutian Islands, Kamchatka, to Hokkaido, Japan. In Sakhalin, the silver salmon is not numerous and mainly occurs in the rivers of the northeast of the island and those flowing into Terpeniya Bay. The ecology of the silver salmon and cherry salmon is similar and it is thought that the latter species replaces the silver in the warmer, southern regions.

The silver salmon undertakes its protracted spawning migration later than all of the other Pacific salmon species and may be found in from early September through to mid-December in some seasons. Spawning sites comprise sections of main river channel and tributaries with upwelling groundwater and with current velocities ranging from 0.08 to 0.7 m/s. Alevins start leaving river gravels and enter the water column at night in late May-mid-June. During their first year, silver salmon fingerlings normally inhabit cut-off channels and tributaries of the main channel of the spawning river where deeper pools, log jams and banks with overhanging tree roots and debris occur (Tschaplinski and Hartman, 1983). These channels and ponds can often harbour large numbers of fish and are thought to provide refuge during the winter months, as total freezing of the river is less likely and therefore mortality rates may be much lower than in mainstream channels.

The typical silver colouration of the migratory phase of this species develops in fish aged 2-3 years old. In the Tym River, this silver form normally appears in the upper reaches of the river in late May and in the middle reaches by early/mid-July with the majority migrating to the open sea by August. Once at sea, sliver salmon spend a year feeding prior to returning to their natal rivers for spawning.

Silver salmon is not considered to be a main commercial species and is normally taken during fishing for the autumn chum salmon run. However, SakhNIRO (2000) report that in some years significant migrations of this species (e.g. up to 40,000 fish in 1961) on the Tym River make it of occasional commercial value. Subsequent to 1961, silver salmon numbers fluctuated in the range of 6,000-15,000 individuals.

6.4.2.4 Cherry Salmon

The cherry salmon occurs in small numbers in Sakhalin rivers and is the first migratory Pacific salmon to appear in coastal waters, normally in mid- to late May in southern Sakhalin. Mass migration upstream occurs during the second half of June to mid-July with spawning occurring in late July to early August. Before spawning, the cherry salmon spends about two-eight weeks in the river, lingering in holes in the main channel and enters tributaries directly before spawning. An important factor in stimulating the spawning migration is a rise in water level and increase in river current velocity (e.g. as associated with spring-early summer floods), which permits fish to reach their spawning grounds, which are situated largely in the upper reaches of rivers. On the southwestern coast and in Aniva Bay, migration generally occurs mid-May to mid-June, while in northern Sakhalin (middle reaches of Tym river) mass migration occurs from the second half of July into the first half of August and spawning from late July to early September.

Normally, cherry salmon spawning areas are isolated from the spawning grounds of other salmon species. In southeastern Sakhalin (in the tributaries of Belaya river - the Naiba river basin) it spawns in areas of pebbles, with rocks and some sand and relatively high current velocities. In northern Sakhalin, spawning grounds are situated in the upper reaches of the main rivers and its tributaries. These sites tend to be small watercourses with an alternation of pools and riffles. Alevin hatching occurs after 35.50 days and by about day 80-85, juveniles start moving into the water column where they begin actively feeding. They leave the redds by the second half of April (later in northern Sakhalin). Shoals of juveniles then disperse into the upper and middle reaches of the rivers where prefer sections of watercourses with a rapid, turbulent current and cover provided by bushes and log jams (SakhNIRO, 2000). During the summer, young fish feed on a varied diet of airborne and aquatic insects as well as the eggs of pink and chum salmon. 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. These are dwarf males, which sometimes occur in large numbers in the upper tributaries and which actively take taking part in reproduction. 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.

From a commercial perspective cherry salmon is of minor importance and is only caught in relatively large amounts in south-western Sakhalin during May-June, in the course of the pink salmon migration. Between the late 1950s and the late 1980, its catch normally did not exceed 5-10 % of the totals caught during the pink salmon migration. In the course of the pink salmon fishery in other parts of the Island, cherry salmon may be present as a bonus catch in small amounts, mainly because the bulk of fish have already entered the rivers for spawning.

6.5 Marine ecosystems

6.5.1 Physical aspects

The Sea of Okhotsk covers an area of 1.6 million km^2, with an average depth of 821m (3916m at its deepest point). It is a semi-enclosed sub Arctic sea located in the northwestern Pacific

Ocean between the Siberian mainland in the west and Kamchatka Peninsula to the east. Via the sounds between the Kuril Islands the Okhotsk Sea is connected to the Pacific Ocean. Different straits link the Okhotsk Sea to the Japan Sea. The shallow Okhotsk shelf spreads far out into the sea, which then steeply deepens to the Kuril basin in the south.

Due to the influence of cold, dry northerly winds during the winter months (October-April) the Sea of Okhotsk is generally almost entirely covered with sea ice. Freezing starts in coastal areas and a closed fast ice cover develops within a few weeks. Offshore winds generate polynyas and open water areas (flaw leads) producing large amounts of frazil ice, which consolidate to drifting floes.

The Japan Sea is a marginal sea located in the western Pacific Ocean nearly entirely enclosed by Asian mainland and offshore islands. It is connected with the Sea of Okhotsk by the Tatar Strait to the north and the La Pèrouse Strait to the east. The sea covers an area of 1,06 million km^2, with an average depth of 1535m (4224m at its deepest point). Prominent circulation features in the Japan Sea include warm currents from the south and cold currents from the north. The warm Japan Current flowing northeastwards through the sea modifies the regional climate and local climate of southern Sakhalin, although ice formation still occurs in the waters of Aniva Bay and surrounding areas during the winter months.

6.5.2 Marine Invertebrates

Within the context of the Sakhalin II Project area description and discussion of marine invertebrate communities is restricted to those areas where project activities occur – namely the north-east Sakhalin shelf and Aniva Bay.

6.5.2.1 North-east Sakhalin Shelf

The marine environment of the north-east Sakhalin shelf is highly dynamic, and is characterised by a strong diurnal tidal regime, tidal currents, heavy wave action in autumn and by sea-ice in winter. The benthic communities and species occurring over the north-east shelf where these conditions predominate are adapted to these dynamic conditions, in which perturbations and disturbance are a common and regular occurrence. This is reflected by the dominance of opportunistic species such as the cumacean (a group of small sediment dwelling crustaceans) *Diastylis bidentata* and suggests that the benthic fauna is adapted to physical change with annual cyclicity.

The benthic fauna of the shelf system of north-east Sakhalin has been investigated by a number of researchers since the early 1980s, notably Averintsev *et al.* (1982), Borets (1985), Dulepova and Borets (1990) and Kussakin *et al*. (2001). This work indicates that the species composition and distribution of benthic communities of the shelf area are largely controlled by sediment types and water depth. Variable biomass and diversity values have been recorded in these studies. Averintsev *et al*. (1982) observed large populations of the sea urchin sand dollar *Echinarachnius parma* in water depths of 15-120m, covering an area of over 13,000km^2, (*i.e.* about 40% of the shelf area). The *E. parma* community is associated with fine sand and 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). In fact, the shelf area of north-eastern Sakhalin differs from other parts of the Okhotsk Sea by the relatively high abundance of sand dollars and amphipods that occur here. Survey results (Borets (1985), Dulepova and Borets (1990)) have shown that amphipods comprise in the order of 7.5% of total biomass, while in other parts of the Okhotsk Sea values for this group of crustaceans ranged from 0.7% (on the Pritauyiskii Shelf) to 2.5% of the total biomass in Terpeniya Bay.

A number of specific survey programmes to determine the benthic interest of the nearshore shelf in the Piltun-Lunskoye area have been undertaken since 1998, particularly with respect to an investigation of the benthic communities in and around the area where the Molikpaq platform (PA-A platform) has been installed. Data gained from these surveys indicate that the sediments of the nearshore shelf region primarily comprise fine to medium grain sands with areas of fine and medium gravels. The benthic community is dominated by amphipods (e.g. *Protomedeia grandimana*, *Ischyrocerus commensalis* and *Pleusymtes vasinae*) and polychaetes (e.g. *Glycera capitata*, *Chone* sp, *Nephthys caeca*, and *Chaetozone setosa*) with bivalve molluscs (e.g. *Yoldia* sp.) also being well represented. The cumacean, *Diastylis bidentata*, often occurs in some abundance and during benthic surveys of the shelf area was found to contribute over 50% of the macro-infaunal abundance at the majority of sampling sites. In terms of biomass, the sand dollar *E. parma* predominates (recorded as contributing 67-99% of the total biomass at sample stations) followed by *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 shelf area.

An intensive benthic sampling of the nearshore area of the Piltun shelf has been undertaken in relation to the two known western gray whale (WGW) feeding areas and control zones where whales have not been observed feeding. These studies demonstrate high but patchy abundance of benthic fauna in the area. The Piltun feeding area contains abundant small crustaceans (e.g., swarming amphipods and isopods), polychaete worms, and bivalve molluscs (e.g. as reported in Fadeev 2005, 2006). The prey distribution corresponds with the distribution and abundance of WGW 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 (i.e. sand dollars). The offshore feeding area is dominated by benthic ampeliscid amphipods that live in tubes, sticking up 10-15cm from the sediment surface, creating a tube forest or carpet along the ocean bottom.

Trawl surveys of the north-east shelf area and data from fisheries vessels indicate that a number of larger crustacean species, of commercial value, inhabit these waters. Of particular importance is the snow crab (*Chionoecetes opilio*) which is widely distributed along the north-eastern Sakhalin coast, occupying all substrates between 90-500m water depth. The blue king crab (*Paralithoides platypus*) occurs more to the southern part of the north-east shelf in the Terpeniya Gulf area at depths of 25-300m, mainly on sand and pebble substrates (SakhNIRO, 2001). Three shrimp species are also relatively common and widely distributed in the area, the sculptured shrimp (*Sclerocrangon boreas*), bear cub shrimp (*Sclerocrangon salebrosa*), which occupies relativel shallow water (30-100m) generally on sandy substrates along the north-eastern coast and the spiny lebbeid (*Lebbeus groenlandicus*).

6.5.2.2 Aniva Bay

A number of surveys (e.g. SakhNIRO 1999; FERHRI, 2003) have been undertaken in the northern part of Aniva Bay to characterise the marine ecology, including the benthic communities in the area where the LNG/OET facilities are to be developed. These surveys are also complemented by several studies and reviews of available information relating to commercial fisheries interests, including information on a number of benthic invertebrate species.

These surveys show that a distinctive feature of the northern part of Aniva Bay is the heterogeneous nature of the seabed sediments, although a basic transition from more rocky substrates through pebbly sands to fine sand/silts with depth offshore occurs. At depths of between 0 to 10m the area is characterised by outcrops of rock, which alternate with patches of pebbly sands. This zone supports dense patches of seagrass (*Zostera marina* and *Phyllospadix iwatensis*), which extend in a continuous belt of variable width (20-1000m) along the shore. The rocky substrate supports a diverse community of algae and invertebrate species. The plant/algal assemblage of the littoral zone is primarily composed of seagrass (*P. iwatensis*), brown seaweeds – *Laminaria japonica*, *Fucus evanescens*, *Pelvetia wrightii* and

Cystoseira crassipes. A number of species of red and green algae are also present including *Laurencia nipponica*, *Corallina officinalis*, *Gloiopeltis furcata*, *Neorhodomela teres*, *Porphyra pseudocrassa*, *Ulva fenestrata* and *Chaetomorpha* sp.). The invertebrate assemblage includes: short-spined sea urchin (*Strongylocentrotus intermedius*), sea anemones, gastropods, molluscs (*Metridium senile*, *Collisella* sp., *Littorina squalida* and *Nucella* sp., the crabs *Pagurus middendorffi* and *Pugettia quadridens* and a number of species of isopods, amphipods and polychaetes.

As the depth increases (to approximately 13m), the algal community develops a three-tiered structure. The upper tier is dominated by *Laminaria japonica*, with more *occasional Laminaria cichorioides* and *Costaria costata*. The under-storey tier comprises a mixed assemblage of red, green and brown algae, although red species such as *Chondrus pinnulatus*, *Odonthalia corymbifera* and *Neoptilota asplenioides* tend to dominate. Brown and green seaweeds that occur in this layer include *Dichloria virides*, *Ulva fenestrata*, *Monostroma crassidermum* and *Bryopsis plumosa*. The basal tier largely comprises coralline seaweeds such as *Clathromorphum circumscriptum*, *Lithothamnion phymatodeum* and *Bossiella cretacea*. The invertebrate assemblage includes *Strongylocentrotus intermedius*, *Patiria pectinifera*, *Asterias amurensis*, *Swiftopecten swifti*, *Boreotrophon candelabrum*, *Neptunea* sp., *Keenocardium californiensis*, *Telmessus cheiragonus* and *Pagurus* sp.

At depths below 10m pebbly sand starts to predominate, replacing bedrock outcrops with a finer-grained and more dynamic substrate that results in a significant change in the associated floral and faunal communities. The algal community primarily comprises the brown kelp *Agarum cribrosum* with an under-storey of red seaweeds (*Odonthalia corymbifera*, *O. ochotensis*) and a basal tier comprising the coralline seaweed *Bossiella compressa*. The invertebrate assemblage also demonstrates a clear change with the incoming of the Japanese scallop *Mizuhopecten yessoensis*, the starfish *A. amurensis* (which is predatory on the scallop) and a number of species of gastropod including: *Patiria pectinifera*, *Crypthochiton stelleri*, *Neptunea* sp. and the sea cucumber *Cucumaria japonica*.

At water depths of 20-30m there is a gradual change in the seabed substrate from pebbly sand to fine sand and silt. Red seaweeds e.g., *Odonthalia corymbifera*, *Congregatocarpus pacificum* and *Lithothamnion* sp. dominate the algal assemblage while sponges such as *Myxilla incrustans*, *Homaxinella subdola* and *Suberites domuncula*, together with hydrozoans and polychaetes, form a significant component of the invertebrate assemblage.

Further offshore, in deeper waters (35-70m), seabed substrates are dominated by fine silts which support bivalves such as *Nucula. sakhalinica*, species of the genus *Yoldia*, *Macoma* and *Liocyma fluctuosa* and polychaete worms including *Onuphis iridescens*, *Praxillella praetermissa* and *Lumbrineris heteropoda*. Biomass and species in these deeper, silty substrates is noticeably lower than that recorded for community types closer to shore within Aniva Bay.

Trawl surveys in the nearshore and offshore areas of Aniva Bay (*e.g.* SakhNIRO, 2001a and 2004b) have also provided information on the presence of species of crustaceans, mainly of commercial value. Snow crab appears to be widely distributed in Aniva Bay although it occurs mainly in the south-eastern part of the region. In trawls undertaken by SakhNIRO (2001b) juvenile (non-commercially viable) snow crab males and females occurred in approximately 40% of the trawls undertaken, forming the main bulk of shellfish catch by number and frequency. Red king crabs (*Paralithoides camtschatica*) were observed in trawl surveys around the Aniva Peninsula area and within the central part of the Bay.

6.5.3 Marine Fish

The Okhotsk Sea sub-system is regarded as the richest fishery region in the world (Alekseev 2006). The volume of biological resources in the Sea constitutes 46% of all marine biological resources in the northern Pacific, with an estimated 7 million tonnes of cod, 2.5 million tonnes of herring and about 1.5 million tonnes of other seafood (e.g. molluscs and algae) (Shuntov 2001). Approximately 340 fish species inhabit the Okhotsk Sea (Froese & Pauly 2005). The main fish products are flounders, herring, capelin, halibut, pollock and crab. Walleye pollock (*Theragra chalcogramma*) is the most abundant commercial species in the Sea.

About 61 species of mesopelagic fish belonging to 53 genera and 33 families have been recorded in the Okhotsk Sea sub-system (UNEP 2006). There are known to be 16 species of squid – an important component of the food web of the Sea's ecosystem – belonging to nine genera and six families. Regarding groundfish, 50% are flatfish, 21% cods, and 11% sculpins. These three groups are a major determinant of the fish productivity of the Okhotsk Sea shelf, which is a fishing area of importance for a wide range of species.

As part of initial environmental investigations undertaken for the Sakhalin II Project, several acoustic and trawl surveys have been undertaken to assess commercial stocks of finfish and shellfish off northeast Sakhalin between September and October 1998, and September and November 1999 (SAKHNIRO, 1999 and 2001). The results showed that, in general, walleye pollock was the dominant species (51% of catch) off north-eastern Sakhalin. However within the Piltun Field, great starry flounder (*Platichthys stellatus*) was dominant (53%). The survey area and sample size was limited therefore was not possible to extrapolate the survey findings to assess fish populations over the wider area.

The walleye pollock (or mintai) is one of the key commercial fish species in the area. The species inhabits the entire water basin of the Sea of Okhotsk, migrating within the sea along the Kamchatka and northern sea coasts. There are considered to be three main spawning areas, on 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. Spawning varies both spatially and seasonally, changing according to location and climate, and occurs at the end of May to the beginning of June on Sakhalin's eastern coast. Mintai yearlings also 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 carried out in 2001 identified a total of 26 species of fish belonging to 21 genera and 13 families. 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 (58.33-83.33%) were the most common fish species recorded in the north-east Sakhalin shelf region.

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, chum or dog salmon, silver (coho) salmon, cherry salmon and the critically endangered Sakhalin taimen.

The recorded fish fauna of the north-east coastal lagoons consists of an assemblage characteristic of 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 and rudd (*Tribolodon* spp.), and the young of marine species such as saffron cod and pacific herring.

6.5.4 Coastal and Marine Birds

The bays along the north-east coast and nearshore marine waters provide habitat for a large number and diversity of breeding and migratory birds. The Piltun, Chaivo, Lunsky and Nabilsky Bays are the most important areas along the north-eastern coastline for waders and seabirds migrating through the area during the spring and autumn. Species 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 (2006). While some species are migrating through the region and may be seen for a very short period of time, others nest and feed in the area and are present for longer periods.

The Salmon Bay area of Aniva Bay is particularly well known as a staging ground, normally during the spring, for a wide range of waterbirds including large numbers of Bewick's and whooper swans and RDB waders. Similarly, Busse lagoon often supports significant populations of waterbirds on migration as well as white-tailed sea-eagle during the winter and on migration.

Surveys undertaken during the spring and autumn migratory periods indicate that these wetland habitats and nearshore coastal waters support significant populations of waterbirds. The exact number of migrating waterbirds that use the waters of Sakhalin Island is unknown, but is obviously higher than the number of locally 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.

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. 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 (*Aythya 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 (*Melanitta 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 Bar).

During the spring migration over 10 000 swans (Whooper Swans [*Cygnus Cygnus]* and Bewick's Swans [*Cygnus 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 also occur in much smaller numbers (e.g. Bean Goose (*Anser fabalis*) and White-fronted Goose (*Anser 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 coastlines 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 approximately 20 % of the world population of Aleutian terns (*Sterna aleutica*), about 5000 individuals, nest on the northeastern coast of Sakhalin Island (IUCN, 2007).

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

Coastal, or neritic species tend to occupy a narrow (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 and almost all waterfowl (especially diving ducks). 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 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 Sakhalin Island coast during these months. The north-eastern coast of Sakhalin Island is the 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 (LGL, 1996). 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, this means that at least 2 million seabirds migrate along the eastern Sakhalin Island in the autumn.

When Species Action Plans and Habitat Action Plans are developed within the framework of this BAP, the migrating and indicator birds will be taken into consideration where appropriate.

6.5.5 Marine Mammals

Data on the presence and distribution of marine mammals (excluding western gray whales) around Sakhalin has been obtained from a number of published sources, specific surveys for marine mammals in the project area and observations obtained during other marine surveys.

Project specific marine mammal surveys were undertaken for the north-east coastal waters of Sakhalin covering the Piltun-Astokhshkoye (PA) and Lunskoye areas during 1999 and 2000 (Sobolevsky, 2000 and 2001). These surveys noted the location and numbers of cetaceans and pinnipeds throughout the survey area. Surveys in the PA area specifically undertaken since the late 1990s to determine the distribution and abundance of western gray whales, also recorded the locations and numbers of other marine mammals encountered.

Marine mammal observations have also been recorded by dedicated Marine Mammal Observers (MMOs) on a number of multidisciplinary marine surveys within the PA, Lunskoye and Aniva Bay areas. The dedicated project survey information, combined with historic data provides an overview of cetacean and pinniped distribution around the eastern and southern coastal waters of Sakhalin. Information on population levels and distribution of species recorded from the north-east coast of Sakhalin and Aniva Bay, together with a summary of data obtained from the various marine mammal surveys and relevant literature is presented in Table 6.1.

6.5.5.1 Pinnipeds

Pinnipeds comprise seals, sea lions and walruses. Six species of pinniped inhabit the Sea of Okhotsk. Four of these species, ringed seals (*Phoca hispida*), largha seals (*Phoca largha*), ribbon seals (*Histriphoca fasciata*) and bearded seals (*Erignathus barbatus*) are "true" or "ice" seals. These species establish ice haul outs during the winter months and breed, nurse young and moult between March and May. When the sea ice retreats, ringed, largha and bearded seals may establish coastal haul outs, whilst some ribbon seals move out into the open ocean. These four species are all relatively abundant in the Sea of Okhotsk and are regularly hunted.

The northern fur seal (*Callorhinus ursinus*) and Steller's sea lion (*Eumetopias jubatus*) are the other two pinniped species that inhabit the Sea of Okhotsk. These eared seals do not establish coastal haul outs, coming ashore only for short periods. The Steller's sea lion is usually observed in the open sea during the summer months. In contrast, northern fur seals migrate through the coastal waters of Sakhalin Island during the spring (between May and June) and autumn (October, November and December) migrations between Tyulenii Island to the south of Sakhalin Island, and wintering places in the Sea of Japan.

6.5.5.2 Cetaceans

Nineteen species of cetaceans are known to occur in coastal and marine waters around Sakhalin Island. Populations of four of these species, the bowhead whale, North Pacific right whale, fin whale and western gray whale have been greatly reduced through decades of mechanised and unregulated 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. The cetacean species most likely to be encountered near the Lunskoye and PA Fields in summer-autumn are western gray whales, minke whales, killer whales, harbour porpoise, and common dolphin. Beluga whales are most likely to be seen during their spring migration.

Table 6.1 Summary of data on marine mammals occurring around Sakhalin Island, including observations from surveys undertaken in relation to the Sakhalin II Project.

Species	Known Distribution in Sakhalin Waters & Project Area	Conservation Status
Phoca hispida ringed seal	Abundant within the Sea of Okhotsk (population 650,000-750,000) and is found along the entire eastern coast of Sakhalin (population 130,000). Observed regularly in Niysky, Lunsky, Chaivo and Piltun Bays at the mouths of estuaries, rivers, straits and channels connecting lagoon habitats with the sea. Aggregations of between 20 and 70 individuals are often recorded. Not generally observed in coastal waters of the south or within Aniva Bay.	Classified on the IUCN Red List as "Least Concern" in 1996. Not listed in the Red Book of the Russian Federation

Species	Known Distribution in Sakhalin Waters & Project Area	Conservation Status
Phoca largha largha or spotted seal	Largha seals, also known as spotted seals, are considered to be abundant within the Sea of Okhotsk (population of 180,000 – 240,000) and have been observed throughout the year along the north-eastern coast of Sakhalin Island. The Sakhalin Island population is estimated at 30,000-40,000 During the winter months, seals are concentrated along the northern third of the Island and in Terpeniya Bay. Pupping rookeries are generally located offshore on drift ice, especially on hummocked floes. 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 (e.g. Piltun, Chaivo and Lunsky). SakhNIRO surveys recorded up to 200 individuals at the mouth of Piltun lagoon and 150 at Lunsky (SakhNIRO, 1999). Small numbers of Largha seals are generally observed in Aniva Bay.	Classified as Least Concern on the IUCN Red List. Not listed in the Red Book of the Russian Federation.
Histriophoca fasciata ribbon seal	This species is widely distributed but occurs mainly in north-east coastal waters with a peak from Lunsky Bay to Chaivo Bay. Ribbon seals are present within southern waters but have not generally been observed during surveys of Aniva and Terpeniya Bays (SakhNIRO, 1999; DVNIGMI, 2001a). Average population estimates, based upon aerial survey data, are in the region of 350,000 to 450,000 for the Sea of Okhotsk and 110,000 for the waters off eastern Sakhalin (Fedoseev, 2000 in LGL 2003). During the winter and spring, the majority of animals are concentrated offshore on hummocked flows. Rookeries may be established 200 to 240km from the ice edge. Ribbon seals are not known to establish coastal rookeries. When the ice melts the seals convert to a completely pelagic lifestyle, and are distributed across the entire Sea of Okhotsk.	Classified as Least Concern in the IUCN Red List and not included in the Red Book of the Russian Federation
Erignathus barbatus bearded seal	There are estimated to be between 200,000 and 250,000 bearded seals in the Sea of Okhotsk, and approximately 60,000 to 75,000 in eastern Sakhalin waters. As benthic feeders, the distribution of bearded seals is restricted to depths of less than 200m (LGL 2003). Bearded seals generally tend not to congregate on ice, but occur singly on the shear zone between shore-fast and drift ice. The main reproductive groups are observed between Cape Elizabeth, at the north of the island, and 50^{o}N (approximately halfway down the island). During the summer months, animals are scattered along the north-eastern and western Sakhalin coasts in low numbers, occurring sometimes in small rookeries. Aniva Bay falls within the geographic range of the bearded seal, but currently the size of the population is unknown.	Classified as “Least Concern” on the IUCN Red List and not listed in the Red Book of the Russian Federation

Species	Known Distribution in Sakhalin Waters & Project Area	Conservation Status
Callorhinus ursinus northern fur seal	Populations are estimated to be as high as 120,000 (LGL, 2003). Northern fur seals migrate from the Sea of Japan to the Sea of Okhotsk in the spring, returning during the autumn. Up to 25,000 to 30,000 animals use that route annually (Kuzin, 1999 in LGL 2003). The population spends summer mainly along the south-eastern coast of Sakhalin Island. 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, 2001b). 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 Terpeniya) where they were abundant. Approximately 75,000 to 80,000 individuals were observed at the rookery on Tyulenii Island, some 20km southeast of Cape Terpeniya, and in adjacent waters eastward of the Island (Vladimirov, 2002 in LGL 2003).	Classified as “Vulnerable” on the IUCN Red List but not considered to be rare in the Sea of Okhotsk. Not listed in the Red Book of the Russian Federation

Species	Known Distribution in Sakhalin Waters & Project Area	Conservation Status
Eumetopias jubatus Steller's sea lion	Steller's sea lion is distributed in two populations around the North Pacific Ocean rim from northern Hokkaido, through the Kuril Islands and Okhotsk Sea, Aleutian Islands and the central Bering Sea, southern coast of Alaska and Channel Islands of California. 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). The only known breeding rookery on Sakhalin is located on Tyulenii Island (Kuzin and Naberezhnykh, 2002 in LGL, 2003). In 2005, more than 1 500 adult and 407 newborn animals were recorded at the only known breeding rookery on Sakhalin, located on Tyulenii 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 southwestern coast of Sakhalin Island. Kamen Opasnosti Rock is used throughout the year, with up to 700 animals congregating there. The haul out at Kuznetsova Cape is usually established between autumn and winter each year and approximately 350 to 500 animals have been observed at this location (LGL, 2003). A smaller haul out is also present on the harbour breakwater at Nevelsk (on the western coast, 50km south of Kholmsk). 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. They are often sighted in Aniva Bay (Sobolevsky, 2000). Steller sea lions may occur, in small numbers, near off north-east Sakhalin although 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 observed during Sakhalin Energy construction activities and it was considered a fairly common species for the project area. It was encountered in all operation areas and during transit, however most of these observations were recorded in Lunskoye area (Sakhalin Energy, 2006). In winter, Steller's sea lions migrate from the Okhotsk Sea to the south. Many of them spend the winter on southern Kurily, Hokkaido, and adjacent small islands (Mizuno *et al*., 2002). These migratory movements have been confirmed by satellite tracking. Individual Steller's seals marked in Hokkaido have also been observed at the haul out site at Nevelsk.	Listed as "Endangered" within the IUCN Red List and the Red Book of the Russian Federation

Species	Known Distribution in Sakhalin Waters & Project Area	Conservation Status
Eubalaena japonica North Pacific right whale	Current population estimates for the species are largely speculative and range from 100 to the low thousands, however, most authorities tend to use 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. Surveys conducted by SakhNIRO in September 1998 and DVNIGMI in July 2001, did not report the presence of the species (LGL, 2003). In 2005, during Sakhalin Energy construction activities, two right whales were observed once at Lunskoye area on 13 October, at a distance of 2000 m from the vessel.	Listed as Endangered by the IUCN and in the Red Book of the Russian Federation
Balaenoptera physalus fin whale	It has been estimated that there are approximately 2,700 individuals in the Sea of Okhotsk, 400 to 600 of which inhabit the waters of eastern Sakhalin Island during the summer and autumn (Vladimirov 1994). Although predominantly a pelagic species, individuals sometimes occur in shallow water, both along the coast and offshore and their occurrence in Aniva Bay is possible. In 2005, during Sakhalin Energy construction activities, a total of 19 fin whales were observed (Sakhalin Energy 2006). Most of them occurred far offshore in the navigational corridors by vessels on transit.	Classified as Endangered by the IUCN and “Vulnerable” in the Red Book of the Russian Federation
Balaenoptera acutorostrata minke whale	The most numerous of the baleen whales remaining in the Sea of Okhotsk with approximately 19,000 individuals being reported (Buckland *et al*., 1992). Minke whales are found along the entire eastern coast of Sakhalin Island and have also been observed in Aniva Bay.	Classified as “Near Threatened” by the IUCN. Not listed in the Red Book of the Russian Federation
Eschrichtius robustus western gray whale	East coast, especially off Piltun and Chaivo Bays. Not observed within Aniva Bay.	Classified by the IUCN as “Critically Endangered” and as “Endangered” within the Red Book of the Russian Federation
Delphinapterus leucas white whale	The population is estimated at 18,000-20,000 (IWC 2000), however, their distribution is not uniform. Beluga whales inhabit cold arctic waters and are typically observed close to the ice edge. Beluga do not permanently inhabit the waters off eastern Sakhalin, but are present in small numbers (400-500 individuals) in the north-eastern and northern parts of the Island only during spring migration. Nyisky Bay is likely to be the southern limit of the distribution of this species in the Okhotsk Sea (TINRO, 1996).	Classified as “Vulnerable” by the IUCN. Not listed in the Red Book of the Russian Federation
Physeter macrocephalus sperm whale	This species occurs throughout the eastern and southern regions of the Sea of Okhotsk but the waters offshore from the Kuril Islands appear to be the centre of distribution for this species. During the summer and autumn period, the total population of sperm whales within the Sea of Okhotsk is estimated to be between 1,000 and 3,000 individuals with approximately 200 to 300 sperm whales inhabiting waters seasonally along the eastern Sakhalin Island coast. Sperm whales are most frequently seen around Cape Terpeniya, Cape Aniva and adjacent waters.	Classified as “Vulnerable” by the IUCN. Not listed in the Red Book of the Russian Federation

Species	Known Distribution in Sakhalin Waters & Project Area	Conservation Status
Orcinus orca orca (killer whale)	Population estimate of 2,000 to 3,000 in the Sea of Okhotsk. Orcas have been observed along the entire eastern coast of Sakhalin Island, and were the only cetacean, other than the western gray whale, to be regularly recorded during aerial surveys conducted in 1999 and 2000 (Sobolevsky 2000). Other survey data have shown the species to be present within Terpeniya Bay, Aniva Bay, La Perouse Strait, Cape Aniva and Cape Krilion.	Classified by the IUCN as being "Conservation Dependent" Not listed in the Red Book of the Russian Federation
Berardius bairdii Baird's beaked whale	This species is endemic to the North Pacific. Eastern and western Pacific populations are migratory, arriving at the continental shelf in summer and autumn. This species usually prefers deep continental shelf waters, but has been observed in shallower waters in the Sea of Okhotsk. Approximately 1,000 to 1,500 animals occur within the southern Sea of Okhotsk. It is estimated that about 250 to 300 individuals visit southern Sakhalin, mainly in Aniva Bay and Cape Aniva, although during project surveys this species was not observed in Terpeniya Bay and Aniva Bay (LGL Ltd. 2003).	Classified by the IUCN as being "Conservation Dependent" Not listed in the Red Book of the Russian Federation
Ziphius cavirostris Cuvier's beaked whale	Beaked whales generally occur in non-continental shelf waters greater than 200m in depth. Most records of beaked whales come from the continental shelf edge and slope and around oceanic islands where the seabed shelves rapidly. This species was observed in northern Aniva Bay during studies conducted in Aniva Bay, Cape Aniva and Cape Krilion between August and September 2001 (Vladimirov, 2002). Its presence within Aniva Bay fits in with the observed preferred marine habitat of the species, as water depths rapidly drop off from 60m in the Bay to 2,000m at a distance of 50-100km to the east. During Sakhalin Energy construction activities in 2005, three Cuvier's beaked whales were observed during transit from Vostochny port to the northeast Sakhalin coast. Two of these sightingsoccurred on the southeast coast of Sakhalin Island. (Sakhalin Energy, 2006).	Classified by the IUCN as Data Deficient and as "Rare" within the Red Book of the Russian Federation
Phocoenoides dalli Dall's porpoise	With an estimated population of between 20,000 and 25,000 individuals within the Sea of Okhotsk, this species is considered to be one of the most numerous cetaceans in the region. Approximately 3,500 to 4,000 Dall's porpoises are thought to occur in eastern Sakhalin Island waters, with most sightings occurring between Terpeniya and Aniva Bays.	Classified by the IUCN as being "Conservation Dependent" Not listed in the Red Book of the Russian Federation

Species	Known Distribution in Sakhalin Waters & Project Area	Conservation Status
Phocoena phocoena harbour porpoise	Harbour porpoise are usually observed in the waters of the inner continental shelf, along the western coast of Kamchatka, the eastern coast of Sakhalin Island and north of the Shantarskie Islands (TINRO, 1996). It is not considered to be rare within the Sea of Okhotsk. The species was the second most abundant cetacean recorded in Terpeniya and Aniva Bays (SakhNIRO, 1999), and DVNIGMIs 2001 surveys recorded harbour porpoise in Poronaysk Port in Terpeniya Bay and within Aniva Bay. Surveys have also confirmed the presence of the species further north, with Sakhalin Energys 2003 survey programme (TINRO, 2003) reporting that the harbour porpoise was the most commonly observed species in the vicinity of Lunsky Bay during August (73 of 103 cetaceans) (LGL, 2003).	Classified by the IUCN as being “Vulnerable” Not listed in the Red Book of the Russian Federation
Lagenorhynchus obliquidens Pacific white-sided dolphin	The Pacific white-sided dolphin is considered to be one of the most numerous cetaceans in the north-western Pacific Ocean, being found in large aggregations averaging 90 individuals but also being observed in groups of up to 3,000. Within the Sea of Okhotsk, the dolphins appear to be concentrated towards the south with frequent sightings being recorded along the Kuril island arc, La Perouse Strait, Cape Aniva and Aniva Bay (LGL, 2003).	Classified by the IUCN as being “Least Concern” Not listed in the Red Book of the Russian Federation
Delphinus delphis short-beaked common dolphin	The Short-beaked common dolphin is considered to be the most common dolphin in offshore waters (Perrin 2002 in LGL 2003) with a world population of several million. Within the Sea of Okhotsk, short-beaked common dolphins are mainly concentrated in the south along the Kuril island arc and along the west coast of Kamchatka. Short-beaked common dolphins were the fourth most common species recorded during SakhNIRO’s 1998 baseline studies conducted within Aniva Bay, with the dolphin accounting for 7% of cetacean observations. Studies conducted between August and September 2001 in La Perouse Strait, Aniva Bay, Cape Aniva and Cape Krilion reported the species as being the second most commonly observed cetacean, having a sighting rate of 16% (Vladimirov, 2002).	Classified by the IUCN as being “Least Concern” Not listed in the Red Book of the Russian Federation
Tursiops truncatus bottlenose dolphin	The bottlenose dolphin is uncommon in the Sea of Okhotsk, but surveys have observed the species in the waters around Sakhalin Island. Studies conducted between August and September 2001 in La Perouse Strait, Aniva Bay, Cape Aniva and Cape Krilion noted the species, which accounted for 2% of cetacean observations.	Classified by the IUCN as being “Data Deficient” Not listed in the Red Book of the Russian Federation
Globicephala *macrorhynchus* short-finned pilot whale	In the Sea of Okhotsk, short-finned pilot whales have been observed in the waters around the Kuril Islands, La Perouse Strait and Cape Aniva on the continental shelf break and inshore waters. The species migrates northwards during the spring and summer, and southwards in the autumn and winter following the migration of squid, which are their target prey.	Classified by the IUCN as being “Conservation Dependent” Not listed in the Red Book of the Russian Federation

Species	Known Distribution in Sakhalin Waters & Project Area	Conservation Status
Lissodelphis borealis Northern right whale dolphin	Northern right whale dolphins are generally observed in the deep, temperate waters of the North Pacific, but they have been reported within the southern Sea of Okhotsk, including the waters around the Kuril Islands, the south-west coast of Kamchatka, La Perouse Strait, Cape Aniva and east of Terpeniya Bay (TINRO, 1996). Northern right whale dolphins were not observed during the studies conducted by SakhNIRO in 1998, DVIGIMI in July 2001.	Classified by the IUCN as being “Least Concern” Not listed in the Red Book of the Russian Federation
Balaena mysticetu s bowhead whale	Bowhead whales occur in only two areas of the Sea of Okhotsk, in the north-east (Gizhiginskaya and Penzhinskaya bays), and the west (near Shantarskie Island and in Konstantin, Ulbanskii, and Tugurskii bays). 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). The species has not, however, been recorded around the island outside of these months and has never been sighted in the waters around the island’s south or south-eastern coasts. 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.	The IUCN categorises the species generally as “Lower Risk-Conservation Dependent”, but also designates distinct populations independently. The Sea of Okhotsk population is classed as Endangered. Listed as “Endangered” in the Red Book of the Russian Federation.
Balaenoptera borealis sei whale	Sei whales have a wide distribution and can be found in the Atlantic, Indian and Pacific Oceans. Sei whales occur in the open ocean and in coastal waters but usually remain beyond the 100m depth contour. In summer, Sei whales penetrate into the southern and south-eastern Sea of Okhotsk through the various straits of the Kuril Islands. The estimated population in the Okhotsk Sea is 200-400 (TINRO, 1996). Surveys carried out by DVNIGMI in 2001 recorded individual sei whales near Lunsky Bay, Poronaysk Port in Terpeniya Bay, and Aniva Bay.	Classified by the IUCN as “Endangered” and “Rare” in the Red Book of the Russian Federation
Kogia breviceps pygmy sperm whale	Pygmy sperm whales have been sighted within the northern and open deep-water areas of Aniva Bay, La Perouse Strait, Cape Krilion and Cape Aniva (Vladimirov, 2002 in LGL, 2003). Thought to be an oceanic species, preferring temperate and tropical offshore waters beyond the edge of the continental shelf.	Classified by the IUCN as being “Least Concern” Not listed in the Red Book of the Russian Federation

6.5.5.3 Western Gray Whale – (WGW)

The western Pacific population of gray whales (*Eschrichtius robustus*) is one of only two surviving populations of this species in the world. Both populations were brought near to extinction by commercial whaling during the nineteenth and twentieth centuries. The eastern Pacific population, which migrates annually between Mexico and Alaska/northeastern Siberia, has recovered substantially following the international ban on the hunting of this species and now numbers about 20,000 individuals. By comparison, the western Pacific population, of western gray whale, which migrates between eastern Russia and China, is extremely small.

The western gray whale is listed as a Category I species (endangered) in the Red Data Book of the Russian Federation (Red Data Book of the Russian Federation, 2000) and this population was recently reclassified as “critically endangered” (facing an extremely high risk of extinction) by the International Union for the Conservation of Nature (IUCN) (Hilton-Taylor, 2000; Weller and Brownell, 2000).

Significant research and monitoring work has been undertaken by Sakhalin Energy and its contractors to gain a better understanding of the population status and ecology of the western gray whale in its feeding grounds off north-east Sakhalin. This work was launched in 1997 and has been undertaken for Sakhalin Energy and Exxon Neftegas by independent Russian and international scientists and is subject to third-party verification. Much of what is now known about this species is the direct result of the programme of systematic and detailed research that contributed significantly to the body of scientific knowledge about this unique whale population.

Data generated by the Sakhalin Energy and Russian-US teams provides up to date observations on the WGW population. Photo ID work by the Sakhalin Energy research team identified 120 individual WGW in 2006, with a further 6 possible individuals recorded1. This is the largest number of individual WGW identified in a single season and helps to raise lower population estimates. Of these it is estimated that there are only 25-35 reproductive females. The chance of population recovery for the western gray whale is likely to be constrained by a variety of demographic factors. Small populations are inherently more vulnerable than large populations to random events and changes in parameters such as sex ratio or birth rate. The observed number of western gray whale calves seen between 1997 and 2006 is very variable and has ranged from a low of two in 1997 to a high of 11 in 2003. The estimate of annual population increase rate increased from 3.3% per year in 2004 to 5.2% per year in 2005 (IISG-IUCN Report, 2006). Both photoidentification studies showed that the calving rate increased compared with previous years, with intervals shortened from 3 to 2 years (Yakovlev and Tyurneva, 2006). This 2-year interval is comparable with that for eastern gray whales.

Although it has not been confirmed, it is thought that the western population overwinters and breeds in the South China Sea. The whales then migrate to their feeding grounds off the north-eastern coast of Sakhalin during a feeding season that extends from the late spring to autumn. It is thought that little to no feeding occurs during the breeding and migration periods and so the whales obtain the great majority of their annual calorific intake during the feeding season off Sakhalin (and possibly a few other as yet unknown areas). The WGW predominantly feed on pelagic mysid shrimps and benthos (mainly amphipod and isopod crustaceans) that they obtain largely through sifting seabed sediment through their baleen plates.

There are, at present, only two known main feeding grounds used by the western gray whale:

- A primary feeding area in the shallow coastal waters off Piltun Lagoon. The PA-A and PA-B offshore platforms are located approximately 12km and 7km respectively eastward of the offshore side of the southern portion of the feeding ground; and
- A secondary offshore feeding area in the Chaivo region, some 20 to 30km south of PA-A.

Results from the photo-identification studies have shown frequent movements of western gray whales between the two feeding areas (Yakovlev and Tyurneva, 2004). Seasonal shifts in whale distribution are likely to occur as whales reduce and deplete their own prey habitat (i.e. top-down effects) or as the biomass and quality of prey fluctuates throughout the season (i.e. bottom-up effects). Besides the observations of whales in the known Piltun and Offshore feeding area, small groups of whales have also been observed further to the north in the shallow nearshore waters off the coast of Okha and in the waters of Elizabeth Cape. Two of these whales were identified as new individuals that had not been observed in the Piltun or Offshore feeding areas in previous years (Yakovlev and Tyurneva, 2006). In 2006 a small

1 The recent 2007 data has 132 individuals recorded in 2007 plus 5 in the temporary catalogue.

number of whales were also observed feeding in the shallow nearshore waters off the coast of Chaivo Bay (Vladimirov *et al*., 2007).

Prey studies conducted throughout the Piltun area since 2001 demonstrate high but patchy prey abundance. Waters typically not used by gray whales for feeding were characterised by lower concentrations of potential gray whale prey or by unsuitable species for feeding (i.e. sand dollars). Studied for the first time in 2002, the Offshore feeding area was found to be a highly productive area dominated by tube-dwelling benthic ampeliscid amphipods, and was comparable in species composition and richness to eastern gray whale feeding areas in the Bering and Chukchi seas. The multiple year results of the benthic studies show the existence of a very strong relationship between distribution and abundance of whales and the availability of prey (Fadeev, 2007).

Since gray whales have a relatively short season in which to feed, any change in distribution or quantity of their prey could result in reduced food consumption. Whales that do not eat enough may lose weight, making them less able to complete their long migration, or for females less able to carry a foetus to term or suckle it after birth.

7 Biodiversity Priorities

7.1 Determining Priorities

7.1.1 Introduction

As stated previously, the objective of the BAP is to miminise the potential impact of long-term project activities and to maintain biodiversity interests. While measures have been developed across the project to minimise environmental impacts associated with all project activities, the focus from a biodiversity perspective relates to those interests that are considered to be of significance and that may be particularly susceptible to the disturbance generated by the project. Providing a focus to the BAP and undertaking some form of prioritization is necessary as it would not be practical, or achievable, to undertake actions that would lead to the conservation of all biodiversity that could potentially be affected by the project. To do so would require an unprecedented amount of data on species population levels, distribution and change in relation to project activities and continuous survey and monitoring. It is also apparent from the ecological work undertaken that much of the existing biodiversity within the potential footprint of the project has been significantly modified by human activity and that relatively common and generally widespread species dominate the various habitats.

As detailed in the previous section, Sakhalin Island has little in the way of endemic species, i.e. those unique to Sakhalin and its biodiversity may be characterised as comprising species that are generally well distributed throughout Far Eastern Russia. However, the location of the island at the meeting point between the northern boreal province and the more temperate does contribute to a unique mixing of species and habitat types at the southern end of the island.

The determination of priorities for action may be undertaken via a number of routes and through the use of different criteria. The basic assumption though is that the developed criteria should reflect relevant priorities and approaches taken elsewhere and must also relate to the potential effects of the project itself (i.e. there is little point in identifying priorities for which project impacts do not exist). The results of this prioritisation process will be those biodiversity interests that are considered significant (i.e. of value) and which may therefore be the focus for assessment and the development of management action (including the development of specific plans where these are considered appropriate).

As with the development of BAPs at a variety of levels (e.g. national, local, company etc.) one of the key criteria for priority selection is the value placed on species and habitats and the protection afforded to them via legislation. Species and habitats that are considered to be under threat, either in Sakhalin or Russia, are protected by a number of different mechanisms, although there remain a number that are inadequately safeguarded. Mechanisms for protection include designated sites of nature conservation importance via national legislation and a series of Red Lists covering a variety of taxonomic groups. These mechanisms can be used as a basic framework for identifying priorities for the Sakhalin II Project BAP and have been used in determining the significance of potential impacts during the environmental impact assessment process. However, rarity value and protected sites alone do not necessarily provide adequate representation of all biodiversity interests that may be considered of value (and which therefore may be of management priority). In this context other considerations that need to be taken into account in determining priorities are:

- Threatened species or ecosystems (including those that may not be covered by national legislation or fully protected);
- Areas of ‘natural’ or relatively intact habitat;
- Habitats and areas supporting high species/habitat diversity;
- Environments sensitive to potential impact (e.g. some wetland types);

- Species and habitats where significant declines in populations and extent of area have been documented and may be continuing;
- Species of economic or social value; and
- Areas and habitats that are considered important for providing and maintaining ecological processes and ecosystem services.

7.1.2 Threatened Species and Ecosystems

Under Russian state legislation, areas of particular importance for the species and habitats that they support may be designated and protected, although in some cases designation may not necessarily be specifically for nature conservation or biodiversity purposes. In this respect, intact areas of natural habitat outside of designated sites may be of greater biodiversity value than sites afforded protection through legislation.

There are almost fifty protected areas on Sakhalin Island, including one *zapovednik* (a strictly protected area with no public access), eight *zakaznik*s (a protected area with restricted public access), and more than 40 *pamyatnik prirody* (nature monument or protected area small in size created specifically for the protection of a natural object and its immediate surroundings). Only *zapovedniks* are effectively protected because of the allocation of security and scientific research resources. No institution is formally responsible for *zakazniks* and nature monuments and their borders are in many instances doubtful. Notwithstanding, Sakhalin's protected areas are currently being catalogued and described to promote conservation efforts.

The protected areas of Sakhalin Island cover about 5,000 km^2 (about seven per cent of the island territory). The largest areas are concentrated in the sparsely inhabited northern part of the island. South of the fiftieth parallel, Poronaysky *zapovednik*, Makarovsky *zakaznik* and Izyubrovy *zakaznik* are the most significant sites.

The Makarovsky reserve is situated to the east of Kamyshovy Mountain Range (west of the town of Makarov) and includes the upper parts of the Makarova, Lesnaya and Lazovaya river basins. The reserve was established in 1992, has a surface area of 45,732ha and is situated on land assigned to the Federal Forest Reserve. The reserve was originally designated as a hunting and forestry area, specifically to protect and facilitate the restoration of some game species populations. Hunting within the reserve area was prohibited; but fishing as well as the culling of certain animal species and recreational activity (when approved by reserve management) were permitted. In 2000, the classification status of the Reserve was changed and the area was designated as a Biological Reserve. The Makarovsky reserve now acts as an area for the conservation of rare and endangered species of plants and animals, including economically valuable animal species, thereby safeguarding the mountain forest biotopes of the southern part of Sakhalin Island.

The Izubrovy Reserve is situated in the Dolinsk district, between the rivers Ai and Firsovka. The Reserve was originally established in 1988 by decree of the Sakhalin Executive Committee. It has an area of 40,000ha and was established for the protection of red deer, sable and mink. As with the Makarovsky Reserve, the Izubrovy Reserve was established originally as a hunting and forestry area and the designation was changed in 2002 to make the area a Biological Reserve. The Department for Protection, Control and Regulation of Use of Sakhalin Oblast Game Animals Committee now manages the Reserve.

The potential establishment of new protected areas (most likely reserves – *zakaznik*s, especially near ROW) can be proposed in specific HAPs and SAPs within the framework of this BAP.

Russia has adopted the international Red List process for identifying species considered of nature conservation concern. Species covered in the Red List books are protected under national and local legislation

The Red Data Book of the Sakhalin Region (i.e. including Sakhalin Island and the Kuril islands) includes 168 species of animals (comprising 105 species of birds, 29 species of other vertebrates, and 34 species of invertebrates), 214 species of plant (comprising 181 species of vascular plants, 24 species of bryophytes and 9 species of algae), as well as 56 species of fungi and lichens. Of those species listed in the regional Red Data Book, 301 species (comprising 12 mammals, 97 birds, 7 fish, 20 invertebrates, 112 vascular plants, 12 bryophytes, 7 algae, 20 lichens and 14 fungi) are know to occur on Sakhalin Island or have been recorded along its coast. Fifty-six animal species, 29 plant species and 8 lichen and fungal species that are present on Sakhalin Island are also included in the Red Data Book of the Russian Federation and thus protected at federal level. Both the federal and regional Red Data Books are legal documents and specify animal, plant and fungal species protected by law.

For the purposes of the BAP, all areas and species that are protected under federal and Oblast legislation are considered to be of significance and a priority for potential management actions. These species and areas have been the focus of concerted protection and mitigation measures during the development of the Sakhalin II Project as a direct result of the recognition of their significance through the environmental assessment process. Many species that are protected by legislation are also those for which significant decline in populations and contraction in distribution has been documented and may be continuing.

7.1.3 Areas of Intact Habitat

To date there has not been an Island-wide assessment of the extent, distribution and status of the different habitat types present on Sakhalin Island. It is therefore difficult to assess the comparative value of habitats and determine whether particular habitat types are of greater or lesser significance. However, given the extensive modification of habitats by man (e.g. felling of original forest cover and planting of non-native trees for commercial timber) it is apparent that surviving areas of natural habitat are likely to be of significance from an ecological and biodiversity perspective.

The fragmentation of areas of contiguous habitat is considered to be one of the main causes of biodiversity loss. Retaining such areas and minimising the potential ecological effects of fragmentation is therefore of importance. This issue is considered in greater detail in Section 8.2.1.

The conservation of habitat that has not been or only partially affected by human activities is considered to be a priority particularly as these areas may retain much of their ecological function and provide habitat for species that are either dependent on a specific habitat type or that may be particularly sensitive to effects such as fragmentation and human disturbance.

No specific analyses of the extent and distribution of areas of intact habitat within the project footprint have been undertaken. However, the siting of facilities and routing of the onshore pipeline was undertaken to avoid areas of relatively intact habitat (e.g. areas of remaining dark coniferous forest). For some sections of the onshore pipeline, it was not possible to avoid some blocks of forest habitat, particularly in the more mountainous areas to the west of the OPF and in the Makarov area. Following construction work the priority in relation to this aspect is to prevent or minimise further potential deterioration of intact blocks of habitat that may have been initially influenced by the project. Targeting such areas to determine and assess the extent of project-related disturbance and also to establish appropriate mechanisms to mitigate for observed impacts is therefore considered a priority.

The issue of retaining areas of intact habitat is of particular relevance with regard to natural climax vegetation types and those that are sensitive to fragmentation. On Sakhalin this suggests that action and priority should be focused upon forest habitats, particularly given that much of the original or even old secondary forest on the island has been lost due to exploitation for timber. Forest habitats that are considered to be of importance in this context are listed below and actions to deal with the potential effects of fragmentation and disturbance on these habitats are viewed as a priority:

- Dark coniferous forest throughout the island
- Larch-ledum forest, particularly in the northern half of the island; and
- Mixed deciduous-coniferous woodland along main river valleys.

Areas of the island where largely unmodified examples of these habitats still exist, particularly in association with each other are also likely to constitute areas of high biodiversity value and the overlap between these aspects is further detailed in relation to the following factor.

7.1.4 Areas of High Biodiversity Value

There has been no systematic mapping at an Island level and identification of areas of species richness / diversity, although the location of sites supporting important assemblages of rare species is relatively well known (e.g. the Pugachevo mud volcanoes, Terpeniya Peninsula). In relation to the Sakhalin II Project, survey work, as reported in Section 6, has revealed that several areas support significant species assemblages and are clearly of biodiversity importance. These are (from north to south):

- The coastal lagoons of the north-east (including Chaivo peninsula) are important as staging grounds for migratory birds during the spring and autumn and also for breeding wetland waterfowl and raptors, including several internationally rare species. The lagoons also provide habitat for coastal fish species, acting as a nursery area for young, and there may be a significant, but as yet, undescribed interaction between the lagoons and nearshore coastal habitats;
- The dark coniferous forests in the Nogliki-Dolinsk region as representative areas of intact forest and for breeding birds such as Siberian spruce grouse and possibly long-billed murrelet;
- Forest habitats in the Makarov area which support a diverse assemblage of birds including several rare (RDB) species and also, in some locations, diverse floras;
- Rivers with intact forest and riparian woodland often support a wide range of plant species within a relatively small area due to the linear transitions between habitat types. Rivers in catchments that are still relatively well wooded and largely unaffected by timber extraction and human development also tend to support higher diversity freshwater faunas (including fish) and abundant salmon populations; and
- Aniva Bay as a staging area for migratory birds during the spring and for its diverse shallow marine fauna and flora.

It is also apparent from the project surveys, available literature and information from experts consulted during the assessment and monitoring process that much remains to be discovered about the distribution and extent of some species groups. As with protected sites, it can also be stated that known areas of ecological value were taken into account during the design phase for the project and these have been avoided wherever feasible during the planning and construction of the project facilities.

7.1.5 Habitats and Species Sensitive to Potential Impact

To varying degrees all habitats and species are sensitive to the effects of human activities, usually with detrimental ecological consequences. Determining in detail the potential sensitivity of an individual species or habitat to the effects of human disturbance is difficult as responses to events and activities can be very variable, uncertain and complex. However, there is sufficient understanding available to indicate that a number of conditions and factors are of significance in relation to determining potential sensitivity and these are useful in identifying possible priorities with respect to biodiversity management:

- Habitats and ecological processes for which recovery from disturbance is slow or unlikely to occur (i.e. some habitats may be particularly sensitive to changes in physical conditions and even small non-natural disturbance may shift systems into a different state – the natural balance may be upset);
- Species that are known to undergo significant behavioural change as a result of human activity. This effect varies widely, but for some species (notably birds and mammals), human presence and activity can adversely affect breeding behaviour and success;
- Species that are reliant on the maintenance of specific habitat associations (e.g. Siberian spruce grouse and dark coniferous forest)
- Animal or plant species, subspecies or varieties that are rare or uncommon, either internationally, nationally or more locally;
- Endemic species or locally distinct sub-populations of a species;
- Species on the edge of their range, particularly where their distribution is changing as a result of global trends and climate change; and
- Species whose populations are in decline and that are considered to be vulnerable to further change in supporting conditions.

Taking into account these basic criteria a number of key biodiversity aspects that are considered to be particularly sensitive to the potential effects of the Sakhalin II project have been identified. These are (in no particular order):

- Remaining primary and older 'natural' secondary forest habitats that could be vulnerable to further fragmentation and/or habitat loss (e.g. dark coniferous forest, larch-ledum forest in north Sakhalin; spruce-fir and mixed forests in the Makarov mountains);
- Wetland ecosystems, particularly peat bogs where disruption to hydrological processes may significantly alter vegetation characteristics;
- Shallow marine and coastal waters in areas where oil pollution incidents may cause
- Breeding bird species and assemblages that are vulnerable to human activity and habitat loss (e.g. localized populations of ground nesting forest birds;
- Local populations of rare and protected plant species (e.g. known locations for RDB listed plants that are in close proximity to project activities);
- Known assemblages of rare species and the habitat areas supporting these species (e.g. the coastal lagoon and wetland systems of the Chaivo Peninsula); and
- Species populations that are in decline, small and/or dependent for survival on very localized habitat conditions (e.g. western gray whale, Sakhalin taimen).
-

The potential establishment of seed banks of rare plants and endemics can be proposed in specific HAPs and SAPs within the framework of this BAP.

When Species Action Plans and Habitat Action Plans are developed within the framework of this BAP, the migrating and indicator birds will be taken into consideration where appropriate.

7.1.6 Species of Economic or Social Value

People derive benefits from biodiversity in various ways, including:

- Enjoyment of nature and natural surroundings (e.g. bird watching);

- Commercial and recreational hunting, fishing and collection of edible wild foods (e.g. berries, fungi);
- Informal recreational activity (e.g. countryside walking); and
- Use of habitat areas for the purpose of learning about wildlife.

On Sakhalin, the main value placed on wildlife and habitats is related to hunting, fishing and the collection of forest products. Many local people actively collect berries, medicinal plants and fungi for personal use and small-scale commercial enterprise. Fishing is widely practiced and is of great importance to many islanders, particularly the indigenous people of the north-east, as it provides a significant source of food.

The majority of animals that are now hunted for meat or their fur are widespread and relatively common or have been introduced specifically for their economic value and do not form part of the native fauna. From a biodiversity perspective some of these species are generalists that are found across a wide range of habitat types and areas (e.g. brown bears) or confined to certain habitat types (e.g. mink, otter and muskrat in wetland/riverine habitats). Regardless of these ecological attributes, thriving populations of many of these species are reliant on the maintenance of both good habitat quality and appropriate management of hunting effort.

For the purposes of the BAP and addressing Sakhalin II project biodiversity issues it is not considered that there are any species for which specific actions relating to hunting should be developed. However, it is apparent, as indicated above, that the management of activities to maintain habitat quality and function will also benefit species that are of hunting value.

On Sakhalin the species group with the most important economic value are salmon. Significant resources have been put into increasing the capacity and efficiency of hatchery and rearing of salmon and much of the islands production is now reliant on hatchery produced fish stock. While some protection has been afforded to river systems important to salmonid fish (e.g. water protection zones along rivers), there has been widespread degradation of natural habitat and fisheries value as a result of deforestation, land use change and pollution. Although the value of the salmon fishery on Sakhalin is clearly recognised it is only in the last few years that a concerted effort has been initiated to address habitat degradation and also to increase awareness of the importance of maintaining and enhancing ecological processes as part of freshwater fisheries management. The Wild Salmon Centre has been instrumental in setting up and spearheading the Sakhalin Salmon Initiative (SSI), which has been actively supported and funded by Sakhalin Energy. The SSI is a public-private partnership initiative to promote conservation and sustainable use of wild salmon and salmon ecosystems and to build institutional capacity for conservation on Sakhalin.

7.1.7 Summary of Biodiversity Priorities

While some biodiversity interests can be specifically identified as having importance in relation to a single aspect it is apparent that there is significant overlap between the various criteria discussed above. Thus, an area of natural dark coniferous forest may be of value for its unfragmented nature, but it may also support a range of protected species, be sensitive to potential disturbance and form part of an area of high biodiversity value. Taking into account these considerations and using the data available from the various surveys that Sakhalin Energy have undertaken for the Sakhalin II Project, a number of biodiversity priorities can be listed, as follows:

Habitats

- Dark coniferous forest – remaining blocks/areas of this habitat, particularly in the north of the island;
- Larch-ledum forest – areas of intact habitat and well developed secondary forest, particularly in Dolinsk-Nogliki area;

- Well developed and largely intact areas of secondary spruce-fir forest (e.g. Makarov mountains);
- Mixed primary or well developed secondary deciduous-coniferous forest along river valleys;
- Tracts of peatland and swamps supporting characteristic vegetation communities;
- River catchments with significant areas of intact forest habitat and those supporting important salmon populations;
- Shallow coastal lagoon systems and fringing wetland habitats; and
- Coastal and marine waters in Aniva Bay and the north-east Sakhalin shelf.

Species (and species groups)

- All species protected under Russian federal and local legislation, but with a particular focus on:
  - Steller's sea-eagle
  - - Sakhalin taimen
  - Western gray whale
- Coastal and wetland birds of the Chaivo peninsula, including: breeding Sakhalin subspecies of dunlin, Aleutian tern, spotted greenshank (if confirmed as breeding in the area) and migratory waterfowl;
- Breeding birds of coniferous forest, including Siberian spruce grouse, long-billed murrelet, black-billed capercaille;
- Breeding birds of river valley mixed woodland, including: spot-bill duck, mandarin duck and several species of owl; and
- Salmonid fish populations of selected river systems (i.e. those that support significant areas of spawning and other habitat).

This is not an exhaustive list, particularly with regard to species, but those habitats and species mentioned above will effectively represent the priorities for action where it is determined that the project is having or likely to have an impact that requires managing. The majority of these interests are likely to be covered by specific Action Plans that will be developed in conjunction with external stakeholders, but it is also possible that additional Action Plans may be produced for other species and habitats not listed above as a result of continued consultation and work with the Biodiversity Group specifically set up to support implementation of the BAP.

As stressed previously, significant effort has already been taken to avoid and minimise potential impacts on biodiversity interests during planning and construction of the project. The BAP provides the framework for the management of project related biodiversity issues through into the operational phase. With regard to this, the focus is therefore on assessing the work that has already been undertaken, continuing with monitoring and ensuring that activities that could impact upon the priorities determined and listed above are managed to ensure that biodiversity is maintained. One of the steps in this process is to consider how effective the measures undertaken so far have been in delivering the maintenance of biodiversity in respect of the determined priorities. The next section of the BAP therefore sets out the main ecological effects associated with the project activities in relation to the identified priorities and provides a broad assessment of impacts, the nature of the mitigation measures employed, apparent gaps in the mitigation process and, where data is readily available, determination of the success of these measures.

8 Activities and Effects Assessment

8.1 Introduction

At a general level, the ecological impacts of oil and gas projects can be split into those that are short term and largely confined to the construction phase and those of a longer term nature that are ongoing during the operation phase of the project.

It cannot be categorically stated that impacts during construction are greater than those that could occur during operation, or vice versa, as much depends on the scale and magnitude of the activity, the sensitivity of the receiving environment and the manner in which any potential impacts are managed. It is apparent from the extensive work that has been undertaken into the ecological effects of oil and gas development (e.g. IPIECA) that impacts generated during construction may be present throughout operation and therefore need management beyond the construction period. This clearly requires long-term commitment to the implementation of appropriate measures to deal with identified impacts and also an assessment approach that takes a longer-term view (i.e. project lifetime) towards achieving environmental goals and objectives.

The types of impacts and issues associated with oil and gas exploration and production and other human activities that have the potential to cause similar ecological effects have been relatively well studied around the World. For Sakhalin II, the extensive ecological survey work (Section 6) provided the basis for impact assessment and the development of appropriate mitigation measures to manage adverse effects. Subsequent and ongoing monitoring has been implemented to measure predicted effects and the effectiveness of the adopted mitigation measures. The impact assessment process identified a wide range and number of potential impacts and assessed the significance of these in light of specific criteria such as regulatory and industry requirements. The number and extent of identified impacts related to Sakhalin II (numbering in the hundreds) is not surprising given the fact that the project covers a significant latitudinal extent of Sakhalin Island, from offshore to onshore and across a number of distinctive vegetation zones and variety of habitats.

The potential effects of project activities on several species and habitat types have been considered, with particular emphasis on ensuring that the project does not adversely impact upon the endangered western gray whale population or breeding Steller's sea-eagles. While these prominent species have been the focus of concerted survey and monitoring programmes, the collection of baseline ecological and environmental data has enabled assessment of different habitats and in relation to many species groups to be undertaken. The focus of this work has largely been at an individual facility (e.g. LNG, OPF, offshore platform etc.) level rather than for the project as a whole, which makes assessment in relation to the various ecosystems with which project activities interact more difficult to understand.

For the purposes of the BAP, this section therefore considers the asssessment of likely effects at a relatvely broad level and with respect to the project as a whole (i.e. the project footprint) rather than in relation to individual project facilities. The focus is on those activities that may modify existing ecosystem processes, either directly or indirectly, or the distribution and extent of habitats and species populations. For potential effects associated with construction activities the emphasis is on monitoring the response of the ecosystems to disturbance and to ensure that identified impacts are either acceptable or mitigated to deliver the objective of maintaining biodiversity. Similarly, operational aspects require that ongoing activities are managed with the maintenance of biodiversity in mind so as to prevent potentially small-scale effects accumulating over time (e.g. clearance of vegetation / habitat loss associated with the ongoing development of facilities). In practice this may require that effects generated during both construction and operation are considered together (i.e. where the temporal effects combine) and as project impacts at the ecosystem level.

The following sections provide a discussion of the effects of oil and gas development on the habitats and ecosystems of significance for Sakhalin II, and describe the assessment of the predicted impacts for the project and the nature of the mitigation measures that have been developed and implemented. In developing this BAP, emphasis has been given to determining whether the impact assessment process has fully addressed potential effects at the project scale and estimated duration. In doing so it is apparent that existing measures are generally in place to deal with the majority of identified effects, but that there are some gaps or areas where further work may be required in order to meet the BAP objective of maintaining biodiversity interests. In these instances, project specific actions are presented at the end of each section.

During implementation of the BAP, further gaps in survey data and the effectiveness of management and mitigation plans may be identified. Where this occurs, corrective action would be initiated, including, for example, the development of new and / or the revision of existing mitigation plans and monitoring and survey programmes. Corrective action might also be guided through a process of prioritisation, so as to allocate resources effectively and efficiently to achieve meaningful and achievable biodiversity related objectives and targets.

8.2 Impacts on Terrestrial and Freshwater Ecosystems

8.2.1 Habitat modification and fragmentation

Fragmentation is inextricably linked to the removal and modification of contiguous habitat at a variety of scales, but is particularly concerned with human disturbance of natural habitats at the landscape level (Fahrig, 2001). The process of fragmentation involves the separation of areas of habitat, generally of a large size, into smaller and more isolated 'islands' by means of natural or human caused disturbance events. In the case of forested landscapes, fragmentation and habitat loss is usually considered as a combined process. Natural disturbance events that may affect forest habitats vary in their scale and intensity, from large forest fires that may consume many thousands of hectares to the collapse of individual trees and the creation of gaps in the forest canopy. However, the scale of disturbance caused through human activity (e.g. clearance for timber, infrastructure development and agricultural development) often far exceeds that resulting from natural events, leading to rapid and in many instances irreversible changes to the ecological structure of forests and the species that these habitats support.

Habitat fragmentation may affect wildlife populations and species in a number of ways, including:

- Increased isolation of populations, which may lead to adverse genetic effects (e.g. inbreeding) and decreased genetic diversity;
- Greater potential of localised extinction of small populations and species with small distributions from catastrophic events such as hurricanes, wildfires or disease outbreaks;
- Altering the vegetation structure and composition of habitats, often providing conditions that support generalist and invasive species;
- Modifying microclimate, which in turn affects vegetation and associated animal communities, even within adjacent and intact areas of habitats (the so called ‘edge effect’);
- Causing abrupt changes in habitats, which may bring together species that otherwise have limited interaction, potentially increasing rates of predation, competition and parasitism;
- The facilitation of increased accessibility which may provide greater opportunity for the exploitation of natural resources by people (e.g. increased poaching, hunting and illegal collection of animals or plants).

The direct loss of habitat or habitat modification/disturbance as a result of linear developments tends to be relatively small in relation to the total area of available habitat within the wider landscape. In an area of oil and gas exploration area in northwestern Alberta, there were 2.08 km of linear development per km^2 (Hornbeck and Eccles 1991, quoted in Jalkotzy *et al*., 1997), with these developments accounting for approximately 13,900 ha of wildlife habitat or 2% of the overall study area. Similarly, oil and gas exploration activity in the Prudhoe Bay Oilfield in Alaska occupies a region of about $2000km^2$, but the total area of infrastructure development area (i.e. the direct footprint) within this is approximately 4,500ha (or 2.25% of total production area: http://arctic.fws.gov/issues1.htm). The effects of such habitat losses may, however, be of less significance in comparison with the potential effects on fauna caused by increased disturbance and mortality.

The fragmentation and loss of habitat caused by linear features can be exacerbated by the creation of 'edge' habitat. Edge habitat is defined as that area adjacent to the edge of a forest where conditions exist that change the suitability of habitat near the boundary, both for forest specialist species, and other species that may move into the disturbed area. Edges occur naturally between terrestrial ecosystems, usually as transitions between habitat types. However, unlike natural transitions, the edge between a ROW or road and forest habitat is normally abrupt and well delineated, leading to often dramatic differences across the edge. The transitional zone between a ROW and adjacent habitat can be characterised by differences in microclimate, habitat and species communities/assemblages. The key driver behind these changes, particularly in forest habitat, is the loss of vegetative structure that results from forest clearance and the associated changes that this has on microclimate within the ROW and in adjacent intact forest.

Chen *et al*., (1995) studied the microclimatic effects of timber clearcuts on remaining areas of old growth forest in the Pacific Northwest, USA. They found that edge effects could be typically detected 30 to >240 m into the forest. From the edge into the forest, air temperatures decreased during the day and increased at night and changes in soil temperature from the edge into the forest were comparable, except that edge effects did not extend as deeply as those for air temperature into the forest. Relative humidity increased from the edge, although change in levels were recorded up to >240 m into the forest. Short-wave radiation decreased rapidly with distance from the edge, reaching interior forest levels by 30-60 m, while wind speed decreased exponentially from the edge into the forest. The orientation of the edge was found to play a critical role in the documented changes for the microclimatic variables, with wind speed/strength and its proopagation into the forest having a particular influence on some of the other variables (e.g. humidity and air temperature). Similar results to those of Chen *et al*. (1995) have been documented for temperate forests in New Zealand (Davies-Colley *et al*., 2000). These researchers found that microclimatic edge effects extended at least 40m into native, temperate forest and possibly at a greater distance depending on factors such as wind speed and topography.

In areas where oil and gas operations occur in Russia, natural ecosystems have often been completely destroyed and replaced by technogenic landscapes. In some instances where heavily contaminated wastewater caused the death of forests, habitats have been colonised by thickets of reed mace and small-reed that are more resistant to pollution; at some large oilfields, these plants cover at 80% of area that is disturbed or irreversibly damaged. Surviving, native plants are mostly found to be unhealthy, and the reproduction of coniferous trees decreases considerably (Feoktistova, 2000).

Whole ecosystems in the Terneysky District of Primorsky Krai, Far East Russia, are now considered critically endangered following vast clear-cutting that took place in the past. Opritova (1988) studied the effect of clear-cutting on the hydrological regime of rivers and streams in Primorsky kray, and assessed 12 years of observations. She concluded that the conservation of mature forests of old growth, large trees would help to maintain the annual flow of rivers, and that the highest forest altitudinal belt below the timberline along the Sikhote-Alin mountain range should be specially protected due to its high potential for water regulation.

Similar processes have also occurred in Khabarovsky Krai, Far East Russia, where the lack of accessible water caused the death of Ayan spruces around clear-cutting areas. Furthermore, large clear-cuttings together with timber-rafting in the Bikin River catchment destroyed spawning areas of salmon, trout, and catfish (Shibnev, 1998).

The physical (i.e. structural) and microclimatic changes that occur at the ROW-forest transition lead to changes in vegetation and fauna, most notably on the ROW itself, but also within adjacent habitat. Within the ROW itself, the disturbance of vegetation clearance and construction and the consequent opening up of once enclosed ground leads to the creation of conditions that are optimal for vegetation and fauna that characterise early successional processes. This modification can be viewed as having a positive effect on biodiversity as the greater complexity of vegetation structure supports species with a wider range of ecological requirements than just forest species, thus leading to an increase in overall diversity. Surveys of songbirds in two forests in northern Minnesota, USA, found 24 species of birds more abundant along roads than away from them (Hanowski and Niemi 1995). Approximately, half these species were associated with edge habitat, including birds like crows (*Corvus brachyrhynchos*) and blue jays (*Cyanocitta cristata*) that use roads as corridors to find food. Another study showed that habitat in roadside ROWs support a greater diversity of small mammals than adjacent habitats (Adams and Geis 1983), but this finding may not apply to narrow ROWs within forests. Studies have shown that wide transmission-line corridors support grassland bird communities of species not found in the forest, and narrow corridors produce the least change from forest bird communities (Anderson *et al*., 1977). However, this species richness, by itself, should not be taken as a measure of positive gain, as the edge-related climatic and vegetation conditions often favour generalist species. Such species tend to be common, well distributed components of the wider landscape and their establishment may come at the expense of the more uncommon habitat specialists (Anderson *et al*., 1977). In this respect, the process of human induced fragmentation and habitat loss represents a biological homogenisation that may ultimately result in the domination of generalist species that are adapted to and can take advantage of the broader ecological niches that are created through fragmentation.

The different conditions found at or near edges, can result in deleterious changes to adjacent forests for species that prefer or require interior forest habitat (Bancroft *et al*., 1995; Reed *et al*., 1996). A number of effects are known to occur with regard to forest bird populations (Fleming, 2001). Some species of forest birds will simply not attempt to breed within a certain distance of a forest edge, largely as a result of the unsuitable changes in plant community, changes in microclimate, i.e. wind, light or temperature, or changes in the animal communities associated with the edge and the neighboring habitat (e.g. Kroodsma, 1982a; Ambuel and Temple, 1983). In forest areas near edges, bird species not typically associated with forests may become more abundant (Rich *et al*., 1994; Schieck *et al*. 1995). Such a change in the bird assemblage may result in increased competition with forest dependent species, as well as increased predation rates. Several studies have demonstrated that nests located along forest edges are subject to higher rates of predation to those found in forest interiors. Nest predation associated with fragmented landscapes and an increase in edge habitat has been suggested as a major factor in the declining popoulations of small, migrant birds in the eastern United States (Wilcove, 1985, Manolis et al., 2002). Many omnivorous mammals and birds (e.g. racoons, squirrels, crows) are nest predators and an increase in the presence of these generalist species has been associated with the habitat diversity that occurs along edges and in fragmented landscapes. These predators travel along edge habitats and use them as means to enter forest habitat to seek out prey. This process of predatory transmission along edges and corridors of open habitat can be particularly detrimental within blocks of intact forest that were previously inaccessible.

In northern taiga zone of Western Siberia, the cutting of trees and shrubs in an oil production area resulted in changes in the distribution of birds. Seventeen bird species stopped nesting, while six species started nesting in the area; this reflected an increase in the proportion of ground-nesting birds and a decrease in the proportion of canopy and shrub birds (Ravkin, 1995; Yudkin, Vartapetov, Kozin, 1996). Furthremore, the total biodiversity of birds decreased by 12%, while the total biomass of birds decreased by 26%; these changes where due mainly to a reduction in game species (Vartapetov, 2000; Yudkin, Vartapetov, Kozin, 1996).

The open spaces created by ROWs (often despite their relatively narrow width) may function as barriers to movement for forest bird species, despite their high mobility. Birds may avoid open areas due to an increased risk of predation by avian predators (e.g., Suhonen 1993). Desrocher and Hannon (1997) found that the willingness of birds to cross an open area decreased as the width of the gap increased and that birds also chose to detour around open areas along forest edges, despite increasing the distance they had to travel, and therefore, their energy cost. The reduction in movement routes for birds could possibly result in the effective separation of populations and expose isolated groups to dangers associated with small populations (i.e. loss of genetic diversity and localised extinction due to natural events).

In a Michigan study on the effects of size and shape of forest disturbances on the densities and spatial distributions of 3 forest-dwelling songbirds, it was found that the amount of disturbance was related to opening size. In general, greater declines in populations were linked to larger openings in the forest and declines were detectable further into a forest interior (22-50% reduction in density over distances of 250m and 400m for medium and large openings, respectively), (Dellasala 1986, quoted in Jalkotzy *et al*., 1997). No avoidance was observed for small or narrow-rectangular openings.

Work by Hagan *et al*. (1996) indicates that if bird surveys are conducted shortly after a disturbance corridor has been created, increased densities of forest-dwelling birds may occur in forest habitat along the corridor. This observed increase in density is probably due to the displacement of individuals from the cleared forest area into remaining, adjacent habitat. The duration and extent of this effect following cutting of a corridor was found to depend on many factors, including the sensitivity of a species to edge and area effects, the duration and rate of habitat loss and fragmentation, and the proximity of a forest stand to the disturbance (Hagan *et al*., 1996).

The influence of human disturbance and habitat fragmentation on marten (*Martes americana*) populations has been relatively well studied in the United States. A study in Colorado found that marten avoided travelling >23m from forest edges. Using snow tracking, researchers in Alberta, Canada, determined that there was no consistent positive or negative responses to habitats adjacent to a cleared pipeline ROW, although it was found that cleared areas were generally avoided. Observations of marten tracks approaching the ROW demonstrated a relatively low crossing success rate (50%), but after two years of study there was no evidence to indicate that the presence of the ROW resulted in reduced marten activity in the immediate vicinity.

Construction of oil pipelines during the development of oil fields in northwestern Russia impacted the migration routes of elk and reindeer (Viktorov, Chikishev, 1985), and resulted in sharp reduction in populations of elk, brown bear, sable, squirrel and other game species.

Foxes, on the other hand, often use the paths of other animals (e.g. ungulates) and people, and during longer trips may use roadsides even when the roads carry heavy traffic (Mosgovoy, Rosenberg, Vladimirova, 1998). Changes in predator prey interactions could result in ecosystem changes and even instability.

ROWs associated with forest roads and pipelines may also have significant effects on site productivity by removing and displacing topsoil, altering soil properties, changing microclimate, and accelerating erosion (see Section 8.2.3). Measurable declines in tree growth are known to occur where soil is excavated to build the road prism. Road building and compaction along ROWs changes soil physical properties including depth, density, infiltration capacity, water holding capacity, and gas exchange rate, nutrient concentrations, and microclimate. Fertile topsoils, often containing most of the organic matter and plant nutrient capital of a site, may be buried under road materials or mixed with inorganic material during construction and may therefore be rendered inaccessible to plant roots. Tree growth is sometimes enhanced on or below fill portions of roads because of reduced competition and greater soil depth. Conversely, Smith and Wass (1980) document significant declines of 23 percent in height growth for lodgepole pine (*Pinus contorta*) and 20 percent for Douglas-fir (*Pseudotsuga menziesii*) below insloped roads, which they attributed to loss of available water through redirected drainage flow.

8.2.1.1 Habitat modification and fragmentation – Sakhalin II

The preceding section has highlighted that fragmentation and habitat modification is a particular issue with respect to forest habitats, although it also applies in varying degrees to many other terrestrial habitats as well. On Sakhalin, fragmentation of forested areas, in terms of biodiversity priorities (see Section 7) is of significance with respect to remaining areas of intact dark coniferous and well-developed secondary forest.

In considering the potential significance of habitat loss and fragmentation resulting from the project, it is important to take into account the existing status of the habitats that occur within the footprint of the project. As discussed in Section 6, human influences on the vegetation of Sakhalin have been considerable and are continuing. Much of the forest now present is secondary (particularly in the southern part of the island) and has either been replanted following intensive logging in the 20th Century or has regenerated naturally (FESU, 2000). There are substantial forestry plantations, and some areas of agricultural land, mainly in the large river valleys (FESU, 2000). Ongoing human effects include land drainage, forest clearance for arable land and homesteads, forest fires, impacts from recreational activities, geological prospecting and grazing.

Habitat change as a direct result of Sakhalin II activities is connected with the construction of the pipeline and associated access roads, construction camps and facilities at the LNG and OPF. Habitat modification and loss associated with the project was estimated during the environmental impact assessment process. However, although the issue of habitat fragmentation was recognised as an adverse impact, no definitive predictions for total habitat loss or modification likely to result from project activities were provided. In fact, given alterations undertaken during the construction period (e.g. re-alignment of parts of the pipeline route, notably the re-route across Chaivo) any figures determined prior to construction may well have been inaccurate.

In the international EIA produced in 2003, the landtake for the pipeline ROW and associated works was given as a total area of 3333 ha, over a total pipeline length of 816 km. Of this area it was estimated that 84% of the pipeline ROW comprised forest habitat (the remainder largely being wetland and agricultural land), although none of this area was determined to contain particular vegetation types that are localised or rare on the island. However, in the context of fragmentation it was determined that, for several forest habitat types (see Table 8.1) the impact of habitat fragmentation and modification would be of moderate adverse significance and would endure into the long term. These impacts related not only to the direct loss of habitat and its effects on species populations (as discussed above), but also in relation to the potential for increased access into the area and the implications that this could have with regard to increased disturbance and hunting/poaching pressure. For other forest types, e.g. secondary coniferous plantations, the degree of habitat modification as a result of human activity is already significant and the overall ecological value of these areas is, perhaps, diminished in comparison with areas where intact, natural vegetation occurs.

Table 8.1 Extent of forest habitat affected by pipeline construction. Data from the international EIA for the Sakhalin II Project (2003).

Forest type	Extent along pipeline right-of-way	Approximate area (ha)
Dark coniferous forest	16%	533
Natural and established open coniferous forest	30.4%	1013
Deciduous forest of flood plains and river valleys	8.1%	270

Due to changes in design and issues associated with construction activity, it is apparent that the figures provided in the international EIA do not represent the actual change in habitat extent that has occurred during construction. The extent of loss does not include forest or other habitat lost or modified as a result of the construction of access roads or the excavation of materials from quarries for use in pipeline laying or road building work. Of note here is the southern access road, which extends from the OPF to the main road running north-south down the island. While some of this road was in existence prior to the initiation of Sakhalin II Project construction, at least 20km of it was built specifically for project use. This section of road passes through a block of relatively intact dark coniferous forest, further fragmenting this area around the OPF, as the pipeline also passes through parts of this forest block further to the north.

Habitat modification and loss has also occurred at the LNG plant and the OPF. Effective habitat fragmentation at both of these sites is limited in extent in comparison to the pipeline due to both the predominance of altered habitat (agricultural land at the LNG) and the configuration of the sites (i.e. the habitat modficiation is non-linear).

Even with available data relating to the extent of habitat modification and fragmentation, determining the significance of these effects and their indirect consequences for fauna and flora is difficult and needs to take account of a number of factors:

- The ecological ‘value’ of the habitats potentially affected by the works (e.g. the level of modification and fragmentation of habitats);
- The location of facilities in relation to areas of existing fragmentation (i.e. does the project contribute further to fragmentation or are the works in areas where significant modification has already taken place and therefore potential impact may be less significant);
- The potential duration of any impacts to habitats and ecological processes and the likelihood of recovery once the impact has ceased;
- The potential for further impact to occur following the cessation of project related activity (or disturbance); and
- The cumulative effect that fragmentation may have at the habitat/ecosystem and landscape scale.

For the purposes of pipeline integrity and safety inspection it is not possible or practical to allow forest regrowth along the pipeline ROW. As such the modification and fragmentation of forest habitat as a result of pipeline construction cannot be mitigated for within the footprint of the project. Following decommissioning (approximately 40-50 years time) vegetation growth along the former ROW would be permitted and, potentially, successional processes would lead to the eventual formation of new forest habitat. For natural coniferous forest this would be expected to occur in a minimum of 50-100 years after decommissioning and probably longer.

Although the fragmentation and modification of forest habitat along the pipeline route has been recgonised as a moderate adverse impact (as stated in the international EIA for the project), no mitigation measures to maintain or address the ecological issues relating to this impact were proposed at the time of EIA production. Under the relevant Russian Federation legislation a fee was paid by Sakhalin Energy to transfer forestry land so that it could be cleared and used for the siting of project facilities. However, Sakhalin Energy has no authority to determine how the fee paid is spent by the authorities, and its use in the restoration of forest habitat is not guaranteed.

It therefore has to be concluded that in respect of the objective of maintaining biodiversity (with regard to habitat extent and quality) that a moderate adverse impact remains with regard to some forest habitats, and this impact will remain so throughout the lifetime of the project and beyond for several decades as a minimum. In effect, this time scale is likely to put full restoration beyond potential management control of Sakhalin Energy (as the timeframe for successful restoration would extend well beyond operational activity).

Taking these points into account, it is considered that the most appropriate means to address this issue is to undertake the restoration of forest habitat through active management during operation, rather than during decommissioning, when significant additional commitment beyond this period might be required. Restoration and the maintenance of the overall forest resource could be achieved through two potential routes:

- Replanting of degraded areas of forest habitat and management to promote natural function where some growth is already present; and
- Management of existing areas of forest habitat, where it is apparent that existing management resources are limited and that enhancement in forest habitat could be achieved.

For both options, or a combination of the two, the overall objective would be to manage and attempt to connect once contiguous blocks of forest in order to achieve specific nature conservation / ecological objectives. It is also possible that some form of sustainable timber management or production of forest products could be developed as part of the scheme. Sakhalin Energy considers that this work would be best undertaken in conjunction with, or led by authorities and / or organisations with both responsibility for and knowledge of forestry techniques and forest ecology. The development of such a scheme within the framework of Sakhalin II could also allow for the offset of any further and potential loss of intact natural and semi-natural forest habitat that could be affected by further oil and gas exploitation on the island.

Given the important role that forest habitat plays in ecosystem health, Sakhalin Energy may also look at how such a scheme could be developed as part of an integrated programme of watershed (river catchment) restoration, which would provide benefit to other components of the island’s ecosystems. Sakhalin Energy has already undertaken work in this area with its programme of restoration measures in the Djimjan River watershed, and progression of this scheme with an increased focus on forestry could be a suitable means for addressing some of the forest habitat loss and fragmentation issues.

8.2.1.2 Actions to manage habitat modification and fragmentation

In line with the biodiversity priorities listed under Section 7.1.7 of this document, habitat action plans (HAPs) to address habitat modification and fragmentation, with a focus on forests, should address the following actions.

1. The extent of loss/modification of dark coniferous forest, natural and established open coniferous forest and river valley deciduous woodland as a result of all project construction activities will be determined. Available data from land allocation permits, remote sensing techniques (e.g. aerial/satellite imagery) and comparison of pre- and post construction plans etc. will be used to identify areas of loss and impact to derive a total area. Where appropriate, some ground truthing may be used to determine the extent and quality of some affected forest types.

2. Given the ecological importance of dark coniferous forest and its relative rarity value in the context of all forest types, a specific Action Plan will be developed to deal with

impact management for this habitat. The development of the Action Plan will be undertaken in conjunction with relevant stakeholders. The objective for the plan will be to offset the loss of forest habitat resulting from project activities. The basic framework for the plan is likely to contain:

- An estimate of the loss of dark coniferous forest as a result of project activities
- Evaluation of suitable techniques and measures to restore and/or replace the loss of this habitat;
- Likely locations where restoration works could be undertaken
- Potential costs for undertaking restoration works and sources of funding
- Responsible parties, actions and timescale
- Maps and figures showing areas affected and proposed sites for reinstatement

3. On the basis of habitat loss/modification data, work will be undertaken with forestry authorities to undertake replacement of the ecological function of natural and established coniferous forest and river valley deciduous woodland. Ideally, needs here could be combined and a scheme or schemes that integrated objectives for both habitats could be developed.

4. Using available survey and monitoring data species populations dependent on forest habitat that may have been adversely affected by project-related habitat loss and fragmentation will be identified and status assessed. It is considered that such species include:

- Ground nesting forest birds such as Siberian spruce grouse and black-billed capercaille
- Breeding long-billed murrelet
- Tree-nesting owls and ducks in primary and well developed secondary forest and river-valley deciduous/mixed forests.

For these species individual plans may need to be developed in order to promote management actions and involve other stakeholders. Where appropriate actions will be combined to facilitate management for several species.

8.2.2 Erosion and run-off from pipeline ROWs and associated infrastructure

8.2.2.1 Introduction

According to data published by Gazprom (January 1, 1996), the total area of land disturbed by the gas production industry in Russia was 62,400 ha, including 58,700 ha of land disturbed by construction activity and 2,950 ha disturbed by exploration and gas production activities. During gas field exploration, construction and operation, many components of ecosystems are impacted as a result of direct disturbance of vegetation and soil cover (Opekunova, 2004)

Infrastructure developments (including ROWs, access roads and industrial facilities) may potentially affect geomorphic processes, which in turn can lead to alterations in habitats and species populations that these habitats support. Generally, four primary mechanisms by which terrestrial construction works may affect these processes are recognised:

- Accelerating erosion from the altered surface (i.e. the ROW, or area disturbed by construction) by both mass and surface erosion processes;
- Directly affecting watercourse channel structure and geometry;
- Altering surface water flow paths, leading to diversion or extension of channels onto previously unchannelized portions of the landscape; and
- Causing interactions among water, sediment, and vegetation at watercourse crossings.

These mechanisms involve different physical processes and have various effects on erosion rates. Under forest/vegetated conditions surface runoff and soil erosion are generally low because surface vegetation cover and erosion rates are generally less than 0.1 Mg/ha/yr (1 Mg = 1000kg), (Elliot *et al*., 1999). If the litter layer is disturbed, then runoff and erosion rates can increase by several magnitudes and erosion rates can exceed 20 Mg/ha/yr. Linear developments and the clearance of vegetation in forested areas adversely impacts forest soil productivity by directly reducing the productive area, and by causing soil erosion.

The results of precipitation on steeply sloped pipeline ROWs during the time between ROW rehabilitation and the establishment of a dense, self-sustaining vegetative ground cover can cause locally severe soil erosion. Besides causing local erosion on the ROW, changes to slope properties and morphology as a result of construction work may, through surface run-off, lead to the loss of surface sediment and deposition of material in adjacent areas of habitat unaffected by direct construction impacts. While such sediment loss may result in the smothering of adjacent ground vegetation, this effect is usually temporary as successional processes lead to the eventual establishment of vegetation and the restoration of original conditions. This may, however, not be the case where, as a result of the opening up of forest habitat on steep slopes, erosion related instability leads to the formation of small landslides or the mass movement of material down slope. Such movement may lead to the further loss of habitat along the margins of ROWs or downslope away from the ROW where it cuts across steep slopes.

One the most prevalent effects of soil erosion and runoff associated with pipeline ROWs and other linear developments is the potential for sediment-laden water from the ROW (or any exposed surface such as a forest road) to enter adjacent watercourses. This is clearly an effect that is at its greatest during and immediately following construction, both when pipeline laying takes place through watercourses and subsequently as a result of the opening up of the ROW and the exposure of the soil surface to the erosive processes associated with precipitation. However, this effect can also persist for prolonged periods in situations where exposed soil remains unvegetated following clearance or, in the case of watercourse crossings, further erosion occurs as a result of bank instability related to poor construction practice and related changes to stream channel profile.

Surface erosion from road surfaces, cut banks, and ditches represents a significant and, in some landscapes, the dominant source of sediment input to streams. Rates of sediment delivery from unpaved roads are highest in the first years after building and are closely correlated to traffic volume and surface-erosion problems are worst in highly erodible terrains (e.g. landscapes underlain by granite or areas of unconsolidated sands and clays). In the Eastern United States, poorly designed and managed forest access and county roads are major sources for higher sediment input rates to streams. Van Lear *et al*. (1995), identified roads as the major source of sediment in the Chattooga River basin, where 80% of the road sources are unpaved, multipurpose roads (forest and county) paralleling or crossing tributary streams. Roads in midslope and ridgetop positions may affect the drainage network by initiating new channels or extending the existing drainage network.

Erosion can also introduce other pollutants into adjacent or nearby watercourses. A survey in the Ob River catchment in Siberia, Russia, found significantly higher concentrations of hydrocarbons, Hg, Zn, Cu and Ni in watercourses impacted by intensive oil production activities (Makarenkova, 2006).

8.2.2.2 The ecological effects of sediment inputs into watercourses

The increase in stream-borne sediment generated during and potentially after in-stream construction work, or as a result of sediment laden run-off from a ROW or road surface, can have a number of direct and indirect effects on freshwater habitats and organisms. Some of the key effects are listed below:

- An increase in suspended sediment concentration and associated turbidity can reduce photosynthetic efficiency in aquatic plants leading to a reduction in growth and increased susceptibility to disease;
- High concentrations of in-stream sediment can dislodge plants, invertebrates, and insects in the stream bed, which in turn reduces prey and food availability for fish;
- Entrained bedload sediment can alter existing riverbed habitats;
- Fish migration and spawning behaviour may be impaired by elevated concentrations of suspended sediment;
- Suspended sediment in high concentrations can cause physiological damage to fish, potentially making them more susceptible to infection and disease. This may be of greater significance for overwintering fish when energy levels need to be conserved. In extreme cases mortality may occur, particularly of juveniles exposed to high concentrations over extended periods of time;
- Fine sediment settling out of suspension can bury and suffocate fish eggs/embryos;
- Released sediment particles can carry toxic compounds derived from agricultural and industrial products which may bio-accumulate; and
- Change to river ecosystems can occur in situations where increased sediment input as a result of works persists in the longer term.

The ecological responses to disturbances in riverine environments, such as that generated by pipeline installation differ, largely with respect to the duration of potential recovery. Direct effects on aquatic biota are generally limited to the duration of the in-stream construction time frame. However, excavated sediment that is transported and deposited downstream can cause more protracted effects on aquatic habitat. The effect on, and subsequent recovery of, benthic invertebrate and fish communities are highly reflective of this habitat alteration and recovery.

8.2.2.3 The effects of increased suspended sediment concentrations

The increase in suspended sediment concentration in the water column generated during construction can have a direct physical impact on organisms present in the stream at the time of the works. Studies on stream benthic invertebrate communities have observed immediate increases in drift rates (the downstream movement of animals) at the onset of in-stream activities. For example, shortly after the installation of a gas pipeline across a small creek in British Columbia where suspended sediment concentrations reached 11,600 mg/l, Tsui and McCart (1981) reported a 74% reduction in the benthic invertebrate abundance.

Significant reductions in the diversity and abundance of stream invertebrate communities have been recorded at some sites immediately following pipeline construction work. These reductions in abundance are attributed to high downstream drift rates during instream construction and changes to the suitability of downstream habitat due to sediment deposition. Anderson *et al*. (1998) reported that one week after construction the downstream benthic invertebrate community in Findlay Creek, Ontario was generally limited to only sediment tolerant species of oligochaetes. At upstream control sites, the benthic invertebrate fauna was far more diverse with over 26 species of chironomid midges, caddis flies, stoneflies, mayflies, and dragonflies.

It is generally accepted that the magnitude of the impact of suspended sediments on fish is a function of sediment concentration and the duration of exposure (Wilber and Clarke, 2001). During in-stream construction, fish may be exposed to an area of increased sediment concentration (known as the sediment plume) if the activity starts in, or moves into, the area in which they live, or the fish move into the plume area. For adult and larger juvenile fish, exposure to high suspended sediment concentration is likely to be of short duration. Most adults are mobile enough to move out of an affected area if they find conditions hostile. Avoidance of areas of high concentrations of suspended sediment by adult fish may limit physiological effects resulting from prolonged exposure. However, some benthic adult fish (e.g. loaches), many juveniles and all eggs of fish have little or no ability to avoid the sediment plume created during construction and may be exposed to high suspended sediment concentration for the total duration of the plume in the water body or area of residence.

An increase in turbidity (which is often closely correlated with an increase in suspended sediment concentration) will also reduce visibility in a water body. Since many open water fish are visual feeders a reduction in visibility could reduce their hunting success. An increase in suspended sediment can also cause respiratory problems in fish due to their gills becoming clogged by sediment particles. In extreme cases this can lead to suffocation.

There has been significant study of the effects of turbidity and suspended sediment concentration on the physiology and behaviour of salmon. These studies generally indicate that salmon are well adapted to fluctuations in suspended sediment concentration and can tolerate short-term (a few days) pulses of high-suspended sediment concentration without detrimental impact to either their health or ability to migrate. Such adaptation would be expected in species that inhabit watercourses subject to rapid changes in sediment loadings as a result of snowmelt or increased run-off.

8.2.2.4 Effects of sediment transport and deposition

The deposition of sediment generated during in-stream construction can occur within a relatively short distance downstream (Anderson *et al.*, 1998). This rapid pulse of sedimentation largely consists of the coarser grained material (sand and gravel) contained within the excavated material and can lead to changes in streambed sediment composition and channel morphology, particularly as it is subsequently transported downstream. The sediment transport in rivers has been likened to a jerky conveyor belt in that, having entered the fluvial system sediment may be moved downstream every time a competent flow occurs in the river. The deposition of finer sediment (clay and silt) from the sediment plume generated during construction will occur further downstream, either as a veneer on streambed sediments (e.g. trapped on organic films coating pebbles) or in areas where current velocity falls to speeds in which settlement can occur (e.g. deeper pools in river beds or temporary channels).

The deposition of sediment from the water column directly following construction and the subsequent transport of sediment as bedload downstream from the crossing point may have a number of relatively immediate and longer-term effects. Fine sediment deposition is of particular relevance to streambed ecology as it can infiltrate pore space between larger sediment particles and alter its porosity and composition, a process known as embedding. Embeddedness is a measure of how much finer sediment surrounds or covers larger sediment particles and higher values are generally associated with lower spawning habitat viability for salmonid fish. Salmon eggs, buried in gravel rely on a steady flow of clean, cold water to deliver oxygen and remove waste products. Once alevin hatch from the eggs they remain in the gravels where they live off the nutrients contained in their yolk sacs. During the typical 30-60 day period when salmon eggs and alevin are in the gravel, major shifts of the stream bottom or changes in sediment type can kill them. Research has shown that increased fine sediment in spawning gravels reduces oxygen availability leading to decreased survival and emergence of salmonid eggs and alevin (Nawa and Frissell, 1993). The area of the stream where flowing water extends down into the gravel is also extremely important for aquatic invertebrates, which supply most of the food for young salmon.

Research work on the survival rates of salmon eggs in gravels demonstrates that it is sediment in the range of 0.1-1 mm, critically about 0.8 mm, which has the greatest influence. Monitoring data from eight open-cut pipeline crossings of the Moyie River in the United States showed that the embeddedness of riverbed material rose from 0-18% to 9-61% as a result of increased sediment deposition (quoted in Reid and Anderson 1999). Studies conducted in actual redds in Olympic Peninsula streams in Washington found that if more than 13% fine sediment (<0.85 mm) intruded into the redd almost no steelhead or coho salmon eggs survived (McHenry *et al*., 1994).

Mining of mineral deposits in upstream of the Khroma River (Yakutia, eastern Russia) caused an increase in the concentration of suspended sediment from 4 mg/l to 223 mg/l. Suspended solids containing montmorillonite, caolinite and other clay minerals could be traced up to 500 km downstream. As a result, the biomass of zooplankton in the river reduced by almost 19 times (Pozdnyakov, 1998), and the concomitant reduction in spawning areas endangered populations of vendace, broad whitefish and common whitefish, while lamprey, grayling and pike vanished from this river.

Mining and dredging activities within catchments of Yana and Indigirka Rivers (also in Yakutia, Russia) dispose more than 1.5 million m^3 of material in water per year. Dredging activities result in high suspended sediment concentrations, which negatively impacts benthic communities and plankton in these rivers, destroys food resources for anadromous and semi-anadromous (whitefish) fish species, and prevents populations of muksun, vendace and whitefish from successful spawning (Kirillov, 2002).

It is apparent that the early life stages of several salmonid species and adult and young of many other resident fish species are dependent on the existence of suitable wintering habitat. Disturbance to habitat during this critical period may have adverse effects on the fish fauna, particularly juveniles. Groundwater or hyporheic upwelling areas and winter ice cover affect flow, temperature, and ice pattern. Small organisms have the advantage of being able to burrow in the substrate or using woody/vegetation debris for protection during winter, but larger individuals must move to deeper areas that have adequate flowing water during severe freezing periods (Cunjak, 1996). Generally, during winter, riverine fishes select habitats with relatively higher temperatures and low flows, such as off-channel backwaters, overhanging banks and areas of in-stream snags and obstructions (e.g. fallen trees). By occupying favorable habitats during winter, fishes avoid the stresses of variable flow velocity in the main channel portion of rivers and are more able to maintain energy levels. Limiting exposure to severe winter conditions allows fishes to persist through winter and with the onset of winter conditions, juvenile fish seek out and occupy habitats that are favorable for increasing the probability of survival during winter.

With respect to river pipeline construction during the winter, no increases in downstream emigration, or mortality of overwintering fish, were noted during the winter construction of a pipeline crossing in the Northwest Territories (McKinnon and Hnytka, 1988, quoted in Reid and Anderson, 1999). In areas where egress of fish is possible then it is likely that an increase in suspended sediment concentration would induce an avoidance reaction and more favourable habitat would be sought by fish (e.g. areas out of the main channel flow).

8.2.2.5 Recovery of aquatic fauna and flora

Post-construction monitoring of downstream streambed conditions indicates that changes to streambed conditions are generally short-term (Crabtree *et al*., 1978; Anderson *et al*., 1998). Fine sediment deposited downstream of a pipeline crossing is typically transported shortly after construction. However, larger deposits in areas of slow current velocity, such as shallow side pools and behind boulders and in stream debris may require longer periods or higher flows for complete removal (Anderson *et al*., 1998). In-stream sediment derived during construction work is generally transported away from a crossing site within 6 weeks to 2 years after construction.

Studies undertaken to date indicate that changes in observed benthic invertebrate communities tend not to be long term and that the full recovery of these communities generally occurs within six months to a year after construction. The rapid recovery of these invertebrate communities has been attributed to the flushing and downstream transport of deposited sediment during both normal and high flow conditions (e.g. storm events or spring snow melt conditions) and invertebrate recolonisation from upstream sites. This type of response is typical of that associated with short term disturbances, where an ecosystem is able to remain within its normal domain and recover to conditions prior to the disturbance. In effect, the species and processes contributing to overall ecological function and integrity are adapted to the effects associated with a disturbance such as that generated by short term instream construction work as these activities generally mimic natural processes and events (Yount and Niemi, 1990). With respect to fish populations, immediate post-construction decreases in downstream fish density have been observed (Anderson *et al*., 1998) although recovery of former population levels were rapid (within one year). Other studies have been unable to detect any direct effects on fish communities.

8.2.2.6 Potential longer-term effects of sediment inputs to watercourses

In-channel works associated with pipeline river crossings result in direct modification of the channel profile at the crossing point and changes to bed and bank structure. Unless the river profile is reinstated with regard to the continuity of natural processes, adjustment in response to high flow events associated with snowmelt or rainfall floods may take place. This response may involve accelerated erosion and further exposure of soil and sediment in the vicinity of the crossing resulting in the continued release of sediment into the river following construction.

Many ecosystems have a large capacity to absorb change without being dramatically altered. However, if disturbance exceeds the resilience of the ecosystem, then a shift in the system may occur and new conditions or states may develop that had not previously been exhibited. A complete shift of habitat conditions in a watercourse due to a single event such as a crossing of a watercourse by a pipeline or road would be unlikely, although on a smaller scale the longer-term introduction of sediment, particularly if fine-grained, from exposed banks at crossing points, or from exposed soils (e.g. from a road or unvegetated ROW) could locally shift habitat conditions in a direction that displaces species adapted to coarser grained substrates. This is of particular relevance to the maintenance of salmonid spawning habitat within rivers, given both the influence upon egg and larval mortality and longer-term habitat suitability that fine sediment infiltration into gravel beds may have.

With respect to the latter effect, it should be noted that the suitability of spawning habitat within a river and within catchments may vary naturally from year to year, depending on factors such as hydrological events (e.g. floods) and changes in channel form, and location and variation in sediment erosion and transport processes associated with these factors. Anadromous salmonid populations are well adapted to these dynamic changes as adults often stray, are highly fecund and juveniles are mobile. Straying by adults aids in the reestablishment of populations in disturbed areas on large and local scales provided there are suitable spawning and rearing conditions available. Pacific salmon are relatively fecund for benthic-spawning fishes with large eggs, which contributes to the establishment and growth of a local population if conditions are favourable.

Longer-term effects and shifts in habitat conditions have been identified in relation to the development of road networks in forested areas in the United States. Studies from various areas indicate that road-stream crossings, or unpaved roads adjacent to watercourses, can be a major source of sediment input into streams. Plugged culverts and fill-slope failures are frequent and often lead to catastrophic increases in stream channel sediment, especially on abandoned or unmaintained roads. Unnatural channel widths, slope, and streambed form are found upstream and downstream from stream crossings and these alterations in channel morphology may persist for long periods. Burns (1984) found that roaded and logged watersheds in the South Fork of the Salmon River drainage in Idaho, USA, had significantly higher channel-bed substrate-embeddedness ratings than undeveloped watersheds.

Several studies at broad scales have documented aquatic habitat or fish density changes associated with road density or indices of road density. Eaglin and Hubert (1993) found a positive correlation with numbers of culverts and stream crossings and amount of fine sediment in stream channels, and a negative correlation with fish density and numbers of culverts in the Medicine Bow National Forest, Wyoming, USA. Road-stream crossings have also been shown to have a long term detrimental effect on stream invertebrate communities. Hawkins *et al*. (2000), found that aquatic invertebrate species assemblages (observed versus expected, based on reference sites) were related to the number of stream crossings above a site. Total taxa richness of aquatic insect larvae (mayflies, (Ephemeroptera); stoneflies, (Plecoptera); and caddisflies, (Trichoptera)) were negatively related to the number of stream crossings.

Construction of various roads in the forest regions of West Siberia where oil and gas operations are located caused significant changes in surface and subsurface hydrological regimes over large areas. Roads acted as barriers to surface run-off and subsurface water flow, resulting in swamping of adjacent areas, including some forests. Upper layers of the disturbed soils were often substituted by loose depositions; natural soils were sometimes destroyed completely and new forms of relief created that included small ridges (grivas). Consequently, almost complete ruin of forests nearby the roads, and movement of soil masses downslope resulted in extremely high levels of erosion and a very high concentration of gullies and ravines (Sedykh, 1996).

The effects of roads are not limited to those associated with increases in fine-sediment delivery to streams; they can also include barriers to migration, water temperature changes, and alterations to streamflow regimes. Improper culvert placement at road-stream crossings can reduce or eliminate fish passage and road crossings are a common migration barrier to fish (Furniss *et al*., 1991).

An assessment of the impact of clear-cutting on salmon spawning rivers was conducted on Sakhalin Island in July-October 1991, at Pilevka River and its tributary Amba River (on the western side of the island). River water quality near areas where clear-cutting had taken place was assessed according to the presence of indicator species, and a biomonitoring index calculated according to the Pantle-Buck saprobic index, as modified by Sládeček. Zoobenthos communities, and thus water quality, was classified as Level 5 in areas near clear-cutting; i.e. of poorer quality than less impacted parts of these rivers located more distant from clear-cutting areas (Spivak, 1994).

Clear-cutting has also been associated very negative impacts to the physiology of trout juveniles. Hystological and haematological analyses of fish tissues showed distrophic and destructive changes in liver and kidney tissues, in oogenesis, and in cardiovascular pathology. These studies reorted that heavy toxicosis was caused by substances exuded from timber. Similar effects of clear-cutting on anadromous fish, silver/coho and cherry salmon, which have comparatively long periods of river existence have also been reported (Spivak, 1994).

8.2.2.7 Management of erosion, run-off, and pipeline river crossings – Sakhalin II

The importance of managing potential slope processes on the cleared ROW and, most importantly, sediment inputs at river-pipeline crossings was recognised by Sakhalin Energy at an early stage in the development of the project. A range of specific technical and environmental mitigation measures were introduced and have been implemented during the pipeline and facilities construction. Additionally, a specific strategy to minimise environmental impacts during river crossings (the River Crossing Strategy) was developed, which took into account Russian Federation requirements and best practice set out in international guidance (e.g. the waterbody crossing guidance of the United States Federal Energy Regulatory

Commission). The strategy set out several objectives in respect of this:

- To minimise sediment generation during construction and potential sediment input into watercourses (i.e. taking measures to reduce suspended sediment concentrations in the sediment plume and therefore reducing its potential for downstream effects);
- To minimise changes to river bed morphology, river banks and river channels; and
- To minimise disruption of known areas of salmon spawning habitat.

Steps taken during the design phase have minimised the potential for adverse impacts through appropriate pipeline route selection and a thorough evaluation of crossing methods, while at the same time focussing on constructability, integrity and safety distances from existing man-made and natural obstacles. For the pipelines, a Protection Zone is required and specified by Russian regulations and is typically 25m either side of the pipeline plus the distance between the pipelines. However, at watercourses this widens to 100m, extending over the watercourse itself, either side of the pipeline plus the distance between the pipelines. As the pipeline ROW is in close proximity to the existing transport network, much of the land that has been disturbed during construction is within the existing range of human influence.

During construction, a number of measures have been used to deal with soil loss (soil erosion) and disturbance and their associated ecological effects. Work has centred on both minimising potential run-off from the ROW and restoring watercourse habitat and function at pipeline crossing locations. A combination of the following measures have been used, depending on site specific requirements at rivers where ecological sensitivities have been identified:

- Watercourses of known importance for spawning salmon and/or known or likely to support taimen have been crossed outside of the spawning period during the winter months, a period when flows in watercourses are also at their lowest, which reduces downstream transport rates of sediment generated during construction;
- On the ROW, the use of silt fences and slope breakers to minimise the transport of sediment from the ROW into adjacent watercourses;
- Targeted slope stabilisation on the ROW, in particular on slopes identified as of high vulnerability, through the use of drainage channels and placement of geotextiles;
- Hydroseeding and manual seeding of the ROW with an appropriate seed mixture with species adapted to local soil and site conditions;
- At river crossings, bank reinforcement and stabilisation using reno mats, gabions and riprap, in order to prevent bank erosion and collapse;
- Placement of clean gravels at pipeline crossing areas to replace potential salmon spawning habitat displaced or removed during pipeline installation; and
- Flow clearance and the removal of ice plugs from bridges and culverts to prevent flooding on the ROW.

Depending on the ground, soil and weather conditions, erosion control measures have been installed directly after construction, although it is recognised that ongoing repair work may be necessary at some locations in order to maintain the efficiency of the measures. Ensuring that these stabilisation measures are maintained into the longer term is important with regard to minimising the potential duration of recovery. Particular attention has been paid to the integrity of river features at pipeline crossing points so that habitat function and use, (e.g. off-channel wetland habitat that may be used by wintering fish) is maintained by reinstating any fluvial or potential fluvial connections that may have been affected by works.

River restoration

As part of its River Crossing Strategy, Sakhalin Energy committed to developing a programme of environmental measures aimed at delivering no net loss of salmon spawning habitat as a result of the pipeline construction works at sensitive river crossings (i.e. those where spawning habitat was known to occur at the crossing or downstream of it). One of the key measures implemented was the replacement of suitable sediments (i.e. gravels) at the pipeline crossing sections following installation of the pipelines. This measure, in itself, has more than replaced the area of spawning habitat disturbed at the crossing sites. However, in recognition of the potential recovery period of affected habitat and as a means to deal with any potential longer-term impacts of the construction works, Sakhalin Energy also developed a separate river restoration project. This was initiated in 2006 following discussion with the Wild Salmon Centre and the United States Forestry Department (USFD), both of whom have extensive knowledge and experience of salmon ecology and undertaking programmes of works on rivers to benefit these species.

The project is being initiated on the River Dhzimdan, in the north of the island, in two phases. In the first phase, discussions have taken place with local fisheries inspectors, relevant Russian experts and the USFD to prioritise the river reaches and areas for restoration, to coordinate and approve the plans and to be sure that all the issues are addressed. Surveys have been undertaken to determine areas along the river where activities and processes (e.g. erosion from road crossings) are causing (or have caused) deterioration of available habitat for salmonid fish and also sampling of riverbed sediment quality and the abundance of upstream/downstream fry migration.

A plan of restoration works for the second phase will depend on the results of the reconnaissance survey in the first phase, which will identify anthropogenic or naturally disturbed areas. Examples of possible restoration works are: removing logjams, culvert replacement, tree planting in the Water Protection Zone, slope stabilisation, reduction of the fine sediment input, improving the spawning ground quality, etc. The experience gained in this project will provide opportunity to review and improve river restoration methods and approaches that could be applied to other river basins if further impacts are identified during monitoring works.

Taimen research

The Sakhalin taimen is a protected species of salmon in the Russian Federation and is listed as critically endangered by the IUCN. During the planning of the river crossings, it was recognized that the works could impact upon the potential habitat of this species and have direct and indirect effects on any populations of taimen inhabiting the rivers. Rivers potentially supporting this species were identified through the use of available data and then classified as high sensitivity which required that specific measures to limit sediment inputs and minimise disturbance at the crossing areas were implemented. During the collection of data to feed into this process, it became apparent that very limited data on the distribution and status of taimen was readily available. In recognition of this aspect and also to provide a foundation for any further potential mitigation measures linked to monitoring of the rivers, Sakhalin Energy launched a taimen research project. The project has been developed through the involvement of international experts from Russia, Japan and the United States with knowledge of the biology and ecology of Sakhalin taimen, and aims to improve our overall understanding of the distribution and ecology of this species on Sakhalin Island.

Spring surveys have been conducted to locate spawning areas and to determine the habitat types used by taimen. This was undertaken through visual surveys from river banks, according to methods that have been used successfully in northern Japan. Despite extensive field survey no spawning taimen were located on the rivers studied, although this may have been in part due to uncertainty over the timing of the spawning run. A second survey was undertaken in the autumn of 2007, with the emphasis of determining the presence and abundance of juvenile taimen in selected rivers and habitat preferences. This survey was more successful and revealed the existence of good juvenile taimen populations in a number of rivers and also yielded valuable information on the types of habitats being utilized by juvenile fish. The objective for the next stage of the project is to undertake another spring survey to try and locate spawning sites for taimen and establish the type of conditions that fish are using. Data from the project will be valuable in both establishing suitable management measures for the conservation of this species but also in ensuring that the mitigation measures being implemented by Sakhalin Energy are effective in maintaining habitat conditions for taimen where this occurs in proximity to river crossing sites. It is anticipated, given the interest in this species and its critical conservation status, that further work on taimen will be the subject of a specific Species Action Plan (see Section 9).

Monitoring of pipeline river crossings and initial results

During the construction of the onshore pipeline river crossings, an extensive monitoring programme was implemented. This work focused on determining the effects of the works during and post-construction through the monitoring of physical and biological parameters. The monitoring programme was detailed in the River Crossing Strategy, and can be summarized as follows:

- **Pre-construction** - monitoring on selected rivers to address: hydrology (river width, flow velocity, channel depth and geomorphological surveys of river and flood plain characteristics); hydrochemistry (pH, dissolved oxygen, suspended sediment concentration, oil products, water temperature); fish fauna (reconnaissance survey to determine most appropriate sampling locations and sampling of fish fauna upstream and downstream of crossing points on 26 rivers); benthos (sampling of invertebrate community at upstream and downstream locations on 26 rivers); and fishery characteristics (field survey to determine presence and extent of salmon spawning areas at crossing points on 432 rivers and assessment of spawning habitat area, number of redds and characteristics of riverbed sediments on 85 rivers).
- **During construction** – monitoring of sediment generation during pipeline installation, and determination of the potential fate of this material. Sampling of turbidity and suspended sediment concentrations was undertaken during construction and post-construction to

determine whether sediment was still being introduced into watercourses following initial remediation works. Additionally, dedicated supervision and compliance monitoring by a team of external observers was undertaken at each river crossing to ensure that mitigation measures to minimise potential environmental harm were being implemented.

- **Post-construction** – turbidity measurements were continued following construction to detect potential sediment inputs that may be due to soil disturbance at river crossings or due to runoff from the pipeline ROW. Post-construction monitoring focuses on the same parameters as pre-construction monitoring, including hydromorphology (e.g. channel profiles), hydrochemistry, suspended sediments and turbidity, ichthyofauna, benthos and fishery characteristics.

Turbidity data were collected during Construction to determine locations of sensitive river crossings where sediment inputs from the ROW could occur. This involved periodic upstream and downstream samples at key sensitive river crossing locations following the spring thaw. The overall approach involved the identification of rivers where turbidity levels downstream were either:

- Greater than 10NTU (Nephelometric Turbidity Units) higher than upstream levels, or
- Less than 10NTU higher than upstream levels, but where the downstream value was greater than twice the upstream value.

In the spring of 2006, turbidity samples taken on 157 rivers found that downstream turbidity levels were over 10NTU higher than upstream levels on at least one sampling occasion on 61 (39%) of these 157 rivers. By the end of June 2006, the proportion of rivers with raised downstream turbidity levels had declined significantly due to improved drainage and erosion control practices and due to the end of spring thaw period. In the medium term (over the next 3-4 years), turbidity monitoring will continue to assess ROW stabilisation, and to determine whether additional management is required to reduce sediment inputs.

Based on data available from previous studies, and with reference to general ecological principles, it was predicted that the watercourses crossed by the pipelines would recover within 2-3 years (River Crossing Strategy). Initial analysis of the post-construction monitoring data obtained so far appear to support this prediction, and even suggest that recovery could be more rapid than predicted. A summary of the initial results is provided below.

On 85 rivers, salmon-spawning habitat (total area and quality) has been monitored in the vicinity of the pipeline crossing locations, from 50m upstream of the crossings to 500m downstream. Due to the timing of pipeline construction, conclusions from the available data can only be drawn at the present time for a sub-set of 41 rivers where both oil and gas lines were installed in the same winter season 2005 / 2006. Data, has so far been collected over a three year period - two years before installation and the year after installation and relates to two parameters:

- The presence and density of redds in the monitored sections and;
- Sediment grain size of riverbed sediments: presence of sediment <1mm and increase in sediment of this grain size in the impacted monitoring zone

Of these 41 rivers, monitoring revealed that:

- Significant numbers of redds were present on 22 rivers within the zone of monitoring, while 16 rivers supported no redds at all over the three year period;
- There is a significant correlation with natural redd variation in majority of the 22 rivers. There are 3 rivers having an increase in redds at the construction site; this is better than would be expected from the background measurement at –50m point.
- There is no significant variation in redd density with distance i.e. from –50m to +500m from the crossing points on the monitored rivers.

Grain size monitoring from 41 rivers (based on 6 samples per river) revealed that:

- There has been a significant increase in sediment of grain size <1mm at the – 50m locations i.e. there has been a significant increase in natural sedimentation over the monitoring period;
- Although there has been in increase in grain size <1mm in 73% of samples at and immediately downstream of the crossing points, only 9% of samples showed an increase which is considered non-natural (i.e. above the increase noted for upstream samples); and
- There is no significant increase in grain size <1mm at locations beyond the +150m locations.

Based on these preliminary results, it can be concluded that the impact of pipeline construction on sediment inputs into the rivers the river crossings is unlikely to be significant within the context of natural variation and beyond a 2-3 year period, although further monitoring will be required to confirm this. It is also important to note that there was no observed increase in sediment grain size at the critical <1mm at distances beyond 500m downstream. In the River Crossing Strategy, it was estimated that spawning habitat that could potentially be affected by the pipeline crossings would be in the range of 0.38-1.34% of the total available spawning area within the sensitive rivers, based on a maximum downstream potential impact distance of 500m. The preliminary results from the post-construction monitoring seem to strongly support this original assessment.

These findings are also supported by analysis of the suspended sediment concentrations during construction. This data indicates that the majority of fine-medium grained sediment in the critical grain size range (0.1-1mm diameter) settled out of the sediment plume prior to 500m downstream. Although, the data indicates that some sediment (approximately 20-30%) in this range was transported beyond 500m, this finding is line with predictions and observations made from other studies, and suggests that sedimentation within the watercourses resulting from construction was largely confined to the immediate area downstream of the crossings.

Although the data has not yet been fully analysed (or indeed collected following completion of the pipeline construction programme), comparison of pre- and post-construction surveys revealed some interesting results with respect to the freshwater macrobenthic fauna (i.e. the larger invertebrate species). For example, in 2005, five months following the crossing of the Dagi River by oil pipeline, the macrobenthos was dominated by the larvae of several insect groups, with a total of 30 species recorded from the sampling sites (50m upstream, the construction site and 25m and 150m downstream). The dominant species of the bottom community were larvae of the mayfly *Ephemerella ignita* and larvae of the craneflies belonging to the genus *Hexatoma*. Caddis flies were also well represented with larvae recorded from six species. Least diversity was recorded 150m downstream of the construction site (6 species) and highest diversity (21 species) 25 m downstream of the construction site, the same pattern as observed in 2004 (i.e. pre-construction). The general pattern of species composition was found to be similar, but interestingly biomass was significantly greater in 2005 than in 2004 (on average by as much as 12 times) and species diversity three times greater. Despite the similarity in the dynamics of the abundance data, the largest difference in the benthic structure was observed at the construction site, as would be expected. The fluctuation of abundance data from sample location to location was probably due to variation in morphological features in the river (riffle – pool sequence) and was not considered to be indicative of any significant human impacts.

In the smaller Sobolinyi Brook a different situation was observed. Here, in August 2005, 41 species of macrobenthos were recorded with larvae of flies, stoneflies and mayflies dominating. Significant variability in the composition of the fauna occurred from site to site due to variations in riverbed conditions. Faunal abundance was found to be sharply different from pre- to post construction, the main change being a large decline in abundance at the construction site and 25 m downstream in 2005. However, at 150m downstream, benthos abundance was much greater in 2005 than in 2004. The pattern that emerges from comparison of the data is that there was significantly more variability in the abundance and composition of the fauna between sampling points in 2005 than that recorded in 2004. Although species diversity was generally higher in 2005 it was not the case at the 25m sampling point immediately downstream of the construction site (see Table 8.2).

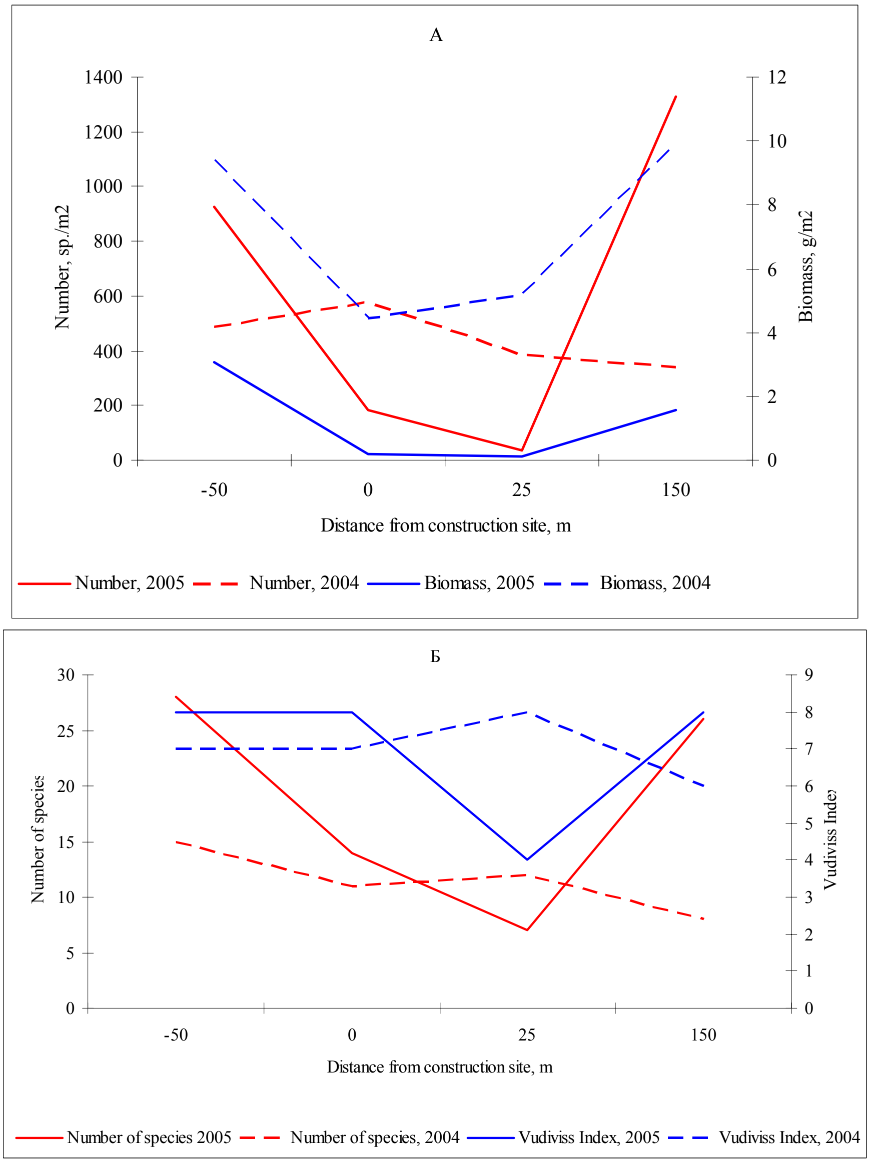


Table 8.2 Comparison of benthos abundance dynamic in Sobolinyi Brook in August 2004 and 2005.

In addition to macroinvertebrates, 5 fish species were found in catches in Sobolinyi Brook in 2005, including dolly varden, cherry salmon, coho salmon, East Siberian char and Siberian barbate loach. With the exception of coho salmon, all fish species found in the brook in 2005 were observed in the August of the preceding year.

With data available from other pipeline crossings, the general conclusion drawn is that there is significant variability in the response of benthic fauna from one river to the next. It is apparent that even within one year, re-colonisation of the streambed area at the pipeline-crossing site occurs, and that diversity and biomass may be higher or lower to that previously recorded. This may in part be due to natural variability in these river systems (as significant changes in upstream values are also observed), but may also be attributed to the effects of the construction work. Perhaps the most noticeable trend recorded was that diversity was lower at the 25m downstream sampling point following construction. This lower diversity and biomass represents initial colonization of deposited sediment washed downstream from the crossing point. At the 150m sampling point, diversity and biomass are generally more comparable bewteen 2004 and 2005 suggesting that the influence of deposited sediment at this distance is reduced from that closer to the crossing site.

Further analysis of data and continuation of monitoring for several years following construction will be required to completely document the recolonisation and recovery process. For the majority of parameters, this will extend to a 2-3 year period (e.g. macroinvertebrates), but for salmon a 3-4 year period will be undertaken to ensure that monitoring covers the life-cycle periods for the key species (see Section 6). As discussed above, data available to date suggests that the impact of construction on riverbed spawning habitat was probably confined to relatively small sections of watercourses and within the context of natural fluxes in sediment transport unlikely to be of ecological significance.

Reinstatement of the pipeline ROW

To reduce the erosion of exposed soil and rock along the ROW and the potential for sediment laden runoff to enter watercourses, a programme of ROW stabilisation and reinstatement has been actively pursued following installation of the oil and gas pipelines. This work involves the following components:

- Temporary erosion control; with the objective to reduce slope instability, minimise surface erosion and prevent sediment run off into adjacent watercourses before installation of permanent erosion control measures;
- Technical reinstatement; involving the removal of construction debris, pipeline ROW clean up, levelling and re-contouring to pre-construction contours where possible, installation of permanent erosion control measures; and
- Biological reinstatement; soil preparation and seeding.

A number of specific plans have been developed which set out the overall objectives, actions, resources and management measures required to achieve reinstatement of the ROW. For temporary erosion control, priority has been given to the locations of crossings of ecologically sensitive rivers and their adjacent slopes. The main activities have involved silt fence and slope breaker installation and repair; Reno mat repair or replacement; temporary and unstable bridge removal, bridge repair, and acquisition of new temporary bridges, flow clearance and the removal of ice plugs from bridges and culverts to prevent flooding on the ROW and slope stabilisation (in particular vulnerable high risk slopes). In addition to temporary technical erosion control measures, temporary biological measures have also been applied where relevant. This has included hydroseeding, manual seeding on riverbanks and some aerial seeding where the topography is appropriate. Hydroseeding forms part of the final biological reinstatement programme and will be undertaken using hydroseeders and hand seeding where required in combination with other control measures.

8.2.2.8 Actions to manage ecological effects of erosion

In line with the above assessment, and biodiversity priorities as set out in Section 7.1.7 of this document, habitat action plans should address the following items:

1. River crossing monitoring – the programme of physical and ecological monitoring of

watercourses should be continued until 2010-2012, depending on the parameter being investigated. Where appropriate the existing programme will be rationalized and integrated with regulatory monitoring requirements to collect complete data sets for some rivers and to obtain a full picture of the recovery of these systems from the disturbance caused during pipeline construction. The objective will be to obtain data for a minmum of 15 key rivers using upstream datapoints as control points and indicators of pre-construction ecological conditions.

2. Reinstatement and restoration of ROW – a specific set of management plans have been developed setting out requirements to ensure that the pipeline ROW is stabilized and sediment loss from the ROW is minimised or prevented, particularly at river crossings. The effectiveness of the measures set out in these plans will continue to be monitored and further management undertaken where deficiencies in these measures are identified. Monitoring actions include aspects such as regular inspections of the ROW and the use of remote techniques, such as aerial observation of the success of vegetation establishment along the ROW.

3. River restoration project – On the basis of the reconnaissance work and initial surveys develop, in partnership with local authorities and departments, a management plan for the Dzhimdan River. This will set out the restoration measures that will be implemented to improve habitat quality at selected sections of the river. On the basis of work undertaken so far these measure are likely to include: repairs to bridges and culverts, tree planting in areas where forest cover along the river banks has been lost and removal of obstacles to fish migration. Monitoring of the restoration works to determine changes in habitat quality will be undertaken.

4. Taimen research project – Further work on taimen by Sakhalin Energy will be the subject of a specific Action Plan (see Section 9). This will be developed in conjunction with Russian and Japanese partners and the Wild Salmon Centre. The findings from the research project initiated by Sakhalin Energy will be communicated via a scientific research report and the results used to identify any specific management measures that could be employed to improve habitat quality for this species. The information gained from the study will also be utilized in: assessing the the potential impact of any future pipeline river crossing works, applied in situations where maintenance of crossings is required and where monitoring reveals that habitat potentially used by taimen is being affected by continued disturbance related to Sakhalin Energy activities. Given the critically endangered status of the Sakhalin taimen and the need for further information on its status and potential response to human activities in riverine environments it is proposed that an Action Plan will be developed for taimen as part of the ongoing implementation of the BAP. The Action Plan will be produced in collaboration with the Biodiversity Group, with the aim of building upon the existing research workl that Sakhalin Energy has initiated. International experts in the ecology of taimen will be invited to take part in the development of the plan and in monitoring its progress.

8.2.3 Invasive species, induced access and human disturbance

8.2.3.1 Invasive species

One of the most often cited and potentially detrimental ecological effect associated with linear corridors such as pipeline ROWs is the facilitated spread of invasive and undesirable species into previously ecologically intact areas. The construction of pipelines and associated infrastructure and subsequent maintenance, particularly in relatively intact habitats, represents disturbance that creates and maintains new edge habitat. In situations where ROWs are disturbed and maintenance is minimal, they can serve as ideal sites for the establishment and spread of invasive species, largely as a function of the large edge-area ratio and the disruption to ecological processes caused by construction and maintenance.

Pipeline corridors and roads may be the first point of entry for exotic species into a new landscape, from which some species may then be able to move into adjacent areas of habitat where conditions are suitable. Invasive species are generally opportunistic in nature and can often out-compete existing flora and fauna, resulting in the biological homogenisation of areas (i.e. complexes of disturbed habitats that comprise species in common). Besides the potential disruption to structure and function of an ecosystem that invasive species may have, their management in situations where their presence is considered undesirable can lead to expensive and long-term eradication schemes.

Zink *et al*. (1995) studied the effect on plant species composition of the construction of a pipeline corridor through a biological reserve in southern California. They found that the corridor supported a relatively homogeneous plant community that had a low similarity to the adjacent native plant communities. Soil organic matter in the disturbed pipeline corridor was significantly less than in contiguous undisturbed areas, but available nitrogen and phosphorus content was higher in the corridor. The greater availability of nitrogen and phosphorus in the pipeline corridor enabled invasive annual species to become established and persist. Zinc *et al*. (1995) also noted that these invasive annual species started to establish themselves in several of the native vegetation communities. Poor restoration management of the pipeline corridor was proposed as the main reason for the significant difference between the corridor and surrounding vegetation communities.

Animals using ROWs to move between areas may transport seeds of potentially invasive plants on their body or in the gut. Humans may also affect ecological processes directly though increased hunting and poaching effort or indirectly through the transport of seeds on clothing, unwashed vehicles or utility equipment.

8.2.3.2 Induced access and human disturbance

One of the indirect, but potentially more significant, impacts of habitat fragmentation through linear development is the increased access that such development provides to natural, expoitable resources such as species of mammals, birds and fish that are valued for their meat or pelts. In tropical countries, this issue is of particular concern with regard to the 'bushmeat' trade and the exploitation of wild populations of mammals and birds that become more readily accessible to hunters.

In relation to oil and gas development, the creation of pipeline ROWs and associated access roads may facilitate access to areas that were previously rarely visited and that may still support significant populations of potentially exploitable prey. Poachers, hunters and users of all-terrain vehicles or snowmobiles may find pipeline ROWs readily accessible, particularly where they intersect with access roads. If vegetation is maintained in a low growing state then a ROW may become a desirable transit route, providing access to areas that may have previously been largely inaccessible and which may also have been relatively intact.

Bears, in particular, experience chronic, negative interactions with humans, and increased human accessibility into areas of habitat used by bears increases the potential for mortality of both bears and man and may lead to high-quality habitats in areas where access has been generated becoming population sinks (Wisdom *et al*., 2000). Smaller carnivorous mammals such as marten, lynx, racoon dog and wolverine may be vulnerable to overtrapping in areas in which access is facilitated via ROWs and associated access roads, despite the setting of quotas by authorities responsible for hunting. Intersections between ROWs and watercourses can provide increased opportunities for the taking of salmonid fish and this is of concern in areas where there is limited or no enforcement of permitted fishing quotas.

Linear developments, more than any other factor, affect the distribution of hunters and therefore, the distribution of the hunter kill. In north-central Minnesota, USA, 143 deer older than 6 months were radiocollared and monitored. Mortality during the hunting season was 2-4 times higher for deer residing <0.2 km from a road than for those >0.8 km from a road (Fuller 1990, quoted in Jalkotzy *et al*., 1997). Increased access can result in the overharvest of local mammal populations. In boreal forest habitat in Ontario, resident marten in uncut forests had higher mean ages, were more productive, and suffered lower trapping mortality than those in logged forests (Thomson, 1994). Logged forests had an associated road network allowing easy access into the areas.

Various developments in the Kamchatka peninsula, Far East Russia, prompted the construction and improvement of roads / easier access, which led to severe increases in salmon poaching activity, and consequent direct impacts on salmon populations in local rivers. For example, construction of an earth road to the Barhatnaya Mountain in the Paratunka River catchment unfortunately provided many poachers with access to spawning areas of various salmon species. Consequently, spawning success rates have decreased significantly, and the current poaching catch of salmon in the area is 70-90% of the total number of fish entering river (Zaporozhets, Zaporozhets, 2003).

In a study of ruffed grouse (*Bonasa umbellus*) near Rochester, Alberta, hunting along roads accounted for 96% of shot birds (Fischer and Keith 1974). Loss of territorial adult male grouse to hunters decreased significantly with increasing distance to the nearest road (e.g. 48% of the birds that were banded within 100m of a road had been shot by 1st October while only 5% of banded birds at a distance of 200-300m from a road were shot). Similarly, in Alaska, hunting along roads in autumn removed about 13% of grouse that had been banded within 2 miles (3.2 km) of roads in summer or early autumn (Ellison, 1974). Jalkotzy *et al*. (1997) conclude in their review of the effects of linear developments that hunters are unlikely to visit marshes and other water bodies if they cannot be reached along a disturbance corridor (e.g. road, trail).

Many species of mammals and birds are also sensitive to human presence and the disturbance that this may cause, particularly during sensitive life cycle stages, such as nesting or breeding. Increased access and associated disturbance may lead to reductions in productivity, increases in energy expenditures, or population displacement from otherwise structurally intact and suitable habitat. Species at particular risk include some grouse species that have long established breeding grounds (e.g. Siberian spruce grouse (*Falcipennis falcipennis*), other tree nesting or ground nesting birds (e.g. some species of raptors, owls etc.) and mammals with large territorial requirements.

The presence of humans, as opposed to human developments, appears to be the most disturbing factor for many bird species. The degree of reaction to different disturbances is species-specific. Male sharp-tailed grouse (*Tympanuchus phasianellus*) demonstrated site tenacity at leks; they remained on leks and displayed despite parked vehicles, taped voices, and a leashed dog (Baydack and Hein 1987). However, they were displaced by human presence. Displaced males remained >400m away and returned immediately following human departure. Female sharp-tailed grouse seemed less tolerant and were not observed on any lek during disturbance.

Breeding birds may respond to potentially disturbing factors in a number of ways (e.g. flight from the disturbance source, remaining on nest sites, increased territorial behaviour etc.). The response of shorebirds and colonial nesting waterbirds, such as terns, has been relatively well studied. Breeding waterbirds are tolerant of human activity up to a certain distance from their nesting sites (known as the flight initiation distance), which from field observations is generally in the range of 50-100m for direct human intervention, depending on the species (e.g. Erwin 1996; Rodgers and Smith, 1995; Blumstein *et al*., 2003 and Finney *et al*., 2005). However, once encroachment within this zone occurs birds are likely to respond by leaving their nest sites and thus subjecting eggs or chicks to periods without parental care which, if these periods are prolonged, may lead to mortality. Occasional disturbance within these zones, if limited, is unlikely to lead to the desertion of nests or chicks by adults. Evidence from studies indicates that breeding waterbirds are far more disturbed by the presence of humans approaching their flight initiation zone than by vehicles or noise associated with human activity. Birds are also unlikely to nest in areas that are influenced by existing and disturbing activities and will seek more suitable habitat elsewhere in which to establish nest sites. This may have adverse consequences in areas where suitable habitat is limited and disturbance-related displacement from potential breeding sites leads to increased competition for nest sites or food resources.

Raptor avoidance of human disturbance is particularly well-documented, although it is apparent that tolerance varies by species. Goshawks do not appear to tolerate human disturbance and thus may avoid areas of human activity. In a Norwegian study of 21 goshawk nest sites, the distance to the nearest house varied from 250m to 1,000m (average 550 m). Swainson's hawks, appear to tolerate humans in close proximity. A study of the distribution of breeding Swainson's hawk in Alberta found that 15 of 68 nests were located within 500m of a human residence. Cooper's hawks also seem to need less privacy. A similar study of the habitat attributes of Cooper's hawk nest sites in an extensively-forested region of the northeastern United States found that nest sites were not significantly further from paved roads than were random sites. Some nests were located within 100m of roads indicating that this species is remarkably tolerant of car traffic. However, most nests occurred in deeper forests with the distance to roads and human habitation averaging 511m and 687m, respectively (quoted in Jalkotzy *et al*., 1997).

Work on the distribution of bald eagles in Chesapeake Bay found that most wintering roosts (86%) were in wooded areas >40ha, and none were in human-developed areas. In contrast, only 23% of random sites were in wooded areas >40 ha, and 9% were in developed areas. Roosts were found to be farther from human development than were random sites (Buehler *et. al.* 1991). It was also observed that shoreline segments used by bald eagles had more suitable perch trees and a larger percentage of forest cover than unused segments, an observation that probably reflects, to a large degree, the lack of these features in developed shoreline sections.

Increased access may also lead to over exploitation of newly available non-timber forest resources such as edible berries, fungi and plants of medicinal or decorative value. A variety of products are harvested from northern temperate forests for personal or commercial use and consumer forces and expanding markets are contributing to the increasing development of these products, particularly as viable economic options for some rural communities. Access to these areas where these resources are present may therefore have important economic value. Opening up new areas of relatively intact habitat may increase the pressure on available resources (through improved access), although for some valued plant species (e.g. berry-bearing forest shrubs) the clearance of forest habitat may increase available habitat and thus the overall resource.

To some extent the human disturbance during oil and gas operation can have the direct impact on biodiversity. For example, the gas flaring has the potential to result in certain impact on the wildlife, especially birds. Everywhere in the world where gas is flared, the dead birds are found in the area around flares. However in the case of Sakhalin II Project's facilities the highest flare (which may have a negative impact on birds) at the LNG and OPF is expected to occur only during start-up and commissioning as well as in emergency cases, while during steady operations the flare will be only 1-2 m high and can hardly impact birds.

8.2.3.3 Sakhalin Energy's management of invasive species and induced access

Invasive species

The native flora of Sakhalin has been supplemented by many species of non-native plants, some of which have the potential to be invasive or that have invaded a variety of habitat types (e.g. *Tussilago farfara*, see Section 6.2.1). Some species of grass (such as *Dactylis glomerata* and *Festuca pratensis*) brought to Sakhalin by Russian and Japanese farmers have spread from meadows into forest edges and light forests.

The establishment of vegetation on the exposed soils of the ROW is viewed as the most significant mechanism for minimising potential sediment loss and run-off into watercourses (see Section 8.2.4). However, for safety and legislative reasons it is not permitted to allow natural revegetation and re-establishment of forest/wooded habitat to occur on the pipeline ROW. Seeding of the exposed ROW with grass and perennial herb species has therefore been undertaken in order to promote soil stability, reduce erosion potential and also allow safety inspections of the ROW to be undertaken in line with legislative requirements. The plants used in the seed mixture applied to the ROW are known to exist on Sakhalin, but are not native to forest habitats through which much of the ROW passes. The spread of these species from the ROW into adjacent forest and wooded habitats would constitute an adverse impact on the native flora and 'naturalness' of existing habitats along the ROW, particularly where these remain relatively unmodified by human activity.

The ecology of the species used for seeding indicates that they would be unlikely to undergo significant spread laterally from the ROW into forest habitat as they are species that require relatively high light levels and fertile soils. The fact that species such as *D. glomerata*, introduced onto the island many decades ago, appear to be confined to forest edges and clearings suggests that its invasive properties are limited. However, some species may take advantage of the opening up of forest/woodland canopy and spread along the ROW and then out into adjacent areas of habitat. While the potential for this may currently be limited, it is difficult to predict whether the effects of potential climate change will enhance the capability of some of these species to undertake further invasion of habitat adjacent to the ROW. It should also be noted that due to the anthropogenic modification of habitats, many non-native species have already become established in areas adjacent to the ROW and facilities. Therefore, while further spread of species via the ROW may occur this in itself may be into areas where modification of the vegetation has already taken place.

In response to the recognized potential for invasive processes, Sakhalin Energy will be undertaking monitoring of the pipeline ROW to determine the presence of invasive plant species over the lifetime of the project. Management actions tied into this monitoring have yet to be developed. However, it is likely that the removal of plants and/or treatment of areas where invasive species become established would be required. Monitoring the entire length of the ROW may prove time consuming and resource intensive. The priority here will therefore be to identify areas and sites where existing plant communities are unaffected by non-native, invasive species and to develop measures to prevent or minimise potential invasion

Management of human disturbance and induced access

The creation of the ROW and associated roads used for the construction of the onshore pipeline has the potential to provide increased access to previously undisturbed or relatively intact areas of habitat. To a certain extent the potential for this has been reduced as a consequence of the pipeline being routed close to existing access networks and infrastructure (e.g. roads, railway and transmission lines), from which access to rivers is already possible. However, it is appreciated that the ROW and the access roads required for construction of the pipeline and the ROW itself may provide an increased opportunity for access to forest areas for hunting and gathering of forest produce and to rivers that support salmon stocks. As a result of this, increased hunting and poaching pressure could be placed on bird and mammal populations in forest habitats and salmon stocks in some rivers. Additionally, greater access into areas by hunters and the potential for a general increase in human activity would also lead to higher levels of disturbance.

Management of access in relation to habitat disturbance and resource use is a complex issue, particularly in this situation given the extensive nature of the construction works, existing level of access to many areas and the already widespread occurrence of poaching. Although the effects of induced access, particularly on fisheries, will not be significant during the construction phase, as works will be undertaken outside of the salmon spawning season, consideration and planning is still required to ensure that appropriate measure are in place following the completion of the works.

Sakhalin Energy is committed to ensuring that the potential for greater hunting, poaching and disturbance as a result of its activities is minimised and managed through the application of suitable measures. A range of management actions are currently being implemented during construction and suitable measures will be put in place during operation.

As discussed above (see Section 8.2.6), construction and associated human activity has the potential to cause disturbance to wildlife, which, if significant, may result in disruption to normal behviours, effective loss of habitat or a reduction in breeding success. Disturbance is of particular concern to species, such as many birds, which utilize specific areas of habitat or even individual trees or sites for breeding. Sakhalin Energy has recognized this issue and undertaken a number of surveys and implemented a range of mitigation measures to deal with potential disturbance to rare breeding birds during construction. This has included:

- Use of data obtained from the sea-eagle research programme (see Section 6.2.5.2) which has identified breeding sites used by Steller's sea-eagles and white-tailed sea-eagles that fall within a potential zone of construction related disturbance. On the basis of data from the research programme, and studies elsewhere, this zone was fixed at 1km. All nesting areas within this zone were subject to the development of specific mitigation measures designed to ensure that disturbance to breeding sites was minimised during the breeding season (March-September). For sites within 500m of construction activity, stringent measures have been adopted that effectively prevent activities occurring within the 500m zone for the entirety of the breeding season. As discussed in Section 6.2.5.2, the whole programme has been overseen by an expert in Steller's sea-eagle ecology. While there have been some isolated instances of activities occurring in the buffer zone within the sensitive breeding period, it is apparent from the monitoring data that this programme of mitigation measures has been successful and enabled eagles nesting close to the construction sites to continue to breed and raise chicks;
- Monitoring of the known population of Siberian-spruce grouse adjacent to the OPF. This species occupies defined sites during the spring that are used by the males for display (lekking sites). Disturbance during this period, or loss of an area, can significantly affect the ability for birds to undertake successful breeding. Annual surveys have therefore been undertaken during construction to ensure that works at the OPF are not adversely affecting the lekking area and that the birds are unaffected by the nearby construction activity. Results from the survey indicate that the population of birds using this area remain as they were prior to construction, indicating that the works do not appear to have had an adverse impact on this species at this location; and
- At Chaivo, where the offshore pipeline from the PA-A and PA-B platforms comes ashore, significant survey and monitoring effort has been undertaken to document the distribution and behaviour of rare breeding birds using the wetland habitats of the Chaivo peninsula. The breeding sites of several RDB species, notably the Sakhalin subspecies of dunlin, Aleutian tern and Steller's sea-eagle have been comprehensively surveyed and mapped during the construction period (2004-2008). Data from the survey has been used to ensure that a suitable 'buffer' distance between areas of habitat used by the birds and

construction activity has been recognized during construction and that activities are not undertaken in this buffer zone while birds are present in the area. This has led to the scheduling of the majority of construction activity during the winter months except where it has been demonstrated that the works would not lead to the disturbance of habitat areas used by these rare species.

8.2.3.4 Actions for management of invasive species, induced access and disturbance

In line with the above assessment, and biodiversity priorities as set out in Section 7.1.7 of this document, action plans should address the following items:

1. Periodic, targeted monitoring of the pipeline ROW and project disturbed areas around the LNG and OPF sites will be undertaken to determine the presence of invasive plant species over the lifetime of the project. The data from this monitoring will be used to determine potential requirements for any actions by the Company to control the growth of invasive species.

2. At a practical level, access to previously inaccessible areas that may have been opened up by the construction works has been discouraged through the use of barriers across roads. Temporary access roads or new extensions to pre-existing roads or tracks constructed during the pipeline laying operations that have been identified as non-operational will be removed and access to the ROW blocked when construction activities have been completed. Periodic monitoring of these access restriction measures will be undertaken during operation to ensure that they remain effective.

3. For the operations phase, in order to optimise the approach taken in dealing with the potential salmon poaching issue, Sakhalin Energy will continue its engagement with the Wild Salmon Centre and Sakhrybvod to determine the most appropriate measures to combat potential access-induced issues and incorporate agreed recommendations into the access planning process. It is likely that this process will involve the identification of core areas of high fishery value where the ROW and access for construction may result in the opening up of areas in which vehicular access was previously not possible or minimal. In such areas, mechanisms to avoid the development of permanent access would be fully considered and all practical measures taken to remove or eliminate access routes associated with the works would be implemented.

4. Monitoring work to determine the effect of construction related disturbance on rare bird species will be continued through post-construction and as a minimum the first three years of operational activity. This survey work will cover the population of Siberian spruce grouse at the OPF and the rare wetland breeding birds at Chaivo using the survey methodologies and approach that has previously been applied. The data gained through the continuation of this work will enable the effectiveness of management measures to be assessed and for any changes to be identified and implemented in instances where disturbance from activities is considered to be potentially adverse. The need for the continuation of this work will be reviewed following analysis of survey data after three years of operational activity at the OPF and Chaivo.

5. The Sea-eagle research project has been a great success and significant and important data on the breeding behaviour and ecology of Steller's sea-eagle has been collected and utilized in the development of measures to deal with potential project-related impacts. With the shift from construction through to operation, the nature of potential activities changes and the potential for disturbance related impacts on breeding sites will decrease. However, with significant human activity and operations occurring in areas used by sea-eagles there is still a need to ensure that Sakhalin

Energy's activities do not adversely affect behavioural aspects of these species such as site selection, breeding success and foraging site availability. The SERP will therefore continue to be undertaken by Sakhalin Energy, but the focus for the programme will shift to determining and managing potential operational impacts and disturbance effects related to this. The establishment of the longer-term monitoring/research plan for sea-eagles will be the subject of a specific Species Action Plan that will be developed by Sakhalin Energy in collaboration with the Biodiversity Group.

8.2.4 Oil pollution in the terrestrial environment

Oil spills in terrestrial ecosystems may have adverse effects on soil properties, plant communities and aquatic habitats. Oil degradation in sub-acrctic and arctic terrestrial ecosystems can be extremley slow particularly in areas of permafrost. A 2,000 gallon experimental oil spill undertaken in Alaska initially led to the death of black spruce trees and modification of the surrounding vegetation. Nearly 25 years later, only 10% of the oil in the mineral soil had been degraded and 40% in the organic layer. This lack of degradation is attributable to low bacterial productivity as a result of limited soil nutrient (notably nitrogen) availability coupled with the low temperatures. In a similar experiment, Seburn *et al.* (1996), report on the vegetation response to the loss of oil from a simulated subsurface pipeline within a cleared ROW (i.e. to model the response likely under standard operating conditions). A total of 20 barrels of oil were pumped into an open ended pipeline buried 1m deep. A significant proportion of this oil then rose to the surface of the pipeline ROW due to the saturated soil conditions. Monitoring of the vegetation post oil spill showed that total plant cover on the heavily oiled ROW declined by 73% in the first growing season. Of the 34 plant taxa identified, 13 declined significantly in abundance by the third growing season after the oil spill, mainly on the heavily oiled ROW. Three growing seasons after the spill, cover of 17 taxa was significantly affected by the oil: two disappeared locally, ten consistently had lower cover, three increased in cover, and one displayed a mixed response. Lichens, native grasses, shrubs, and forbs appear to be most negatively affected by oil, while mosses, agronomic grasses (*Alopecurus arundinacea*, *Phleum pratense*, *Poa glauca* and *P. pratensis*), and sedges appear to tolerate oil or, in the case of *Carex* spp., thrive in its presence. Negative effects were most evident in the low-lying areas of the ROW, where the plants were subjected to high concentrations of crude oil. In lightly contaminated areas, there was little or no negative response to the oil after three years.

In northwestern Siberia, hydrocarbons degrade very slowly due to the acidic, cold, hydromorphic, low humus conditions of soils, so that oil concentrations from repeated spills accumulate. Under these conditions, soil contamination lasts for many years. In the forest-tundra zone (near Labytnangi), heavy contamination and well-defined "oil spots" were present without any signs of oil decomposition two years after an oil spill (Shtina, Nekrasova, 1988). Algae and invertebrates were completely absent, and only fungi and bacteria were recorded (Opekunova, 2004).

These findings reflect those of Moscow State University, which studied the impact of oil and gas production on the environment in the largest oil and gas fields of the European Russia and Western Siberia: in Samara, Tyumen and Tomsk provinces. They found that soil contamination was followed by impoverishment and degradation of soil mesofauna. The biodiversity of soil mesofauna (including annelids, nematods, adult insects and their larvae, spiders, myriapods, and molluscs) around oil spills was 2-3 times lower than in the uncontaminated soils. Annelids were not found at all, and the number of spiders and rove beetles in topsoil and litter was about 50% in comparison with the undisturbed ecosystems.

Phytotoxicity of oil depends on its concentration. Studies in Siberia showed that, after small oil spills when the residual amount of hydrocarbons two years after a spill did not exceed 4-5 kg/m^2, both soil and vegetation demonstrated self-restoration. Plant species which were the most tolerant to oil belonged to genera of Typha, Juncus, Carex, Alisma, Eleocharis, Phalaris, Calamagrostis, Eleocharis, Chamaenerion, and Eriophorum. Following mild spills, pre-spill phyto-abundance was reached within 3-5 years; under heavier spills, restoration took 10-15 years. They noted that recent spills were particularly toxic for seedlings of tree species; threshold limits were 1-2%. Tolerance of tree seedlings to oil contamination decreased between genera; ranging less to more sensitive were white birch, Siberian cedar pine, common pine, Siberian spruce, Siberian fir, and larch (Chizov, Zakharov, Garkunov, 1998).

Oil spills in wetland areas may pose particular problems as a result of the transport and spread of oil via hydrological processes and the difficulty in clean-up of such areas. Generally the recovery of wetlands after exposure to an oil spill relies on removal and degradation of oil, and revegetation. Revegetation may occur naturally via vegetative growth (e.g. from rhizomes and roots) and seedling emergence or through restoration efforts (e.g., planting of nursery stock). Emergence from the seed bank may provide the most rapid recovery of vegetation in terms of cover, diversity and community structure because wetland soils contain an abundance of seeds. Through laboratory studies, Vavrek and Campbell (1997), demonstrated that the regeneration of wetland vegetation from a seed bank can be slowed by exposure to oil, largely due to adverse effects on germination potential. Nevertheless, in wetland areas exposed to oil, seed banks potentially contribute a substantial number of seedlings indicating that they are an essential component of freshwater wetland recovery after a spill. Exposure to oil may, however, affect the composition of the recovering vegetation, if differential sensitivity to oil by species occurs.

Although ground spills from pipelines may be significant, impacts from them tend to be localized. However, this may not be the case where oil is spilled at a river-pipeline crossing as any oil will quickly be transported downriver. Areas where spilled oil is likely to collect downstream will often be where water velocities are reduced (e.g. where watercourses enter wetlands), or in areas where water flows through or against gravel and sand structures in the river (e.g. bars). Although "dilution" of oil occurs and this factor has been often cited as a partial solution to spills in river systems and marine environments, it is apparent from recent research that oil residues in river systems may be toxic at proportions of parts per billion, rather than previous standards of parts per million.

In rivers, dissolved oil and oil products can reach concentrations of 10-30 mg/l. Known, lethal concentrations for fish eggs and juveniles are 0.005-0.1 mg/l, for plankton 0.1-1 mg/l, and for adult fish 10-15 mg/l (Khaustov, Redina, 2006). Even comparatively low levels of oil contamination, which previously were considered harmless, cause changes in blood composition and carbohydrate metabolism in fish and molluscs (Keselman, Makhmudbekov, 1981).

Surveys in the Malaya Kimitins River catchment showed that most oil contamination in these Kamchatka streams and rivers, even at low concentrations, had a negative impact on salmon spawning areas. Studies of adaptational reactions of fish and molluscs to non-lethal concentrations of toxic compounds in freshwater (Danilchenko et al, 1983) showed that juveniles' survival was significantly lower, even within the first generation. Continuous exposure to contaminants considerably weakened fish immune systems (Wedemeyer et al., 1981), while chronic effects included damage of the surface of gills and mucous membranes, increased sensitivity to various infections, cancers, and physiological stress (Novoselov et al., 1999; Heintz et al., 1999).

Following the Exxon Valdez oil spill in 1989, subsequent studies found that the subsurface cobbles and gravels of stream banks harbored biologically available oil, exposing and killing pink salmon embryos for at least 4 years (Peterson *et al*., 2003). Heavily oiled coarse sediments formed and protected subsurface reservoirs, sequestering oil from loss and weathering in intertidal habitats containing fish eggs. After the spill, fish embryos and larvae were chronically exposed to partially weathered oil in dispersed forms that accelerate dissolution of 3-, 4-, and 5-ringed hydrocarbons. Laboratory experiments showed that these polyaromatic hydrocarbons (PAHs) from partially weathered oil at concentrations as low as 1 ppb are toxic to pink salmon eggs.

Several studies documented cascades of events indirectly affecting individual survival or reproduction of salmon after sublethal exposures. Oil exposure resulted in lower growth rates of salmon fry in 1989, which in pink salmon reduce survivorship indirectly through size-dependent predation during the marine phase of their life history. Laboratory experiments also demonstrated that after chronic exposure (to 20 ppb total PAHs) as embryos, the subsequently marked and released pink salmon fry survived the next 1.5 years at sea at only half the rate of control fish. In addition, returning adult pink salmon exposed to oil as fry in 1993 showed reproductive impairment due to a reduction in embryo survivorship in eggs. These experiments show that sublethal exposure of sensitive early stages to oil byproducts can lead to enhanced mortality and reproductive impairment later in life through endocrine disruption and developmental abnormalities. In relation to the Exxon Valdez spill such effects were noted for at least four years following the spill, but after ten years streams and pink salmon were considered to have either undergone full recovery or near full recovery (Carls *et al.,* 2003).

8.2.4.1 Actions for biodiversity management of oil spill response (terrestrial systems)

Sakhalin Energy is producing an oil spill response plan for the onshore oil pipeline system. This is being produced in line with Russian regulatory and international best practice requirements and will set out the various range of measures that will be utilized in the situation when a spill occurs. As part of the planning, a sensitivity assessment has been undertaken to determine locations where sensitive receptors (e.g. wetlands) are present along the pipeline route and appropriate response measures linked with these receptors. The response plan will be implemented during operation and following agreement with the relevant Russian authorities. From a biodiversity perspective, the plan takes into account key sensitivities and contains appropriate measures to ensure that ecological interests are safeguarded (e.g. water and sediment quality in sensitive salmon spawning rivers) and response measures are appropriate to the known effects of oil spills on terrestrial systems. When Species Action Plans and Habitat Action Plans are developed within the framework of this BAP, SEIC will take into consideration Oil Spill Response Plans where appropriate; likewise, OSRP will take into consideration the requirements of this BAP.

8.3 Impacts on Marine and Coastal Ecosystems

8.3.1 Construction work in the marine environment

The dynamic nature of coastal and marine systems means that construction works in these environments may have both immediate impacts and, as a result of process modification, indirect and longer term effects. These latter effects may often be difficult to predict and take time to manifest. However, it is also important to consider that many coastal habitats and species are often adpated to the significant variations in conditions that occur. Construction work in the coastal and marine environment may have a range of effects on physical processes, habitats and species. Direct effects include:

- Land take with consequent loss of habitat from intertidal or subtidal areas;
- Severance or fragmentation of areas (e.g. by the construction of barriers or causeways);
- Loss of marine flora or fauna and disturbance to habitats caused by extraction of material from the sea bed;
- Burial of marine flora and fauna by deposits on the sea bed; and
- Noise and vibration disturbance to fish and marine mammals, e.g. from blasting or drilling operations.

Indirect effects are largely related to changes that a development may have on existing processes (e.g. sediment transport) and the consequent effect that such change may have on habitats and species. These effects include:

- Changes in tidal prisms or sediment budgets in natural systems caused by a one-off "capital" dredge or frequent maintenance dredging; and
- Interruption or other changes to natural coastal processes (e.g. changes in sediment erosion or deposition).

In respect of the works being undertaken for the Sakhalin II project, the main impacts relate to the following components:

- Direct loss of shoreline habitat due to construction of LNG facilities at Aniva Bay;
- Dredging and disposal works undertaken during construction of the jetty for the LNG facilities in Prigorodnoye, in Aniva Bay;
- Discharge of waste water from the LNG plant into Aniva Bay; and
- The laying of the offshore pipelines from the PA-A and Lunskoye platforms to landfalls at Chaivo and Lunsky Bay and the offshore pipeline to the TLU in Aniva Bay.

8.3.1.1 Dredging and disposal

The most direct and obvious impact of construction in the marine environment is disturbance to habitats and species, notably benthic communities, as a result of dredging works and the disposal of dredged material. These activities may have a variety of effects in coastal and marine environments including: the loss of or change to benthic habitat, the generation of significant increases in suspended sediment concentrations, the release of potentially toxic compounds (via contaminated sediment) into the water column, and noise associated with dredging activity.

During dredging, fish may be exposed to high suspended sediment concentrations (the sediment plume) generated by the dredger if the operation starts in, or moves into, the area in which they live, or the fish move into the plume area. It is generally accepted that the magnitude of the impact of suspended sediments on fish is a function of sediment concentration and the duration of exposure (Newcombe and MacDonald, 1991; Newcombe and Jensen, 1996; Wilber and Clarke, 2001). Available data indicates that the majority of coastal fish species are adapted to large, natural changes in suspended sediment concentrations (SSC) and, unless conditions are particularly dynamic, SSC levels are usually limited to the immediate dredging site. Potentially, fish which remain within a sediment plume for a prolonged period could suffer from physiological harm and/or mortality. However, the vast majority of benthic fishes have the capability to move out of an area (temporary displacement) and return once dredging ceased.

Increasing SSC also reduces visibility in a water body. Since many open water fish are visual feeders, a reduction in visibility could reduce their hunting success. For instance, in the silverside (*Atherina breviceps*) even quite small increases in turbidity (increased turbidity is often closely correlated with higher SSC) have been shown to reduce their ability to feed. An increase in SSC may also cause respiratory problems in fish due to their gills becoming clogged by sediment particles. In extreme cases this can lead to suffocation. This factor is probably of more significance for those fish species that are not adapted to naturally high SSC (e.g. open water, non-estuarine or nearshore species). It is interesting to note that Ritchie (1970) found no evidence of gill pathology in 11 species of estuarine fish exposed to conditions found in sediment plumes from dredging. Fish try to avoid areas of low water quality, for example coho and sockeye salmon smolts will change depths to avoid low quality water (Newcombe and MacDonald 1991). If sediments to be dredged have a high biological or chemical oxygen demand, it is possible that the level of oxygen in the water near the dredging site will be depleted. Low oxygen has been linked to many sub-lethal effects in fish. Fish will not enter an area with very low oxygen levels and a large area of oxygen-depleted water may cause a temporary block to fish migration routes. In a well-mixed, turbulent water body the effect is likely to be short lived.

There has been significant study of the effects of turbidity and SSC on the physiology and behaviour of salmon. These studies generally indicate that salmon are well adapted to fluctuations in SSC and can tolerate short-term (a few days) pulses of high SSC without detrimental impact to either their health or migration. Such adaptation would be expected in species that inhabit watercourses subject to rapid changes in sediment loadings as a result of snowmelt or increased run-off.

The settling of suspended solids can lead to smothering of benthic organisms and eggs. Species of fish with demersal eggs, such as herring, are particularly vulnerable to this impact (Wilber and Clarke 2001). Even thin layers of sediment are shown to have an effect. In experiments, the smothering of white perch eggs to a depth of 0.45 mm had no effect. Once the depth increased to between 0.5 to 1mm then 50% mortality was observed. Sediment layers of 2mm resulted in 100% death (Morgan *et al*., 1983).

Dredging leads to the removal of surface, mobile sediments and underlying material (bedrock or unconsolidated sediments) thus effectively eliminating existing benthic communities within the dredge area. The recovery of community types present within an area is dependent on similar conditions being established following the cessation of dredging. However, changes in water depth resulting from dredging may lead to a change in species composition in comparison with former conditions. The colonisation of disturbed or new areas of exposed sediment following dredging has been relatively well documented. Available data indicate that recovery periods vary significantly from one substrate type to the next (Nedwell & Elliot, 1998; Newell *et al.,* 1998), but typically recovery following the process of colonisation-establishment takes place within 1-5 years in the majority of coastal environments. Areas of undisturbed deposits adjacent to a dredged area may provide an important source of colonising species, which may promote faster recovery than might occur solely by larval settlement. There is, however, good evidence that disturbance of seabed deposits by man may result in a shift from an "Equilibrium Community" characteristic of undisturbed deposits towards a "Transitional Community" which characterises deposits in areas of natural environmental disturbance (MMS, 1999).

The disposal of dredged material in the marine environment may have a number of impacts on benthic communities (infauna and epifauna):

- Burial of existing organisms within the direct footprint of the disposed material;
- Smothering of organisms through increased rates of sediment deposition;
- Increased SSC in the vicinity of the disposal site;
- Alteration of substrate conditions.

One of the main impacts associated with the disposal of dredged material at sea is smothering of the existing benthic infauna and mortality if individuals are unable to migrate through any deposited sediment and/or their feeding and respiration apparatus becomes clogged.

Several studies have examined the effects of the burial of invertebrates by sediment. Maurer *et al.* (1981a, 1981b) carried out experiments on the lethality of sediment overburden on selected macroinvertebrates. They concluded that many motile epibenthic and infaunal animals could withstand a light overburden of sediment (about 1 cm), especially when the overlying sediment was native to their habitat. Many of the macrofauna that live in areas of sediment disturbance are well adapted for burrowing back to the surface following burial. Studies by Maurer *et al.* (1978) showed that some benthic animals could migrate vertically through more than 30cm of deposited sediment, and this ability may be widespread even in relatively deep waters. However, if there is a change in the character of the sediment (from fine to more coarse) it may be either difficult or impossible for organisms adapted to fine sediments to burrow through to the surface.

During disposal, an area of higher suspended sediment concentration will be created both within the water column and at the seabed. Increased SSC can also affect organisms on the seabed, particularly filter feeders, which rely on extracting organic material from the water column for food. Blanketing or smothering of benthic animals by sediment settling out of suspension may cause stress, reduced rates of growth or reproduction and in the worse cases the effects may be fatal (Bray, Bates and Land, 1997) if levels are maintained over relatively long periods. In general, however, studies of filter feeders which live in turbid coastal waters show that bivalves in particular are highly adaptable in their response to increased turbidity such as can be induced by periodic storms, dredging or spoil disposal and can maintain their feeding activity over inorganic particulate loads (Newell *et al.,* 1998). In deeper or naturally clear waters (>30m), fluctuation in SSC will be significantly lower than that occurring in shallow turbid waters and therefore potentially species characteristic of these areas are more likely to be sensitive to SSC increases.

8.3.1.2 Sakhalin Energy's approach to dredging activities

All of the marine dredging and pipeline laying works for the project (as listed above) have been undertaken with regard to the sensitivity of the marine environment. Surveys of all of the areas subject to dredging and pipe laying were undertaken prior to any works to determine the presence of any sensitive habitats and species, and monitoring has been undertaken following dredging to assess post-construction effects and the recovery of affected areas. In particular the activities associated with the LNG jetty construction (dredging and disposal) in Aniva Bay have been well monitored, given the importance of the area for its marine flora and fauna and coastal fisheries interests.

Environmental monitoring of areas where offshore pipelines were constructed (from offshore platforms to landfalls) revealed that sediments in these areas were not significantly affected by the works. In the context of the very dynamic conditions of the north-east Sakhalin shelf, the disturbance caused by pipeline laying activities was minimal and the benthic communities in these areas have been quick to recover and re-establish in areas disturbed by the works.

The most intensive dredging works of the Project were undertaken in Aniva Bay, during the construction of the LNG jetty and the MOF. Here, disposal of a large quantity of material from dredging works was required. Due to the environmental sensitivity of Aniva Bay, a monitoring programme was developed to assess the effects of dredging and disposal operations and the effectiveness of adopted mitigation measures. Chemical and biological parameters in the water column and in the seabed were surveyed at the dredge area and dumping site prior to the commencement of dredging and dumping activities to provide a baseline against which potential change could be compared. These parameters included suspended sediment concentration; sediment composition and chemistry (including hydrocarbons); plankton; benthos; and fish fauna.

The disposal site has been monitored annually during and post construction to determine benthic recolonisation and recovery; data showed that there were initial effects on the benthic community. Benthic samples collected in autumn-winter 2004 showed a significant decrease in benthic biodiversity across all groups of organisms (7 species from 4 taxonomic groups, with sipunculid worms of the genus *Golfingia* prevailed, constituting 95% of the total biomass). Small benthic epifaunal/infaunal organisms (less than 5mm) and benthic filter feeders were found at the area adjoining the disposal site following disposal operations. For instance, the species *Eudorella emarginata*, *Harpiniopsis orientalis*, *Spionidae* sp. were still present at all locations 300m from the disposal site. This observation suggests that SSC generated during disposal and associated sediment deposition were not sufficient to cause 100% mortality of benthos within the 300m zone of the disposal site. Subsequent monitoring demonstrated that there has been a relatively rapid re-colonisation of the disposal area (within the 2-3 years predicted in the EIA) and recent results indicate that many of the species that would be expected in the area are now present, indicating that recovery of the benthic fauna has occurred. On the basis of the monitoring showing that recovery of the area has occurred in line with predictions, only limited and occasional monitoring of the disposal site will be undertaken during operation of the LNG facility.

8.3.2 Underwater noise associated with oil and gas production activities

A large number of studies have now been undertaken that indicate that the generation of underwater noise by human activities can have significant and detrimental impacts on marine life, particularly marine mammals and some species of fish. Marine mammals are especially dependent upon hearing for navigation, communication, foraging and maintaining social structures. Therefore, change in the acoustic environment that may adversely affect their use of hearing in these activities is of particular concern.

Underwater noise can have severe impacts on receptors in the immediate vicinity of high-level sources, such as sonar or airguns used in seismic exploration. As the distance from the source increases the noise levels decrease and effects diminish. Three basic types of underwater noise effects are recognised:

- Primary effects, such as immediate or delayed fatal injury of animals near to powerful sources, such as the blast from explosives underwater;
- Secondary effects, such as injury or deafness, which may have long-term implications for survival, and
- Tertiary (behavioural) effects, such as avoidance of the area, which may have significant effects where the man-made noise source is in the vicinity of breeding grounds, migratory routes or schooling areas.

With regard to the primary effects, underwater noise emissions can cause injuries and resulting mortality to fish, although these normally occur only at high sound pressure levels. Such injuries are known as ‘barotraumas’. Typical effects of rapid pressure change include over-expansion and rupture of the swimbladder during the passage of pressure waves and formation of gas embolisms in the bloodstream, especially in the eyes (Turnpenny & Nedwell, 1994).

The data available show that all marine mammals have a fundamentally mammalian ear that, through adaptation to the marine environment, has developed broader hearing ranges than are common in land mammals. Available data indicates that there is considerable variation among marine mammals in both absolute hearing range and sensitivity, with the composite range spanning the ultra to infrasonic (10Hz – 200kHz, with best thresholds near 40-50 dB re 1 µPa) (Richardson *et al*., 1995). The consensus of the data is that virtually all marine mammal species are potentially impacted by sound sources with a frequency of 300Hz or higher. Any species can be impacted by exceptionally intense sound, and particularly by intense impulsive sounds, although there is very limited data directly concerning injury to marine mammals caused by impulsive noise. However, at increasing distance from a source, which is the realistic scenario as opposed to “at source”, the effects are a composite of three aspects: intensity, frequency, and individual sensitivity. Relatively few species are likely to receive significant impact for lower frequency sources (Hildebrand, 2004).

In recent years, particular attention has focused on the role that intense sound sources have played in instances of whale strandings, as there is evidence to suggest that some strandings have been associated with the use of high-intensity sonar during naval operations and airguns during seismic reflection profiling. A global list of beaked whale strandings involving two or more animals shows that, apart from two individuals in 1914, there are no records of multiple-animal strandings until 1963. However, from 1960 to 2000, three to ten multi-animal strandings have been recorded per decade (Hildebrand 2004). The increased incidence of multi-animal beaked whale stranding events since 1960 is coincidental with the advent and use of high-intensity sonar on a broad range of naval ships. Cuvier's beaked whales are by far the most common species involved in stranding events, making up 81 percent of the total number of stranded animals.

The reasons for the strandings are not clear although a combination of reasons are probably attributable. Potentially, Cuvier's beaked whale is more prone to injury from high-intensity sound than other species and its behavioural response to sound may make it more likely to strand. It is also likely to be the most abundant of the beaked whales and therefore the number of strandings involving this species (amongst beaked whales) tends to be greater.

Underwater noise levels associated with construction activity and increased vessel traffic area also an issue of concern with regard to some seal species, notably Steller's sea lions. There is very limited data on the underwater hearing capabilities and sensitivities of Steller's sea lions and typically available data on other eared seals (e.g. Californian sea lions) has been used in situations where assessment of potential impact due to underwater noise is required. Pinnipeds in the *Phocidea* family (e.g. fur seals) generally hear from 1 kilohertz to between 30 and 50 kilohertz, with thresholds between 60 and 85 dB re 1 μPa (Richardson et al. 1995). Sensitivity for most phocids remains good until approximately 60 kilohertz, after which sensitivity is poor (Richardson et al. 1995). Underwater sensitivity at the high- and low-frequency ends for pinnipeds in the *Otariidae* family (e.g. Steller's sea lion) is generally lower than that for phocids, but there is little difference in the middle frequencies (Richardson et al. 1995). The tolerance of pinnipeds to underwater noise levels is not well established and no definitive data for Steller's sea lion is available. However, on the basis of data from a range of studies, it is predicted that exposure to sound levels ~ 140 dB re 1μ Pa would cause temporary hearing loss in pinnipeds and it is also doubtful that marine mammals (including seals) would remain in an area that was ensonified at 120 – 140 dB re 1μ Pa long enough to suffer any temporary, or possibly permanent hearing loss (LGL 2003, quoted in NPS 2003).

Estimates of potential noise levels associated with vessel traffic moving en route to Aniva Bay (LNG facility) via La Perouse Strait suggests that it is highly unlikely that underwater noise would reach levels at the haul out at Kamen Opanosti that would cause disturbance to Steller's sea lions. This haul out is approximately 15km away from the main shipping channel and on the basis of data on noise levels for large tankers, it is estimated that the haul out occupies a location that would be about 10km from any ensonified area in which noise levels could cause disturbance to Steller's sea lions. Additionally, the majority of Steller's sea lion activity would be likely to be concentrated within 10km of the haul out. Animals venturing beyond this area would be unlikely to enter areas of increased noise that would disturb them (i.e during vessel passage). As vessel movements would also be transitory, any ensonified area likely to cause disturbance (i.e. outside of 10km distant from the haul out) would be temporary. The predicted volume of vessel traffic due to project activities would also leave large periods of time when noise disturbance would permit movement by animals closer to or across the shipping channel.

A major shift in assessing underwater noise related impacts has been to provide "perceived noise levels" for various species, which are suitable for investigating and analysing the behavioural effects of underwater noise. As the tertiary effects of noise, and also auditory damage, are related to the perception of noise by a species, any scale for evaluating its effects must incorporate the hearing ability of the given species. Concerns over the environmental effects of offshore seismic shooting using airguns led to the development of a perception scale for the evaluation of behavioural effects for a wide range of species (Nedwell 1998).

Levels of sound in excess of 200 dB re 1 □Pa may be recorded underwater during civil engineering activities; this corresponds to levels in excess of 170 dB re 20 □Pa in the units that are conventionally used in air. Many marine mammals and fish are adapted for living in the noisy underwater environment, and have hearing thresholds (sensitivities of hearing) 100 dB, or 10^5 times, higher than humans, i.e. their hearing is 10^5 times less sensitive. For this reason they are able to tolerate much higher levels of noise.

8.3.2.1 Management of construction related noise and potential impacts on western Gray whale

The potential for noise-related disturbance in relation to marine construction works has been of particular concern with regard to the population of western gray whale (WGW) that feeds during the summer months off the north-east Sakhalin coast. As highlighted in Section 6.4.5.3., the WGW is critically endangered and given its extremely small population, any activity that may potentially affect its breeding success is of extreme concern. Sakhalin Energy has been engaged with the international community regarding WGW issues since 1997 and has undertaken a comprehensive survey and monitoring programme which has provided valuable data on the ecology and behaviour of this population of cetaceans.

As the Sakhalin II project comprises the construction of offshore pipelines and installation of a huge platform offshore at Piltun, within an area that could potentially disturb summering WGW, Sakhalin Energy has adopted a cautious and proactive approach to managing potential impacts on the WGW. Much of the work has focused on ensuring that animals using the feeding area or migrating to and from it are not subject to construction noise related disturbance. In 2004, Sakhalin Energy announced postponement of its offshore activities in order to re-evaluate the offshore pipeline route in the Piltun region. The original route included a landfall within the southern portion of the primary WGW feeding ground. An evaluation of the construction work required for this pipeline meant that the near-shore trenching of the pipeline would need to be deeper than originally anticipated and hence the potential to be noisier and of longer duration with increased risk of impact on the WGW. Two other pipeline route options were assessed and the results presented by Sakhalin Energy as the Comparative Environmental Analysis Report (CEAR) in 2005. The CEAR and the pipeline route options were subject to review by an independent scientific whale panel, which was commissioned by the IUCN.

The Independent Panel has since morphed into a long-term Western Gray Whales Advisory Panel (WGWAP), made up of leading whale and marine scientists who are providing independent advice regarding management of risks to the WGW. The panel's overarching objective is to create a framework for co-ordination and co-operation among all interested parties, with the ultimate aim of assisting the conservation of the WGW population.

One of the key areas that the WGWAP has been involved with is the review of the underwater noise modelling work undertaken by Sakhalin Energy and proposed mitigation measures to deal with potential impacts during construction work.

Noise acceptability criteria, defined in terms the numbers of WGW and/or the proportion of the feeding ground ensonified to certain noise levels and durations, were set out by Sakhalin Energy in the CEAR. In designing construction activities to ensure that the acceptability criteria can be met, Sakhalin Energy has used predictive noise modeling. It is not possible to directly determine whether the acceptability criteria are met during actual construction, so instead sonar-buoys located along the perimeter of the feeding ground are used to monitor noise levels. Post-construction analysis of these noise data can then be used in conjunction with the noise model to estimate the actual noise footprints and durations in order to assess whether the acceptability criteria have been met. During construction work, the noise levels recorded by the perimeter sonar-buoys are monitored and compared with intervention criteria, which if breached lead to the implementation of intervention actions, including, if necessary, cessation of construction activities. These intervention criteria comprised both noise-based criteria for perimeter noise levels of 140dB and 130dB and also an outline for real-time behavioural change criteria that apply at lower noise levels (down to 120dB).

To assess the effectivness of the noise model and its application to construction activities in the Piltun field, it was first tested during installation of the Lun-A platform Concrete Gravity Base Structure (CGBS), which is located well to the south of the WGW feeding area. Following completion of the installation of the Lun-A CGBS, the model predictions were validated against the actual noise levels monitored during installation and refinements then made to the model. Model predictions for the PA-B CGBS installation were then subsequently compared and validated against the noise levels monitored by an array of acoustic sonar buoys deployed around the eastern perimeter of the WGW feeding ground during installation activities.

Although there have been issues raised by the scientists on the independent advisory panel regarding limitations in the analytical process and monitoring of noise, it is apparent that to date, construction activity has not triggered intervention as defined by the sound intervention criteria developed by Sakhalin Energy. The installation of the PA-B topsides in July 2007 was performed in line with the noise level criteria recommended by the WGWAP in 2005 and Sakhalin Energy has used them stringently in the 2006 and ongoing 2007 seasons.

As part of the overall programme of determining the potential effects of construction noise on the WGW, behavioural studies of the WGW population have also been undertaken to identify any shifts in whale distribution that could be linked to construction activities. Undertaking this work can provide useful data on the WGW response to noise stimuli and help to further refine mitigation measures. Using monitoring data obtained during construction on the location and distribution of whales, multivariate analysis is being used to determine whether works offshore at Piltun have had an effect on the behaviour of the WGW population. Analysis of data to date has not identified any large-scale effects on WGW as a result of construction work. Some small-scale behavioural effects were indicated following construction work in 2005, suggesting that WGW were observed further offshore when noise exposure was higher. Although, the identified effects were small, potentially they could have had some biological significance (e.g. prey biomass levels may be lower further offshore). Proving a causal link between this behaviour and construction activity has proved difficult, particularly given the potential influence of other factors such as the presence of research vessels in the area. However, the general conclusion is that despite uncertainties there is no strong evidence to suggest that the construction work in the Piltun offshore area and the noise generated during this work has had a significant impact on the whales.

During 2008 there will be a further two meetings of the WGWAP as well as a number of task force meetings that will focus on planned seismic activity in 2009 and on how best to analyse and interpret collected data.

8.3.3 Invasive species and ballast water

The introduction of non-native species (that then become invasive) to new environments via ships ballast water and other vectors, has been identified by the International Maritime Organisation (IMO), as one of the four greatest threats to the world's oceans. The comb jelly, *Mnemiopsis*, invasion in the Black Sea and zebra mussel, *Dreissena*, invasion in the North American Great Lakes, are recent examples of alien species introductions via ballast waters, that have resulted in disastrous ecological consequences and huge economic losses for the local community (Panov et al. 1999). Locally, the oyster killer, *Polydora cornuta* (which originates from New Zealand) has been detected in Peter the Great Bay and the Sea of Japan, fouling shells of the scallop, *Mizuhopecten yessoensis*. In all cases, the species was found near international seaports and it is likely that the species has been transported to new areas in the ballast water of cargo ships.

Shipping moves over 80% of the world's commodities and transfers approximately 3 to 5 billion tonnes of ballast water internationally each year. A similar volume may also be transferred domestically within countries and regions each year. Ballast water is essential to the safe and efficient operation of modern shipping, providing balance and stability to un-laden ships (Global Ballast Water Management Program, 2007). Invasive species may be taken up either as adults, larvae or cysts from a donor (the country of origination) within ballast water or the associated sediments.

Natural barriers, such as temperature and land masses, have prevented many species from dispersing into certain areas. The use of water as ballast and shorter voyage times, combined with increasing world trade, means that natural barriers to species dispersal are being reduced. It is estimated that at least 7,000 different species are being carried in ships' ballast tanks around the world (Global Ballast Water Management Program, 2007). The majority of marine species carried in ballast water do not survive the journey (see Table 8.3), with the small percentage that do survive, discharged into differing environmental conditions with competition from native species. However, when environmental conditions are favourable, an introduced species may survive to establish a reproductive population in the host environment, out-competing native species and then potentially multiplying into ecologically damaging and economically nuisance scale proportions.

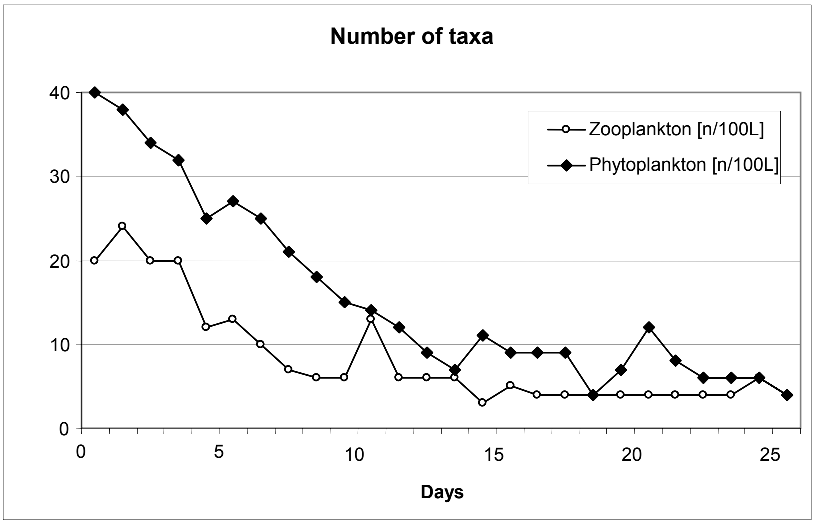


Table 8.3 Number of taxa within a ballast tank over time (Source: Gollasch *et al.*, 2000).

Worldwide there are hundreds of examples of invasive species reaching pest proportions and causing economic, ecological and health problems. The Convention of Biological Diversity website (2007) states that:

'Alien species that become invasive are considered to be a main direct driver of biodiversity loss across the globe. In addition, alien species have been estimated to cost our economies hundreds of billions of dollars.'

Impacts on the local receptor community may include; the collapse of local fisheries and aquaculture, direct and indirect health effects, damage to industrial developments (through fouling of structures), impacts on tourism and often-irreversible effects on local species and ecosystems. Once established in a new region, non-native species may invade new areas adjacent to the area of establishment by natural dispersal, e.g. via transport in water currents in the case of many seaweeds and phytoplankton.

Non-native species may displace native organisms by preying on them or out-competing them for resources, such as for food, space or both. Two such examples in Russia are the Ukrainian mussel, Dreissena bugensis, and the Chinese Mitten crab, Eriocheir sinensis. D. bugensis impacts local zooplankton abundance, biomass and species composition causing decreases in native diversity (Global Invasive Species Database, 2007). It also has negative impacts through fouling on recreational boating activities and commercial shipping, as well as on raw water-using industries, such as power stations. The Chinese mitten crab, is a migrating crab, which has invaded Russia and North America. It contributes to the local extinction of native invertebrates and modifies local habitats. The mitten crab also causes erosion by its intensive burrowing activity and costs fisheries and aquaculture industries several hundreds of thousands of dollars per year by stealing bait and feeding on trapped fish (Global Invasive Species Database, 2007).

In some cases these invasions have led to the elimination of indigenous species from certain areas. Hybridisation can alter the genetic pool (a process called genetic pollution), which is an irreversible genetic change. When an invasive species has established itself in the marine environment, it is likely to be impossible to get rid of it. These effects are often exacerbated by global change and chemical and physical disturbance to species and ecosystems (The Global Invasive Species Program (GISP) 2007).

8.3.4 Management of ballast water issues by Sakhalin Energy

With the development of the LNG plant and oil export terminal at Prigorodnoye, vessel traffic within Aniva Bay will significantly increase. Many of the vessels arriving at the port to take on LNG and oil cargoes will have come from other parts of the World (notably Japan, south Korea and China) where marine conditions, flora and fauna differ to those present in Aniva Bay. As the ballast water in these vessels may have also originated from these areas, potentially it may contain organisms that would be 'alien' to the marine ecosystems of Sakhalin and also hold the potential to be invasive. Sakhalin Energy has recognised the importance of the risks faced by invasive species in ballast water and has taken a proactive approach to dealing with the issue in relation to shipping movements from and to Prigorodnoye.

A Ballast Water Risk Assessment has been undertaken for the port of Prigorodnoye (Royal Haskoning 2007). The risk assessment has, on the basis of data available on the potential invasive species present at the vessel source ports, identified the 'top ten' most potentially deleterious species that could be introduced via ballast water, as listed below:

- Mytilus galloprovincialis (Mollusca)
- Perna viridis (Mollusca)
- Hemigrapsus sanguineus (Crustacea)
- Mytilopsis sallei (Mollusca)
- Crepidula fornicata (Mollusca)
- Mytilopsis leucophaeta (Mollusca)
- Xenostrobus secures (Mollusca)
- Balanus improvisus (Crustacea)
- Hydroides elegans (Polychaeta)
- Callinectes sapidus (Crustacea)

Through the identification of these major risk species and their donor countries, it is possible to reduce the risks and impacts posed by invasive species, through targeted and rapid assessment monitoring programmes. Measures that respond to invasions that are already established are costly and have very low success rates. In view of this the International Maritime Organisation (IMO) have addressed the prevention of invasive species establishment and uptake through a number of initiatives, including:

- The adoption of Resolution A.868 (20) on the Guidelines for the control and management of Ships Ballast Water to minimise the transfer of harmful aquatic organisms and pathogens;
- The development of a new international legal instrument (International Convention for the Control and Management of Ships Ballast Water and Sediments (BWMC), as adopted by an IMO Diplomatic Conference in February 2004; and
- Providing technical assistance to developing countries through the GEF/UNDP/IMO Global Ballast Water Management Programme (GloBallast).

The Convention and guidelines above recommend management and control measures to limit the uptake of potential invasive species. These include limiting uptake areas to those away from where harmful organisms are known to occur (i.e. ports, shallow waters, near algal blooms, at night and near sewage outfalls), promoting effective ballast cleaning measures, removing sedimentary build-ups within ballast tanks and instigating the development of ballast water management procedures. IMO member countries have also agreed to develop a mandatory legal regime to regulate and control ballast water. This process resulted in the adoption of the *International Convention for the Control and Management of Ship's Ballast*

Water and Sediment on 13 February 2004 (as listed above).

Ballast exchange at sea currently provides the best-available method to reduce the risk of transfer of harmful aquatic organisms, but it is subject to ship-safety limits and is less than 100% effective in removing organisms. In addition, ballast water exchange will be phased out as an acceptable method for complying with the Convention from 2009 to 2016, dependent on the size and build date of the vessel. Treatment technologies are therefore being tested globally, which enable compliance with the standards set in the Convention.

Once the vessel arrives at the destination port there are still a number of practical and management measures that can be taken to reduce the risk of species introductions and establishment. These include the following:

- Sampling of vessels to determine potential risk;
- Designation of ballast water exchange areas;
- Shore based ballast water reception facilities;
- Discharge to reception vessel;
- Treatment within the port; or
- Return the vessel to sea for exchange

The management measures that can be taken include:

- Review of ballast water management certificate from each vessel;
- Verification that a Ballast Water Management Plan specific to the ship and approved by the Flag State is onboard;
- Undertake an inspection of the Ballast Water Record Book (Ballast Water Reporting Forms); and
- Undertake vessel monitoring.

8.3.5 Oil pollution in the marine environment

8.3.5.1 The effects of oil pollution on marine flora and fauna

Most biological communities are susceptible to the effects of oil spills. Marine flora and fauna are subject to contact, smothering, toxicity, and the chronic long-term effects that may result from the physical and chemical properties of the spilled oil.

There is no clear relationship between the amount of oil in the marine environment and its likely impacts. A small spill in a sensitive environment may prove much more harmful than a larger spill in a less sensitive area or at a time when biological productivity is reduced. The size of an oil spill may not be the main or only factor of importance in terms of what environmental damage can be caused by an oil spill. In 1976, a spill estimated to have been less than 10 tonnes killed more than 60,000 long-tailed ducks wintering in the Baltic Sea (Johanssen *et al*., 1980). This can be compared to the effects on seabirds in Alaskan waters from the approximately 40,000 tonnes large Exxon Valdez oil spill in 1989, when an estimated 30,000 birds were oiled.

Significant factors related to the impact of an oil spill on marine fauna and flora are:

- The spread of the oil slick;
- The type of oil spilled, its toxicity, persistence and movement and weathering characteristics;
- The location of the spill and its timing (e.g. during bird migration);

- The area affected and the sensitivity of the regional environment (e.g. proximity to a bird breeding colony); and
- The number of different habitats impacted, such as rocky shore, beach, mangrove, or wetland.

The effects of oil on different biota may vary considerably:

Benthic communities

Surface spills of light oils (such as the Vityaz-Lunskoye crude blend) are unlikely to impact offshore benthic communities. However, shallow-water communities may be impacted by oil that dispersed into the water column through wave action. Leaks or ruptures in the pipeline that runs from the OET to the TLU could also result in localised contamination of sediment and benthic communities.

Similarly heavy fuel oil (HFO) on the surface is unlikely to impact benthic communities, and HFO is less likely than crude oil to disperse into the water column. Under certain circumstances, however, HFO can sink and impact the underlying benthic sediments, resulting in localised impacts on the benthic faunal community.

Fish

Fish may ingest large amounts of oil through their gills and if exposed to oil they may suffer from changes in heart and respiratory rate, enlarged livers, reduced growth, fin erosion and a variety of effects at biochemical and cellular levels. If this does not kill them more or less directly, the oil may affect the reproductive capacity negatively and/or result in deformed fry.

Large scale fish mortality after oil spills is rare, especially in open waters. However, significant loss of eggs and fish larvae can occur if present in the area of an oil spill. The eggs of fish that spawn in coastal areas (e.g. herring) can be exposed to spilled oil that has become entrained into seabed sediments Juvenile fish occupying shallow coastal areas and lagoons are generally more vulnerable than open and deeper water species Most severe effects are believed to be associated with large spills of fresh oils (particularly of light oils). Adult pelagic fish are considered to be at low risk due to a reduced likelihood of exposure (i.e. contact), greater mobility and, possibly, a capacity to avoid floating oil.

Birds

Oil at sea affects seabirds through a number of different routes. One of the main effects is that if a bird becomes oiled its feathers lose their protective insulation and a bird, even if only partially covered by oil, can die from hypothermia in cold climates. The buoyancy provided by the air trapped in feathers may also be lost and because of this birds may drown.

Oiled birds as they preen, trying to rid themselves of oil may lead to inhalation and ingestion of oil. Due to the toxicity of oil, ingestion may result in detrimental effects such as pneumonia, congested lungs, intestinal or lung hemorrhage, liver and kidney damage. This poisoning is often as deadly as hypothermia, although the effects may not manifest themselves as quickly. Shorebirds may encounter oil in varying states (according to how weathered it is) while feeding or roosting on the beach. They are less likely than seabirds to encounter fresh oil, which is more acutely toxic. Terrestrial species may hunt or forage on the coast and come into contact with oil on the shoreline or ingest oil with their food.

Marine mammals

The sensitivity of marine mammals to oil spills is highly variable and appears to be most directly connected to the insulation properties of their fur. Thus, marine mammals living in cold climates are likely to be more vulnerable than those living in temperate or tropical waters.

Seals may be very vulnerable to oil pollution because they spend much of their time on or near the surface of the water. They need to surface to breathe, and regularly haul out onto beaches. During the course of an oil pollution incident, they are at risk both when surfacing and when hauling out. The effects of oil on pinnipeds vary depending on the type of oil spilled. Oil type may also affect the ability of pinnipeds to detect and avoid oil. Although avoidance has been observed there is no guarantee that pinnipeds will keep away from oiled areas. Potential effects include:

- Inhalation – short chain aromatic petroleum hydrocarbons can cause respiratory problems in pinnipeds. This has been observed both in the wild and under controlled laboratory conditions, however significant population effects are only likely to result if large numbers of pinnipeds inhale vapours in a confined area such as a contaminated ice lead or bay.
- Ingestion – observations of pinniped behaviour suggest that they are unlikely to ingest significant amounts of oil in the wild following a spill.
- External exposure – pinnipeds commonly suffer damage to eye tissues. Damage to mucous membranes on contact with oil, which, if severe, causes difficulties in keeping the eyes open.
- Oil may be transferred from mother to pup through various routes.
- Thermoregulation – disruption of thermal balance in pinnipeds with oil-fouled fur can lead to hypothermia and debilitation. Fur Seals are more sensitive as they rely on the pelage for insulation, unlike the phocids and Steller's Sea Lions, which use blubber and vascular control to retain heat. Fur Seal pups are particularly at risk before their fur and blubber layer develops.
- Physical effects on mobility – there are some recorded instances of pups being unable to swim when coated in heavy oil, leading to drowning.
- Ingestion of oiled prey – Bearded Seals and Steller's Sea Lions are bottom feeders and are therefore at risk from ingesting oil from benthic filter feeders.

Due to their migratory behaviour and mobility, cetaceans would appear to be relatively unaffected by oil spills and there is little documented evidence to indicate that they are. Cetaceans exposed to oil are generally not considered at high risk compared to other marine mammals 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. However, some species of cetaceans may ingest oil in contaminated water or food, or it could be absorbed through the respiratory tract. Baleen whales, in particular, may be susceptible to oil ingestion while feeding as they take in large quantities of water when filtering out their prey. However, it is considered likely that any effects are likely to be minor and reversible within a few days.

There are also indications that cetaceans can inhale droplets of oil, vapours and fumes if they surface in slicks when they need to breathe. Exposure to oil in this way is unlikely to be significant enough to cause serious internal damage but could adversely affect mucous membranes and lead to injuries in airways. Cetaceans present in the vicinity of an oil spill could also suffer sublethal effects, through oiling of mucous membranes or the eyes if they swim through a slick, but this observation has not been reported in scientific literature. As an indirect impact from oil spills, cetaceans, particularly whales, may be susceptible to ship traffic and noise impacts associated with oil spill cleanup activities.

8.3.5.2 Recovery of marine communities from oil pollution incidents

The recovery of affected habitats and species following an oil spill will to a large extent depend on the type of ecosystem, the vulnerability of the species and the climate of the region where the oil spill occurred. Generally, recovery proceeds more quickly in warmer climates and on rocky shores relative to cold climates and soft sediment coasts. Available data from studies following oil pollution events indicates that some areas may recover within weeks while other sites may take decades.

Following the Sea Empress oil spill in the United Kingdom, many studies were commissioned to look for further impacts, both immediate and longer term. As well as checking for changes in population size and distribution of a variety of species, studies also focused on sub-lethal effects and changes in breeding success. These studies concluded that:

- There appeared to have been no impacts on mammals;
- Although tissue concentrations of oil components increased temporarily in some fish species, most fish were only affected to a small degree, if at all, and very few died; and
- Several important populations of seabirds were not significantly affected, and there was no evidence of any effects on seabird breeding success.

The Sea Empress studies indicate that the main impacts all occurred at the time of the spill or shortly afterwards, and there appear to have been few major longer-term effects. Seabird populations recovered to former population levels and there has been good recruitment of many species along much of the affected shorelines. Fish and mammals were able to avoid the worst of the oil, and any oil they may have absorbed probably broke down fairly rapidly through their efficient enzyme systems. Many species were able to survive a degree of oiling; for example, oiled gulls were seen alive many months after the spill, and at the time of the spill it was noted that some marine organisms had survived even heavy oiling. Many marine species are able to re-populate an area rapidly following a decrease in numbers, particularly where the eggs and juveniles go through a planktonic stage – i.e. they are carried by currents in the water and so can be brought to an affected area from nearby areas.

One of the most intensively studied oil spill incidents and the impacts of the event and recovery from it was the massive spill from the *Exxon Valdez* tanker in 1989 in Alaska. Since the spill NOAA have been monitoring the response of the marine and coastal ecosystem to the recovery operation undertaken immediately following the spill. It is apparent from the large number of individual studies undertaken that the affected systems are far more resilient than previously considered. The majority of intertidal communities recovered within less than 10 years although some areas that were stripped of algal cover by high-pressure hot water have not yet fully recovered. Some oil is still present in the system, but the overall conclusion from the monitoring work is that recovery has been significant although not complete (NOAA, 2001).

One aspect that is apparent from all studies of oil spill response and recovery is that much of the recovery depends on the varying degrees of natural resilience of organisms to changes in their habitats. The natural adaptations of populations of animals and plants to cope with environmental stress, combined with their breeding strategies, provide important mechanisms for coping with fluctuations in their habitats and for recovering from stochastic events, such as oil spills. While it may be difficult to determine exactly what constitutes recovery, it is widely accepted that the natural variability of ecosystems makes recovery to exactly the same conditions prior to an oil spill extremely unlikely. Definitions of recovery therefore tend to focus on the re-establishment of faunal and floral communities that are characteristic of the habitat and that are ecologically functional within known and understood limits.

8.3.5.3 Sakhalin Energy response to potential oil spills

Oil spill prevention and response is an important issue for Sakhalin Energy. The company's approach to managing this complex subject is comprehensive:

- Prevention of spills in the first instance, through the robust design of production facilities, regular inspections and monitoring, and adherence to international standards and best practice;

- Minimisation of the volume and impact of any oil spill;
- Efficient and effective planning (including determination of spill frequencies, volumes, trajectory modeling, identification of environmental resources potentially at risk, as well as GIS mapping), supported by trained personnel and appropriate resources;
- Acquisition, storage, deployment and maintenance of suitable oil spill response equipment;
- Ongoing research in, and development of, new technologies to enhance Sakhalin Energy's oil spill response preparedness; and
- Co-operation with local, regional and international agencies, qualified service providers, as well as other operators.

Sakhalin Energy's Oil Spill Response Plans (OSRPs) set out the organisation and responsibilities for oil spill emergency preparedness and response. They have been developed in compliance with relevant Russian Federation legislation and encompass the range of requirements and recommendations for OSRP structure and content including procedures, guidelines, checklists and other information that enables the company to plan for, respond to and manage oil spills emanating from Sakhalin Energy operations.

Marine response strategies are provided in each of the offshore facilities' OSRPs that include information on *inter alia* the legal framework for oil spill response, the fate and modelling of spilled oil, environmental conditions and potential impacts, response communications, resources, preparedness drills, as well as spill surveillance. Marine response efforts are guided using the following criteria:

- Response should result in the highest possible net environmental benefit;
- Response strategies should aim for the highest possible level of cleanup and the lowest possible environmental damage or disturbance;
- Response should target areas and resources that have the slowest, or least likely, rate of self-cleanup or recovery from damage;
- Response should ensure the most efficient use of materials and human resources; and
- Response should result in the minimum possible generation of waste materials.

A number of marine response methods are available and include monitoring (i.e. relying on natural weathering processes), deflection and physical dispersion, containment and recovery, application of dispersants from vessels, in-situ burning, and shoreline protection. Immediate response strategies are based on containment and recovery, monitoring, and the physical break up of sheens (oil films). These methods have no potential additional adverse environmental effects and are the preferred methods of response. Ongoing response may utilise dispersant and burning methods, which require careful planning and assessment before they are implemented.

The effectiveness of marine response methods can be limited by sea state, oil type and weathering. Each spill scenario, and the effectiveness of methods and available equipment, would therefore be assessed and monitored throughout the response.

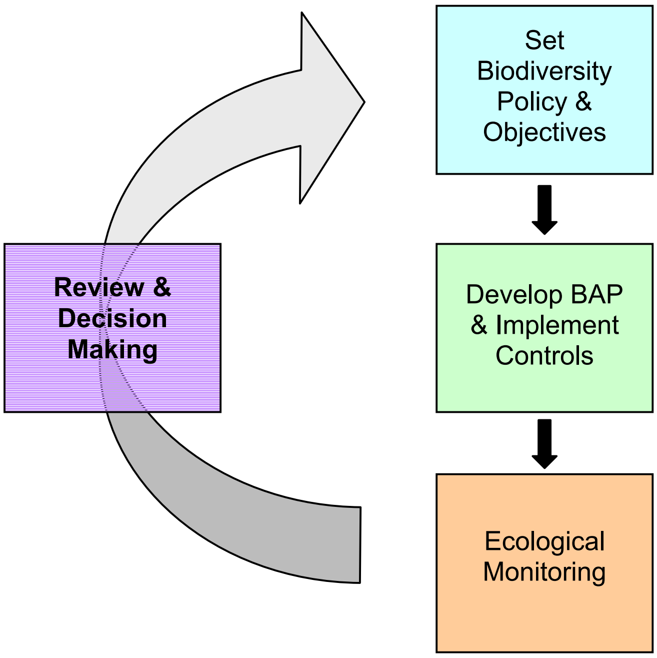
Further detail on response planning is provided in each facility OSRP that covers the geographic area corresponding to the maximum possible zone of oil pollution based on a 'worst case scenario' resulting from facility operations.

When Species Action Plan and Habitat Action Plans are developed within the framework of this BAP, SEIC will take into consideration Oil Spill Response Plan where appropriate.

9 Monitoring

9.1 Introduction

Sakhalin Energy manages biodiversity interests through an adaptive approach. Adaptive management is a systematic process of continual improvement of policies and practices based on an evaluation of the effectiveness of operational controls. Essentially, there are four main steps to adaptive management *viz*. 1) establishment of management objectives, 2) design and implementation of plans to meet those objectives, 3) assessment and monitoring to check the extent to which those objectives have been met, and 4) review and decision-making.



Therefore, ecological monitoring is an important component of biodiversity management. In general, the management of biodiversity requires information about the location of an ecological resource, the nature and abundance of the resource, changes in the resource over time, and the factors responsible for those changes. Ecological monitoring and analysis evaluates trends in the health and integrity of species populations, communities, habitats and ecosystems to provide information for decision-making within the BAP.

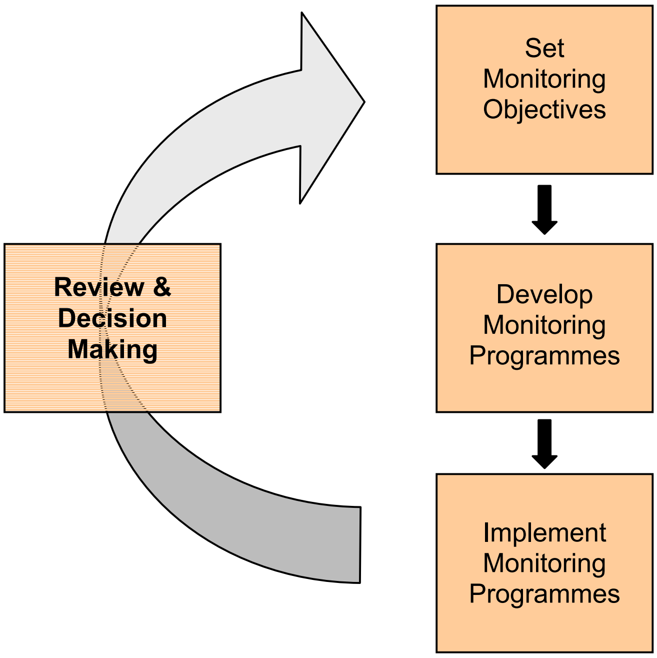
More specifically, ecological monitoring allows us to analyse and evaluate the impacts (including cumulative impacts) of Sakhalin II's activities on the environment, and to revise our management approach accordingly. It considers relationships between biotic and abiotic elements, providing important insight into the composition, structure and functioning of complex ecosystems. Monitoring may indicate advanced warning of undesirable ecological change, and allow development of preventive action against potential impacts.

It is worth mentioning that in many cases the monitoring of ecosystem can give the best answers when the Project impact on environment is sought. Therefore when Species Action Plans and Habitat Action Plans are developed within the framework of this BAP, the ecosystem monitoring will be taken into consideration where appropriate.

9.2 Development of Monitoring Programmes

Sakhalin Energy's ecological monitoring and assessment programmes aim to improve our understanding of ecosystems and to evaluate the effectiveness of our mitigation plans. They are developed in relation to the biodiversity interest or ecological processes under management, taking into consideration the purpose for which the data will be used.

Monitoring programmes are reviewed on a regular basis to improve the collection of information, for example to accommodate changes to scope, technical adjustments, or the introduction of new methods and techniques. The following diagram describes the development, implementation and review of ecological monitoring programmes.



Monitoring programmes should include information on objectives, activity planning, data collection, data verification, reporting, analysis, and review.

9.2.1 Objectives

Monitoring objectives should be set early and clearly, among other things, to:

- Identify key habitats;
- Describe habitat structure, composition and diversity within the area of influence;
- Determine current conditions; and
- Identify and assess potential effects of operations on biodiversity, and to assess the mitigation of such effects.

Different types of monitoring programmes are derived from specific objectives:

- Baseline monitoring – sets the standard against which future changes are evaluated i.e. provides a reference point for comparison. Early investigations can also provide useful information for project design and provide indication of sustainable development;
- Implementation monitoring – quantitative feedback on whether operations are carried out as planned i.e. a means of quality control to audit the degree of compliance with

established standards and guidelines;

- Effectiveness monitoring – assess the impact of operations i.e. evaluates how effective the operational controls were in meeting the needs and expectations of management plans; and
- Validation monitoring – assess validity of pre-defined assumptions and whether the models for developing management plans are correct.

9.2.2 Activity Planning

Monitoring protocols address sampling design, methodology, data management and analysis, interpretation, and reporting requirements.

Sampling Design - Development of a sampling design should reflect the objectives and the required level of precision guided by evaluative constraints (e.g. statistical requirements). For ecological programmes, a sampling approach includes consideration of spatial and temporal variability to construct qualitative and quantitative descriptions of pattern and process.

Different methodologies such as continuous recording at a permanent sampling point to measure temporal variability, or optimising discrete point sample patterns to measure spatial variability are also considered, often in relation to cost and effort.

To understand and accurately define pattern and process, the approach to sampling design should consider:

- The biotic and abiotic parameters of the biodiversity interest;
- Spatial and temporal scales representative of the biodiversity interest;
- Possible variation, and the limits of change that are important to detect;
- Sensitivity requirements to detect changes;
- The degree of confidence expected from the results; and
- How the data from the monitoring programme will be used.

Methodology - Broadly, ecological monitoring can be qualitative or quantitative. In some circumstances, qualitative monitoring may be more practical than quantitative methods, but it is often more variable due to subjectivity factors. Standardisation is therefore an important consideration in selecting methods.

Legal requirements may also influence the methodologies of monitoring programmes; legislation and binding agreements often prescribe monitoring methods, at least to the extent of national standards. Scientifically defensible methodology is also an important where there may be a need for backup in case of political or legal challenges to conservation.

Since ecological assessments of pattern and process generally occur over many years, methods should be selected to avoid future changes; changes should only be made after careful consideration, and supported by a period during which both new and old methods are used in parallel to establish comparability. Confidence in long-term data is required for detecting the magnitude and duration of change, and for early warning or indicators of ecosystem health. The intended use of the data will therefore influence the selection of methodology.

Data Management - A systematic approach for environmental data collection, management, and storage is necessary to facilitate data analysis and reporting. Therefore, a standardised approach is required to ensure that environmental data can be compared over time (trend / relationship analysis), that there is consistent long-term storage of survey deliverables (e.g. digital and paper files, photos, drawings, maps etc), that there is easy access to survey deliverables (e.g. through a central repository), and that document history is tracked.

Data management includes the accurate transfer of information from field data records and the secure storage of information. Managing data sets includes data entry, verification, validation, archiving and documentation. The inclusion of metadata (i.e. all information pertinent to a survey, such as locations, sampling techniques, observers, records, etc.) is vital for future confidence in and usefulness of the data.

Analysis and Interpretation - Data analysis should ensure that monitoring objectives are addressed effectively, emphasising the importance of early detection of critical changes to allow lower cost-solutions. Results from analysis can contribute to knowledge about the biodiversity interest being monitored and can provide managers with a scientific rational for setting appropriate standards.

Analysis requires a base or expected norm against which potential changes can be compared. For Sakhalin II, baseline information has been obtained from initial surveys conducted during the EIA process. For new projects, baseline biodiversity assessments will be critical for future analysis and interpretation of cumulative effects.

Activity planning should therefore consider the analysis and evaluation that will elicit answers to the questions underlying the biodiversity objectives, allowing recommendations and calibration of the biodiversity programme. Furthermore, the review process should also check that the methods are reliable, and applied in a timely manner.

Where findings determine that biodiversity trends are within expected values, protocols should continue without substantial alteration – where trends change, design the most appropriate response. Reasons for monitoring are also evaluated at this stage, including whether the monitoring is indeed still required and whether the objectives changed.

Reporting - Activity planning should also address the preparation of reports, detailing findings and recommendations from data analysis that are presented in a format that enables others to interpret and understand the information.

9.2.3 Implementation

The requirements and approach for successful implementation of ecological monitoring programmes are addressed in greater detail in Section 10. In essence, such programmes should build on existing systems and infrastructure, meaning that it is important to integrate monitoring programmes into Sakhalin Energy's HSE-MS, to avoid duplication and conflict with established structures and processes. Generally, a 'project management' approach to monitoring programmes is useful to establish scope, schedule, costs, technical tasks, controls, and tracking systems.

Furthermore, leadership commitment and general organisational awareness are important for successful programme implementation, and should be supported by standard processes including:

- Resourcing and organisation, including allocation of roles and responsibilities;
- Competence and training;
- Internal and external communication; and
- Effective contractor management.

Seven characteristics of effective monitoring programs are:[2]

(1) Design the program around clear and compelling scientific questions. Questions are crucial because they determine the variables measured, spatial extent of sampling, intensity and duration of the measurements, and, ultimately, the usefulness of the data.

(2) Include review, feedback, and adaptation in the design. The guiding questions may change over time, and the measurements should be designed to accommodate such changes. The program should have the capacity to adapt to changing questions and incorporate changing technology without losing the continuity of its core measurements.

(3) Choose measurements carefully and with the future in mind. Not every variable can be monitored, and the core measurements selected should be important as either basic measures of system function, indicators of change, or variables of particular human interest. If the question involves monitoring change in a statistical population, measurements should be carefully chosen to provide a statistically representative sample of that population. Measurements should be as inexpensive as possible because the cost of the program may determine its long-term sustainability.

(4) Maintain quality and consistency of the data. The confidence of future users of the data will depend entirely on the quality assurance program implemented at the outset. Sample collections and measurements should be rigorous, repeatable, well documented, and employ accepted methods. Methods should be changed only with great caution, and any changes should be recorded and accompanied by an extended period in which both the new and the old methods are used in parallel, to establish comparability.

(5) Plan for long-term data accessibility and sample archiving. Metadata should provide all the relevant details of collection, analysis, and data reduction. Raw data should be stored in an accessible form to allow new summaries or analyses if necessary. Raw data, metadata, and descriptions of procedures should be stored in multiple locations. Policies of confidentiality, data ownership, and data retention times should be established at the outset. Archiving of soils, sediments, plant and animal material, and water and air samples provides an invaluable opportunity for re-analysis of these samples in the future.

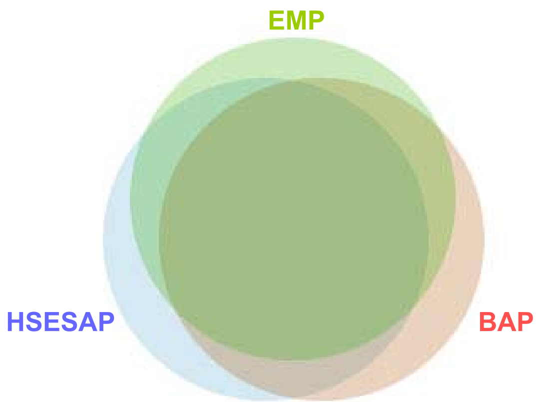
(6) Continually examine, interpret, and present the monitoring data. The best way to catch errors or notice trends is for scientists and other concerned individuals to use the data rigorously and often. Adequate resources should be committed to managing data and evaluating, interpreting, and publishing results. These are crucial components of successful monitoring programs, but planning for them often receives low priority compared to actual data collection.

(7) Include monitoring within an integrated research program. An integrated program may include modelling, experimentation, and cross-site comparisons. This multi-faceted approach is the best way to ensure that the data are useful and, indeed, are used.

2 Quote adapted from Lovett et al., *Who needs environmental monitoring?* Front Ecol Environ 2007; 5(5): 253–260

9.3 Sakhalin Energy's Monitoring Programmes

Sakhalin Energy's monitoring programmes are developed from various sources, including TEOC, EIA, RF legislation, international standards. Although there is considerable overlap between the EMP, HSESAP and BAP, each contains some monitoring requirements different to those in the other monitoring programmes due to different terms of reference. The relationships between the monitoring requirements of the EMP, HSESAP and BAP may be depicted as follows:



9.3.1 Environmental Monitoring Project

The Environmental Monitoring Project (EMP) combines the monitoring chapters of the Environmental Protection Books of TEOC for the Operations Phase. Sakhalin Energy's EMP was approved by the State Environmental Expertisa Review (SEER) on 5 June 2007, and represents a *contract* between Sakhalin Energy and the Russian Government. The approved EMP consists of four volumes:

- Volume 1: General Information
- Volume 2: Monitoring of Offshore Assets
- Volume 3: Monitoring of Onshore Assets
- Volume 4: Information Systems Support

The EMP describes how Sakhalin Energy will collect, transmit, store, and report information to measure the environmental effects of Sakhalin Energy's activities. Since the terms of reference for the EMP were the TEOC and Russian Federation law, it does not address all of Sakhalin Energy's environmental commitments, for example, Shareholder and Stakeholder requirements. It therefore constitutes only part of Sakhalin Energy's Monitoring Programmes.

In Russian, the EMP is termed "Industrial Environmental Control and Local Monitoring System". Essentially, industrial environmental control requirements address parameters "inside the fence" while local monitoring requirements address parameters "outside the fence" of the asset. Onsite and offsite parameters to be monitored in terms of the EMP include:

- Environment – emissions, air quality, discharges, water quality, waste, soil quality, erosion, groundwater, geological processes, flora and fauna;
- Sanitary – noise, heat, radiation, light, potable water; and
- Seismic – geodynamics.

9.3.2 Health Safety Environment and Social Action Plan

In line with International Financing Corporation Guidance, the HSESAP includes details of the mitigation, management, monitoring, and institutional measures that have been agreed between Sakhalin Energy and the potential Phase 2 Senior Lenders to eliminate identified adverse health, safety, environmental and social impacts, offset them, or reduce them to acceptable levels.

The HSESAP requires that Sakhalin Energy will, in addition to regulatory requirements of the Russian Federation, comply with the World Bank / IFC environmental, health, safety and social policies and guidelines, as well as EU environmental and health and safety directives that are specified in relevant standards.

The HSESAP includes Onshore and Offshore Biodiversity Commitments, the key objectives of which are to:

- Ensure that biodiversity issues are fully considered in all project planning and activities in order to meet relevant Russian Federation legislation, Sakhalin Energy Standards and any other appropriate biodiversity protocols;
- Minimise the ecological footprint and impact on ecological processes resulting from project activities through sensitive planning, the use of best practice construction techniques and effective management of construction and operational processes;
- Utilise suitable techniques to restore impacted habitats and ecological processes to their original status where this can be technically achieved;
- Manage activities and personnel to ensure that disturbance to fauna and flora is minimised and confined to defined working areas;
- Implement monitoring programmes to determine the efficacy of mitigation measures during and post construction and to put in place procedures to develop and undertake remedial measures if required;
- Ensure that personnel engaged in project activities are fully aware of commitments made by Sakhalin Energy with respect to hunting, gathering and fishing and that these commitments will be enforced;
- Discourage illegal / increased access to previously inaccessible areas through the removal of temporary construction roads and appropriate use of fencing and other measures to restrict access to the pipeline right-of-way.

Annex C of the HSESAP sets out the monitoring commitments applicable under the agreement. In general, the monitoring programmes have been developed on the basis of recommendations and requirements set out in the relevant TEOC and Environmental Protection Book documentation. Consequently, there is considerable overlap between the EMP and HSESAP Annex C. However, Annex C also includes monitoring requirements related to World Bank and EU standards as specified under Annex A.

9.3.3 Biodiversity Action Plan

The BAP derives from government, corporate, and company policies, stakeholder interests, and from best practice. The Government of the Russian Federation is committed to a policy of sustainable development, and the conservation of biodiversity is an integral part of the country's sustainable development agenda. A National Strategy for the Conservation of Biodiversity in the Russian Federation has been produced by the Russian Academy of Sciences and the Ministry of Natural Resources and was adopted in 2002.

The Biodiversity Action Plans for areas supporting endangered or critically endangered species, and for areas that are generally considered as vulnerable, has been developed in line with the Sakhalin Energy corporate standards.

Sakhalin Energy is committed to conserving the biodiversity of Sakhalin Island that could be affected by the activities of the Sakhalin II Project. This commitment is reflected in Sakhalin Energy's HSE Commitment & Policy, and in its Biodiversity Standard that states, "Sakhalin Energy shall comply with:

- Applicable Russian Federation laws and regulations;
- HSESAP Commitments;

Although the EMP includes a range of industrial environmental controls and local monitoring, it does not address all biodiversity interests, for example wetlands, dark coniferous forests, taimen, and Chaivo habitats, nor does it assemble a framework suitable for the management of biodiversity interests.

In line with the above legal requirements and guidance, Sakhalin Energy's BAP will provide the framework for biodiversity monitoring, with reference to and comparison with baseline information to assess the biodiversity situation and achievement of BAP objectives. Existing and planned ecological and environmental monitoring programmes will be reviewed to determine suitability and coverage in relation to biodiversity priorities. If required, specific monitoring programmes will be developed or alterations made to planned programmes to ensure that biodiversity interests are adequately addressed.

Sakhalin Energy's BAP also provides for stakeholder engagement. The Sakhalin Biodiversity Group (BG) is an independent advisory body representing regulatory, scientific, NGO, and other stakeholders' interests in the management and conservation of biodiversity on Sakhalin Island. The establishment of the BG, which was facilitated by Sakhalin Energy, could be seen as an important element in the implementation of the RF National Biodiversity Strategy. Since some of Sakhalin Energy's programmes for the management of priority biodiversity interests are submitted to the BG for comment, the BG may influence those monitoring programmes, although Sakhalin Energy has final decision.

9.4 Overview of Current Monitoring and Surveys

The following programmes are derived from the EMP, HSESAP and the BAP.

9.4.1 Western Gray Whales

The WGW photo-ID programme aims to document WGW population status, abundance, body condition, calving intervals and rate, as well as movement using photographs and location methods to match individuals to those previously seen and catalogued. Other monitoring programmes define WGW distribution and seasonal and multiyear variations; whales are observed during vessel, land as well as air-based surveys where dedicated helicopter flights with two trained Marine Mammal Observers onboard are routed once a month along the coast from Nogliki to Okha to scout for beached whales and carcasses.

Furthermore, the prey of WGW are monitored by sampling benthic communities in the Piltun and offshore feeding areas from a research vessel or inflatable boat at certain points on an established grid. Samples are analysed to study prey composition, biomass, distribution and probable correlation to oceanographic processes.

The acoustic environment and hydrology of WGW habitat off the north east coast of Sakhalin Island are also monitored. Ambient and anthropogenic-generated underwater sound at permanent locations within, and at the borders of, the Piltun and offshore (Chaivo) feeding areas are measured in relation to noise thresholds specified in the Marine Mammal Protection Plan. Transmission loss experiments will also be conducted to understand propagation and attenuation of sound in the areas close to the feeding grounds of the WGW population.

9.4.2 Steller Sea Eagles

Monitoring of the SSE population continues, in part due to the substantial interest in this species from international (mainly Japanese) stakeholders. The surveys are being conducted by the same team, which has extensive experience in SSE research. Monitoring is scheduled twice per year. On the basis of data collected, mitigation measures have been updated and implemented.

In addition to the spring and late summer surveys, semi-permanent observation of SSE (specifically nests) has been arranged at the OPF and Chaivo to determine whether mitigation measures are being implemented correctly and whether the birds' behaviour has changed. This surveillance is particularly important during construction and commissioning works.

9.4.3 Protected Birds

Four protected bird species have been recorded in areas that are potentially affected by Sakhalin Energy’s activities, *viz*. Aleutian tern, dunlin, long-beaked murrelet, and Siberian spruce grouse. During baseline surveys, nesting areas of these species were observed in close proximity to the pipeline right-of-way.

In addition, some nesting colonies of dunlin and Aleutian tern occur in the right-of-way impact zone at Chaivo spit. Both these protected species are cited in the Russian-Japanese Agreement for the Protection of Rare Migratory Birds. Monitoring of these species was initiated in 2004, and continues twice a year during nesting and migration.

The Siberian spruce grouse (photo) is a Red Data Book species with a low population density. Monitoring of spruce grouse around the OPF site commenced during 2006 and continued in spring 2007. Surveys have shown that the dark coniferous forest adjoining the OPF site from the southwest is an important nesting territory for this species. Experts anticipate a negative impact on the spruce grouse population due to increased disturbance and occurrence of opportunistic species such as crows, foxes and bears. Furthermore, the spruce grouse is highly vulnerable because of its 'trusting' behaviour.

The long-beaked murrelet is a protected rare migratory bird. Each day, it flies long distances between its feeding area along the seashore and its nesting area located in inland forests. Observing daily migration is considered important as this species is at risk of serious harm or mortality from flaring at the OPF.

Research and mapping of dunlin and Aleutian tern nesting areas at Chaivo spit were initiated in 2007. Appropriate mitigation will be developed based on results of this survey. The migration of birds along the lagoon and seashore will also be studied.

9.4.4 Sakhalin Taimen

Sakhalin taimen is a critically endangered salmonid listed in the Red Data Books of the IUCN, Russian Federation, and Sakhalin Oblast. This species is endemic to Sakhalin and the adjacent mainland and islands. It is believed that Sakhalin holds more than 50% of the world population. Despite its high profile as one of the largest salmonids, it is poorly studied on Sakhalin; there are poor data on taimen abundance along the pipeline, and no data on taimen spawn counts. Taimen are still poached on Sakhalin, where the estimated annual consumption is believed to be many thousands of individuals, causing a rapid decline in numbers.

Discussions were held between Sakhalin Energy and the US-based Wild Salmon Centre (WSC) in 2005-2007, during which it was decided that Sakhalin Energy would participate in an international programme for Sakhalin taimen research coordinated by the WSC. In line with these initiatives, Sakhalin Energy's Sustainable Development Council approved the Sakhalin Taimen Research Project in 2006 (SD Project # HSE-32).

The objectives of the study are to a) identify river systems along the pipeline route that are inhabited by taimen, and b) establish a baseline to assess the impact of anthropogenic activities and for future scientific work. The results of these and future surveys will provide information on taimen spawning areas and juvenile density that has not yet been reported from Sakhalin thus far.

9.4.5 River Crossings

Sakhalin Energy's pipelines cross over 1,000 watercourses, 179 of which are listed as salmon spawning rivers and classified as Group 2 and Group 3 (the most sensitive rivers). While eight crossings were performed using horizontal directional drilling (HDD) and auger bore methods, 170 crossings were done using open cut methods during the winter months of 2004 / 05, 2005 / 06 and 2006 / 07 (i.e. out of the spawning season and in low flow conditions). External observers monitored the company's compliance with commitments formulated in the River Crossing Strategy, and observations were made available to the public. A compliance rating of 90% was achieved in 2006 / 07. River crossing activities have now ceased.

To assess construction related impacts and the potential requirements for corrective action, post-construction monitoring will commence in 2008 through to 2011. Where river health has been negatively affected, appropriate remediation, as agreed with local authorities, will be applied.

9.4.6 River Restoration

The River Restoration Project, an off-shoot of the River Crossing Strategy, was approved by Sakhalin Energy's Sustainable Development Council in 2006 (SD Project # HSE-33). The focus of this project is the restoration of salmon spawning habitats through the use of appropriate management techniques, such as limiting input of fine sediment from sources adjacent to watercourses, and / or the creation of new in-channel habitat. Such measures will be viewed within the overall concept of restoring and sustaining the ecological function of selected river systems so as to benefit a range of species, not only spawning salmon.

A pilot project covers the Djimdan River, a system selected from the Nogliki District. The project aims to manage activities that cause habitat degradation - which in turn prevents habitat use and enhancement by salmon. The project comprises two phases; Phase one includes site selection, field surveys, watershed assessment and planning (initiated in 2007), and Phase two includes restoration works, monitoring and management (with implementation during the following two to five years). Potentially, management and monitoring may be required beyond this period to ensure the success of the restoration works.

The following monitoring and survey activities are included during Phase 1: (i) survey of downstream fry migration; (ii) reconnaissance survey; (iii) upstream migration and spawning areas survey; (iv) research of invertebrates and egg mortality plus study of ground quality; (v) assessment of water quality; (vi) workshop with local population, to be conducted by US Forestry experts; (vii) development of plan for restoration works; and (viii) implementation of the first stages restoration works.

9.4.7 Monitoring of Salmon

Pacific salmon form the basis of Sakhalin's regional fisheries, and provide sustainable employment for the local population. Salmon account for over 15% of the protein intake by local people, and are important in indigenous culture and traditions. Pacific salmon also play a role in both offshore and onshore ecosystems, influencing many other animal and plant species.

Recognition of the ecological and commercial importance of Pacific salmon has led to efforts to mitigate the effect of construction activities on spawning rivers, and to compensate for impacts where they have occurred. Monitoring of salmon and their habitats began at the start of construction (2003). Various aspects subject to monitoring include spawning grounds of representative rivers crossed by pipelines, ecological parameters of these spawning areas, downstream fry migration, and quality of water and bottom sediments. At the LNG construction site and its surrounds, the upstream migration of pink salmon, and downstream fry migration have been assessed. Surveys are subject to review by international, independent observers.

9.4.8 Wetlands

Wetlands have been identified as an important habitat type on Sakhalin Island. In general, wetlands are highly valued because they support vital ecological processes such as water regulation and purification, and they provide essential habitat for birds (including rare and protected species) during seasonal migrations. However, some of Sakhalin's wetlands are oligotrophic bogs that are poor in biodiversity and do not support migratory birds. A need therefore exists to characterise wetlands along the right-of-way in terms of their characteristics, function, or biodiversity, and whether and / or how they have been affected by project activities. Wetland survey data will provide the information necessary to develop appropriate management actions where they are required.

A Scope of work for wetland surveys was developed in line with the American Federal Energy Regulatory Commission report on Research of Wetland Construction and Mitigation Activities for Certificated Pipeline Projects (FERC, 2004). Monitoring surveys have addressed, and will continue to address, hydrology (including measurements of water table dynamics during snow-free periods and between seasons), soils (including pH, nutrients, and peat type) and vegetation (cover, dominant species, community composition, health, and invasive species).

9.4.9 Ballast Water

For many years, governments and the international shipping community have recognised that alien species and pathogens introduced through the transport and discharge of ballast water can cause severe impacts on local environments. There have been several ecological catastrophes caused by ballast discharge, such as the introduction of the zebra mussel from the Black Sea to Western Europe, North Europe and North America; for the USA alone, costs of up to $1 billion USD have been attributed to the zebra mussel invasion. Other examples include outbreaks of cholera in South America and the Gulf of Mexico that were directly associated with ballast water discharge.

With up to 150 LNG carriers and 100 crude oil ships loading cargo annually in Aniva Bay, and discharging up to 45,000 metric tonnes of ballast water per loading operation, this is clearly an issue that will require careful and effective control.

The objectives of the baseline survey and monitoring for assessment of impact of ballast water on sea flora and fauna in Aniva Bay are to establish baseline information for assessment of species composition and structure of bottom and pelagian coenosis in the ballast water discharge area, and to contribute to future monitoring of potential ballast water impact on the flora and fauna of the Aniva Bay.

To achieve these monitoring objectives, surveys will include:

- Study of the composition, structure, quantitative characteristics and seasonal dynamics of phytoplankton, zooplankton, and ichthyoplankton;
- Identification of the composition, structure and quantitative characteristics of benthos coenosis associated with various types of sediment and depths including the tidal zone;
- Evaluation of the composition and quantitative characteristics of macrobenthos by means of sampling with a beam trawl; and
- Study of the composition, structure and quantitative characteristics of marine growth on the coastal mooring constructions and accompanying structures in the area of Prigorodnoye.

10 Implementation

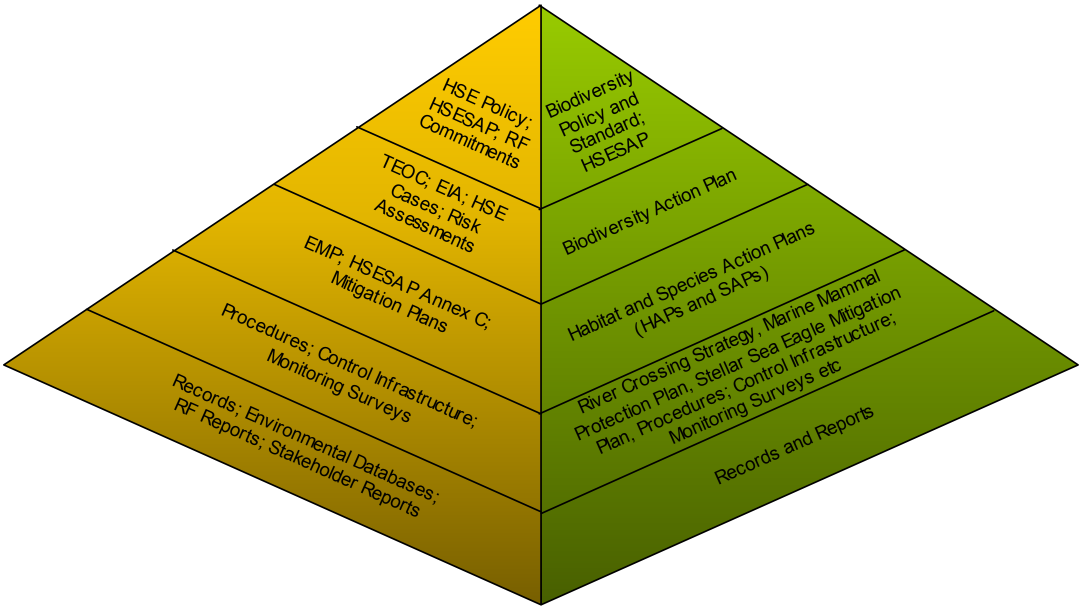
10.1 Biodiversity Control Framework

Sustainable Development is one of Sakhalin Energy's overriding project objectives, and will be achieved through careful planning of activities and our conduct in the three perspectives of "economic development", "environmental protection" and "social responsibility". Consistent, outstanding, demonstrable performance within these three pillars of Sustainable Development is necessary to build trust with our stakeholders and to protect Shareholder reputation. The BAP is of importance to Sakhalin Energy in meeting its sustainable development objectives, and therefore requires a systematic and integrated approach for successful implementation.

Sakhalin Energy's Health Safety and Environment Management System (HSE-MS) describes the controls that the Company uses to manage the HSE risks and effects of our industrial activities. The HSE-MS is a framework of documents designed to ensure that the Company's operations and activities are performed in accordance with requirements under the existing agreements governing the structure and affairs of the Company, whilst encouraging continuous improvement in HSE performance. The eight elements of the HSE-MS are shown in Table 10.1.

Table 10.1 Elements of Sakhalin Energy's HSE-MS.

Already, commitments that are relevant to the management of biodiversity interests are included in the HSE-MS by way of the company's Industrial Environmental Control and Local Environmental Monitoring Programme (EMP), Health, Safety, Environment, and Social Action Plan (HSESAP), and Sakhalin Energy's Environmental Standards, all of which set the basis of the company's obligations for environmental management. By using existing strategies, plans, standards, procedures, and programmes of the HSE-MS, plus new action plans to cover any gaps, biodiversity interests can be managed and monitored by a combination of elements conceptually understood as a *biodiversity control framework*. The following diagram shows the integration of the biodiversity control framework into the HSE-MS pyramid.



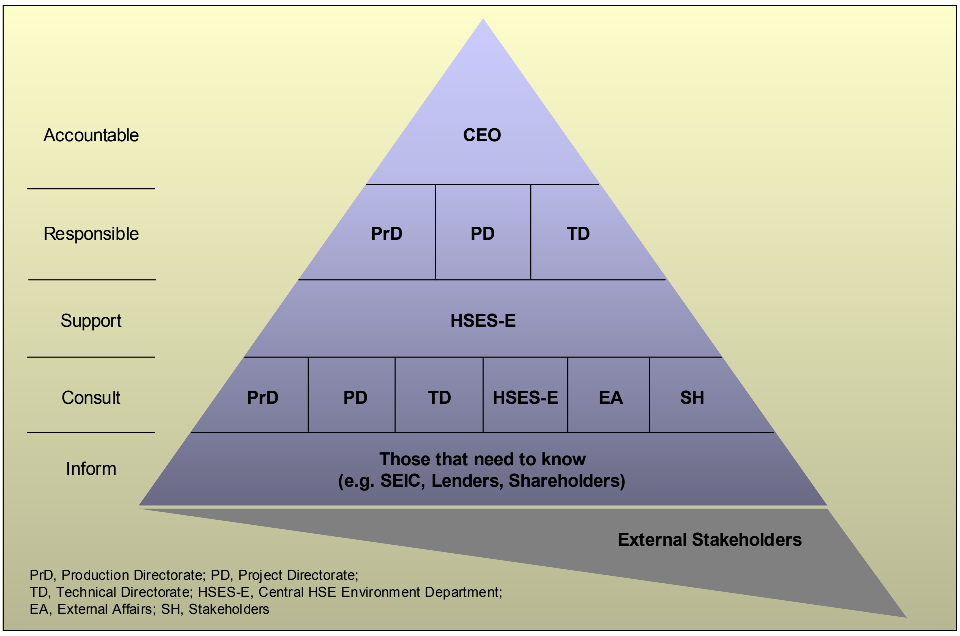
Accordingly, implementation of the BAP will use HSE-MS mechanisms to:

- Maintain an appropriate organisational structure and define responsibilities for managing biodiversity interests;
- Allocate sufficient resources (human, physical and financial) to fulfil those responsibilities;
- Provide assurance that personnel and contractors are competent to fulfil their responsibilities;
- Build capacity and conduct training to support biodiversity management actions;
- Communicate on requirements and performance; and
- Define the methods by which staff and contractors carry out their activities ensuring that biodiversity is protected.

10.2 Roles, Responsibilities and Resources

Resource management in the organisational framework is a major factor affecting the success of projects. Effective implementation of the BAP requires sufficient allocation of human, physical and financial resources. BAP resource requirements should be considered during the planning and management review processes as described in the HSE-MS. Resource allocation should also be considered in managing change and when assessing the effectiveness of biodiversity controls.

Human resources for implementation of the BAP include both Sakhalin Energy personnel and contractor personnel working on its behalf. These resources should be organised in a manner that ensures everyone is empowered and committed to achieving their deliverables. The high level organisational structure for implementation of the BAP could be depicted as follows:



Lower level organisational structure for implementation of individual species and habitat action plans would fall under this framework and would be plan-specific. Essential roles in BAP delivery include, for example:

- Investment decision-making – the use of capital, operational and human resources, based on BAP needs, best-practice, affordability and cost-effectiveness;
- Ownership – to be assumed by a senior individual in the company, who has the status and authority to provide the necessary leadership, and who has accountability for BAP delivery and outcome. This individual should also ensure that sufficient resources are made available to enable successful implementation of the BAP;
- Delivery – ongoing day-to-day management and decisions to ensure that BAP objectives are delivered. Personnel in this role should have adequate knowledge and information about the BAP to make informed decisions;
- Advisory – provision of advice to all role-players on issues related to BAP implementation and performance.

The key responsibilities of some role-players in BAP implementation are listed in Table 10.2.

Table 10.2 Key responsibilities for BAP implementation.

Central Environment	External Affairs	Assets
• Collate and analyse environmental data • Develop biodiversity database / GIS • Establish priorities and objectives for action • Develop or revise mitigation and management actions • Determine and implement monitoring programmes • Implement specific actions / projects • Liaise with stakeholders • Report on implementation	• Assist with stakeholder engagement • Manage stakeholder / Sakhalin Energy expectations • Assist with reporting mechanisms • Assist with communications protocols	• Implement management actions / mitigation measures • Assist with resourcing for specific actions and projects • Support monitoring programmes

Unclear roles, responsibilities and authorities directly affect project performance. If people are unclear about why they are participating, or what they should do in a BAP programme, the resulting confusion will jeopardise short term and long term objectives. Therefore, clear definition of roles, responsibilities and authorities must be communicated to the individuals and groups required for the successful implementation of the BAP. Although most of the relevant roles, responsibilities and authorities have already been defined in associated programmes under the HSE-MS, implementation of the BAP will serve as a useful opportunity to check these.

The organisation and deployment of Sakhalin Energy's physical resources also need to be addressed during implementation. Infrastructure such as facilities, buildings and access roads are available, as are technologies such as satellite imagery and geographic information systems. Equipment such as plant, vehicles, vessels and aircraft are also already organised and deployed for onshore and offshore monitoring programmes, which are supportive of many of the BAP priorities, or focus areas. Efficient use of these resources, to ensure that controls are implemented and monitoring conducted in a competent and well-organized manner, is an issue already incorporated into planning processes under the HSE-MS activity and budget frameworks. The biodiversity control framework would integrate into these existing processes.

Financial management processes and procedures are already established in Sakhalin Energy's management system. Business Planning is the structured process by which the company's strategy and business objectives are translated into plans. The annual business planning cycle is used to develop a challenging but realistic Integrated Business Plan for the company that meets shareholders' expectations. Implementation of the BAP would need to integrate into the business planning and budget approval processes. Parts of species and habitat action plans that are not already addressed by existing environmental management and monitoring programmes would need to be identified, costed, and submitted for management approval.

10.3 Training and Capacity Building

Education is critical to securing support for biodiversity conservation. Training, awareness and competence of those involved in the management of environment and more specifically, biodiversity interests, and the availability of human resources to perform tasks required to meet BAP objectives, need to be considered and defined.

In order to improve environmental management and performance in the business process, Sakhalin Energy requires staff to undergo training. The specific purpose of training is to:

- Develop the basic and advanced knowledge and skills of individual employees or groups of them (teams/departments), as required for their jobs or personal effectiveness;
- Improve employees' understanding of their own work and of the organization of which they form part;
- Contribute towards employees' future development and employability.

Training, development and competence assurance processes are already established in Sakhalin Energy's HSE-MS, and must be followed during BAP implementation. Basic training delivered during HSE induction programmes includes awareness-level information about biodiversity management, while training needs for task-specific competencies are addressed in more targeted programmes.

Capacity building inside and outside the organisation should also be considered in developing biodiversity interests. Partnerships with stakeholders can aid in the dissemination of information on biodiversity to educate the public of its importance and benefits; greater public understanding leads to increased acceptance and support for biodiversity-related projects.

10.4 Communication

An important component of the implementation and evaluation of the BAP will be to report on and communicate its progress and outcomes. This will need to be undertaken internally (i.e. within Sakhalin Energy and with shareholders), and externally (i.e. Russian Federation, stakeholders and with relevant interested parties). The various groups with whom Sakhalin Energy communicates are described in the following diagram:

All of these groups are concerned with aspects related to biodiversity interests. Communication with these groups is therefore a key process in developing support among internal and external stakeholders, so that the potential success of current and future biodiversity-related activities is enhanced.

In order to achieve this successfully, communication protocols must ensure consistency in their delivery of information. Communications procedures are established in Sakhalin Energy's management system framework, and must be followed during implementation of the BAP. Where a specific communications strategy is required, tools such as memos, newsletters, brochures, posters, performance appraisals, slogans, and enclosures, may be considered. In particular, a clear structure of meetings (at which information is communicated and decisions are made), and reports (through which progress, recommendations and conclusions are documented and communicated) must be defined for (a) the BAP overall, and (b) for each biodiversity priority programme.

The Company holds several levels of internal HSE meetings at which objectives and performance are communicated. Existing meeting and reporting structures should therefore be used as much as possible (e.g. company-wide HSE Communications Sessions, Sakhalin Energy Quarterly Environmental Review Meetings and Annual Reports), to maximise integration of the BAP into existing processes, and to minimise requirements for additional resources. Policies and procedures need to reinforce and be consistent with the messages being sent by other "channels".

The Company's intranet and public website are also used for communicating information about biodiversity interests and environmental management. Sakhalin Energy's public website includes a library containing several documents that are directly relevant to this BAP (e.g. EIA's, Marine Mammal Protection Plan, Western Gray Whale Protection Programme, River Crossing Strategy, Policy on Fishing Gathering and Hunting During Construction, and Remedial Action Plans).

In developing Species and Habitat Action Plans (SAPs and HAPs) for the biodiversity priorities identified in Section 7, opportunities for co-operating with Russian and international research and educational institutions may be considered where those associations and co-operative programmes significantly improve the achievement of biodiversity objectives, through assisting research, implementing controls, and communicating findings and conclusions in scientific publications that contribute to the broader scientific knowledge base.

Information published in independently peer-reviewed, scientific journals carries special status in that it represents external, objective verification of the findings and conclusions of the work. This is useful in that it:

- Communicates the strategy, methodology, findings, and conclusions to interested parties;
- Receives feedback during the peer-review process that can be used to confirm or shape the SAP or HAP approach;
- Enhances the image of the BAP through independent verification of the work

Independent verification is widely understood to be a requirement for scientific progress.

10.5 Contractor Management

Contractors are an important part of Sakhalin Energy's organisational framework. They allow the company to increase capacity and to maintain service levels. However, contractors also represent a major exposure for HSE (including biodiversity) management. For example, supply vessels and crew change boats operated by contractors working off the northeast coast of Sakhalin, risk collision with marine mammals and western gray whales in particular. Likewise, onshore construction contractors may impact the water quality and habitat integrity of rivers used by salmon and taimen for spawning.

Therefore, contractor activities can have a direct effect on the environment, and more specifically on biodiversity interests. It is therefore imperative to put in place HSE controls that

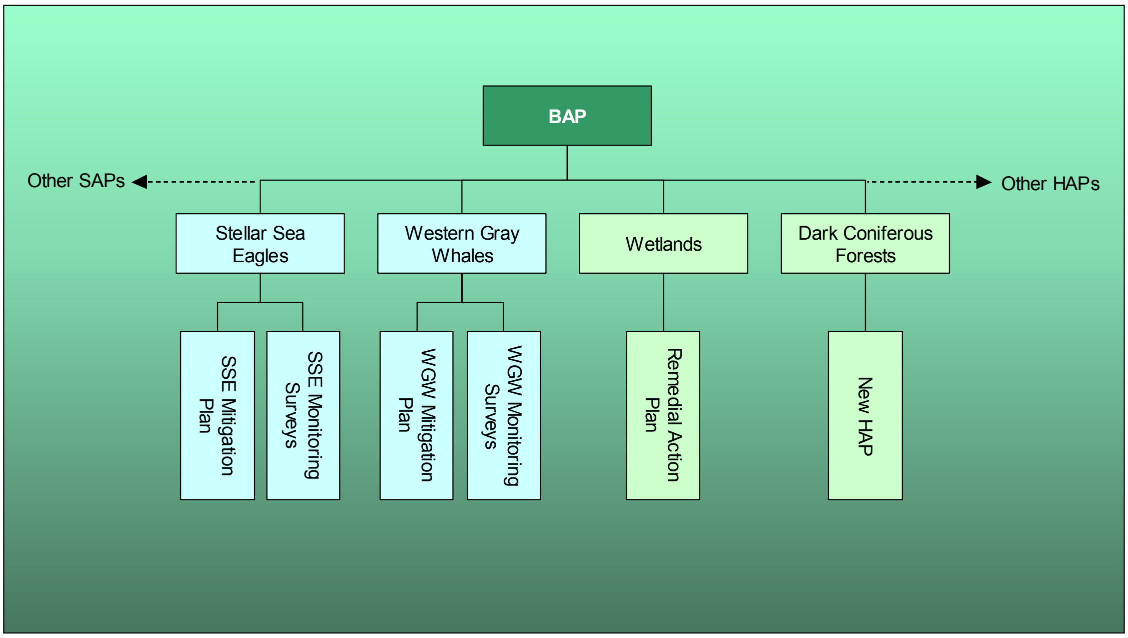
reduce the potential for contractor activities to cause unnecessary damage.
Sakhalin Energy has established a comprehensive process for Contractor HSE Management, which requires that pre-qualification of contractors takes environmental controls into consideration, that the environmental (and biodiversity) risks and effects of a proposed scope of work are identified and assessed, and that controls are incorporated into HSE Plans as part of the contracting and procurement process.

10.6 Species and Habitat Action Plans

The effects assessment and biodiversity prioritisation process detailed in Sections 7 and 8 guides the development of species and habitat action plans (HAPs and SAPs). These action plans provide frameworks for managing particular biodiversity interests. By defining objectives, actions, and resources for managing a biodiversity interest, HAPs and SAPs provide lower level control frameworks.

Wherever possible, HAPs and SAPs refer to existing systems, strategies, plans, standards, procedures, and programmes. Where existing controls do not meet all requirements for management of the biodiversity priorities identified in Section 7, additional requirements may be defined in HAPs and SAPs to address the gaps.

The structure of this BAP and its lower level HAPs and SAPs in relation to existing HSE-MS content can be represented for example as follows:



Existing mitigation and monitoring plans can be referenced for biodiversity priorities such as Steller's sea-eagles, western gray whales, and wetlands, while new management programmes will need to be developed for dark coniferous forests, for example. As discussed previously, these elements can be conceptually understood as a *biodiversity control framework*.

Thus, habitat and species action plans must be defined for each relevant priority area. The HAPs and SAPs provide a framework for the management of the biodiversity interest, providing context for a brief understanding of the issue and current status. The objectives for protection of the biodiversity interest and an overview of the resource, control and monitoring actions required to achieve those objectives are also included in HAPs and SAPs. Importantly, the HAPs and SAPs cross-reference the existing controls under the HSE-MS, plus any new plans that must be added to complete the biodiversity control framework.

Habitat and species action plans may be consolidated according to the format outlined for example under Table 10.3. It is intended that HAPs and SAPs would have the capability to address both Sakhalin II's requirements during the lifetime of the project and also contribute towards managing island-wide ecological and biodiversity issues. In this context, objectives may fall outside the direct capabilities of Sakhalin Energy and collaboration with external parties such as other oil and gas operators on the island will be required to progress certain activities.

Table 10.3 Guidance in preparing a habitat action plan that will be developed to address identified deficiencies or work to consolidate existing measures intended to deal with project related impacts on biodiversity interests.

Issue / impact	Description of the impact – source / cause / effect
Habitat Type	Habitat classification / identification
Definition(s)	Overview / description of terms
Current status	Brief description of distribution of habitat type on Sakhalin and wider area, including key vegetation and faunal associations. Note any characteristics that make this habitat distinct from those occurring on the Russian mainland. If historical context is available (e.g. change in distribution or decline in extent due to human influence) then this should also be noted. Presence of habitat in relation to project activities (using available baseline and monitoring data). Protection status, if applicable.
Factors affecting habitat	List and describe the primary factors influencing the habitat on Sakhalin. Description of potential project-related impacts / effects that have affected or may affect this habitat.
Objective	Define what is the project objective for this habitat and any associated target(s).
Actions	Define what management actions (mitigation measures, research, monitoring) are to be undertaken to minimise impacts to, or maintain this habitat and the species that it supports. Is there any legal status afforded to this habitat or federal / local policies that relate to its management or protection? List and describe any legislative requirements / changes that may be required in order to achieve the stated project objective. May include the need to inform policy makers and / or legislators to ensure that habitat management needs are incorporated into current and future management and development plans (e.g. future oil and gas exploration plans). Also, are any licenses or permits required to implement activities? Describe any actions needed to provide guidance, training or advice to project staff, managers, partners etc. to explain required management measures and their implementation. For each task, allocate responsibilities and timeframes for implementation.
Resources	Provide a summary of anticipated costs, budget source and allocation.
Monitoring	What research and monitoring work is proposed to support management actions for this habitat? Such work need not be confined to project-related activities and effects, but could recognise wider needs for more detailed ecological / biological data. Work in this area could include: • Site-specific monitoring work (e.g. documenting ecological processes and linkages to potential impacts or effects) • Collation, analysis and dissemination of data collected by the project • Monitoring of extent, distribution, community types etc. to determine potential change linked to project activities • Research to reveal information on ecology or biology that may be required to better inform management decisions related to this habitat and the species that it supports.
Communication	Description of actions that may be required to increase awareness (internal and external)

	of the work being undertaken. Identify opportunities for internal and external parties to be involved in the work being undertaken. List opportunities for media involvement.
Partners	List and describe role of other partners (if any) involved in developing and implementing the Action Plan. (or associated projects, initiatives)
Reference Documents	List relevant procedures / documents necessary for successful implementation of actions (e.g. scope of works for monitoring activities).
Other	Notes / comments etc.

11 Stakeholder Engagement

Although this BAP is owned and will be implemented by Sakhalin Energy, the value of collaborating with other stakeholders in the development and implementation of specific plans, and in the broader context of regional biodiversity management, is recognised. A partnership approach to implementation may also enable external funding sources to be sought, and allow for greater and wider benefits to be achieved. A further benefit of successful partnerships and engagement with stakeholders can be opportunities to promote trust, avoid conflict, and manage its reputation (both locally and internationally).

Therefore, an important element of the BAP process is the identification of and consultation with stakeholders, so that potentially conflicting issues and / or priorities among stakeholders can be addressed. Opportunities to develop partnerships to deliver biodiversity objectives and actions contained within or linked to the BAP will be explored and developed where suitable.

11.1 Ecological Council and Biodiversity Group

During development of the BAP, Sakhalin Energy has and will continue to take into account the views of Russian and international experts on biodiversity interests. Recognising that biodiversity must be protected and managed also in terms of a broader approach, Sakhalin Energy engages with Sakhalin oblast authorities, scientific organisations and communities on BAP-related matters. It is generally considered appropriate that consultation with external parties be coordinated via the ‘Ecological Council of the Sakhalin Oblast’.

The Ecological Council is an advisory body that exists under the regional Committee for Natural Resources (CNR). Providing a combination of legislative, scientific and environmental expertise, the Council is able to provide a forum for constructive dialogue on issues relating to biodiversity.

Sakhalin Energy’s strategy for the management of biodiversity was presented to the Council during August 2007. At that meeting, it was resolved that a ‘Biodiversity Working Group’ be constituted *to foster working relationships within the Group with respect to exchange of information, experience and guidance between biodiversity experts and to develop best approaches to the conservation of Sakhalin’s biodiversity.* Members of the Biodiversity Group invited to participate by the regional CNR included representatives from government, regional biologists, international experts, and representatives from NGOs.

Resolution of Meeting of Ecological Council of Sakhalin Oblast **7 August 2007**
Ecological Council of Sakhalin Oblast **1. supports the initiative of Sakhalin Energy to develop the biodiversity strategy and action plan;** **2. recommends to create the Biodiversity expert working group (Biodiversity Group)**

which will report to the Ecological Council with the following proposed member composition:

- **representative of the Ecological Council of Sakhalin Oblast (Chairperson of the Group)**
- **representative of the Committee of natural resources and environment protection of Sakhalin Oblast**
- **representative of the Department of forestry and protected areas of Sakhalin Oblast**
- **representative of Rosprirodnadzor**
- **representative of Rostekhnadzor**
- **representative of Sakhalin State University**
- **representative of the Institute of Marine Geology and Geophysics of Russian Academy of Science**
- **representative of SakhNIRO**
- **representative of the Sakhalin botanical garden (Russian Academy of Science)**
- **representative of the NGO "Sakhalin Environmental Watch"**
- **representative of the NGO Worldwide Wildlife Fund (WWF)**
- **representative of Moscow State University**
- **representatives of Japanese scientific institutions and NGOs (two persons)**
- **representatives of Sakhalin Energy (two persons)**

3. **Decisions of Biodiversity Group are the subjects of consideration of the Ecological Council of Sakhalin Oblast.**
4. **The terms of reference of the Biodiversity Group and the relevant decision making procedure are to be developed.**
5. **The Chairperson can enlarge the Biodiversity Group when necessary inviting representatives of other state, academic and non-government organisations.**

On 20 November 2008, at the meeting of the Biodiversity Working Group, the Terms of Reference for the working group were approved (see insert below).

Регламент деятельности Рабочей экспертной группы по биоразнообразию при Экологическом Совете Сахалинской области

Terms of Reference for the Biodiversity Working Group

Преамбула	**Preamble**
Рабочая экспертная группа создана на основании решения Экологического Совета Сахалинской области от 07 августа 2007 года.	The Biodiversity expert working group was created by the decision of the Ecological Council of the Sakhalin Oblast on 7 August 2007.
Экологический Совет Сахалинской области представляет собой совещательный орган, созданный постановлением губернатора Сахалинской области и действующий при администрации Сахалинской области.	The Ecological Council of the Sakhalin Oblast is an advisory body that was established under the Sakhalin Governer's Resolution and exists under the Sakhalin Oblast Administration.
Состав Рабочей экспертной группы формируется из представителей государственных природоохранных органов федерального и областного уровней, производственных, научно-исследовательских организаций, международных экспертов и представителей российских и международных неправительственных организаций.	The Biodiversity Group includes the representatives of the government environmental agencies, both federal and regional, commercial, scientific organisations, international experts and representatives from Russian and International NGOs.

Цель

Выработка оптимальных подходов к сохранению биоразнообразия в Сахалино-Курильском регионе.

Задачи

1. Оказывать помощь в разработке и реализации региональных и корпоративных планов и программ по сохранению биоразнообразия, включая обсуждение их результатов.
2. Давать экспертные заключения и рекомендации государственным, коммерческим и неправительственным организациям по вопросам, связанным с сохранением биоразнообразия.

Методы работы и основные виды деятельности

Для достижения вышеозначенной цели и решения поставленных задач Рабочая экспертная группа использует широкий спектр методов работы, включая ведение переписки о предоставлении информации, необходимой для осуществления своих функций, организацию семинаров, рабочих встреч, конференций и т.д., которые позволят привлечь к обсуждению рассматриваемых вопросов максимально широкий круг заинтересованных сторон.

Основные виды деятельности:

- Оказание помощи Экологическому Совету Сахалинской области в разработке концепции региональной стратегии и политики в области сохранения биоразнообразия;
- Подготовка экспертных оценок и рекомендаций по вопросам, связанным с сохранением биоразнообразия государственным, коммерческим и неправительственным организациям;
- Оказание помощи в разработке и реализации региональных и корпоративных планов и программ по сохранению биоразнообразия (в соответствии с запросами).

Goal

To develop the best approach to the conservation of Sakhalin's and Kuril's biodiversity.

Objectives

1. To assist in development andf implementation of regional and corporate biodiversity related plans and programmes, including discussion of their results.
2. To provide expert advice and recommendations to governmental and commercial institutions as well as NGOs with regard to the issues related to the biodiversity conservation.

Method of Operation and Core Activities

To achieve the above defined goal and objectives the Working expert group use a variety of mechanisms, which include communication regarding provision of information needed for the proper functioning of the Group and participation in workshops, meetings, seminars etc., providing an opportunity for engagement of the maximum of stakeholders.

Core activities include:

- To assist the Ecological Council of the Sakhalin Oblast in shaping a regional biodiversity strategy and policy;
- To develop expert advise and recommendations to governmental and commercial institutions as well as NGOs with regard to biodiversity related issues;
- To assist in the development and implementation of regional and corporate biodiversity action plans upon request.

Члены группы

В соответствии с резолюцией Экологического совета от 7 августа 2007 г., Рабочая экспертная группа избирается в следующем составе:

- представитель Экологического совета Сахалинской области (по согласованию)
- представитель Комитета природных ресурсов и охраны окружающей среды Сахалинской области (по согласованию)
- представитель Департамента лесов и особо охраняемых природных территорий Сахалинской области (по согласованию)
- представитель Департамента по рыболовству Сахалинской области (по согласованию)
- представитель Росприроднадзора (по согласованию)
- представитель Ростехнадзора (по согласованию)
- представитель Сахалинского государственного университета (по согласованию)
- представитель Института морской геологии и геофизики РАН (по согласованию)
- представитель СахНИРО (по согласованию)
- представитель Сахалинского ботанического сада РАН (по согласованию)
- представитель общественной организации «Экологическая вахта Сахалина» (по согласованию)
- представитель общественной организации «Всемирный фонд дикой природы» (WWF) (по согласованию)
- представитель Московского государственного университета им. М.В.Ломоносова (по согласованию)
- представители японских научных и общественных организаций (по согласованию – 2 чел.)
- представители компании «Сахалин Энерджи» (по согласованию – 2 чел.)

Из своего состава члены Рабочей экспертной группы открытым голосованием избирают председателя группы и его заместителя, а также секретаря группы.

При необходимости председатель группы может увеличивать ее состав, приглашая представителей других государственных, научных и общественных организаций.

Members

According to the Resolution of the Ecological Council of 7 August 2007, the Group has the following membership:

- representative of the Ecological Council of Sakhalin Oblast (Chairperson of the Group)
- representative of the Committee of natural resources and environment protection of Sakhalin Oblast
- representative of the Department of forestry and protected areas of Sakhalin Oblast
- representative of the Department of fishery of Sakhalin Oblast
- representative of Rosprirodnadzor
- representative of Rostekhnadzor
- representative of Sakhalin State University
- representative of the Institute of Marine Geology and Geophysics of Russian Academy of Science
- representative of SakhNIRO
- representative of the Sakhalin botanical garden (Russian Academy of Science)
- representative of the NGO “Sakhalin Environmental Watch”
- representative of the NGO World Wide Fund for Nature (WWF)
- representative of Moscow State University
- representatives of Japanese scientific institutions and NGOs (two persons)
- representatives of Sakhalin Energy Investment Company (two persons)

The group members by open ballot elect the Chairperson of the Group, his/her deputy as well as the Secretary of the Group.

The Chairperson can enlarge the Biodiversity Group as required, inviting representatives of other state, academic, scientific and non-government organizations.

Организация деятельности Рабочей группы

Группа собирается на свои заседания не менее двух раз в год.

При необходимости председатель группы может назначать внеочередные заседания.

Члены Рабочей группы уведомляются о дате очередного либо внеочередного заседания не менее, чем за 45 календарных дней.

Материалы и/или документы для обсуждения на заседании Рабочей группы предоставляются секретарем означенной группы членам Рабочей группы не менее чем за 45 календарных дней.

Рабочая группа правомочна принимать решения, если на её заседании присутствует более половины членов.

Решения принимаются открытым голосованием. Заседания Рабочей группы оформляются протоколом. Протокол Рабочей группы ведется секретарем Рабочей группы.

Решение Рабочей группы считается принятым, если за него проголосовало более половины членов Рабочей группы, присутствующих на заседании. В случае, если в ходе голосования голоса членов Рабочей группы распределились поровну, голос председателя Рабочей группы является решающим.

В целях повышения оперативности работы Рабочей группы некоторые вопросы могут рассматриваться методом опроса членов означенной группы, при этом позиция каждого опрошенного члена Рабочей группы должна подтверждаться факсограммой или письмом.

Протокол заседания Рабочей группы предоставляется председателю не позднее 10 рабочих дней после проведения заседания.

Протоколы заседания подписываются председателем или по его поручению заместителем председателя.

Вся переписка Рабочей экспертной группы ведется от имени председателя или (по его поручению) заместителя председателя.

Хранение протоколов заседаний и материалов, обсуждаемых на заседаниях Рабочей группы, осуществляется председателем или по его поручению заместителем председателя.

Organisation of the Working Group Activity

Group meetings shall take place at least twice a year (or more often).

If necessary, the Chairperson may schedule special sessions.

Group members must be notified about the date of planned or extraordinary meeting at least 45 days in advance.

Materials and/or documents for the discussion at the next Biodiversity Group meeting are sent by the Biodiversity Group secretary to the members of the Group at least 45 days in advance.

The quorum for the competent decisions of the Group is 50% of its members.

The decisions are made by an open ballot. Meetings of the Group are minuted. The Secretary is responsible for minuting.

The decision of the Working group is considered to be accepted if more than half attended Group members voted it. If the votes of the Group members are distributed evenly, the vote of the Chairperson is decisive.

To increase the effectiveness of the Working Group some questions may be discussed by the querying of the Group members; in this case the opinion of each queried Group member must be confirmed by the fax or letter.

Minutes of a meeting shall be submitted to a Chairperson not later than in 10 working days after a meeting.

Minutes of meetings are signed by the Chairperson or his/her Deputy (on the instructions of the Chairperson).

The correspondence of the Working Group is done on behalf of its Chairperson or his/her Deputy (on the instructions of the Chairperson).

The keeping of minutes of meetings and materials/documents discussed at the meetings is the responsibility of the Chairperson or his/her Deputy (on the instructions of the Chairperson).

Отчетность	**Reporting**
Группа по биоразнообразию подотчетна Экологическому совету Сахалинской области.	The Biodiversity Group shall report to the Ecological Council of Sakhalin oblast.
Регламент Рабочей экспертной группы утверждается на заседании Рабочей группы.	The terms of reference of the Working Group are ratified at the Biodiversity Group meeting.

An overview of Sakhalin Energy's Biodiversity Action Plan structure was presented to the BG at its inaugural meeting, followed by discussions on biodiversity interest prioritisation and consideration of assemblages in developing species and habitat action plans.

The recommendations of the Working Group will be considered by Sakhalin Energy in a constructive and inclusive manner, allowing considerable scope for discussion and agreement on the manner in which specific actions will be implemented, how additional benefits can be achieved (e.g. involvement of research scientists in some of the work) and how to manage changing priorities (e.g. which species are covered by the BAP).

However, it is not intended that the BG's recommendations will be binding on Sakhalin Energy, especially as there is no legal requirement for the BAP. Instead, the overall intent will be to foster working relationships between the Group members that promote understanding of the issues involved and enable the principles of biodiversity planning and management to be more widely applied on Sakhalin.

11.2 Wild Salmon Centre

The Wild Salmon Centre (WSC) is an international non-profit organisation. Working in partnership with universities, government and private enterprise, the centre is committed to identifying the best remaining salmon ecosystems of the Pacific Rim, and to developing practical and scientifically sound strategies to protect salmon habitats and associated biodiversity.

Salmon are dependent on freshwater and estuarine ecosystems, and are extremely sensitive to changes in water quality. Juvenile salmonids feed on freshwater invertebrates, which are also indicators of water quality. The reduced capacity of a watershed to support salmonid juveniles suggests a decline in the health of the ecosystem. Therefore, understanding and maintaining salmon habitat is an essential element of coastal ecosystem protection.

Activities of the WSC are implemented via a network of regions and river basins that serve as sites of collaboration and information sharing to develop salmon conservation efforts and to build sustainable economies around salmon ecosystems. In prioritising investment in Pacific salmon conservation, watersheds are ranked based on landscape properties, salmon abundance and diversity. There is also focus on rare and endangered species, and consideration of social and community factors.

The Sakhalin region is considered unique as it supports unusually high production of pink salmon (*Oncorhynchus gorbuscha*), and approximately 50% of the global population of the endangered Sakhalin taimen (*Parahucho perryi*). It is also the only known area of sympatry with Siberian taimen (*Hucho taimen*), and is the southern distributional limit for coho salmon (*Oncorhynchus kisutch*). The Sakhalin region is also under growing threat from poaching and impacts associated with oil & gas developments.

In February 2008 the Wild Salmon Centre and Sakhalin Energy announced a landmark agreement that will jointly fund a three-year program for wild salmon conservation efforts on Sakhalin, known as Sakhalin Salmon Initiative (SSI). SSI is a collaborative effort to promote conservation and sustainable use of wild salmon and the ecosystems upon which they depend, to build institutional capacity for conservation and to promote sustainable economic development on Sakhalin Island. Sakhalin Energy is the founding sponsor of the SSI. The SSI is managed by the Sakhalin-based SSI centre and overseen by the SSI Coordinating Committee that includes the Sakhalin Oblast Administration, regional and federal agencies, academic institutions, business enterprises, commercial fishermen, indigenous communities and local and international NGO's.

List of Acronyms

BAP	Biodiversity action plan
BS2	Booster station 2
EIA	Environmental Impact Assessment
EPB	Environmental protection book
HAP	Habitat action plan
HFO	Heavy fuel oil
LNG	Liquefied natural gas
OP	Onshore pipeline
OPF	Onshore processing facility
RDB	Red data book
ROW	Right-of-way
SAP	Species action plan
TEOC	Technical and Economic Substantiation for Construction
TLU	Tanker loading unit

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