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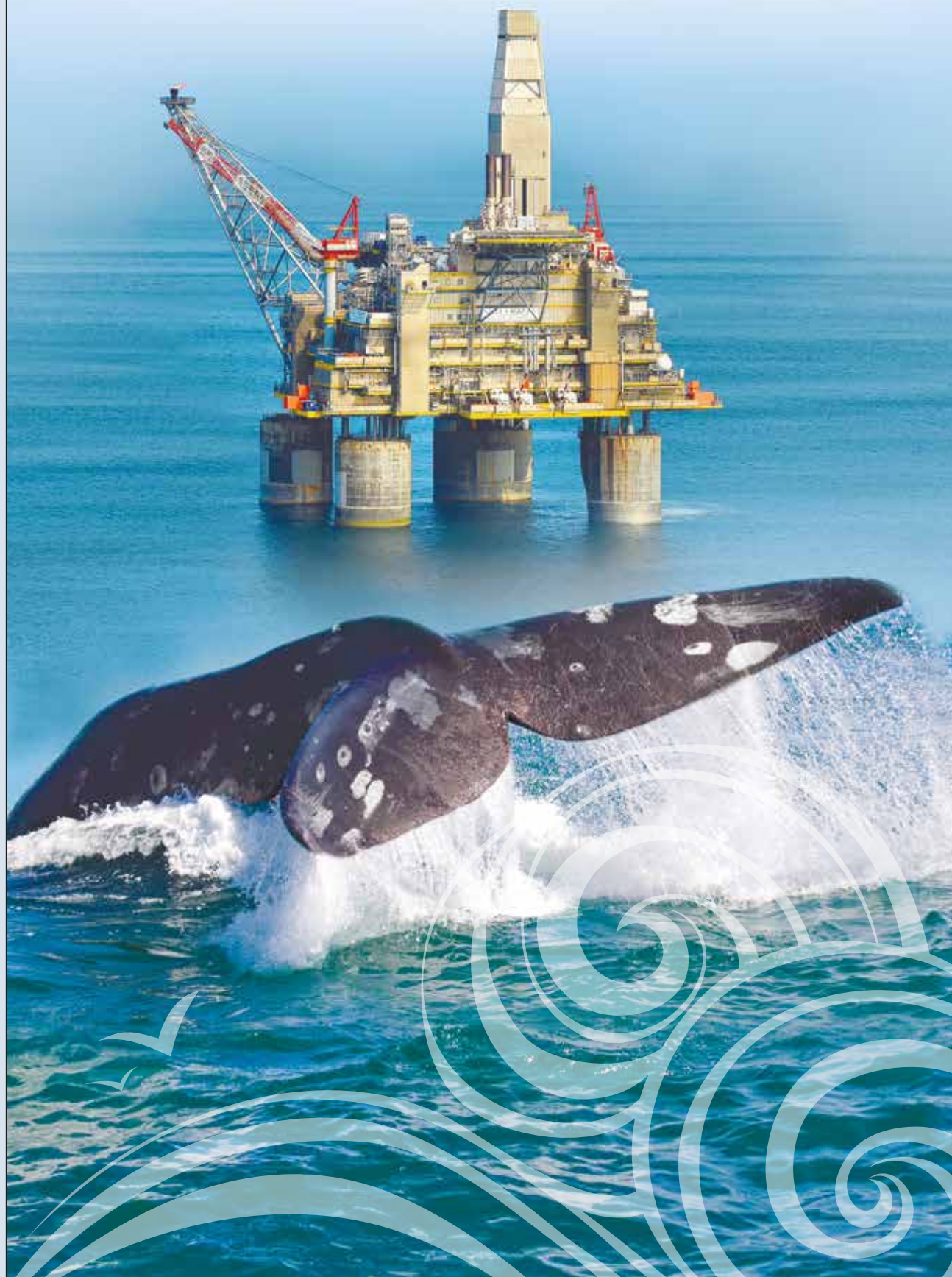
САХАЛИН ЭНЕРДЖИ
SAKHALIN ENERGY

ENVIRONMENTAL PROTECTION AT NORTHERN ASSETS OF SAKHALIN ENERGY



Edited by A. Samatov,
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SAKHALIN ISLAND

Sakhalin is the Russia's largest island being extremely rich in natural resources. Mineral reserves of the island are diverse and rather large in certain types: Sakhalin has more than 50 types of mineral raw materials, of which oil, gas, hard and brown coal, peat, and fresh groundwater have commercial value and are developed.

Extensive territory of Sakhalin predetermines considerable diversity of climatic conditions: from the ones in the north being hard for living and production to mild climate in the south of the island.

The air temperature goes down to minus 40 degrees Celsius in winter in the north of the island, and the sea is covered with ice for virtually six months. Wave height at Piltun-Astokhskoye and Lunskoye fields, where Sakhalin Energy Investment Company Ltd. (Sakhalin Energy) produces oil and gas, reaches several metres.

Sakhalin is specific not only for severe weather conditions but also for high seismic activity. The island is located at the border of the so-called Ring of Fire, a tectonic belt that fringes the Pacific Ocean, causing earthquakes in California and Japan as well as strong earthquakes on the Kuril Islands and Sakhalin.

Climatic features determine island's unicity of flora and fauna, when southern, subtropical species directly coexist with northern ones. Sakhalin and surrounding waters of the Sea of Okhotsk and the Sea of Japan are inhabited by thousands of animals and plants, including rare and protected species listed in the Red Books of the Sakhalin Oblast and the Russian Federation and in the Red List of the International Union for Conservation of Nature (IUCN). These waters are a zone for commercial and amateur fishing and a source of foodstuffs for Sakhalin North indigenous peoples residing in the adjacent territories and engaged in fishing, marine animal hunting and gathering.

Sakhalin Energy strives to reduce any negative impact on wildlife to an absolute minimum: both terrestrial and marine flora and fauna. For this purpose, first of all, it is necessary to understand the processes that take place in the environment of the island. Therefore, the company carries out environmental research, implements industrial environmental control and monitoring programmes, and applies an integrated system of measures for preservation of biodiversity.

SAKHALIN-2 PROJECT

Sakhalin-2 project operated by Sakhalin Energy is one of the most technically challenging projects undertaken in recent decades in the global oil and gas industry. While developing the oil and gas fields, the company has built a large-scale infrastructure for production, treatment, transportation and subsequent sale of hydrocarbons. Sakhalin-2 project's production facilities include three fixed offshore platforms, offshore and onshore pipeline systems, the onshore processing facility (OPF), the OPF compression (OPFC) under construction[1], booster stations (BS), the Prigorodnoye production complex[2] including an oil export terminal with a tanker loading unit, the Russia's first liquefied natural gas (LNG) plant with an LNG jetty, and gas transfer terminals.

Environmental safety of the whole infrastructure of Sakhalin-2 project is one of the most important tasks of Sakhalin Energy. The company's production facilities are designed so that to withstand any impacts, including most powerful ones, in severe natural and climatic conditions of the island. Production operations (including wells drilling, oil and gas production and transportation) are performed according to the key principle of the company's policy: 'No Harm to the Environment'.

[1] As of the end of 2018.

[2] Information on the Prigorodnoye production complex is presented in the brochure 'Environmental Protection at the Prigorodnoye Production Complex', 2017.

OFFSHORE PRODUCTION FACILITIES OF SAKHALIN ENERGY

PILTUN-ASTOKHSKOYE-A PLATFORM

The Piltun-Astokhskoye-A (PA-A/Molikpaq) platform is the first fixed (rested on the sea bottom) ice class offshore oil production platform installed on the Russian shelf.

The name Molikpaq means 'a big wave' in the language of the Eskimo of the north Canada, the place where it was based earlier (in the Beaufort Sea) as an exploration platform. In 1998, owing to a 15-metre spacer specially designed for operation in severe ice conditions that was added to the platform base, the platform was installed in the Astokh area of the Piltun-Astokhskoye field in the Sea of Okhotsk 16 km from the coast, where the sea depth is 30 m. The platform successfully resists sea waves up to 10 m high. Nogliki located at about 100 km is the nearest settlement.

The Molikpaq is a caisson (substructure) filled with sand and serving as a ballast that presses the platform bottom to the surface of the sea bottom, thereby ensuring efficient fastening of the platform.

From 1999 to 2008, the Molikpaq platform was the central facility of the Vityaz asset, which also included a twin-hulled floating oil storage named Okha for storage and export of oil, a single anchor leg mooring, and an offshore pipeline. Drilling, production, and export of oil, as well as the related auxiliary and exploration works were carried out at the asset. Oil production continued for about six months a year in the ice-free season.

Since December 2008, year-round production is carried out from the platform. The produced hydrocarbons (oil and associated gas) are transported to the OPF and then via the trans-Sakhalin pipeline system to the LNG plant and the oil export terminal at Prigorodnoye production complex.

PILTUN-ASTOKHSKOYE-B PLATFORM

The Piltun-Astokhskoye-B (PA-B) offshore oil and gas platform is the largest platform built under the Sakhalin-2 project. It was installed in 2007 in Piltun area of the Piltun-Astokhskoye field 12 km from the shore at the depth of 32 m and 80 km to Okha.

Intended for year-round production of oil and gas from Piltun reservoir, the PA-B is a drilling, producing, and processing platform. The Piltun-Astokhskoye-B is installed on a reinforced concrete gravity base structure with four legs supporting the platform topsides with process facilities of 28,000 t. The large weight of the base structure (90,000 t) makes it possible to install it on the sea bottom without additional fastening in the form of piles. Gravity base structures maintain stability under any weather conditions. They can resist waves, withstand a magnitude nine earthquake due to their big on-bottom weight. The platform height from the sea bottom to the top of the deck is 121 m, i.e. it is equivalent to the height of a 30-storey building.

Power generators with turbine drives operating on gas or diesel fuel are used for the platform power supply (just like for PA-A).

LUNSKOYE-A PLATFORM

The Lunskoye-A (LUN-A) platform, Russia's first offshore fixed gas platform, was installed in June 2006 in the Lunskoye gas condensate field in the Sea of Okhotsk 15 km from the shore where the sea depth is 48 m. The nearest settlement (Nogliki) is located 44 km from the platform.

The LUN-A platform is supplied with power by means of electrical cables laid on the bottom of the Sea of Okhotsk from the OPF.

The lower part of the platform is a reinforced concrete gravity base structure of 111,000 t. It is 160 m high, which is higher than the famous Pyramid of Cheops.

The LUN-A became the world's first offshore platform on which equipment reducing ice and wave impact load on the platform was installed, which also allowed making its operation more safe and reliable. Friction pendulum bearings are placed under the platform topside in order to ensure its mobility during an earthquake, while reinforced concrete gravity base structures keep firmly standing on the sea bottom. The same structure is installed on the PA-B platform. The platform topsides almost of 22,000 t is similar by weight of two Eiffel Towers.

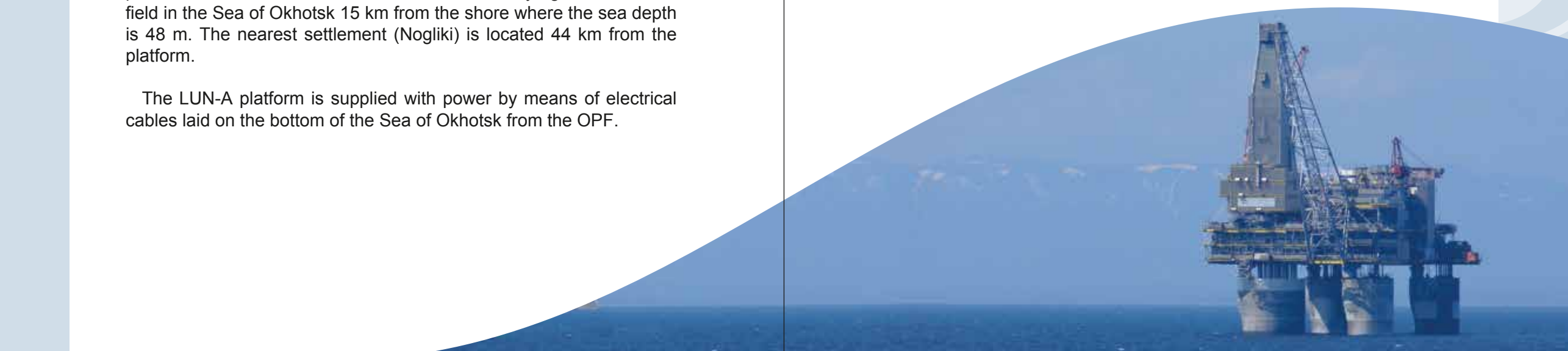
All year round, the platform produces the bulk of gas for the LNG plant.

Initial treatment of gas is carried out at the OPF, then this gas is transported to the LNG plant.

Each platform is equipped with a flare unit having different heights of its stack (the PA-A: 60 m, the PA-B: 98.6 m, the LUN-A: 105 m) which is intended for safe burning of hydrocarbons during start-up, technical maintenance of equipment, as well as in case of shutdowns.

In order to ensure maximum safety, the flare unit, the wellheads zone and accommodations are located at opposite sides of the platform. The main working areas of the platform are closed, temperature and ventilation control are provided therein. Outdoor equipment is protected against icing and low temperatures.

Prevention of oil spills and emission of gas from the wells is ensured by advanced blow-out preventers, an emergency system of hydrocarbons production shutdown, downhole controls, and subsurface valves shutting off the well in case of any failures in the system.



NORTHERN OFFSHORE PIPELINES

PILTUN-ASTOKHSKOYE FIELD

Offshore pipelines connecting oil and gas production platforms of the Piltun-Astokhskoye field with onshore facilities ensure uninterrupted transportation of hydrocarbon products.

Oil and gas produced on the PA-A and the PA-B platforms undergo a complete cycle of treatment on them and then, after water separation, are transported to the shore through separate pipelines.

Gas and oil pipelines are laid parallel to each other along the entire route. The route of the offshore pipeline from the PA-A platform to the shoreline is 46 km long, from the PA-B to the shoreline is 71.4 km long. The length of onshore pipelines (oil and gas) from the junction with offshore ones to the OPF is 157 m.

LUNSKOYE FIELD

There are two offshore pipelines between the LUN-A platform and onshore structures, in the direction from east to west. They uninterruptedly transport hydrocarbon raw materials (a mixture of wet natural gas, gas condensate[3] with small amount of oil, and aqueous solution of mono-ethylene glycol (MEG)[4].

Why do we need MEG? During production, a part of water is left in the gas condensate mixture. Under high pressure and at low temperatures, methane (the main part of natural gas) and water can form hydrates. Methane hydrate is a solid substance being similar in appearance to compacted snow. By depositing on the pipe walls, hydrates dramatically reduce their throughput capacity and can block a pipeline completely. To prevent the hydrates formation, high-concentrated MEG is constantly injected into the gas condensate mixture on the LUN-A platform.

[3] Gas condensate is a mixture of liquid hydrocarbons separated from produced gas upon reduction of pressure and/or temperature. Under standard conditions, the condensate consists of liquid hydrocarbons (pentane) where a certain quantity of gaseous hydrocarbons (methane, ethane, propane, and butane) is dissolved.

[4] Mono-ethylene glycol is an oxygen-containing organic compound, a dihydric alcohol, being a transparent, colourless, and slightly oily liquid.

When passing together with gas and liquid through the pipeline from the platform to the OPF, MEG absorbs water and prevents formation of hydrates. However, as this takes place, concentration of MEG decreases (from 85% to 65%), and it becomes unsuitable for further use to prevent formation of hydrates. It is recovered at the OPF and is transferred through the pipeline back to the platform.

The aforesaid pipelines share the corridor with an electrical cable for the platform power supply and an auxiliary fibre-optic cable to ensure control and communication with the platform.

The overall length of the pipelines from the Lunskoye field to the OPF is 21.3 km, including the offshore part equal to 14.3 km.

Design features and concrete coating of offshore pipelines ensure their stability, integrity, and minimum environmental impact.

In order to prevent pollution of the marine environment during transportation of produced hydrocarbon raw materials, pipelines are equipped with remotely controlled shutdown valves. This makes it possible to block pipelines safely and stop the hydrocarbons transfer.

The company annually carries out technical inspection of offshore pipelines and performs maintenance. The work is performed in the ice-free period, provided that there are favourable navigation and weather conditions, subject to safety requirements during diving and operation of engaged marine vessels and specialised technical devices.

ONSHORE PROCESSING FACILITY

The OPF is located in the north-eastern part of the island, 7 km from the coast of the Sea of Okhotsk and the landfall of pipelines from the Lunskoye-A platform. The nearest settlement (Nysh) is located 44 km from the OPF.

The main purpose of the OPF is initial treatment of gas and condensate supplied from the Lunskoye field, before they are transferred through a pipeline to the Prigorodnoye production complex. Oil and associated gas (gas dissolved under reservoir pressure in a field but released during production) produced at offshore platforms of Piltun-Astokhskoye field also pass through the OPF. Gas separation, removal of liquid is carried out at the OPF for the gas subsequent transfer. In its turn, condensate is stabilised, released from gas fractions, for it to acquire constant physical and chemical properties. This is achieved by removing light (gas) fractions of hydrocarbons, which results in obtaining a product containing liquid hydrocarbons and being suitable for transportation. These are the necessary conditions for transportation of hydrocarbons through trans-Sakhalin pipelines.

The BS 1 is located at the OPF. It ensures gas compression, that is, increasing its pressure by means of a compressor. Booster pumps increase the pressure of stabilised condensate and oil.

The OPF central dispatcher service coordinates the whole production process, controls the pressure in the gas pipeline and pipelines cleaning, so, it monitors each action of the facility.

Each and every process requires uninterrupted electricity supply, therefore, the OPF operates its own power unit (four gas turbines with the total capacity of 100 MW). The obtained power is also sufficient to supply the LUN-A platform, with all its considerable production needs.

The OPF includes a laboratory that services offshore platforms and the facility itself. Skilled personnel uses means of modern equipment to carry out testing of physical and chemical properties of oil and oil-containing fluids (crude oil, untreated condensate), glycol, commodity products (oil, condensate, natural gas) and lubricants.

Sakhalin Energy follows the highest standards in the area of environmental protection; therefore, the OPF laboratory also monitors process waters of the facility and potable water. Additionally, it analyses chemical reagents utilised in technological processes.

Due to production of gas and condensate, reservoir pressure of Lunskoye field decreases, therefore, construction of the OPFC is carried out for compensation of reservoir pressure decrease. The project provides for installation of inlet separators and equipment for feed gas compression, construction of a new flare system, utilities.

ENVIRONMENTAL PROTECTION

Environmental activity is a part of business principles of Sakhalin Energy, sustainable development policy, and general policy in environmental protection, health, occupational and industrial safety, and social performance.

At all phases of Sakhalin-2 project, Sakhalin Energy pays great attention to the environmental protection, having undertaken to work in compliance with the Russian legislation and global environmental standards.

The company is focused on proactive risk management and environmental impact assessment. For this purpose, the company monitors the environment in the area of the production facilities in compliance with the industrial environmental control and monitoring system that was developed and agreed with all regulatory authorities in 2007. The industrial environmental control programmes include protection of atmospheric air, protection of water bodies and rational use of water resources, waste management.

For efficient control of environmental impact, the company implements a number of environmental monitoring programmes. Programmes of marine environmental monitoring including water, bottom sediments and biota[5] quality evaluation, cover the areas of potential impact of platforms, pipelines and berthing facilities. Monitoring of flora and vegetation, soils, groundwater, protected bird species is carried out in the potential impact area of the OPF. Besides, the company developed a biodiversity action plan (BAP) the implementation of which ensures fulfilment of the company's obligations regarding minimisation of impact, development and introduction of measures aimed at preservation of both rare and endangered species and ecologically significant and vulnerable biotopes (habitat). In accordance with BAP, a gray whales monitoring programme is fulfilled and marine mammal protection plan is implemented in the area of impact of the northern offshore facilities. The monitoring data is used to assess the environmental condition, identify any negative changes and develop mitigation measures.

[5] Biota is a group of plant, animal or microorganism species of a particular sea area.

CONTROL OF IMPACT ON ATMOSPHERIC AIR

Sakhalin Energy seeks to minimise environmental impact, including air emissions reduction.

Production facilities of Sakhalin Energy are operated in accordance with the approved design documentation and permits for air emissions issued by the authorised state body. The compliance with the maximum permissible emissions standards established in the permits ensures the required quality of atmospheric air.

The main sources of emissions during operation of the platforms and the OPF are as follows:

• flare units designed to burn natural and oil-associated gas during normal production, maintenance of process equipment and pipelines, as well as in the period of shutdowns;

• turbines, compressors, and drivers of pumping equipment;

• diesel units used on the platforms and the OPF for generation of heat and electric energy for technical needs and process operations.

The main equipment operates on natural gas being the cleanest fossil fuel which, when burnt, produces smaller quantity of harmful substances than in burning of coal or oil products. The power plants using natural gas have high fuel efficiency which ensures decrease in emissions. Besides, the OPF turbines are equipped with a special system of nitrogen oxidation suppression which reduces their emissions. Diesel fuel is only used as reserve fuel, while fuel with low sulphur content is preferred.

Besides, measures for improvement of operational reliability and trouble-free operation of equipment are taken at the platforms and the OPF to reduce air emissions. For timely identification of potential gas leaks, the company performs regular inspections, diagnostics, required repair and maintenance of equipment by using fixed and portable gas analysers.

Around the OPF, a sanitary protection zone is established. On the border and outside of this territory, the impact indicators remain within or are lower than regulatory requirements. To control the OPF impact on atmospheric air, Sakhalin Energy takes quarterly measurements of pollutant concentrations at the border of the sanitary protection zone. Results of the control show that quality of atmospheric air in the OPF area complies with sanitary regulations.

CONTROL OF IMPACT ON WATER BODIES

Sakhalin Energy strives to reduce water consumption for production purposes and to minimise environmental impact caused by wastewater discharge.

All offshore platforms were designed with account for specific features of operation in marine environment and for international requirements, including MARPOL Convention[6] ratified by the Russian Federation.

Sea water is used for water supply of platforms. Special fish protection devices (louvres) are installed to prevent ingress of aquatic bioresources into the water intake system. Seawater used for production and domestic needs of the platforms is desalinated at special units. The largest volumes of water are used to cooldown the equipment. During cooling, the water is not exposed to pollution, nevertheless, it is constantly controlled before discharge into the sea.

Modern drilling technologies used by the company make it possible to use water rationally, including repeatedly, in production processes.

During extraction, water comes to the surface together with hydrocarbons; this is water present in rock formations and saturated with oil and its accompanying chemical compounds. This produced water is separated from oil and is re-injected to maintain reservoir pressure but is not discharged into the sea.

Wastewater from open parts of the platforms is not discharged into the sea either but is collected through special open drainage systems in tanks and is injected into wells. Injection of such wastewater into deep subsurface horizons is the most efficient measure to prevent pollution of the sea.

[6] International Convention for the Prevention of Pollution from Ships (MARPOL 73/78). It was signed in 1972 and focuses on prevention of the sea pollution with discharge of waste and other materials from ships, airplanes, fixed and floating platforms or other artificial structures in the sea.

Apart from production wastewater, domestic wastewater is formed on the platforms which is associated with accommodation and life support of the offshore facilities staff (207 persons can live and work on the PA-A platform, 155 persons on the PA-B, and 140 persons on the LUN-A).

Biodegradable detergents and similar household chemicals used on the platforms make pollutions in such wastewater non-aggressive towards the marine environment. Before being discharged into the sea, domestic wastewater of the platforms is purified and decontaminated.

Wastewater quality is controlled before and after purification at the treatment plant, before the water discharge into the sea with involvement of an independent accredited laboratory. Seawater quality is controlled, such parameters as colour, temperature, transparency, pH value of water, content of oil products, biochemical oxygen demand and microbiological indicators are examined.

Over the entire period of observations, no excess of maximum permitted concentrations (MPC) of pollutants has ever been noticed at control points.

The OPF is supplied with water from an independent water-supply system. Water is produced from underground boreholes at Spokoyny subsurface area located 2 km away from the OPF. The water intake volume and groundwater level are controlled on a daily basis, and quality of produced water – on a monthly basis.

The process water formed during natural gas and gas condensate recovery is delivered to the OPF from the LUN-A platform. This water as well as the surface wastewater from the territory of the OPF industrial zone is injected into a specially built disposal well that ensures secure isolation of the wastewater in deep subsoil horizons. To control security of such placement of wastewater, as well as to control any potential impact on the subsurface, sampling and study of chemical composition of water from monitoring wells is carried out twice a year. The results of the long-term observations confirm absence of any impact.

The OPF storm water is virtually not contaminated with oil products, since tight control of technical condition of vehicles and potential leakages from equipment is established at the facility. Chemical composition of water at outlets is controlled on a monthly basis.

Domestic wastewater from administrative and domestic modules, the canteen, the laundry, as well as from the sanitary equipment installed in production buildings in the industrial zone is delivered to the biological treatment plant. Wastewater is decontaminated at UV decontamination units before its discharge. Operation of the treatment plant and wastewater quality are controlled on a monthly basis.

Construction of the OPF compression project site is carried out in boggy areas which requires large volume of earthworks and implies constant dewatering. Disposal of drainage wastewater from the construction site is provided for through water-diversion ditches in the direction of the Vatung River. Domestic wastewater from the construction camp is taken to the biological treatment plant. Control of the treatment plant operation quality and wastewater quality, as well as quality of water at the control point and above it (background point) is carried out on a monthly basis.

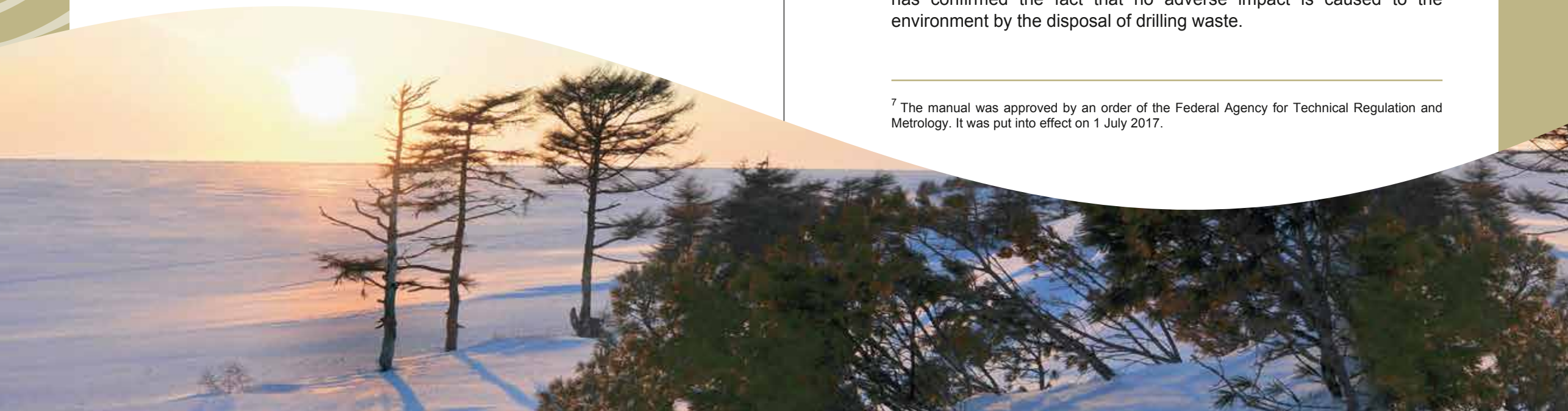
Long-term environmental monitoring did not reveal any adverse impact on the water bodies located in the areas of the company's production facilities.

WASTE MANAGEMENT

All waste is divided into five hazard classes, based on the degree of impact on the environment: from extremely hazardous to virtually non-hazardous. Most of the OPF and platforms' waste is low-hazardous for the environment, 4 and 5 hazard class waste. These are mainly drilling waste and solid domestic waste.

At the OPF and platforms, waste is collected separately for subsequent disposal, treatment, and reducing the amount of waste transported to landfills. Waste is timely removed from the company's facilities, according to the waste type and with account for formation of shippable quantity.

Environmental impact in waste management is primarily associated with the disposal at solid domestic waste landfills. All 1–3 hazard class waste being most hazardous for the environment (mercury-vapour lamps, batteries, spent oil, fuel and oil filters, etc.) is transferred to licensed organisations for neutralisation and disposal. Waste of 4–5 hazard class as well as formed during the OPFC construction (solid domestic and construction waste) is sent for disposal to landfills of the Sakhalin Oblast (Nogliki, Korsakov) and the Primorsky Krai (Nakhodka). Drilling waste is the exception.



All platforms of Sakhalin Energy operate in the mode of zero discharge of drilling waste to the environment. The company implements a technology of drilling waste injection into deep subsurface horizons: drilled cuttings are separated from the drilling mud, crushed (the maximum size of particles is 380 microns), added the required amount of liquid and chemicals, then the cuttings are injected into the reservoir. As compared to the technologies of waste disposal on the ground surface, such method has a number of advantages: environmental, economic, resource and energy-saving ones. Drilling waste is isolated in deep subsurface horizons at a depth of about 2 km, which eliminates its negative impact on the environment. Besides, there is no need to transport it anywhere from the place of its formation or to build special landfills and depots on the ground surface. Moreover, in this case, it is possible to dispose considerable amount of waste. In 2016, this technology was included into a manual[7] of the best available for waste disposal technologies.

The company continuously monitors the injection process and takes all reasonable measures to reduce the volume of drilling waste formation. In the area of underground sites of drilling waste disposal, the company monitors the seawater condition in the bottom layer, bottom sediments, and benthos (bottom-dwelling organisms). Based on the monitoring results, the state environmental supervision authority has confirmed the fact that no adverse impact is caused to the environment by the disposal of drilling waste.

[7] The manual was approved by an order of the Federal Agency for Technical Regulation and Metrology. It was put into effect on 1 July 2017.

MARINE ECOSYSTEMS

Environmental monitoring of potential impact of offshore production facilities is carried out for the purpose of timely identification of possible impact and forecasting of development of the processes affecting the quality of seawater, bottom sediments, and the condition of biological communities.

The monitoring is conducted in the area of the PA-A, the PA-B, the LUN-A fixed oil and gas platforms, offshore pipelines, wellheads of abandoned wells drilled at early stages of reserves exploration, as well as at drilling waste disposal sites within the boundaries of Piltun-Astokhskoye and Lunskoye fields.

The programme of offshore environmental monitoring is conducted on competitive bidding by contractors having a license of the Federal Service for Hydrometeorology and Environmental Monitoring (Roshydromet) and chemical laboratory accredited for carrying out necessary tests.

During the programme implementation, quantitative and qualitative characteristics of marine biota, as well as quality of their habitat are evaluated.

For reliable assessment of presence or absence of actual impact against high natural variability of the examined parameters, modern methods of statistical analysis and interpretation of the data obtained at the operation stage are used for comparison with the baseline data of the pre-construction stage and established standards for the quality of sea water and bottom sediments.

Based on the available data obtained as a result of long-term monitoring, scientists have made the following main conclusions:

• All hydrochemical characteristics including concentrations of petroleum hydrocarbons, heavy metals, phenols, and detergents[8] in the area of offshore production facilities are annually within the range of baseline values for these water areas and comply with the standards and water quality requirements for fishery water bodies.

• The content of chemicals (phenols, detergents, petroleum hydrocarbons, and heavy metals) in bottom sediments around offshore production facilities is distributed unevenly, which is due to specific geological features of the region and distribution of different types of soil on the north-eastern shelf of Sakhalin. Overall, the content of pollutants in bottom sediments varies within the baseline values known for these water areas and is below the limit of concentrations causing initial biological effects at the level of organisms and communities of marine ecosystems.

• No effluence of petroleum hydrocarbons or methane was detected at the wellheads of all abandoned exploration wells. Concentrations of petroleum hydrocarbons in the bottom layer and bottom sediments, at the boundaries of drilling waste disposal sites, do not exceed the baseline values obtained earlier.

[8] Detergents are surface-active substances used in industry and household as cleansing agents and emulsifiers, they are among the main chemicals polluting the surface water.

• Benthos and plankton communities are typical for water areas of the Sea of Okhotsk shelf and are characterised by rich species diversity with high quantitative indicators comparable to the baseline values. The areas of the platforms are inhabited by several bottom communities located on various types of sea ground. The basis of the biomass of benthic communities is formed by sea urchins, actinias, bivalves, gastropods, polychaetes, and crustaceans. Amphipods and polychaete worms dominate by species abundance, bivalves and gastropods are characterised by richness of species. The structure of benthos near the platforms is rather stable, no tendency towards decrease in biomass was identified for this region as a whole. Taking into consideration high values of quantitative and structural indicators of bottom communities near the platforms, it has been concluded that there are good environmental conditions in the habitat which is not exposed to human induced impact.

The results of the long-term research demonstrate the stability of local marine ecosystems components in the areas of offshore production facilities at the operational stage and absence of any impact of production activities on the quality of seawater, bottom sediments, and the condition of marine biota near the fields.

MARINE MAMMALS

Each year, a small aggregation of gray whales comes to the north-eastern coast of Sakhalin Island for feeding. They come late May or early June, after the water area gets free of ice, and remain until the beginning of winter migration in November or December. Two main areas of gray whales feeding in the waters of the north-eastern Sakhalin are known: a shallow, near-shore area named Piltun and a deeper one called Morskoy. The Piltun area is located eastwards of the Piltun Bay, in close proximity to the shore, at depths of up to 20-25 m, and near Piltun-Astokhskoye oil and gas field. The Morskoy area is located about 40-50 km southward, to the east of Chaivo and Nyisky Bays, with depths of 35-60 m.

In the RF Red Book, whales of Okhotsk-Korean population, or western gray whales, are classified as endangered (the first category). In the IUCN Red List, this population has the status of critically endangered. In this regard, Sakhalin Energy pays great attention to preservation of gray whales near offshore production facilities.

By the beginning of the development the Piltun-Astokhskoye oil and gas field of the Sakhalin-2 project, the fundamental data on the whales' abundance, migration, feeding periods and areas, necessary for development of the impact prevention and mitigation measures, was unknown. To obtain the necessary information, in 1997, Sakhalin Energy started implementing one of the first, large-scale programmes to study and monitor gray whales. Since 2002 and to this day, an integrated joint monitoring programme is being conducted in cooperation with the operator of the Sakhalin-1 oil and gas project. During the monitoring, unique scientific information on behaviour, age and sex structure, reproduction, as well as number and distribution of whales on the north-eastern shelf of Sakhalin has been received. Furthermore, gray whales' habitat conditions have been studied in detail: seasonal and year-to-year changes in feeding benthos communities; levels of natural and man-caused noises; topographical and hydrological specific features of feeding water areas.

Satellite tagging conducted in 2010 and 2011 resulted in new discoveries about migration of whales. Contrary to a conventional belief that all western gray whales winter near the shores of South-East Asia, tagged animals, in autumn, took the course to North America and reached the shores of Mexico, the wintering grounds of Chukotka-Californian, or eastern gray, whales. This discovery is also important because the eastern population of gray whales has recovered after prohibition of whaling, and if scientists confirm the facts which may be indicative of common features of western and eastern whales, the view of the situation may change. The obtained results of genetic analyses also confirm the absence of isolation between Sakhalin and Chukotka-Californian gray whales.

Another interesting result of this research is that one of the tagged whales, a female named Varvara, has set a world record in distance of migration among mammals. Over a period of five and a half months, she covered a way of 22,511 km, swimming from the shores of Sakhalin to Mexico and coming back next summer.

Photo-identification, i.e. photographing of individual gray whales, is an important research area. Presence of numerous spots varying in shape (marks of ectoparasite fouling) on an animal's body allows making its individual portrait. The obtained data is summarised in a special photo catalogue that annually refills due to detection of new calves and mature animals. If in the middle of 80s of the last century, about twenty gray whales were found, then in 2017 283 individuals have already been included in the special catalogue; newly-born

calves are registered every year, and adult whales that have not been encountered before are regularly observed. According to specialists' estimates, the population is increasing by 2-5% a year.

In recent years, a new method of research with application of state-of-art unmanned aerial vehicles, or drones, was implemented. Owing to these methods, high-quality photos were obtained, which helped to identify more extensive body parts of whales. The use of drones provides ample opportunities to study the natural behaviour of whales, to make a more accurate estimate of their number in groups, and to determine mother-calf pairs. An important advantage of using drones is the possibility of recording animals at a close range without disturbing them.

Apart from gray whales, about 20 species of marine mammals can be found in the area of the company's oil and gas platforms. Most of cetacea are observed in this water area in the ice-free period, including protected species: bowhead whale, pacific right whale, fin whale, Cuvier's beaked whale, and harbour porpoise. In winter and spring periods, the vast majority of these animals are concentrated in a wide strip along the eastern coast of the island. In the area of Piltun-Astokhskoye and Lunskoye fields, four species of true seals can be found. True seals include marbled or ringed seal, largha or spotted seal, ribbon seal, and bearded seal. Eared seals are represented by two species: northern fur seal and sea lion. Ringed seals, bearded seals, and spotted seals inhabit this area all year round. Ribbon seals usually appear here in winter and spring, while sea lions and northern fur seals are mainly seen in summer and autumn.

According to the special marine mammal protection plan, the company believes that it is necessary to consider all risks arising from industrial activities and to take, in a timely manner, all mitigation measures, in relation to all marine mammals and not only to endangered species.

With participation of Russian and international scientific and environment protection organisations, the company's specialists have developed a set of measures intended to evaluate and minimise potential impact of construction and operation work on marine mammals. It includes restriction of vessels traffic speed and development of special corridors for them, obligatory presence of observers on vessels, adjustment of work schedules, so that to minimise or completely avoid the work performance in those months when whales feed near the shores of Sakhalin, noise standards, safe distances, etc. The offshore facilities construction project itself has also been adjusted: changes were made to the plans, including costly rerouting of pipelines in order to bypass the gray whale feeding area.

The data obtained as a result of the long-term scientific research shows that the oil and gas project implementation has not affected gray whales or other marine mammals, which confirms the efficiency of the impact minimisation measures implemented by Sakhalin Energy.

COASTAL AVIFAUNA

Rich species composition and high concentration of birds due to specifics of geographical location are distinct features of avifauna of north-eastern Sakhalin shelf. An intense migration flow of birds nesting at the northern latitudes passes through the area. Along with exclusively marine bird species which spend the most part of their life cycle in open water, such groups of birds as anatidae, grebes, divers, waders, birds of prey, and passerines fly over the sea along the coastal line. Their number is especially high in spring and progressively increases in autumn, when the breeding period is over. The majority of anatidae and waders move on the shelf along the coastal line, density of migrating species gradually decreases as they move away from the shore but it is still considerable in the areas where the company’s offshore platforms are located.

In summer and autumn period, southern species of shearwaters, sooty and short-tailed shearwaters, are migrating widely in the Sea of Okhotsk. Their flocks can reach several thousand individuals. As for the northern species of shearwaters, northern fulmars nesting on islands in the Sea of Okhotsk dominate over the other species in terms of number. Guillemots, cormorants, tufted puffins, auklets, and horned puffins can be found on the shelf all year round, except during the ice period. There is a large breeding group of long-billed murrelet in the coastal area of Lunsky Bay.

Various species of gulls can be found over the water of the Sea of Okhotsk. Slaty-backed gull and black-tailed gull prevail in summer, while a lot of black-legged kittiwakes can be observed in autumn. Gulls move actively throughout the space, forming gatherings near oil and gas platforms and flying after vessels in search of food and places for rest.

Shelf area is important for summer molting of males of three anatidae species: black scoter, Siberian scoter, and harlequin duck. Their number is several tens of thousands individuals, while the number of Siberian scoter can reach several hundreds of thousands birds.

The company pays great attention to security of hydrocarbons production and transportation, prevention of oil spills which could harm sea birds. Front-end engineering, development of mitigation measures, and monitoring during construction work have made it possible to keep unchanged both communities of birds and populations of protected species.

With account for all risks, year-round monitoring of avifauna is conducted in the areas of the platforms' location. Results of the monitoring have revealed that cormorants, diurnal birds of prey (falcons and eagles), anatidae, seagulls, sandpipers, and passerines are the main groups of birds in the area of the offshore platforms. The most abundant group is gulls whose typical behaviour is to visit and escort vessels, as well as to visit offshore platforms as resting places. There are other abundant groups: anatidae and sandpipers observed around the PA-A offshore platform, and cormorants (pelagic cormorant) around the PA-B platform.

Small number of birds is characteristic of winter period and early spring. In April and May, migration activity of birds increases, but in terms of flyover intensity, spring migration is less active than in autumn, and lasts for a shorter time. Summer months (June and July) do not see a great variety and number of birds, either. In this period, some single gulls and cormorants stay near the offshore facilities. In August, remigration of birds becomes noticed, it gets most intense in September and in the first half of October. In these months, migratory falconine bird species of prey such as peregrines, gerfalcons or hobbies stop on the platforms. At this time, they hunt passerines sitting on the platform for rest during the flight.

Evaluation of seasonal distribution and number of birds makes it possible to identify essential zones of their concentration and the most vulnerable periods in the annual cycle.

TERRESTRIAL ECOSYSTEMS AROUND OPF

SOIL AND GROUNDWATER

Soil is an indispensable element of the land surface owing to which existence of plant and animal bodies becomes possible. Its composition is a result of many years' natural processes, it is an indicator of long-term impact of various pollution sources.

A system of regular observations of soil characteristics allows for timely detection of negative change trends, identification of causes of the changes, and timely development of the necessary measures to prevent or mitigate the impact.

Soil studies carried out at the stage of development of the OPF construction project have made it possible to determine the main types of soils, their morphological, physical, and chemical characteristics, and to establish a network of stations for subsequent monitoring.

The OPF is situated on the undulating plateau of the Nabil Lowland, where brown taiga soils under the forest vegetation intersperse with peat bog soils under marsh vegetation. Thickness of peat layer on moss bogs to the north of the OPF is 80 to 120 cm. Sites for further monitoring of soil were set on four cardinal directions at a distance of up to 4 km from the OPF. A total of 16 testing sites and one testing site in the protection zone of the southern access motor road were set.

For soil monitoring, an unified approach is used when samples are taken by an ‘envelope method’, i.e. at five points: four on the corners of a testing site and one in its centre. Analysis of such indicators as pH, grain-size composition, content of humus, nitrate nitrogen, labile phosphorus and potassium makes it possible to track changes in agrochemical properties of soils. Apart from that, the monitoring includes observing the erosion processes signs and water-logging of soil.

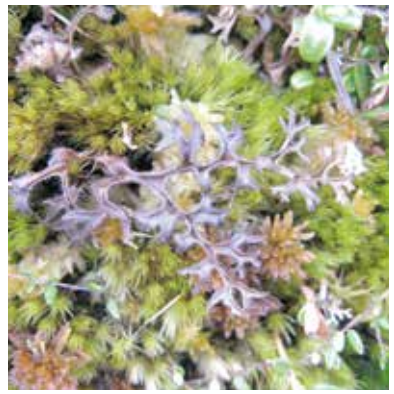
Results of the long-term soils monitoring show that such parameters as structure of the soil profile, grain-size composition of mineral reservoirs, and morphometric indicators are rather stable in time. The pH level – acidity of soil – is one of the important indicators. It shows saturation of soil with alkaline minerals and acid salts which hinder plants’ ability to uptake useful elements. Ash content in soil – presence of mineral impurities in it – is another important indicator. Upon insufficient supply of mineral substances from soil, biochemical processes in plants’ cells may be disturbed, and this reflects in their external appearance. Monitoring of soils on sampling sites shows certain changes in values of the soil acidity and ash content. However, the observed deviations are due to natural variability of signs, as chemical reactions constantly take place in soil. Average content of oil hydrocarbons, as the main pollutants of soil, is lower than the maximum permissible concentrations. Signs of soil degradation are of natural origin and are in no way related to the construction and operation of the facility.

Monitoring of groundwater condition is carried out at 19 reference boreholes of various depths including five production ones. Four boreholes are outside the OPF fencing: two on the western side and two on the northern side. The other boreholes are located right in the territory of the processing facility, close to potential sources of impact.

Groundwater samples are taken from all boreholes two times a year, after snow melting in spring and after rain floods in autumn. Borehole activities including water level and temperature measurements, as well as borehole cleaning and maintenance (if required), are performed by a contractor competent in hydrogeology. Water samples taken from the boreholes are delivered to an accredited laboratory for analysis. Based on the data obtained, the contractor prepares special reports describing the current condition of groundwater, variations and trends, as well as analysis of data compared to previous years of monitoring.

In general, the groundwater situation is characterised as stable. This is indicative of efficiency of the soils and groundwater protection measures implemented at the OPF which include ensuring the invariability of hydrological parameters of the rocks overlying and isolating the subsoil horizons in which industrial wastewater from the OPF is placed.

FLORA AND VEGETATION


Preservation of vegetation is very important for support of stability of ecosystems. It ensures the habitat for animals and insects, along with other important functions.

Increased content of pollutants in soil and air can lead to death of plants, reduction of the growing time, change in the species composition, decrease in the number of species, etc. Because of that, it is very important to track the condition of vegetation in the area of potential impact of the OPF.

Large part of the territory to the north of the OPF is occupied by various types of bog communities formed due to natural changes taking place under conditions of excessive moisture and imperfect drainage. Most of these changes occurred because of periodical crown fires which destroyed primary (dark coniferous) forests or secondary permanent (light coniferous) forests.

Larch and dark coniferous forests dominate in the western direction. Most of such vegetation communities represent a certain stage of changing from light coniferous (larch) forests to dark coniferous (spruce and fir) forests.

To the south of the OPF, there is a narrow strip of larch and dark coniferous forests similar to those being adjacent on the west. Further to the south, spruce and fir gradually disappear in the timber stand, and larch and dark coniferous forests give way to rather thinned larch ones the most typical type of which is fruticous larch forest. This forest type has formed as a result of local fires leading to violation of hydrological regime.

In the eastern direction, there remain scattered areas of larch and dark coniferous forest that are separated by burnt forest areas becoming bogged up.

On trunks of coniferous species, one can find such species of protected epiphytic lichens as Bryocaulon pseudosatoanum and Lobaria pulmonaria and mosses like Dicranum drummondii.

Monitoring of vegetation, including protected species, is conducted on permanent testing sites at a distance of up to 4 km on four cardinal directions. The testing sites are used to monitor the species composition and structure of vegetation communities, plant development phases, and the condition of rare and protected species populations. Diversity of the testing sites reflects floral diversity of the territory.

The monitoring results show insignificant variations in the number of trees which are due to natural causes. The subordinate layers (vegetation being lower that timber stand) are preserved in good condition. The species composition in all testing areas remains unchanged.

Minor changes are observed in lichens, they have signs of certain impact due to microclimate disturbance in the construction period. But, along with suppressed thalluses[9], young thalluses of the same lichen species appear, which indicates that there is no change in the species diversity.

[9] Thalluses (from Greek thallos, meaning ‘young branch’) are bodies of plants not divided into organs, e.g. algae, fungi, lichens, and some mosses.

PROTECTED BIRD SPECIES

Extensive territory of Sakhalin determines considerable differences in environmental conditions forming in southern and northern areas of the island which, it its turn, influences the specifics of the fauna. A unique species composition of birds is observed in the north of the island, in the vicinity of the OPF. A total of 170 species are registered, including protected ones, such as Siberian spruce grouse, long-billed murrelet, and several owl species.

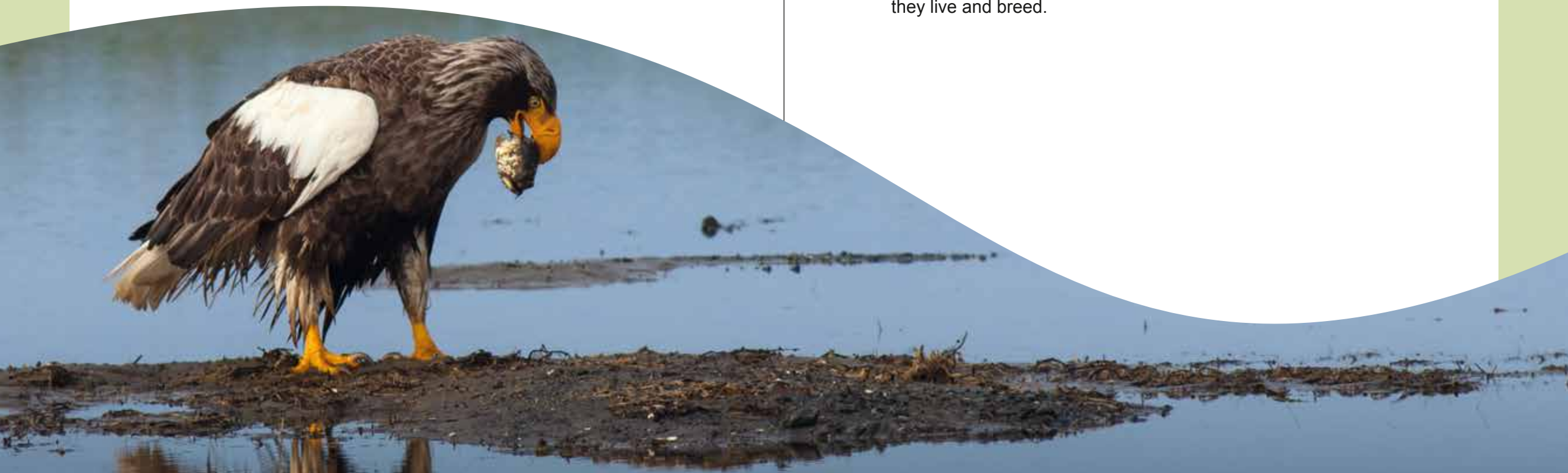
As part of the BAP, Sakhalin Energy monitors the abundance of protected species and their distribution, evaluates the condition of their habitats and the degree of impact of the production facility. To study rare bird species, it is necessary to use special recording methods, due to specifics of their biology.

Long-billed murrelet is one of important representatives of ornithocomplexes around the OPF. A natural feature of this species is to lurk at the sight of a predator or human, which makes it rather an elusive bird. Meeting a long-billed murrelet in Sakhalin forests is considered to be a great piece of luck. Areas of dark coniferous forest that surround the facility on the west, south, and east are typical habitats of this bird. Long-billed murrelet monitoring is carried out in a short spring period when males are actively courting and are easiest to notice. Individual marking of males with coloured rings has shown that high conservatism is characteristic of this species: males occupy the same courting grounds from year to year. During many years, density of long-billed murrelets remains stable.

Siberian spruce grouse is another protected species that remains unusual and still unexplored in many respects. This is the only specie of marine birds that nests in forest trees, at a distance from the sea coast. Siberian spruce grouses spend most of their life in the open sea, but in the period from June to August couples fledge one chick onshore. To arrange their nests, they require old larches with horizontal crowns where they can find a site for egg laying. In the breeding period, these birds make flights from the sea coast to the nesting places twice a day: in early morning hours and late in the evening. According to the assessment of ornithologists, six to eight couples nest in a 4 km area around the facility, and about 400-600 individuals cross the area, moving to the inland of the island.

Rare protected species of owls living here include great grey, boreal, pygmy, hawk owls and Eurasian eagle-owl. Their number is associated with the number of mouse-like rodents and shrews on which they feed, therefore, abundance of owls undergoes cyclical variations during several years.

For preservation of rare protected species of birds, it is important to preserve, in the area of the OPF, mature coniferous forests in which they live and breed.



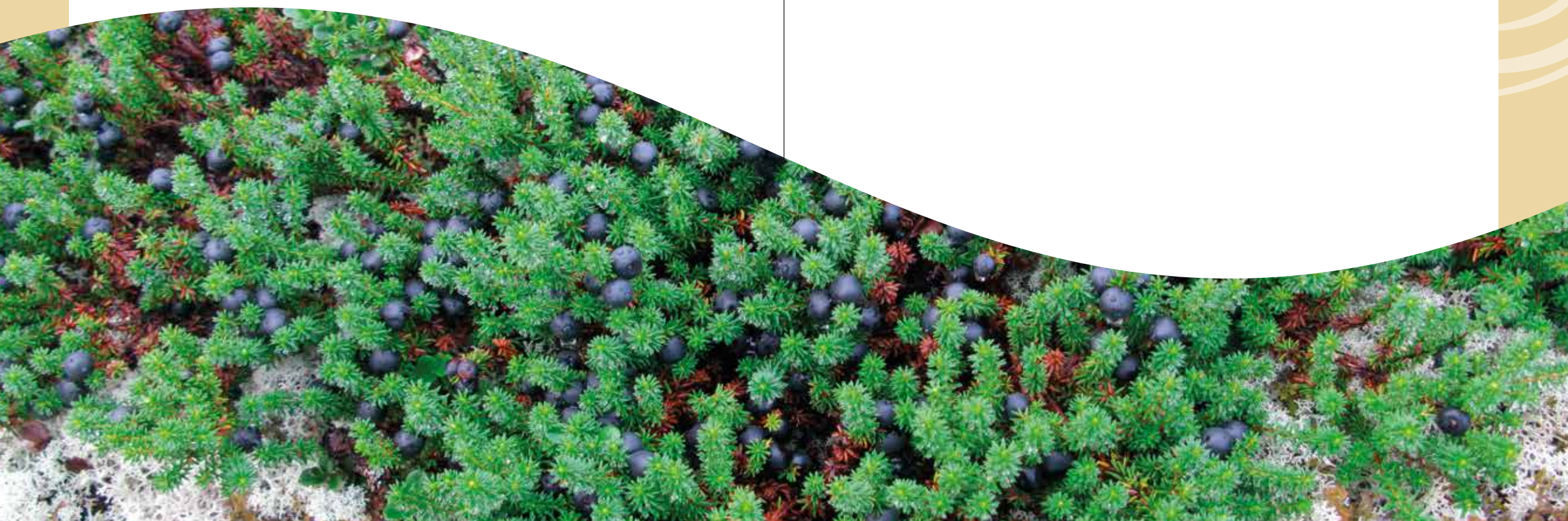
SMALL MAMMALS

The environmental group of small mammals, including mouse-like rodents and shrews, is traditionally used to evaluate the condition of the environment. Such biological features of small mammals as high reproductive potential, short life period, and fast turnover of population make them sensitive to any changes in the habitat including man-induced pollution.

In the vicinity of the OPF, monitoring of small mammals is carried out on three permanent test sites located near the boundaries of the production facility and three reference sites located a considerable distance, outside the zone of potential impact. By comparing the reference and test sites, the following indicator parameters of the population are assessed: morphometric specifics, age and sex composition, and reproductive characteristics. Structure of communities of small mammals, dynamics of their abundance and species composition are analysed. The structure of small mammals communities in the northern part of the island has its specifics and differences from the structure of communities of the southern part of the island.

A total of six species of mouse-like rodents and five species of shrews are revealed in the research area. Wood lemming, long-tailed birch mouse, least Siberian shrew, and large-toothed shrew are rare and small-numbered species. Northern red-backed vole is the most abundant rodent species; as for shrews, cyclical change in domination between Laxmann's shrew and slender shrew is observed during several years.

Many years of monitoring of small mammals in the area of the OPF did not reveal any changes in the structure of their populations, the results obtained for test sites and reference sites were similar.



ENVIRONMENTAL SAFETY PERFORMANCE

Multifunction support vessels are on twenty-four-hour duty near each platform. These vessels (Stepan Makarov, Fyodor Ushakov and Evgeny Primakov) perform the tasks of duty and oil spill response vessels, they also ensure, in case of an emergency, the whole set of measures for the environment protection and safety of personnel. Besides, in case of an operational need, up to 60 workers of platforms can be accommodated on each of these vessels. If necessary, these vessels can be used as supply vessels for transportation of materials and equipment. Sakhalin-2 project also operates four supply vessels (SCF Endeavour, SCF Endurance, SCF Enterprise and Gennadiy Nevelskoy) chartered by the company on a long-term basis and complying with all applicable provisions of the Russian and international environmental legislation.

At present[10], these vessels are one of the best in their class, they are designed for operation in challenging ice conditions of the Sea of Okhotsk. Permanent duty of such vessels in the water area of the Sea of Okhotsk improves the safety and security of the work being performed.

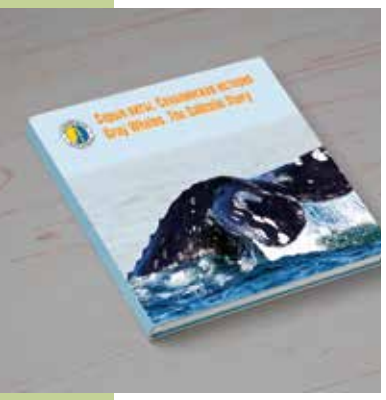
The company has developed measures making it possible to minimise the probability and consequences of emergency situations, primarily, oil spills. Oil spill response plans have been developed for all relevant production facilities and agreed with the authorities. Non-professional emergency response teams of facilities are in constant preparedness. Management teams are on 24-hour duty in case of emergency and crisis situations: on-duty members of the crisis management team and emergency coordination team.

Since the beginning of the Sakhalin-2 project implementation[11], not a single oil or oil products spill that could be classified as an emergency situation has occurred at the company's facilities, nor any pipeline accidents or ruptures resulting in spills of oil, condensate or oil products have been registered.

[10] As of the end of 2018.

[11] Since commissioning of Molikpaq platform in 1999.

CONCLUSION



Compliance with all safety requirements and respect for nature of the island had made it possible for Sakhalin Energy not only acquire a wealth of experience in the course of monitoring surveys, but also gain new knowledge and unique facts about Sakhalin nature. They were presented to a wide readership in a series of books: The Birds of Sakhalin Island, 2010; Steller's Sea Eagle, 2011; Gray Whales. The Sakhalin Story, 2013; The Rivers of Sakhalin Island, 2013; Sakhalin Flora, 2014.

Sound and efficient use of natural resources, introduction of advanced technology and partnership for environmental protection and biodiversity conservation help to ensure protection of Sakhalin's flora and fauna.

Sakhalin Energy regularly shares the monitoring results and experience at various Russian and international forums. For example, in partnership with the Project of United Nations Development Programme, Global Environmental Facility and the Ministry of Natural Resources and the Environmental of the Russian Federation (UNDP/GEF-Minprirody of Russia) 'Mainstreaming biodiversity conservation into Russia's energy sector policies and operations', the company contributed to the formation of a common environmental protection and biodiversity conservation culture in the region, industry and in the country as a whole.

The company's partnership with the Project of UNDP/GEF-Minprirody of Russia facilitated the development of the Sakhalin Oblast Biodiversity Conservation Strategy, which was approved by the Governmental Decree of the Sakhalin Oblast No. 263 dated 7 June 2017. 'Guidelines on large cetacean monitoring and set of measures to reduce human impact in course of economic operations in Russian marine waters' were prepared.

Sakhalin Energy has worthily repeatedly taken leading positions in the environmental responsibility rating of oil and gas companies in Russia. The rating is held by the World Wildlife Fund for Nature (WWF) of the Russian Federation and CREON Energy, the provider of advisory services to the fuel and energy industries, in partnership with the National Rating Agency.

The results of the environmental monitoring and biodiversity conservation measures have confirmed that the company is minimising the impact of its production activities on the environment through its environmental protection management system, which includes risk assessment and prevention and prompt mitigation of identified risks.